MICROGRIDS: AN ASSESSMENT OF THE VALUE, OPPORTUNITIES AND BARRIERS TO DEPLOYMENT IN NEW YORK STATE

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NEW YORK STATE
ENERGY RESEARCH AND
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Final Report

Prepared for the
**NEW YORK STATE
ENERGY RESEARCH AND
DEVELOPMENT AUTHORITY**

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ABSTRACT

Microgrid systems that link multiple distributed power generation sources into a small network serving some or all of the energy needs of participating users can provide benefits including reduced energy costs, increased overall energy efficiency and improved environmental performance and local electric system reliability. The growth of distributed generation combined with emerging technologies, particularly energy storage and power electronic interfaces and controls, are making the concept of a microgrid a technological reality. Still, energy market regulations and policy lag behind this progress, creating uncertainty and inhibiting investment in microgrids and the benefits they might provide. This report examines the potential value of, as well as current pathways and barriers to deploying microgrids in New York State. It provides a typology of microgrid ownership and service structures and a series of case studies on existing and planned microgrid projects; explores the legal and regulatory framework that microgrids would be subject to in New York State; reviews the status of microgrids in other parts of the United States; and examines microgrid value streams. This work is based on a detailed review of the literature on microgrids and distributed energy resources, legal research, and interviews with microgrid developers and state energy regulators from outside New York. The paper concludes with recommendations for policymakers to facilitate investment in microgrids.

KEY WORDS

Microgrid, distributed generation, distributed energy resources, smart grid, virtual microgrid, microgrid policy

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ACRONYMS AND ABBREVIATIONS

AC	Alternating current
AGC	Automatic Generation Control
AMI	Advanced metering infrastructure
CCHP	Combined cooling, heat and power
CEC	California Energy Commission
CESIR	Coordinated Electric System Interconnection Review
CHP	Combined heat and power
CO_2	Carbon dioxide
CPCN	Certificate of Public Convenience and Necessity
DADRP	Day Ahead Demand Response Program
DC	Direct current
DER	Distributed energy resources
DG	Distributed generation
DLCP	Direct Load Control Program
DLRP	Distribution Load Relief Program
DOE	Department of Energy
DR	Demand response
DSASP	Demand-Side Ancillary Services Program
EDRP	Emergency Demand Response Program
EPRI	Electric Power Research Institute
ERC	Emission reduction credit
ESCO	Energy Service Company
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse gas
HAN	Home Area Network
HEFPA	Home Energy Fair Practices Act
Hz	Hertz
ICAP	Installed capacity
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Provider
kV	Kilovolt
kVar	Kilovolt-ampere reactive
kW	Kilowatt
kWh	Kilowatt-hour
LAN	Local Area Network
LBMP	Location based marginal price
MMBtu	Million British thermal units
MW	Megawatt

MWh	Megawatt-hour
NAS	Sodium sulfur
NO_x	Nitrogen oxide
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
NYSEG	New York State Electric and Gas
NYTO	New York Transmission Owner
NYU	New York University
PACE	Property Assessed Clean Energy
PCC	Point of common coupling
PM	Particulate matter
POLR	Provider of Last Resort
PQ	Power quality
PSC	Public Service Commission
PSL	Public Service Law
PUHCA	Public Utility Holding Company Act
PURPA	Public Utility Regulatory Policy Act
PV	Photovoltaic
REC	Renewable energy credit
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
SBC	System Benefits Charge
SCADA	Supervisory control and data acquisition
SCR	Special Case Resource
SDG&E	San Diego Gas & Electric
SIR	Standardized Interconnection Requirements
SO_2	Sulfur dioxide
TDRP	Targeted Demand Response Program
TEL	Thameswey Energy Limited
UPS	Uninterruptible power supply
Var	Volt-ampere reactive

FINAL REPORT SUMMARY

This report investigates the potential value, opportunities and barriers to deploying electric and thermal energy microgrids in New York State. Microgrids are small-scale distribution systems that link and coordinate multiple distributed energy resources (DERs) into a network serving some or all of the energy needs of one or more users located in close proximity.[1] DERs include distributed generation (e.g., solar photovoltaic, small wind installations, small engines, combustion turbines and fuel cells), energy storage technologies, and power system control devices. In a microgrid, such DERs are linked together with multiple local energy users by separate distribution facilities (i.e., wires and pipes) and managed with advanced metering infrastructure, communications, and automated control systems.

Emerging technologies are making it possible to deploy advanced microgrids capable of integrating multiple DERs into a single system that can operate both independently from (i.e., in "islanded" mode) and seamlessly with the extant electric grid. By aggregating multiple loads and sharing supply resources, microgrids can take advantage of energy demand diversity – both electric and thermal – to integrate DERs in a manner that may be more optimal than on a single-site basis alone. Due to their small scale and ability to coordinate and deliver both thermal and electric energy, microgrids may be viewed as demonstrations of the potential benefits of a smarter grid or as an alternative path to the aggrandized smart "super-grid."

This report distinguishes between two types of microgrids: *physical* and *virtual*. We define a *physical* microgrid as:

> *A small, local energy system with integrated loads (i.e., demand from multiple sources) and distributed energy resources – producing electric or both electric and thermal energy – which can operate connected to the traditional centralized electric grid or autonomously from it, in an intentional island mode.*

Although the appropriate size of a microgrid is debatable, the research team found most microgrids to be 10 megawatts (MW) or less of electric generating capacity, but that larger systems, particularly those serving campuses may involve as much as 40 MW. Ultimately, the size of the microgrid will vary depending on the deployment context, but we believe 40 MW to be a reasonable – if somewhat arbitrary – upper bound.

While *physical* microgrids may be interconnected at high voltage and participate in regional wholesale energy and ancillary service markets, it is more likely that they will be connected at lower voltages to the local utility from whom they may buy and sell power. An important feature of physical microgrids is that they may also be operated independently from the larger grid – which we refer to in this report as the macro-grid – if disruptive events such as faults (i.e., short circuits), voltage fluctuations and momentary interrupts occur upstream. This provides microgrid participants with a level of power quality and reliability usually unavailable from the local utility. From the vantage point of the macro-grid, physical microgrids appear as a single coordinated load behind a single connection point – the point of common coupling.

While the focus of this report is principally on *physical* systems, we distinguish them from *virtual* microgrids, which integrate distributed generation (DG), energy storage and demand response (DR) across multiple end-users separately connected to the macro-grid. Unlike physical microgrids that locally integrate DERs and proximate loads with separate distribution facilities (i.e., wires and pipes), virtual microgrids rely primarily on the existing electricity grid (or possibly a large district steam system if excess thermal energy is available) to share and maximize the value of these resources among customers.

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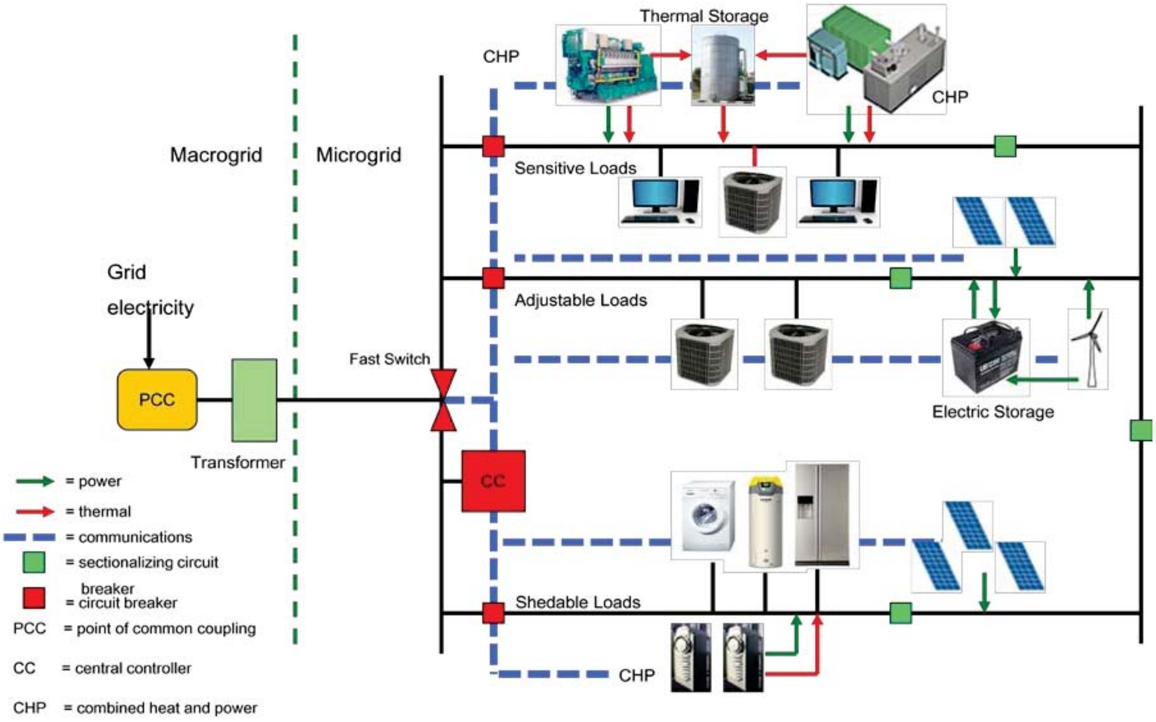
[1] It is important to note that while they may overlap in some respects, microgrids deploying CHP are not the same as district energy. District energy systems, which may involve cogeneration of electricity, typically use large boilers to produce and distribute steam or hot water for heating or cooling large districts. Con Edison's steam system in mid-town and downtown Manhattan is an example of a district energy system. While it is possible that some large microgrids could be construed as providing district energy, most microgrids will be much smaller (e.g., less than 40 MW of electric capacity) and serve a much smaller number of customers with both electricity and thermal energy.

Microgrids may employ a wide range of distributed energy technologies – including generation, storage and advanced controls, metering and communications – to provide tailored, efficient and reliable energy services to connected end users. Figure S-1 is a schematic of a physical microgrid.

Figure S-1 – Sample Physical Microgrid Schematic



These controlled networks provide electricity and, by employing combined heat and power (CHP or cogeneration), thermal energy to local interconnected loads. CHP technology captures the "waste heat" created during the production of electricity, for productive use including hot water, space heating, space cooling, or process heat for industrial applications. The productive use of waste heat from such systems can result in overall energy efficiency of these systems as high as 80%, providing significant environmental and economic performance benefits.

Microgrids are largely customized solutions to the energy requirements of connected loads and as a result, it is unlikely that any two systems will use the exact same technologies or configuration. Important variables for determining microgrid design and technology include, but are not limited to, the type, level and density of demand on-site for thermal energy; the type and level of electric demand considered uninterruptible (i.e., affecting the amount of capacity that must be available at all times); the local utility's energy tariffs, requirements for interconnection and interaction with the extant electric grid; and the local fuel supply.

This report is one of the first to examine the potential pathways and barriers for the deployment of microgrids within a specific state regulatory framework. To date, very little practical experience or structured thought informs national or state policy on this matter. We currently face a situation where, although the theoretical advantages of microgrids are well understood and the technological capabilities exist, barriers to their installation seem to be so widely presumed that few capable actors have begun to develop plans or strategies to test them, much less develop actual systems.

To address the ongoing uncertainty regarding state policy on microgrids, this report: (1) provides a working definition of microgrid to support future policy considerations; (2) identifies a typology of potential microgrid ownership and service structures; (3) presents case studies covering existing and proposed microgrids; (4) describes and analyzes the relevant legal and regulatory opportunities and barriers to microgrids; and (5) outlines the potential benefits and value streams of microgrid deployment, both to participants and the state. Key findings and recommendations are provided below.

Findings: Microgrid Value Streams

As small networks that use distributed generation, energy storage and system control technologies, microgrids will provide benefits associated with the particular DER applications, energy distribution design and control schemes deployed. For example, benefits might include the greater energy efficiency achieved through the use of CHP, reduced air pollution from the incorporation of renewable technologies, or enhanced power quality and reliability from the application of advanced storage and power conditioning technologies. The scale and type of benefits created from microgrids will also vary depending on customer and location-specific circumstances, including the thermal and electric demands of interconnected loads, the configuration of the local distribution system, the ability of existing macro-grid infrastructure to meet local or regional load growth, the local utility's mix of resources and the retail cost of energy, among others.

Economic Value Streams

The direct economic benefits potentially created by microgrids are the critical factor driving deployment decisions. One of the most attractive aspects of a microgrid is the ability to optimize the production and use of electric power and thermal energy over multiple sites, generation resources, and loads. For example, while traditional combined heat-and-power systems are optimized across a single facility, microgrids optimize energy supply over multiple end-use facilities. As a result, microgrids offer the promise of matching diverse multiple building load and generation profiles into systems that markedly improve overall energy efficiency.

Reduced overall energy costs: Depending on the generating technologies deployed, microgrid participants may benefit from reduced overall energy costs in several ways, including:

- *Reduced purchases of grid-sourced electricity and utility transmission and distribution services:* Through the use of DERs and sharing of power among multiple customers, microgrids may allow participants to eliminate most, if not all, purchases of macro-grid power, avoiding electric generation, transmission and distribution as well as other electric utility bill charges (i.e., reactive power charges, competitive transition charges or other surcharges). Moreover, if employing fuel-free renewable resources such as solar or wind, participants may benefit from reduced energy market price volatility. Ultimately, the realization of energy cost benefits will depend on the installed and operating costs of microgrid DERs deployed as well as prevailing macro-grid electricity prices.

- *Reduced fuel purchases for on-site thermal energy supply:* For microgrids that use CHP, an important value stream will come from the useful recovery of waste heat produced by generation sources. Recovery of heat from exhaust or engine cooling jackets for productive purposes such as hot water or space heating, process heat or steam, or as input to a thermally activated cooling system, significantly improves the overall fuel efficiency of an onsite electric power generation facility. This allows microgrid participants to avoid or reduce thermal energy production from onsite boilers, which in New York State typically burn natural gas, distillate fuel, and to a lesser degree, coal.

Sales of excess power to the macro-grid*:* microgrids that are interconnected to the extant electric distribution and/or transmission system may be able to capture the value of sales of electricity either directly to utilities or other electric customers, or into wholesale energy markets managed by the New York Independent System Operator (NYISO). Sales of excess electricity to the macro-grid may help microgrids optimize their energy production, particularly if CHP is included and the heat-to-power ratio of microgrid electric and thermal supply is not coincident with microgrid electric and thermal demand.[2]

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[2] The heat-to-power ratio refers to the proportions of heat and power produced by a given technology

Participation in organized demand response markets: by virtue of their ability to precisely control sources of supply and demand in response to market prices or other signals, interconnected microgrids[3] may be able to participate in organized demand response markets. In New York State the NYISO manages both reliability- and economic-based demand response programs. These programs pay customers (or microgrids) with the ability to curtail their electricity consumed from the grid on demand either by shutting off non-essential equipment or by using distributed generation on-site. Reliability-based programs call on participating customers to shed load during emergency periods when power supply may not be able to keep up with demand. Economic-based programs allow customers to bid their demand reduction into day-ahead energy markets to compete directly with power supply resources.

Reduced purchases or provision of transmission and distribution ancillary services: ancillary services are functions performed by electrical generating, transmission, system-control and distribution system equipment and people to support the basic operations and services of electric generating capacity, energy supply, and power delivery. Ancillary services can include reactive power[4] and voltage control, energy loss compensation, scheduling and dispatch, load or demand following, and energy imbalance, among others. The NYISO administers markets for ancillary services at the transmission level including regulation, voltage support, and black-start service, while utilities manage ancillary services at the distribution level.

The ability of microgrids to precisely control interconnected loads and manage customer voltage profiles can reduce the distribution utility's cost of providing reactive power and voltage control at microgrid participants' locations.[5] Moreover, microgrid participants may be able to avoid utility reactive power charges, which are now being implemented in New York to encourage customer power factor improvement to reduce electric system line losses. Microgrids may also be able to provide certain ancillary services to the macro-grid. In some cases, such as regulation service, reserves and black-start support, microgrids with the proper configuration may be able to receive financial remuneration from utilities or the NYISO for providing these services to the grid.[6] The provision of these services, however, may come at the expense of using microgrid capacity for serving internal loads and should be assessed on a case-by-case basis.

Reduced electric transmission and distribution losses: when electric current moves through the power distribution system, it encounters resistance from every system component it flows through, which produces heat and results in efficiency losses. In New York, these losses average 5-10% of power delivered to the transmission system from generating stations (i.e., net electricity produced), depending on the age of the system and the degree of electric loading on the lines. By removing load that would otherwise be served by the macro-grid and producing power at the site of demand, microgrids can help reduce losses, providing indirect social benefits in the form of capacity market savings. Microgrids can reduce T&D losses to about 3% of net power produced.

Deferred or avoided electric transmission and distribution capacity investments: electric utilities must invest in the transmission and distribution system so that there is always enough physical capacity to deliver the amount of power required by customers. Utility T&D capacity investments – high-voltage transmission lines, lower-voltage feeders, transformers or even new substations, for example – are typically "lumpy" (i.e., occur in relatively large segments of capacity) and can come at significant capital cost. This is particularly true in downstate New York where the higher cost of underground distribution and property acquisition can drive T&D upgrades to as high as $800/kW.

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[3] We use the term interconnected microgrid to distinguish microgrids that are connected to the grid and capable of providing or consuming power, or otherwise interacting with the macro-grid, from those that are entirely electrically isolated.

[4] Reactive power is that portion of electricity that does not perform work in an alternating current circuit, but that must be available to operate certain types of electrical equipment, such as motors. Reactive power complements real power (work-producing electricity), which is measured in units of watt-hours. Reactive power consumed by motors and other magnetic equipment during distribution of electricity, must be replaced on the grid, typically by generators or capacitors, in order to avoid causing current and voltage to be out of phase resulting in system losses. See: Pacific Gas and Electric, *Resource: an encyclopedia of energy utility terms*, Second Edition, 1992.

[5] S. Chowdhury, S.P. Chowdhury, and P. Crossley, *Microgrids and Active Distribution Networks,* Institution of Engineering and Technology: London, United Kingdom, 2009

[6] Information on ancillary service markets managed by the NYISO is available at: http://www.nyiso.com/public/markets_operations/market_data/ancillary/index.jsp (accessed on March 30, 2010)

It has long been recognized that DERs and other demand reducing activities, such as energy efficiency, can be used to avoid or defer these investments. By removing load that would otherwise be served by the macro-grid, microgrids can reduce peak demand or area load growth and similarly help utilities avoid or defer new power delivery capacity investments. Such deferrals can produce financial value to both utilities (e.g., reduced capital budget, lower debt obligations, a lower cost of capital) and ratepayers (i.e., lower rates). Since 2003, Con Edison's Targeted Demand Side Management program has solicited investments in energy efficiency and DG to provide distribution load relief. Nevertheless, due to stringent physical assurance requirements and short lead times, the program has not supported DG and it is appears unlikely that a new microgrid would be able to participate. As a result, the indirect T&D deferral benefits associated with microgrid investments are likely to remain uncompensated social benefits under most non-utility microgrid ownership structures.

Utility option value for long-term planning purposes*:* utility transmission and distribution capital investment decisions are made as a consequence of demand forecasts that have a certain degree of risk. If the projected demand does not materialize, the utility and its ratepayers may have invested in an uneconomic asset. Because of the nature of utility revenue recovery, ratepayers will absorb much of the costs of uneconomic capital investments. Using microgrids to defer utility investment may provide the utility (and ratepayers) greater control over its exposure to changing market conditions in the future. Still, the longer lead times required for most non-utility owned microgrids might diminish this value.

Enhanced electricity price elasticity*:* through the use of dispersed generation, microgrids may be able to provide value to all ratepayers in the form of enhanced electricity price elasticity. By reducing its consumption of electricity from the macro-grid, particularly when system demand is high, microgrids may be able to reduce the output from high marginal cost or "peaking" plants, thereby reducing the clearing price for electricity in wholesale energy markets or reducing the marginal cost of energy consumed (in a vertically integrated, cost of service environment). Given the uniform pricing principles adopted across organized US power markets (i.e., each customer within a given customer class pays the same rates), this means that other consumers – including ratepayers of utilities - will benefit too. Other wholesale "power" market benefits include mitigating capacity shortages and minimizing peaking plant owners' market power (by expanding the pool of competition that existing plant owners face). Microgrids can receive compensation for providing these services in the NYISO's Installed Capacity (ICAP) and demand response programs.[7]

Enable greater use of renewable generation*:* through the use of advanced control systems, demand response and generating sources that have good load following capabilities (e.g., reciprocating engines or fuel cells), microgrids may enable greater use of intermittent distributed renewable technologies both internally and externally for grid-connected systems. Microgrids located near utility-scale renewable power facilities may be able to support the NYISO in managing variations in output from typically intermittent resources, such as wind or solar. Additionally, by improving energy efficiency and reducing the amount of electricity delivered by utilities, microgrids may reduce the cost of meeting the New York State's renewable energy target of 30% by 2015. Microgrid participants may benefit from the integration of renewables particularly if net-metering[8] policies that provide microgrids with retail-level credits for exports apply or if the renewable energy credits (RECs) produced by the microgrid may be sold into either voluntary markets or for use by regulated entities in the renewable portfolio standard program. Additionally, the integration of renewable technologies and fuels into a microgrid could reduce participant exposure to future carbon regulation and cost.

Reliability and Power Quality Value Streams

Sophisticated electronics are playing an increasingly important role in business and our everyday lives. This equipment is sensitive to power quality (i.e., voltage fluctuations or imbalances and harmonics) and requires more reliable sources of power. While higher overall power quality and reliability is arguably an economic good, not all consumers of electricity require or are willing to pay for the same high level of service. It may also be that only a

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[7] See NYISO for more information at: http://www.nyiso.com/public/markets_operations/market_data/icap/index.jsp (accessed on August 28, 2010)

[8] Net metering provides customers that own qualified forms of distributed generation, typically renewable, with credits on their electricity bills for any surplus power they produce and deliver to the grid. These credits offset purchases they would otherwise make for grid-based power delivered when their on-site system is not producing energy.

portion of a customer's electricity demand is considered "uninterruptible" or particularly sensitive to power quality conditions. With the capability of providing varying and customized levels of power quality and reliability to interconnected loads, microgrids may be able to deliver tailored services to these loads at a lower overall cost than providing it universally.[9]

Reduced power interruptions: power reliability is a critical issue for many electricity consumers, representing a significant business, safety and health risk to their operations. The social cost of unreliable power has been estimated to be $80-120 billion per year nationally and as much as $9 billion per year in New York. For many customers, the risk of losing power at critical times, even if just momentarily, requires them to install uninterruptible power systems or back-up generation. Thus, an important potential benefit of microgrids to participants – and a frequent driver of investment – is the improved electric reliability that comes with the ability to isolate internal loads from the macro-grid during outages or other events. The magnitude of this value to participants will vary depending on the type of customers involved. In fact, the incorporation of a range of reliability requirements into a microgrid can enhance the economics of reliability by allowing low priority loads to be shed, reducing the capacity required to serve internal loads when operated independently from the macro-grid. Microgrids may also provide reliability benefits to the macro-grid by reducing loads in areas suffering from transmission or distribution congestion.

Enhanced power quality: power quality typically refers to the characteristics of voltage delivered to end-users. When voltage or current levels deviate from specified standards, equipment can be damaged or fail resulting in economic losses to customers. It has been demonstrated that through the use of modern power electronics (i.e., static power converters and rectifiers that convert "raw" power into a precisely regulated waveform), microgrids can provide integrated power supply with different levels of power quality, including carefully controlled voltage and frequency levels or different classes of alternating current or direct current power.[10] This kind of control over the quality of power delivered to end-users can provide valuable benefits to loads with little tolerance for voltage deviations. Additionally, in certain circumstances and with the appropriate generating sources and power quality control devices, microgrids may be able to provide voltage support by injecting reactive power into the local distribution system. This may be particularly beneficial to distribution systems that use long radial feeders, which frequently suffer from voltage or frequency irregularities.[11]

Environmental Value Streams

Microgrids have the potential to reduce the environmental impact of energy use through the integration of low or zero emissions generating technologies and by increasing the overall efficiency of the energy delivery system. As noted above, producing power closer to the point of consumption reduces electric system losses and the emissions associated with those losses, which are a function of the regional power supply mixture upon which that microgrid load would otherwise be reliant. Similarly, microgrids can facilitate the use of waste heat produced by some generating units, which effectively doubles the efficiency of primary energy use and can reduce thermal energy supplies from on-site boilers. This report identifies two specific environmental value streams associated with the potentially improved emissions profiles of microgrid systems.

Reduced emissions of carbon dioxide (CO_2): the potential and magnitude of microgrid CO_2 emissions reductions will be a function of the fuels and overall efficiency of supply technologies deployed within the microgrid as compared to the power and thermal energy supplies the microgrid is displacing. Because CO_2 is largely an unregulated pollutant, the value of reductions represents a positive externality (i.e., a benefit to society for which the microgrid usually will not receive direct compensation). Until CO_2 is a more broadly regulated pollutant (i.e., through the establishment of a national cap-and-trade program or a carbon tax), reduced emissions will not represent a significant or reliable value stream for microgrid owners or participants. Investment in a low-carbon microgrid, however, can reduce the risk to participants associated with potential near- or medium-term regulations on carbon

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[9] Chris Marnay, "Microgrids and Heterogeneous Power Quality and Reliability," Lawrence Berkeley National Laboratory, July 2008, LBNL-777E

[10] Afzal Siddiqui, H. Asano, N. Hatziargyriou, C. Hernandez and C. Marnay, "Microgrids: Engineering and Economics," SPIN Springer, May 2008

[11] Robert Lasseter et al., *Integration of Distributed Energy Resources: The CERTS MicroGrid Concept*, LBNL-50829, Berkeley: 2002

emissions. Microgrids may also be a valuable near-term pathway to deliver CO_2 reductions to achieve public policy objectives (e.g. New York City's goal of reducing local government emissions by 30% from 2006 levels by 2017).

***Reduced emissions of criteria pollutants**:* criteria pollutants are air pollutants – notably ozone, particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), and sulfur dioxides (SO_2) – that are federally regulated, using human health or environmentally based criteria for setting permissible levels. At certain concentrations these pollutants can have deleterious effects on human respiratory systems (i.e., asthma) or the environment (i.e., acid rain and global warming). To the extent microgrids incorporate CHP that displaces the use of building boilers burning coal or residual fuel (No. 4 or 6 oil), which is common in New York State, microgrids can provide significant local reductions in emissions of NOx, SO_2 and PM. Namely because more energy is being produced on site, microgrids using combustion technologies that burn fossil fuels may, in some cases, result in a net increase of site emissions. The extent of the increase will depend on the fuel sources and combustion technologies used.

Security and Safety Value Streams

Microgrids have the potential to provide public security and safety benefits in the form of improved overall electricity system resilience while also serving as safe havens during extended power outages. Facilities that receive energy from microgrids capable of separating and operating independently from the macro-grid can serve as community refuges during emergencies or long-term grid outages. Similarly, by reducing reliance on the macro-grid and remote sources of power, microgrids may make it a less appealing target for terrorist attacks. Finally, a high penetration of microgrids could improve the robustness of the macro-grid by containing disruptions and possibly limiting cascading outages. These benefits, while highly valuable from a social perspective, appear infrequently and are difficult for microgrids to monetize.

Findings: Microgrid Ownership and Service Models

Previous efforts to clarify and resolve some of the regulatory barriers to microgrid implementation have found that regulators' views of what a microgrid is and how one might operate differ.[12] As a result, it is likely that the viability of a given microgrid within today's legal and regulatory structure will depend on how the project is framed, particularly with respect to who owns the microgrid infrastructure, which types of customers receive service from the microgrid, and how profits from those services are earned. Below we provide a typology of microgrid ownership and service models to help identify the range of options for deployment and begin to shed light on the types of applications that may face the biggest hurdles (see Figure S-2). The typology includes nine models within two major categories of ownership: utility and non-utility (e.g., cooperatives or community systems, independent firms, and independent campuses). Where possible, examples of the models are identified.

Physical Microgrids

A. *Vertically Integrated Utility Model*: An existing electric utility owns the microgrid distribution infrastructure and generation and storage technologies operating on the system, providing electric and/or thermal energy services to participating customers. It also operates the microgrid control system, determining which generating units run and directing customer demand response or the shedding of non-critical loads in the event of a macro-grid interruption or for economic reasons. The microgrid allows the utility to differentiate its product and services to customers in the form of varying reliability and/or power quality services at varying costs. The research team did not identify an example of a vertically integrated utility microgrid; however, aspects of this model are represented by a reliability project undertaken by Central Hudson Gas and Electric in New York and the City of Naperville's smart grid initiative in Illinois.[13]

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[12] M. G. Morgan and H. Zerriffi. (2002). "The Regulatory Environment for Small Independent Micro-Grid Companies." *The Electricity Journal*: 52-57

[13] Central Hudson deployed a diesel back-up generator on a feeder line serving a rural community to improve local reliability and reduce cost in one of its most troublesome distribution areas. The generator allows the utility to continue serving the community as an island even when the line goes down due to weather or for servicing. Similarly, the City of Naperville has undertaken a significant deployment of SCADA systems and automated controls across its distribution system to address deteriorating

B. *Unbundled Utility Model*: An existing electric utility owns and maintains the electric distribution facilities serving the microgrid, which provides electric and, possibly thermal energy, while generation or storage assets are owned by participating customers or third parties. The utility will likely operate or direct the microgrid control system, and possibly use a control scheme that can accommodate the interests of multiple DER asset owners (i.e., one that enables and can integrate multiple "agents," or generators, acting on their own behalf). In this model, the utility would be an active partner with customers and generators to facilitate and manage the aggregation of loads and the deployment of generation on the microgrid. An example of an unbundled or hybrid utility microgrid is the project San Diego Gas and Electric (SDG&E) is developing in Borrego Springs, California. While SDG&E will own generation and storage assets located at its substation, it is also encouraging customer-sited generation and developing a price-driven demand response program for residential customers. At least one circuit served by the substation area will be capable of islanding to improve local reliability (see SDG&E case study in the Appendix).

C. *Landlord/Campus Model, Type 1*: A single non-utility owner operates the system and installs private wires and generation technologies on site, supplying electric and/or thermal power to multiple buildings also owned by the landlord-operator. Buildings and streets have the same owner and there are no previously unaffiliated parties receiving service from the microgrid. The system's wires and pipes do not cross a public way or utility franchise. An example of this type of microgrid is the Cornell University campus system (see the Cornell case study in the Appendix).

D. *Landlord/Campus Model, Type 2*: This model is the same as Type 1, but wires/pipes may cross a public way or utility franchise. An example of a Type 2 Landlord/Campus model is New York University's (NYU) microgrid in the Washington Square Park area of Manhattan (see the NYU case study in the Appendix).

E. *Landlord/Campus Model, Type 3*: This model is also the same as Type 1, but wires/pipes may cross a public way/utility franchise *and* previously unaffiliated neighboring customers may voluntarily join the micro-grid and be served under contract. The Burrstone Energy Center in Utica, NY, which provides electric and thermal energy to the Faxton-St. Luke's Hospital, St. Luke's Nursing Home and Utica College (across a public street) is an example of this model (see the Burrstone case study in the Appendix).

F. *Joint Ownership/Cooperative*: Multiple individuals or unrelated firms collectively own and operate the microgrid to serve their own electric and/or thermal energy needs. Other customers may voluntarily join the microgrid and be served under contract. The system's wires and pipes may cross a public way/utility franchise. The research team did not identify an operational microgrid that fit the cooperative description, but the Energy Improvement District initiative in Stamford, Connecticut appears to contemplate the development of joint ownership microgrids (see the Stamford case study in the Appendix).

G. *Independent Provider*: An independent, non-utility firm owns and manages the microgrid and sells electricity and/or thermal energy to multiple unaffiliated customers. This business model is strictly commercial. The independent owner/operator produces primarily for sale to others and not for its own consumption, which differentiates it from the Landlord/Campus and Joint Ownership models. The system's wires and pipes may cross a public way/utility franchise. The Woking Town Centre Energy Station, owned by Thameswey Energy Limited in Woking Borough, United Kingdom, is an example of an Independent Provider microgrid system. The Woking project uses a law that allows private wires to interconnect previously unaffiliated customers to CHP and other clean energy systems, subject to a maximum capacity limit (see the Woking case study in the Appendix).

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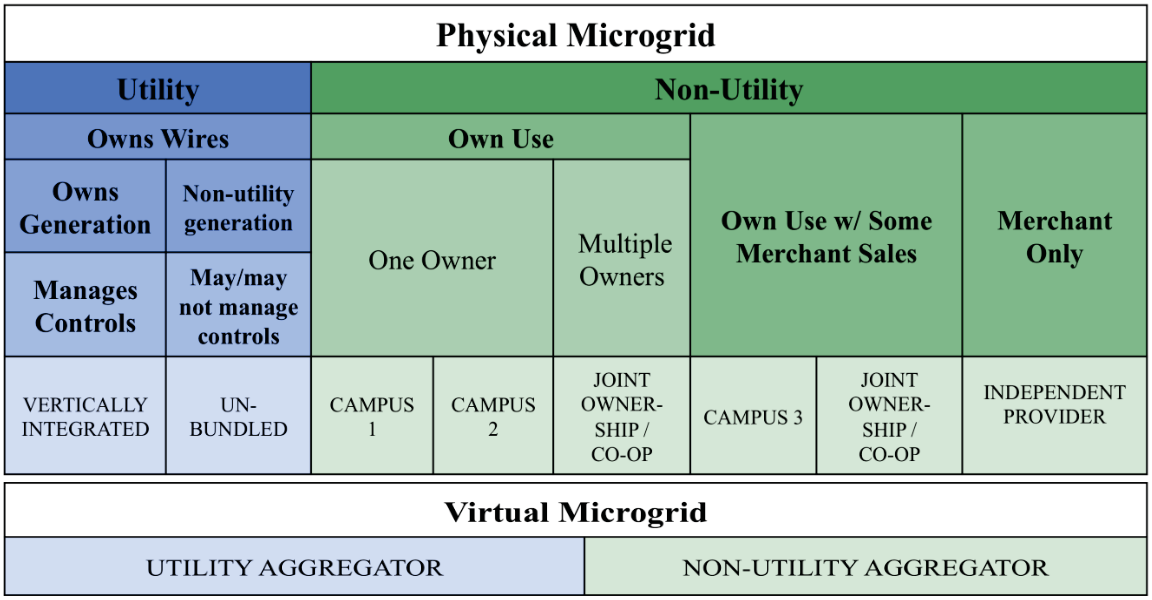
reliability issues. As a result of its investment, the municipal utility has reduced its annual average interruption time from 120 minutes to 18 minutes in 2010. Naperville recently received a smart grid grant from the DOE to deploy time-based pricing and introduce electric vehicles. More information on Naperville's smart microgrid initiative can be found in a case study produced by the Galvin Initiative available at: http://galvinpower.org/sites/default/files/Naperville_CaseStudy_Final.pdf (accessed on August 23, 2010)

Figure S-2 – Microgrid Ownership and Service Typology



<table>
<tr><th colspan="8">Physical Microgrid</th></tr>
<tr><th colspan="2">Utility</th><th colspan="6">Non-Utility</th></tr>
<tr><th colspan="2">Owns Wires</th><th colspan="3">Own Use</th><th colspan="2" rowspan="3">Own Use w/ Some Merchant Sales</th><th rowspan="3">Merchant Only</th></tr>
<tr><th>Owns Generation</th><th>Non-utility generation</th><td colspan="2" rowspan="2">One Owner</td><td rowspan="2">Multiple Owners</td></tr>
<tr><th>Manages Controls</th><th>May/may not manage controls</th></tr>
<tr><td>VERTICALLY INTEGRATED</td><td>UN-BUNDLED</td><td>CAMPUS 1</td><td>CAMPUS 2</td><td>JOINT OWNER-SHIP / CO-OP</td><td>CAMPUS 3</td><td>JOINT OWNER-SHIP / CO-OP</td><td>INDEPENDENT PROVIDER</td></tr>
</table>

<table>
<tr><th colspan="2">Virtual Microgrid</th></tr>
<tr><td>UTILITY AGGREGATOR</td><td>NON-UTILITY AGGREGATOR</td></tr>
</table>

Virtual Microgrids

H. *Utility Aggregator*: The utility pools customer- or third party-owned DERs and demand response capabilities and manages output and loads on its distribution system. The utility also continues to meter and bill customers for energy services, possibly, but not necessarily under a combined bill. Participating customers share the benefits of the energy produced and receive either bill credits or direct payments for excess generation. The utility may continue to charge for use of the distribution system, but proximate customers are able to avoid most transmission and grid-derived generation costs. The research team did not identify an example of a utility aggregator virtual microgrid, however new Community Net Metering programs in several states resemble this kind of system by allowing groups of customers to share in the benefits of a renewable energy system even if they are not physically connected.

I. *Non-Utility Aggregator*: A private, cooperative or public entity pools together a group of customer- or third party-owned DERs and manages output and loads on the utility's distribution system. The aggregator separately meters and bills the participating customers for energy used. Participating customers may benefit from aggregating demand response capabilities and earning revenue by bidding their collective load shedding capabilities into energy markets or demand response programs. From the utility perspective, the aggregated customer loads are one entity, under a single utility account. The non-utility aggregator may separately meter and apportion charges and credits to participants. The pooled customers must pay distribution system charges, but otherwise avoid most grid transmission and energy costs. If necessary, the aggregator can procure energy services from the wholesale market to balance loads.

Findings: The Legal and Regulatory Status of Microgrids in New York and Beyond

Legal and regulatory uncertainty for microgrids presents a significant hurdle to their deployment in New York State. The risk associated with this uncertainty is compounded by the small-scale nature of microgrids. Many potential projects would be unable to bear the administrative burden of full regulatory treatment as a distribution utility under State law. In tandem, the lack of legal identity and regulatory certainty presents a variety of obstacles for investors, utility customers and engineers considering these types of projects.[14] These obstacles are problematic because the

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[14] For example, investing even in preliminary stages of engineering feasibility studies will be uneconomical if the PSC ultimately denies an exemption for regulation, thus deterring the capital markets from backing these types of projects.

installation of such facilities has the potential to reduce costs to customers and to further public policy by improving the reliability and efficiency of power sources.

Section 4.0 of this report examines microgrids in light of the current legal and regulatory framework of the electric industry in New York State and reviews what other states are doing with respect to microgrids. Generators of electricity are subject to a complex set of federal and state laws that relate to property permissions, environmental protection, consumer rights, technical efficiency and administrative orders. The New York State Public Service Commission (PSC or Commission) enforces the Public Service Law (PSL) and regulations for electric corporations, which essentially means all companies owning electric plants. Although there are advantageous exemptions and privileges available to certain facilities under state and federal law, these facilities in many cases are not statutorily defined legal entities. They are currently regulated by *ad hoc* PSC rulings, and it is unclear how they will be regulated in the future.

While distinguishable, existing and proposed microgrids share sufficiently common characteristics to be characterized and regulated as a distinct legal entity. We propose ways in which microgrids are or could be treated by analogy to entities regulated under existing PSL, and how they should be treated if this is an energy delivery architecture that New York State wishes to encourage. The key findings of this research are provided below.

General Legality of Microgrids in New York State

- Microgrids are not defined legal entities within existing New York State law governing the electric and steam industries. As a result, under current circumstances, microgrid developers will have to anticipate, based on the ownership and project service characteristics of a given project, how it will be viewed under the PSL and treated by state regulators.

- Based on the project team's research, there is nothing in the PSL suggesting that any of the microgrid ownership and service models identified in this report would be viewed, on their face, as illegal. Nevertheless, the specific terms of regulation will vary depending on the particular features of the project, including the technologies deployed, whether the system is located entirely on private property, crosses a public way, serves multiple previously unaffiliated customers (or other customers), serves residential customers, and the size of the distribution area served.

Likely Treatment Under the Existing State Legal and Regulatory Framework

- A physical microgrid will likely be characterized as an electric corporation (i.e., distribution utility) by the PSC, particularly if it intends to serve multiple, otherwise unrelated, retail customers, cross a public way with power lines, and/or obtain a franchise from a local authority.

- If a microgrid is deemed by the PSC to be an electric corporation, it is likely that the specific terms of regulation will be determined by the PSC, using a "realistic appraisal analysis," which evaluates the appropriateness of different provisions of electric corporation regulation for new entities. It is possible that the PSC will determine that a lighter form of regulation is appropriate, but the specific terms will likely vary depending on the facts of the proposal.

- Microgrids using cogeneration and distributing thermal energy in the form of steam or hot/chilled water may be subject to state law relating to steam corporations. Regulation of steam corporations generally follows that of electric corporations and may include rate regulation, among other requirements. Due to their small scale, however, microgrids will likely fit within one of the State's exempt classes for regulation of steam service providers; this is particularly likely for microgrids that reflect the landlord/campus and cooperative models involving a non-profit entity.

- Virtual microgrids, which would use the wires of incumbent distribution utilities for distributing or "wheeling" power among participants, are likely to resemble energy service companies (ESCOs) in many respects. In contrast to ESCOs, which provide competitive generation service to retail customers that continue to pay for transmission and distribution service, virtual microgrids would likely seek to avoid or diminish transmission charges by pooling load and generation located on distribution systems. Another example of an entity similar to a virtual microgrid is a demand response aggregator. These companies pool retail customers' demand response capabilities for participation in programs operated by the NYISO and receive payments when they shed load in response to either economic or reliability-related events. A distinguishing feature of virtual microgrids is that they also include generation resources and "deliver" power on the utility system to participating customers. There are currently no provisions in state law that authorize virtual microgrids, however, nor are there regulations that obligate utilities to accommodate them.

Franchises and Other Consents to Distribute Energy in New York

- All microgrids that intend to use public ways (i.e., deliver either power or thermal energy to a customer across a public street) must apply to the presiding municipal authority for permission, whether in the form of a franchise or another, lesser consent. Franchises, which represent contracts between a company or service provider and the local municipality, require specific legislative approval and are granted for a limited number of years.

- In municipalities where an incumbent electric utility currently operates under an existing franchise that is not by its terms exclusive, a subsequent franchise may be issued to a microgrid developer. Under state law, however, municipalities must provide a competitive process for determining the franchise grantee, thereby allowing incumbents and other service providers to bid against the microgrid developer for the franchise.

- Operation of a microgrid under a local franchise will require approval from the PSC in the form of a Certificate of Public Convenience and Necessity (CPCN), which is required by State law to exercise the rights granted under the franchise, including installation and subsequent use of electricity distribution facilities. A CPCN confirms that the exercise of a right, privilege, or franchise to build and operate a major energy production or delivery facility is *necessary or convenient* for the public service. A microgrid developer seeking to operate under a local franchise must obtain the CPCN through a public hearing prior to commencing construction of a physical plant.

- A microgrid project may also have to obtain a CPCN if it is deemed to sell electricity via direct interconnection to retail customers. Nevertheless, some microgrids may qualify for exemption from this regulation, particularly those that use cogeneration or other facilities that qualify under New York State law.

- Due to their small scale and limited scope of service, it is unlikely—except in a limited number of circumstances—that microgrids will have to obtain a franchise to operate. In most cases it is likely that a lesser form of consent, such as a revocable consent, will suffice when a microgrid proposes to occupy public space to provide service. Operation under this lesser form of consent, in contrast to operation under a franchise requiring a CPCN, does not appear to trigger PSC jurisdictional authority.

Exemptions from Regulation as Steam and Electric Corporations

- A microgrid may be found to be exempt from State regulation as an electric corporation if it is deemed a qualifying facility under either federal or State law; qualifying facilities generally include either cogeneration or other clean small power production technologies that meet related criteria.

- Importantly, a microgrid that qualifies as a cogeneration facility, alternate energy production facility, or small hydro facility may be able to use the "related facilities" exemption also to qualify wires and pipes that would cross a public way and otherwise trigger electric corporation or CPCN requirements. While it is difficult to anticipate exactly how PSC will rule in any given case, a microgrid that has characteristics similar to existing exempted facilities may be able to raise those similarities as persuasive precedent in seeking exemption.

Other Important Legal and Regulatory Considerations: Consumer Protections, Provision of Default Service and Exit Fees

- Any microgrid that provides service to residential customers will very likely have to comply with the statutory consumer protections as prescribed by the New York State Home Energy Fair Practices Act (HEFPA). Nevertheless, some microgrids, particularly those where residential customers are involved in the ownership of microgrid facilities, or are tenants of the microgrid owner, may not be subject to these requirements.

- If a microgrid is deemed an electric corporation or a steam corporation, there is a possibility that it will assume a statutory obligation to serve. An obligation to serve would require the microgrid to provide service upon the written or oral request of an applicant. This obligation may be more likely to apply to a microgrid if it serves an area that is otherwise electrically isolated from the local distribution company. If the microgrid provides service where a local distribution company provided service before, it is probably less likely that the microgrid would have this obligation. Ultimately, it may depend on the accessibility of the applicant to the incumbent distribution company.

- The provider of last resort is a legal obligation traditionally given to utilities, to provide service to a customer when competitors have chosen not to or are unable to provide service. In New York's electricity market, distribution utilities maintain the obligation to serve and are the providers of last resort. For physical microgrids, the provider of last resort obligation will likely follow the obligation to serve; if the PSC determines a microgrid has an obligation to serve, it may also find that the microgrid is the provider of last resort. For microgrids that serve customers that were previously interconnected to the local utility, or that also continue to receive standby or back-up service from the utility, it is likely that the provider of last resort obligation will remain with the local distribution company.

- Microgrids that use thermal power production through the combustion of fossil fuels, biomass or other materials will be subject to State and federal laws governing air emissions. The need for a permit, and the associated conditions of operation, will depend on the particular features of the project, including its location and emissions level.

- Exit fees are intended to keep a utility, as the default service provider, financially indifferent to the departure of customers from their system. During restructuring, in order to avoid discouraging competition, exit fees were generally prohibited in New York. The only exception to this was made for Niagara Mohawk (now National Grid), which is allowed to assess a competition transition cost charge. For departing load due to the installation of on-site generation, where the customers continue to also receive back up or "standby" service from the grid, standby charges provide utilities with an opportunity to recover their fixed costs. Thus, it is unlikely that the customers of a microgrid, previously served by a local distribution utility, will be assessed exit fees upon departure, unless they do not take standby service and are located in Niagara Mohawk's service territory.

- Microgrids are not mentioned under existing provisions for net metering. It is very likely that microgrids – as defined in this report – would not be eligible because net metering is currently only available to single customers (i.e., excluding microgrids that involve multiple customers) and does not provide for hybrid systems that incorporate multiple technologies (e.g., solar and gas-fired reciprocating engines). As a result, it is likely that a microgrid owner or developer seeking to receive net metering service from a utility will either be rejected on these grounds or will require a voluntary agreement from the utility.

Regulatory and Policy Environment for Microgrids in Other States

In order to assess the status of microgrids in other states, semi-structured telephone interviews were conducted with staff at regulatory agencies and legislative offices in eleven jurisdictions: Arizona, California, Connecticut, Delaware, Illinois, Maryland, Minnesota, Oregon, Pennsylvania, Texas, and Washington DC. These particular states were selected in order to create a group with geographic and market diversity. The interviews with state officials focused on the legal status of microgrids from the perspective of State public utility commissions. Interviews were supplemented with additional research on State public utilities law as well as on policies related to distributed generation that may be valuable for consideration in New York State microgrid policy. The major findings are summarized below.

- The overwhelming response from those interviewed was that microgrids fitting our definition are either not being considered, or are just beginning to be discussed at the regulatory level.
- In some jurisdictions, discussion of specifically including microgrids into the legal and regulatory framework had recently transpired, but was either never transposed into law or was done so in a limited, or vague fashion.
- In some states, developers or owners of existing generation had inquired about whether they might be able to serve multiple unaffiliated sites across public ways, but no formal applications were submitted; in these cases, laws forbidding private wires to be strung across public ways preempted potential microgrid projects.
- Other states indicated that while discussion had not yet been seriously extended to accommodating physical microgrids, policies to encourage distributed generation, particularly those related to net metering, such as meter aggregation and community net metering, were beginning to be implemented at the regulatory level.
- Of all the states contacted for this study, California has probably taken the most coordinated approach to addressing microgrids, by adopting a functional definition and funding research and development through its Public Interest Energy Research program. The state has also implemented policies that may be encouraging for the development of virtual microgrids, including virtual and multi-facility net metering.[15]
- In general, our research indicated that microgrids operating on a single customer's or property owner's site – and which would not attempt to sell electricity to previously unaffiliated entities, cross property lines or a public right-of-way, or would always operate in island mode – would be perceived as being less problematic from a regulatory perspective than those which would attempt to sell electricity to others or extend beyond private property lines.
- The most frequently cited barrier to microgrids was the requirement to have electricity marketer or public utility status to be able to sell electricity to others (i.e., previously unaffiliated customers).
- Franchise violations when selling electricity to customers within a utility's existing service territory, and when running wires across public right-of-ways, were the other primary barriers to the development of microgrids.
- In general, the interconnection of microgrids to the distribution grid was not perceived as posing a greater problem from a technical or regulatory perspective than the interconnection of any other type of distributed generation.
- Lastly, while several state officials expressed that non-utility owned microgrids should be un-necessary if the local distribution utility was effective at its job, we observe that microgrids are receiving an increasing amount of national interest, particularly in the context of smart grid.

Conclusions and Recommendations

The 2009 New York State Energy Plan[16] articulates five key objectives for the State's energy system over the next 10 years:

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[15] Multi-facility net metering accommodates sites with multiple generation sources, including both net metering eligible and non-eligible technologies (i.e., solar and natural gas-fired CHP)

[16] For more information on the 2009 New York State Energy Plan see: http://www.nysenergyplan.com/# (accessed on October 10, 2010)

- Maintain reliability
- Reduce greenhouse gas (GHG) emissions
- Stabilize energy costs and improve economic competitiveness
- Reduce public health and environmental risks
- Improve energy independence

As this report addresses in detail, microgrids have the potential to contribute to each of these policy objectives. Although the types of energy technologies and configurations will vary from one application to the next, microgrids have demonstrated the ability to improve the efficiency of overall energy use; reduce GHG emissions; provide energy cost savings to participants and macro-grid customers; reduce the environmental and public health risks attendant with current modes of energy production and delivery; and improve local energy independence by reducing reliance on the macro-grid.

While several microgrid systems have been deployed in New York State over recent years, and interest continues to grow, the ability to develop microgrids remains clouded in uncertainty. Much of this uncertainty is in regard to how the microgrid is organized and to whom it provides service. If microgrids are to serve a role in achieving New York State's long-term energy policy objectives, the State must take action to clarify the right to organize microgrids and the responsibilities attendant with different types of systems. Similarly, incentives or other policies designed to help finance microgrids and properly compensate owners for the positive externalities they provide would go a long way toward helping some of these projects get off the ground. Our recommendations regarding legal and regulatory issues, financing and incentives, and research and development are below (for more detail, please see Section 6.0 of the report).

Recommendations on Legal and Regulatory Issues

- Enact a Statutory Definition of "Microgrid" to Formalize the Elements of this Legal Entity.

- Provide Statutory Authorization for Sharing of Electric and Thermal Resources and Loads Among Previously Unaffiliated Utility Customers.

- Statutory Authorization Should Also Address the Respective Legal Obligations of Microgrids and the Interconnecting Distribution Utilities.

- Statutory Authorization Could Include Measures that Would Encourage Development of Microgrids, such as Net Metering, Virtual Net Metering, or Retail Wheeling.

- Statutory Authorization Could Include an Explicit Recognition of Community-based or Cooperative Microgrids as Eligible to Receive Property Assessed Clean Energy (PACE) Financing.

- Statutory Authorization Could Include Options for Municipalities to Adopt Property Tax Credits for New or Redeveloped Areas to Integrate High Efficiency, Advanced Microgrid Systems Into their Development Plans.

- Irrespective of Statutory Authorization, the PSC Should Adopt Policies to Encourage Microgrids in New York State.

- The PSC Should Commence a Proceeding to Examine the Issues Associated with Microgrid Development in New York State, and to Adopt Design Guidelines for Maximizing Performance and Efficiency of Microgrids.

Recommendations on Financing and Incentives

- Inventory the Current System of State Energy Incentives As They Relate to Creating Favorable Conditions for Microgrid Project Development.
- Provide Incentive Resources for both Development and Demonstration Type Microgrid Projects with a Priority Placed on New Development or Redeveloping Areas.
- Develop a Multi-Stakeholder, Peer Reviewed Process for Identifying a Set of Screening Criteria and Project Guidelines for Optimizing the Investment of State Funds in Microgrid Pilots.
- Create an Expert Advisory Board and Stakeholder Process to Ascertain the Role that Microgrids Might Play in Addressing Concerns Regarding the Level of Geographical Balance in the State Renewable Portfolio Standard (RPS) Program.
- Conduct State Supported Research Studies Creating Protocols for Incorporating Microgrids Into Existing and Prospective Energy Markets.

Research & Development Recommendations

- Conduct a National Survey of Microgrid R&D That Identifies Critical R&D Funding Gaps and Research the Available Resources for Filling Those Gaps in New York and Identify Near-Term.
- Facilitate Integration of Microgrid's Power-Electronic Components into Modules or Building Blocks with Defined Functionality and Interfaces that Serve Multiple Applications.
- Enhance Technology Transfer by Expanding Collaboration Interfaces Among Researchers, Entrepreneurs, Investors, and Other Parties Involved in Commercialization of Microgrid Technologies.
- Institute a Collaborative Process for Streamlining the Development of Standards and Protocols for Microgrids.
- Promote Public-Private Partnerships for Accelerating Development and Deployment of Critical Microgrid Technologies.

1.0 INTRODUCTION

Microgrid systems that link multiple distributed power generation sources into a small network serving some or all of the energy needs of participating users are rapidly overcoming technological barriers. The growth of distributed on-site and embedded generation resources, such as combined heat and power (CHP) applications or solar photovoltaics, combined with emerging technologies, particularly power electronic interfaces and controls, are making the once futuristic concept of a microgrid a technological reality. Still, energy market regulations and policy lag behind this progress, creating uncertainty and inhibiting investment in microgrids and the multiple benefits they might provide. This is true in New York State, and as we will discuss below, this is also true across the United States as a whole.

This white paper is one of the first to closely examine the potential pathways and barriers for the deployment of microgrids within a specific state regulatory framework. To date, very little practical experience or structured thought informs national or state policy on this matter. We currently face a situation where, although the theoretical advantages of microgrids are well understood and the technological capabilities exist, barriers to their installation seem to be so widely presumed that few capable actors have begun to develop plans or strategies to test them, much less develop actual systems. Underlying this situation are several key questions:

1. What are the defining characteristics and key technological features of a microgrid?
2. What are the primary ways that microgrids can be incorporated into the existing New York State energy regulatory structure and market context?
3. How might existing regulations and market structures be optimized to better suit microgrid development?
4. What are the potential values of microgrid projects under the different market conditions that exist around the state?
5. What actions should interested policy makers take to promote and facilitate microgrid deployment?

The presupposition of this study is that unless these questions are answered, New York may lose out on the potentially significant opportunity microgrid deployment represents. Without a basic accepted understanding of the "shape of the playing field," progress toward capturing the advantages of microgrids will remain out of reach.

To address the ongoing uncertainty regarding state policy[17] on microgrids, this report will: (1) provide a working definition of microgrid to support future policy considerations; (2) identify and assess the range of potential microgrid ownership and service structures; (3) present cases covering existing and proposed microgrids that we believe represent important microgrid ownership and service models; (4) describe and analyze the relevant legal and regulatory opportunities and barriers to microgrids; (5) outline the potential benefits and value streams of microgrid deployment, both to participants and to the region and state; and (6) provide policy makers with an outline of the important issues and a realistic set of options to successfully promote microgrids in New York.

1.1 Why microgrids?

New York State views the development of renewable and other clean and efficient sources of energy production as an important means to achieving various policy objectives including fuel diversity, energy security, economic development, greater retail competition and customer choice, and reducing the environmental impact of the energy supply.[18] While many forms of renewable power are large-scale and plug into the transmission system largely as wholesale production facilities (e.g., large wind, hydroelectric or geothermal power production), many are also

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[17] As a consequence of its early development as a local service, the electric industry in the United States is today largely regulated at the state level by appointed commissions empowered by state legislatures to ensure the public receives reliable and low cost service. New York State was one of the first to establish a regulatory commission in 1909. As the electric system has grown and extended beyond state borders, the federal government has become increasingly involved in the industry, particularly with respect to transmission and wholesale power rates in interstate commerce. Still, states continue to exercise authority over the franchising of utilities, the regulation of retail rates, and the siting of generation and transmission infrastructure. Because they are small scale and likely to be interconnected to state regulated utility distribution systems, it is at the state level that regulatory clarity for microgrids is most urgently required.

[18] New York State Energy Planning Board, "New York State Energy Plan and Final Environmental Impact Statement," June 2002, Section 3.3 Renewable Energy Assessment, pp 3-40 – 3-79

small-scale and distributed (e.g., solar photovoltaic, small wind installations, or fuel cells operating on renewable fuel). These small-scale electricity production systems – also called distributed or embedded generation – are normally more conveniently and economically located at customer sites within the low-voltage electric distribution network.[19]

Distributed generation is frequently included as part of a broader category of distributed energy resources (DER), which include energy storage technologies and power system control devices.[20] Customer-sited DERs can displace energy otherwise purchased at retail rates, and reduce demand on the local utility and regional grid. Still, interconnection to and interoperability with utility distribution systems is currently a major barrier to wide-scale deployment of these technologies. Because the legacy grid is not designed for two-way power flows, many utilities limit the export of energy onto their distribution systems as a condition of interconnection. Satisfying this restriction requires either the installation of costly grid protection devices (i.e., direct transfer trip equipment or power relays) that effectively shut generation systems off if export were to occur, or the intentional under-sizing of systems so that they never produce more than demanded on site. While typically required to ensure the safety of utility workers and protect utility equipment, these requirements can reduce both the potential scale and ultimate value of distributed power applications.[21]

One way to address these barriers to distributed generation may be through the development of microgrids, small-scale distribution systems that link and coordinate multiple DERs into a network serving some or all of the energy needs of one or more users located in close proximity. Today, emerging technologies such as electronic interfaces and digital control systems are making it possible to deploy advanced microgrids capable of integrating multiple DERs into a single system that can operate both independently from and seamlessly with extant utility distribution areas.[22] These controlled networks provide electricity and, by employing combined heat and power (CHP), thermal energy to local interconnected loads. CHP technology captures the "waste heat" created during the production of electricity for productive use, including hot water, space heating, space cooling, or process heat for industrial applications.[23] Although capable of using renewable fuels such as biomass or landfill gas, CHP applications today predominately use fossil fuels, particularly natural gas. The productive use of waste heat from such systems, however, can result in overall energy efficiency of these systems as high as 80%, providing significant environmental performance benefits. Notably, microgrid control systems allow multiple DERs to be coordinated with demand response from connected loads to operate in a manner that is both economically and environmentally optimal. In 2005, one study counted approximately twenty operating microgrids in the United States, representing 785 MW of capacity providing electric and thermal energy services to university campuses, petrochemical facilities, and national defense bases.[24]

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[19] Distributed generation is more conveniently and economically placed at or close to customer locations because it can then displace purchases customers would otherwise make from the grid at a cost that can be comparable to or less than bundled retail prices; customer-siting of DG can also avoid the need for additional transmission and distribution infrastructure to deliver power to load centers.

[20] For more information on distributed energy resources see: Amory Lovins, et al., *Small is Profitable: The Hidden Economic Benefits of making Electrical Resources the Right Size,* Snowmass, CO: Rocky Mountain Institute, 2002

[21] Stephen Hammer, et al., Center for Energy, Marine Transportation and Public Policy, "CHP in NYC: A Viability Assessment," 2007, Available at: http://www.sipa.columbia.edu/energy/researchprograms/urbanenergy/documents/uep_chp_200709.pdf (accessed on November 4, 2009)

[22] Chris Marnay, Hiroshi Asano, Stavaros Papathanassiou, and Goran Strbac, "Policy Making for Microgrids: Economic and Regulatory Issues of Microgrid Implementation," *IEEE Power & Energy Magazine*, May/June 2008

[23] Hammer, et.al., 2007

[24] Resource Dynamics Corporation, *Characterization of Microgrids in the United States: Final Whitepaper*, Prepared for Sandia National Laboratory, Vienna, Virginia, 2005

Although microgrids may be interconnected at high voltage and participate in regional wholesale energy and ancillary service[25] markets, it is more likely that they will be connected at lower voltages to the local utility from which they may buy and sell power. An important feature of microgrids is that they may also be operated independently from the larger grid – that we refer to in this report as the macro-grid – if disruptive events such as faults (i.e., short circuits), voltage fluctuations and momentary interrupts occur upstream. This provides microgrid participants with a level of power quality and reliability usually unavailable from the local utility.

Central to the microgrid concept is a reevaluation and modernization of traditional grid architectures and energy services. The existing electric transmission and distribution systems in the United States employ technologies and strategies that are many decades old and include a limited use of digital communication and control technologies. The system was designed for one-way power flows incompatible with increasing numbers of customer-owned and distribution-sited power systems. It was also designed to provide universal levels of power quality and reliability; however, not all consumers require the same quality of power or degree of reliability.[26] In a modern digital economy, demand for power quality and reliability can vary significantly. Commercial customers with critical computer systems require high levels of power quality and are often willing to pay for it, while most residential consumers may not. This is evidenced by investment in uninterruptible power supply (UPS) by commercial customers to protect computer and data systems from outages.[27] Today's grid also relies on large scale or central station thermal power plants that operate at average net efficiencies of 28-33% and transmit power along high-voltage transmission lines to load centers far away (this is illustrated for the national power system in 2008 by the US Energy Information Administration in Figure 1.1 below).[28]

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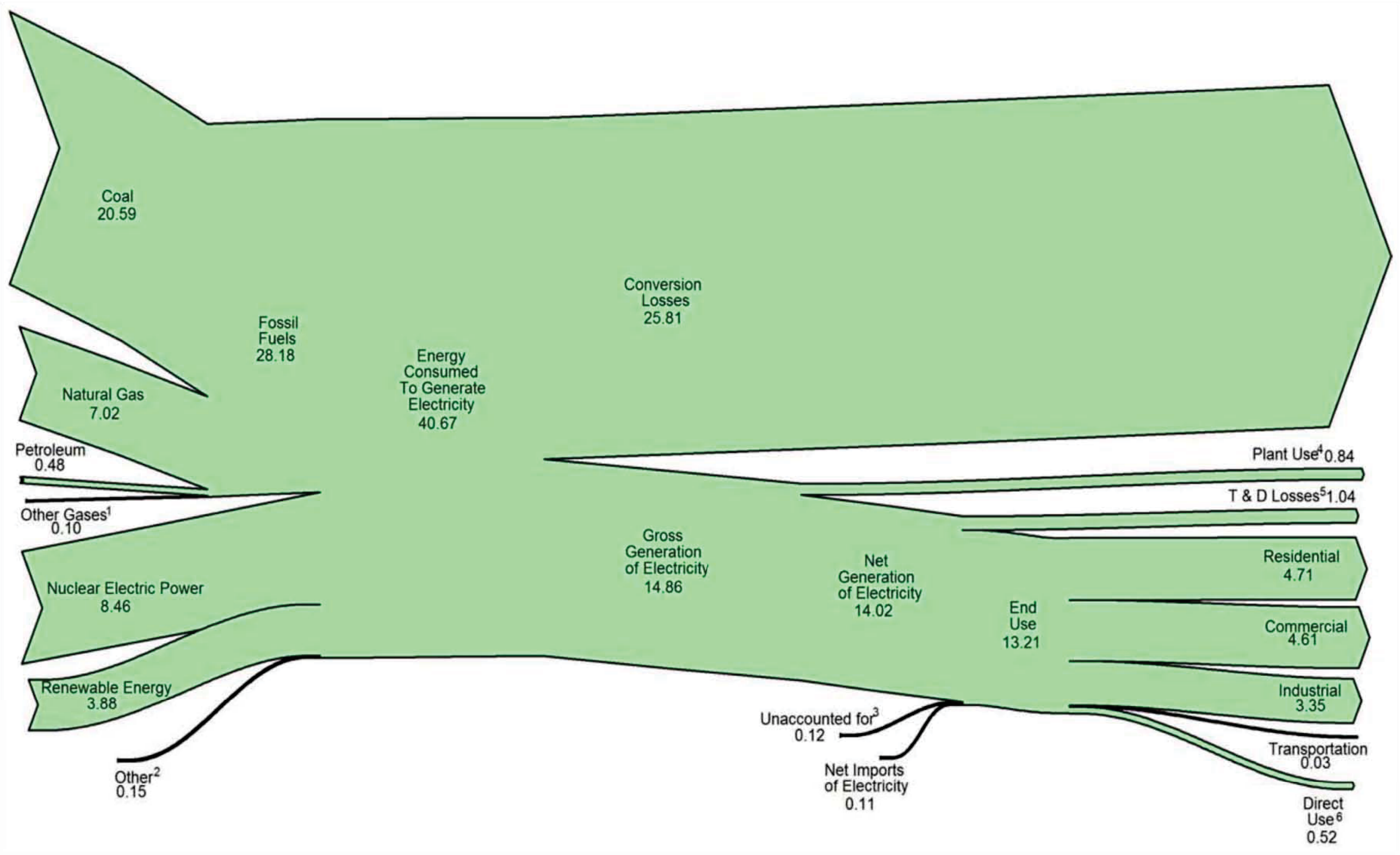
[25] Ancillary services are the functions performed by electric generating, transmission, system-control and distribution system equipment to support the basic services of electric generating capacity, energy supply and power delivery. These services may include spinning reserve (generating capacity that is ready to be dispatched if and when system demand requires it), black start support (generating capacity that is capable of going from a shutdown condition to an operating condition, and start delivering power without assistance from a power system), and voltage support (generating sources or other devices that can help the system maintain the desired voltage level). For more information on the New York Independent System Operator's ancillary service products see: http://www.nyiso.com/public/products/ancillary_services/index.jsp (accessed on October 5, 2009)

[26] Chris Marnay, "Microgrids and Heterogeneous Security, Quality, Reliability and Availability," LBNL-62460, Paper Presented at the 2007 Power Conversion Conference, Nagoya, Japan, April 2, 2007

[27] UPS systems are essentially batteries that provide emergency power to an electric load when the input power source, typically the utility supply, fails or is in some way compromised to the extent that it could damage a power customer's critical equipment. While not limited to protecting any particular type of equipment, a UPS is commonly used to protect computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause serious business disruption and/or valuable data loss. The independent run-time of a UPS system is relatively short, approximately 5–15 minutes for smaller units, but sufficient to allow an auxiliary power source to be brought online, or to properly shut down the protected equipment.

[28] Thermal power plants use steam as the prime mover in electric generation. Water is heated, turns into steam and is inserted at pressure into a steam turbine, which drives an electrical generator. Most coal, nuclear, geothermal, solar thermal electric and waste incineration plants and many natural gas power plants are "thermal" in that these fuels or energy sources are used to produce the steam to move a turbine to drive an electric generator. The operating electric efficiency of a thermal power station is measured by the amount of saleable energy produced at the plant busbar, or point of interconnection between the plant and the grid, as a percentage of the heating value of the fuel consumed by the plant as a primary input. Unless captured or stored for other purposes, the percentage of primary fuel heating value not converted into electricity becomes unused heat, which must be removed from the plant. In conventional central station thermal plants, this excess heat is processed in a condenser, which reduces it to liquid form, and is disposed of either with cooling water or in a cooling tower.

Figure 1.1 – US Electricity Flow, 2008 (Quadrillion Btu)



Source: US Energy Information Administration (2009)

Figure 2.1 illustrates that fully two-thirds of all primary energy inputs not converted into electricity is lost as waste heat, which is usually vented into the atmosphere or local bodies of water with significant economic and environmental consequences. The EIA's data reveals that in 2008, losses from conversion to electricity from all sources exceeded, in terms of total energy value measured in quadrillion British thermal units (Btu), the entire amount of coal burned to produce electricity nationwide by 25%. Furthermore, in the process of transmitting power, the existing grid creates, on average, additional losses of 9% before electrons reach even consumers.[29] These trends are similar for the State of New York. In 2008, the overall efficiency of the electric sector in terms of inputs of primary energy against power delivered to customers was 30%, with a full 70% of primary energy unaccounted for and likely lost either in conversion or in transmission of power.[30] To put the scale of this unaccounted for energy in New York State's electric energy system into perspective, it is equivalent in terms of total energy, to six and a half years of current average electricity usage in New York City, or approximately three years of total building non-electric energy use (i.e., non-electric building heating, cooling, etc.).[31]

The existing system is also less reliable than it should be, particularly at the distribution level, where the lack of local intelligence (i.e., sensing and communications) and system visualization frequently forces utilities to rely on customer phone calls to help them identify interruptions. Unreliable and low quality power is expensive; it costs the U.S. an estimated $80-150 billion annually in lost productivity and damaged goods.[32] Even momentary interruptions are costly for certain customers at more than $11,000 per event for medium and large commercial customers and $200 per average kW interrupted to small commercial customers (See Table 5.8 in Section 5.0).[33]

A report published in 2006 by Lawrence Berkeley National Laboratory, estimates the economic cost of power interruptions in the Mid-Atlantic region, which includes the states of New York and Pennsylvania, at approximately $9.7 billion annually.[34] A majority of this cost is borne by commercial electricity customers, which nationally assume approximately 72% of the economic costs of interruptions. By comparison, costs to the residential sector represent only 2% of total outage costs.

With the growth of the digital economy, electricity is forecast to grow as a percentage of total energy use.[35] The DOE estimates that electricity use by data centers represented 61 billion kWh in 2006, or 1.5% of the US total, and is growing at an annual rate of 12% (i.e., total usage will double every five years). The resulting growth in demand for high quality and highly reliable power supplies combined with the fact that many existing facilities are aging and will require replacement, suggests that significant investment will be required in the electric power supply,

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[29] US Department of Energy and Energy Information Administration. *Annual Energy Review 2007.* DOE/EIA-0384, 2007, Energy Information Administration, Washington DC, Available at: http://www.eia.doe.gov/aer/elect.html (accessed on January 27, 2010)

[30] New York Energy Research and Development Authority, "New York State, Energy Fast Facts, 2008," Available at: http://www.nyserda.org/Energy_Information/fastfacts.pdf (accessed on April 30, 2010)

[31] In 2008, New York State used approximately 1,635.9 trillion Btus of primary energy in the production of electricity while approximately 491 trillion Btus (or 144,053 GWh) of electricity were sold to the state's consumers (i.e., about 30% of primary energy used in generating electricity was delivered to end consumers as electricity, which it is important to note is a higher value form of energy). Moreover, on average, New York City consumes approximately 50,000,000 MWh (or 175 trillion Btus) of electricity annually and approximately 386 trillion Btus for non-electric building energy uses. See: NYSERDA, "New York State, Energy Fast Facts, 2008," and the New York City Mayor's Office, "Inventory of New York City Greenhouse Gas Emissions," September 2009

[32] The Galvin Electricity Initiative, "Summary of the Microgrid Workshop and Roundtable," June 27-28, 2006, Chicago, IL, Available at: http://www.galvinpower.org/files/Final_Microgrid_Workshop_with_changes.pdf (accessed on November 4, 2009)

[33] Michael Sullivan, Matthew Mercurio and Josh Schellenberg, "Estimated Value of Service Reliability for Electric Utility Customers in the United States," Ernest Orlando Lawrence Berkeley National Laboratory, June 2009, LBNL-2132E

[34] See Kristina hamachi LaCommare and Joseph H. Eto, "Cost of Power Interruptions to Electricity Consumers in the United States," Ernest Orlando Lawrence Berkeley National Laboratory, February 2006, LBNL-58164, Available at: http://www.netl.doe.gov/moderngrid/docs/Cost_of_Power_Interruptions_to_Electricity_Consumers_in_the_.pdf (accessed on January 20, 2010)

[35] US DOE, *Annual Energy Outlook 2007, with Projections to 2030*, Washington, DC: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0383, 2007 and Paul Scheihing, "DOE Data Center Energy Efficiency Program," US DOE, April 2009 also for a good summary of the increasing electrification of the economy, see Global Smart Energy and Global Environment Fund, "The Electricity Economy," August 2008, Available at: http://www.globalenvironmentfund.com/data/uploads/The%20Electricity%20Economy.pdf (accessed on February 1, 2010)

transmission and distribution system.[36] Indeed, the Energy Information Administration estimates that more than $200 billion will be spent nationally, simply to maintain and extend the *existing* infrastructure between now and 2020.[37]

New York State is no exception to this national trend. According to information recently provided to the New York Public Service Commission (PSC), much of the utility transmission and distribution infrastructure in the state averages 30-50 years old and is in need of near-to-medium term replacement. Table 1.1 summarizes the age of infrastructure for selected New York State utilities.

Table 1.1 – Age of Selected Utility Electricity Distribution Infrastructure in New York State

Utility	Distribution Cables	Transmission Cables	Transmission Transformers	Distribution Transformers
NYSEG	40 years (overhead) 20 years (underground)	34-47 years	44 years	42 years
Con Edison	25 years (underground) 48 years (overhead)	37 years (overhead) 42 years (underground)	46 years (stations)	35 years (stations)
RG&E	34 years 25 years	37-48 years	26 years	42 years
Orange & Rockland	In most need of replacement	35-50 years	21-31 years	

Source: New York State Energy Plan

To address the need to replace aging infrastructure, the New York State Energy Plan observes that several utilities are requesting much higher than historic levels of investment for electric infrastructure replacement. For example, in compliance filings with the PSC in 2008 both National Grid-KeySpan and Con Edison proposed five-year spending levels that were three times higher than expenditures in the previous decade.[38]

To address our aging power supply and delivery infrastructure and meet the modern needs of electric customers, government and private enterprise are increasingly directing resources toward developing the economic, technological and regulatory basis for a modern – or "smart" – grid. Through its Modern Grid Initiative, the US Department of Energy has defined "smart grid" as the application of advanced sensing, communication and control technologies to produce and distribute electricity more effectively, economically, and securely.[39, 40] The smart grid implies a general modernization of the existing system to improve grid management and provide new and expanded options for energy production and use.

Microgrids should play an important role in the effort to make the electric grid smarter, greener and more resilient. In fact, in the DOE's "Smart Grid System Report" – now required biennially by the Energy Independence and Security Act of 2007 to detail the status of smart grid deployments nationwide – microgrids were identified as one of twenty metrics "for measuring the status of smart-grid deployments and impacts."[41] By producing energy at or near where it is consumed, microgrids avoid most of the line losses created when electricity is transmitted to areas of demand from power plants located remotely. The capture of waste heat by CHP systems for use at or near the point of production can double the efficiency of energy production while the aggregation of multiple loads can help optimize DER use and achieve greater scale economies. Perhaps just as significant as the potential efficiency

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[36] Global Smart Energy and Global Environment Fund, "The Electricity Economy," August 2008

[37] The Galvin Electricity Initiative, "Summary of the Microgrid Workshop and Roundtable," June 27-28, 2006, Chicago, IL

[38] New York State Energy Planning Board, *Electricity Assessment: Resources and Markets, New York State Energy Plan*, December 2009

[39] Information about the DOE's Modern Grid Initiative is available at: http://www.netl.doe.gov/moderngrid/resources.html (accessed on November 4, 2009)

[40] "San Diego Smart Grid Study, Final Report," prepared for the Energy Policy Initiatives Center, University of San Diego by the Science Applications International Corporation Smart Grid Team, October 2006. Available at: www.sandiego.edu/**epic**/.../061017_SD**SmartGridS**tudyFINAL.pdf *(accessed on November 6, 2009)*

[41] DOE, *Smart Grid System Report,* July 2009, Available at: http://www.oe.energy.gov/DocumentsandMedia/SGSRMain_090707_lowres.pdf (accessed on May 5, 2010

benefits, microgrids provide a way to deliver high quality and highly reliable energy services to end users that are willing to pay for it without "gold plating" the electricity grid by providing this level of service universally.[42]

Due to their smaller scale, microgrids can serve as low-risk demonstrations of the benefits of building a national smart grid. The Electric Power Research Institute (EPRI) recently estimated the effort would likely cost $165 billion over the next twenty years, while a report written by the Brattle Group estimated that the entire sector would require a $1.5 to 2 trillion investment by 2030.[43] This includes the installation of many new communications, metering and load control technologies that will require testing in field conditions to justify large-scale deployment. As a recent paper by the World Economic Forum argues, cities will likely play a critical role during the early stages of the transition to smart grids, demonstrating the "art of the possible" and reducing the risk associated with larger regional or national implementation.[44] To be sure, microgrids, deployed in cities, may be among the first examples of how well-developed smart grids could accommodate an increased deployment of distributed energy resources and renewables, while improving the efficiency of the electricity system and overall reliability.

While microgrids can help maximize the value of DERs, the fact that they link multiple loads and sources together makes them sufficiently different from traditional distributed generation applications that the regulatory environment is still considerably uncertain.[45] While policymakers have made progress toward facilitating the development and adoption of distributed generation technologies through the use of standard interconnection procedures and net-metering policies among others, our research indicates that many regulatory officials in the United States are unfamiliar with the microgrid concept and uncertain about how existing and future policies relate to this new energy delivery architecture. To address this lack of familiarity, this report aims to define the microgrid value proposition and identify the current regulatory and policy environment for the deployment of these systems in New York State. This work will inform a roadmap for policymakers that identifies key regulatory and market design measures that may be taken to encourage investment in and unlock the benefits of microgrids.

1.1 The benefits of microgrids

Microgrid value streams are derived principally from two sources: (1) the benefits provided by the specific DER applications that are deployed within a given microgrid (e.g., clean generation and controls systems) and (2) the additional benefits created by the unique configuration of DERs into the microgrid architecture (e.g., reduction of line losses and improved efficiency associated with cogeneration). As small networks that use distributed generation, energy storage and system control technologies, microgrids will provide benefits associated with the particular DER applications and energy distribution design and control schemes deployed. For example, benefits might include the greater energy efficiency achieved through the use of CHP, reduced air pollution from the incorporation of renewable technologies, or enhanced power quality and reliability from the application of advanced storage and power conditioning technologies. The scale and type of benefits created from microgrids will also vary depending on customer and location-specific circumstances, including the thermal and electric demands of interconnected loads, the configuration of the local distribution system, the ability of existing macro-grid infrastructure to meet local or regional load growth, the local utility's mix of resources, and the retail cost of energy, among others.

A substantial body of research has established the benefits associated with distributed generation and DERs. While many of these benefits flow directly to system owners or hosts – energy cost savings and improved reliability, for example – other benefits are more diffuse and frequently may not be captured by system owners (e.g., the value of reduced CO_2 emissions or electric distribution system deferrals). Unlike single-site applications of DG, a microgrid may create additional value through the exchange of power or heat across multiple sites. By using appropriate

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[42] Marnay, LBNL-62460, 2007

[43] David J. Leeds, GTM Research, "The Smart Grid in 2010: Market Segments, Applications and Industry Players," July 2009 and The Brattle Group, " Transforming America's Power Industry: The Investment Challenge 2010-2030," November 2008. Available at: http://www.eei.org/ourissues/finance/Documents/Transforming_Americas_Power_Industry.pdf (accessed on February 1, 2010)

[44] World Economic Forum in partnership with Accenture, "Accelerating Smart Grid Investments," 2009

[45] Douglas King, "The regulatory environment for interconnected electric power micro-grids: insight from state regulatory officials," Carnegie Mellon Electricity Industry Center, Working Paper CEIC-05-08, 2006, Available at: www.cmu.edu/electricity (accessed on September 21, 2009)

electronic controls and aggregating multiple end-user loads a microgrid can combine some of the benefits of the macrogrid (e.g., load diversity and economies of scale associated with aggregated demand) with the benefits of DERs.[46]

The potential benefits provided by microgrids can be bundled into four principal categories: economic, environmental, reliability and security.[47] Figure 1.2 provides a basic schematic of these categories and the benefits typically associated with each. These categories are fluid in the sense that certain benefits commonly spill over into multiple categories. For example, reduced line losses simultaneously deliver both economic and environmental benefits and reduced power interruptions can provide both economic (e.g., uninterrupted productivity) and security/safety benefits.

Figure 1.2 – Microgrid Value Stream Taxonomy

Economic

- ***Direct***
  - Energy cost reductions
    - Reduced purchases of electric generation, transmission & distribution services
    - Reduced purchases of fuel for on-site thermal energy demand
    - Reduced purchases of ancillary services
  - Sales of excess electricity to the macro-grid
  - Participation in demand response programs
  - Provision of ancillary services to the macro-grid
- ***Indirect***
  - Reduced electric T&D losses
  - Deferred electric T&D capacity investments
  - Utility option value for long-term planning purposes
  - Enhanced electricity price elasticity
  - Support for deployment of renewable generation

Reliability & Power Quality

- Reduced power interruptions
- Enhanced power quality

Environmental

- Reduced emissions of greenhouse gases
- Reduced emissions of criteria pollutants

Security and Safety

- Safe havens during power outages

Each of these value streams as they pertain to New York State is discussed in detail in Section 5.0 below.

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[46] Douglas E. King and M. Granger Morgan, "Customer-Focused Assessment of Electric Power Microgrids," *Journal of Energy Engineering,* September 2007

[47] See Electric Power Research Institute, *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects*, EPRI Report No. 1020342, Palo Alto, CA, 2010

2.0 Overview of microgrids

2.1 What are microgrids? A review of the major functional characteristics

While New York State officially recognizes what constitutes an "Electric Corporation" or "Energy Service Company," the term "microgrid" does not appear in the statutes or administrative rules governing the electric industry. This fact significantly muddles the regulatory and policy environment for parties interested in deploying microgrids, leaving developers to speculate whether a potential project would be treated as a utility, electrical corporation, energy service company, or disallowed entirely under current provisions. In order to develop policies and guidelines that encourage microgrid adoption in New York State, it is important that policymakers address this fundamental uncertainty and formalize the definition and legal rights of a microgrid.

This report, for the most part, focuses on issues associated with *physical* microgrids with their own dedicated electric and/or thermal generation and distribution infrastructure. Nevertheless, in the section below that addresses microgrid ownership and service models, we also introduce *virtual* microgrids. A concept that has been examined in the United Kingdom and Japan, virtual microgrids are aggregations of distributed energy resources (i.e., generation and demand response), which instead of being physically connected through a separate distribution system are linked on an accounting basis and possibly by a common control platform. Virtual microgrids use the existing electric wires to distribute excess generation locally, with wheeling charges paid to the local distribution company. Although different than physical microgrids in the services and benefits they can provide, the adoption of virtual microgrids could be an attractive way to promote increased deployment of distributed generation by energy users.

A review of the literature on *physical* microgrids indicates that varying definitions exist. These definitions differ in two major ways: 1) as a result of different interpretations of what a microgrid's basic physical characteristics and minimum technical capabilities should be; and 2) according to who owns the microgrid and the number of customers and type of services it might provide. The latter point is particularly important from the regulatory standpoint and we address these issues further in our discussion of ownership and service models and the current legal and regulatory context for microgrids below. For our purposes here, we focus on the functional aspects and technical capabilities of microgrids in order to develop a general definition that can later be further differentiated by ownership and service type.

From the standpoint of a microgrid's physical characteristics and capabilities, there are points of common agreement for basic features. These are that a microgrid should be small-scale, include multiple distributed energy sources and sinks, and, when producing and distributing electricity, be able to operate in parallel or in an intentional island mode with the surrounding grid. A physical microgrid is not a group of uncoordinated generation sources located near one another, but a set of resources optimally sized and operated for dedicated loads with coordinated demand response an integral feature. A single microturbine or reciprocating engine located in and supplying power to a single building also does not qualify as a microgrid; this is distributed generation.[48] Fundamental to the concept of a physical microgrid is the notion of control. As noted above, using modern communications and electronic interfaces, microgrids can provide the ability to control the quality and type of electricity delivered, a capability that is not currently offered by most existing electric distribution systems.[49, 50] This control also extends to

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[48] California Energy Commission and Navigant Consulting International, "Microgrid Business Cases," Distributed Energy Resources Integration Research Program, Public Interest Energy Research Program, December 2004

[49] One of the most frequently cited benefits of microgrids is the ability to provide multiple types of power quality to end users, also termed "heterogeneous power quality." A project in Sendai, Japan, which serves municipal buildings and a medical school, provides a good example of a microgrid delivering heterogeneous power quality. Participating loads receive different levels of quality and types of power. Some loads receive normal grid quality alternating current power, while others receive grid power with some enhancement, and still others receive direct current. For some loads, the Sendai project controls power quality very carefully by running it through a DC bus and either supplying DC power directly, or by conditioning it back to AC afterwards allowing very precise control. See: Chris Marnay, "Providing Energy Services Locally," A Google Tech Talk, March 25, 2009, Available at: http://www.youtube.com/watch?v=3XuCJBvq6Sk (accessed on October 3, 2009)

[50] Chris Marnay, 2007

interconnected loads, as the use of demand response as an internal resource is vital for balancing supply and demand in a microgrid.

Work done by Navigant Consulting International (NCI) for the State of California provides the most comprehensive review to date of microgrid definitions from the perspective of industry participants and researchers active in microgrid development and design.[51] NCI interviewed industry participants and asked them whether certain microgrid characteristics or capabilities were a "necessity," "optional, but preferred," "not required," or "no comment." Table 2.1 summarizes the results of NCI's microgrid characteristics review, supplemented by several additional sources the project team identified in the course of its research.

Table 2.1 – Percentages of Responses for Different Physical Microgrid Characteristics

Microgrid Characteristic	Necessity or Preferred	Not Required	No Comment
Capable of Island Operation	100.0%	0.0%	0.0%
Capable of Operating in Parallel with the Grid	100.0%	0.0%	0.0%
Autonomous Control of System	64.3%	0.0%	35.7%
Single Point of Interconnection to Grid	50.0%	21.4%	28.6%
Non-interconnected systems can be micro-grids	35.7%	50.0%	14.3%
Ability to Meet Participant Customer's Full Load	35.7%	14.3%	50.0%
Capable of Two-Way Power Flow with Macro-Grid	35.7%	14.3%	50.0%
More than 1 Generation Source	78.6%	7.1%	14.3%
More than 1 Participating Customer or Facility	57.1%	14.3%	28.6%
Employs CHP	64.3%	14.3%	21.4%
Employs Storage Technology	35.7%	21.4%	42.9%

Following NCI's work, the California Energy Commission adopted a general definition for microgrids that reflects the points of common agreement.[52] The important components of California's microgrid definition are multiple distributed resources, multiple interconnected loads, and the system's ability to operate in parallel or islanded from the grid. Additionally, NCI found that microgrids should be capable of providing sufficient and continuous energy supply for most of the internal demand and that a system's ability to move between parallel and islanded operation will be a function of its configuration and control system.

Consistent with industry views on the most important physical characteristics and capabilities, we use the following general definition for a physical microgrid for the remainder of this paper.

> *A small, integrated energy system of interconnected loads and distributed energy resources (producing electric, both electric and thermal energy), which can operate in parallel with the grid or in an intentional island mode.*

This definition is general in the sense that it does not assume all microgrids should be of a certain size, configured with a certain number of generating resources, use storage or have a certain type of control system. It also allows for the possibility that the microgrid distributes thermal energy in addition to or separately from electricity. One of the advantages of microgrids is that they can facilitate the use of low-grade heat produced close to loads through the application of CHP.[53] The use of CHP in a microgrid implies the existence of a demand for the captured thermal energy. If the customer hosting the CHP system cannot use the thermal energy produced by the system, it could be shared with a neighboring building or facility. In this way, microgrids present an opportunity to optimize the scaling of distributed resources with multiple loads and in cases where CHP is used, the potential to distribute thermal energy in addition to electricity to multiple proximate locations. There can be significant energy efficiency gains from this kind of operation.

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[51] California Energy Commission and Navigant Consulting International, 2004

[52] The CEC's definition of microgrid is: "an integrated energy system consisting of interconnected loads and distributed energy resources, which as an integrated system can operate in parallel with the grid or in an intentional island mode."

[53] Chris Marnay, Judy Lai, Michal Stadler and Afzal Siddiqui. "Added Value of Reliability to a Microgrid: Simulations of Three California Buildings." Paper presented at the Cigre *Integration of Wide-Scale Renewable Resources into the Power Delivery System* conference, Calgary, Canada, July 29-31, 2009.

In crafting a statewide definition for microgrids, policymakers may want to identify certain microgrid characteristics with more specificity than provided in the general definition above. The microgrid characteristics and capabilities that may have policymaking implications, and should possibly be addressed in an official definition, include:

- *Physical or virtual microgrid*: Does the microgrid use its own separate distribution systems (i.e., electric and thermal) to link resources and loads or does it rely on the existing grid to distribute energy? This distinction is important from a regulatory perspective as systems that use separate distribution systems raise questions with respect to competition in the provision of electric distribution services and how electric franchises are defined. Moreover, with an increasing penetration of communication technologies and control devices on utility distribution systems, the potential to manage distributed resources located on the same network "virtually" improves.

- *Interconnected to macro-grid*: the concept of the microgrid implies a small independently controlled system that may be embedded within or interconnected to a larger one. Still, microgrids could be designed to function entirely as self-sufficient islands, which would likely reduce many of the issues that otherwise might concerned regulators. Such systems could emerge in rural or remote areas without existing access to the grid. On the other hand, microgrids may be interconnected to the utility at low or medium voltage on the distribution system or to the transmission system at high voltages. The voltage at which a microgrid is interconnected may influence the degree to which it can participate in wholesale electricity markets or whether federal regulatory jurisdiction applies. If interconnected to the low-voltage distribution system, it may be necessary for state regulators to specify interconnection procedures or requirements for microgrid systems.

- *Ability to island*: central to the physical microgrid concept is the ability to operate the system in parallel or isolate it from the macro-grid without significantly affecting internal service (although some microgrids may employ load shedding of non-priority loads to accommodate islanded operation). This is significant because engineering standards and procedures for interconnecting distributed generation to utility networks, based largely from Institute of Electrical and Electronics Engineers (IEEE) P1547 – *Standard for Interconnecting Distributed Resources with Electric Power Systems*, do not currently provide direction for intentionally islanding. Utilities are understandably cautious about islanding of DG – particularly "unintentional islanding" – principally due to the hazards energized lines present to workers during outages. Utilities also want to protect against large fault currents, effectively reverse power flows on the grid, which could damage its distribution equipment. As a result, systems that intend to island typically require custom engineering and additional grid protection equipment. Due to increasing interest and need for standardization of these configurations, however, the IEEE is currently in the process of developing standards for intentional islanding of systems interconnected to utility networks (IEEE P1547.4), which will likely serve as a guide to inform revisions to utility tariffs for interconnection.[54]

- *Size*: the size of the microgrid can refer to several characteristics including the number of generators serving the system with power (i.e., whether there must be more than one generation source), the number of participating customers or buildings (i.e., a single, or multiple unaffiliated customers), and microgrid generating capacity and peak demand (i.e., serving one facility, a single feeder[55], or a substation area). In order to keep microgrids manageable, especially as markets for microgrids develop, regulators may want to specify a maximum number of potential participating customers and/or a maximum generating capacity (e.g., 40 MW or less).[56]

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[54] See Institute of Electrical and Electronics Engineers, IEEE P1547.4 Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems, Available at: http://grouper.ieee.org/groups/scc21/1547.4/1547.4_index.html (accessed on April 30, 2010)

[55] A feeder is a circuit that carries a large amount of electric power to a sub-feeder or a branch circuit or to some point at which the block power is broken into smaller circuits. A substation is a unit within an electricity generation, transmission and distribution system where voltage is transformed from high to low, or the reverse, using transformers. In the course of delivering electric power from generating plant to consumer, power may flow through several substations and may be changed in voltage along the way in several "steps."

[56] Douglas King and M. Granger Morgan, "Guidance for Drafting State Legislation to Facilitate the Growth of Independent Electric Power Microgrids," Carnegie Mellon Electricity Industry Center, 2005

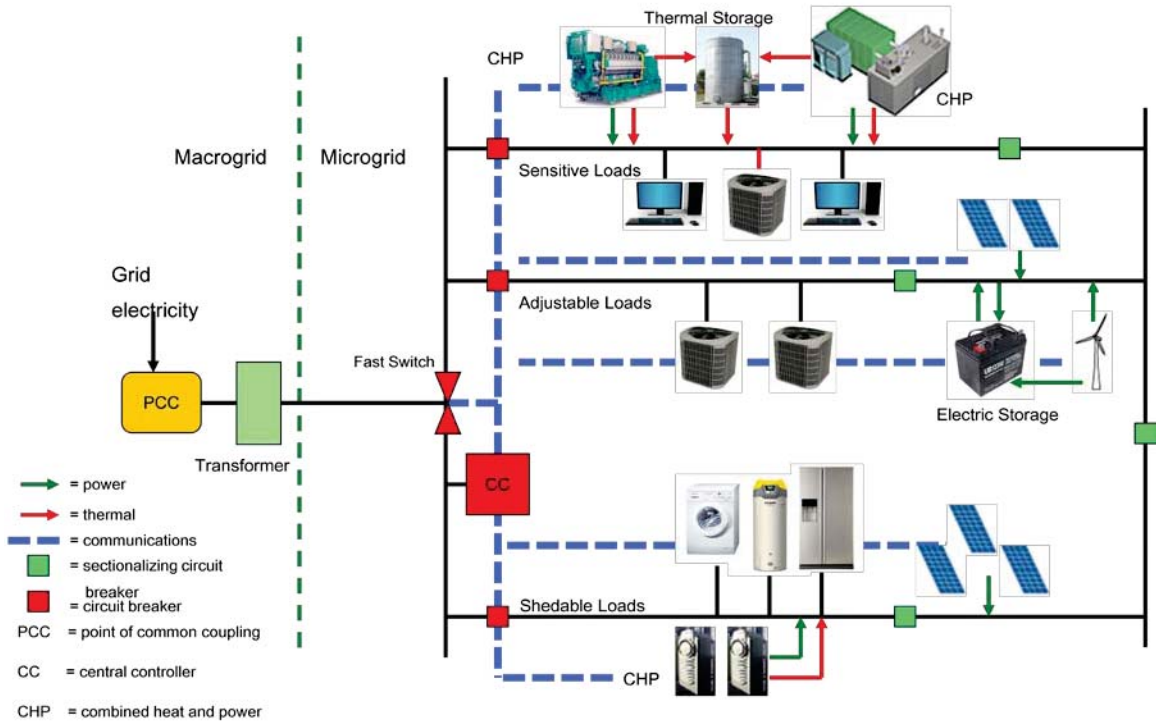
- *Resource types & energy produced*: not every microgrid will use the same distributed energy resources and technologies. Policymakers might want to develop microgrid policies that explicitly encourage the deployment of distributed renewable generation or efficient CHP. For example, under the Public Utility Regulatory Policies Act (PURPA), qualifying small power producers and cogeneration projects (qualifying facilities or QFs) are currently exempt from certain state and federal regulatory requirements (see Section 4.0 for a more detailed discussion). Additionally, while most research on microgrids focuses on the production and distribution of electricity, we believe that the distribution of thermal energy among multiple users is just as important a feature, particularly if it enables more optimal sizing of energy production facilities and encourages more efficient use of energy overall.

- *Ownership/service types*: microgrids may be organized under different ownership structures to provide various types of services to participating customers. Incumbent utilities may want to provide microgrids as a way to differentiate their services, particularly to customers that require very high levels of reliability or power quality, such as hospitals or data centers. Non-utility entities may also want to form microgrids to provide cost savings to participants or higher levels of renewable energy than the utility can provide. Non-utility microgrids could be intended solely for self-service (owners are also the customers) or merchant activities (an independent company in competition with the utility). Microgrids might only serve commercial or industrial customers, or could serve a new residential subdivision or group of apartment buildings. The ownership and service orientation of a microgrid will likely be important to regulators, raising important policy questions such as how much oversight is required over a microgrid or whether customer protection requirements should apply. To support such considerations, a typology of microgrid ownership and service models is presented in more detail in the next section.

2.2 Microgrid topology, technologies, and architectures

Microgrids may employ a wide range of distributed energy technologies – including generation, storage and advanced controls, metering and communications – to provide tailored, efficient and reliable energy services to connected end users. Because microgrids are largely customized solutions to the energy requirements of connected loads, it is unlikely that any two systems will use the exact same technologies or configuration. Important variables for determining microgrid design and technology will include the type, level and density of demand on-site for thermal energy; the type and level of electric demand considered uninterruptible (i.e., affecting the amount of capacity that must be available at all times); the local utility's energy tariffs, requirements for interconnection and interaction with the extant electric grid; and the local availability of fuel supply, to name just a few. Below we provide a schematic of a typical microgrid followed by descriptions of the following types of technologies that may be employed in microgrid systems.

Figure 2.1 – Sample Microgrid Schematic[57]



The microgrid schematic above generally reflects the kinds of components and capabilities that are frequently associated with microgrids. In reality, microgrids can be configured in many different ways and the specific components, capabilities and design adopted will vary with local environmental and energy market conditions, the energy performance requirements of local loads and the cost expectations of participants, among other things. This schematic shows the configuration and principle components that most advanced microgrids would incorporate in one way or another, including distributed generation, energy storage, control devices, advanced metering infrastructure and communications, self-healing distribution and fast switches.

Microgrids interconnected to the utility grid will do so at the point of common coupling (PCC), which is where the microgrid will interface with the macro-grid at either medium or high voltages. It is from this point that the microgrid will transfer between two states of operation, grid-connected and grid isolated, or islanded mode. In Figure 3.1, transformers are located at this point to either step-up microgrid exports to grid voltage or step-down imports to the microgrid distribution voltage. The fast switch, which is essentially an advanced circuit breaker, is able to sense conditions on the macro-grid and rapidly connect and disconnect the microgrid from the macro-grid. Each of the three feeder lines in Figure 2.1 (identified as serving sensitive, adjustable and shedable loads) can also be connected or disconnected via separate circuit breakers (i.e., red boxes in Figure 3.1). This design highlights the important role of demand response as an internal resource for a microgrid as interconnected loads are designated for varying – or heterogeneous – levels of service reliability.

The operation and management of the microgrid is controlled and coordinated via both local micro-source controllers, which are sited with generation or storage devices interconnected to the microgrid, and a central controller, which executes the overall control of the microgrid and coordinates the operation and protection requirements of the micro-source controllers. These devices collect and share information to ensure that voltage and frequency conditions on the microgrid are optimized. Sectionalizing circuit breakers or automated switches (i.e, small green boxes in Figure 2.1) located on each of the feeders, combined with multiple power feeds, allows faults

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[57] This microgrid schematic is modeled after versions presented by Lawrence Berkeley National Laboratory and S. Chowdhury, S.P. Chowdhury and P. Crossley, 2009

to be isolated on the distribution system preventing outages from affecting the entire microgrid area. An advanced metering and communications infrastructure allows real time monitoring of energy use on the microgrid and automated controls through the central control system. An energy management system is programmed to ensure that conditions on the microgrid stay within pre-determined levels (e.g., active and reactive power or voltage and frequency) and dispatch generation, storage devices or control shedable loads to ensure that supply and demand is balanced. Each of these is described in more detail separately below.

2.2.1 Distributed Generation

A major objective of microgrids is to integrate and combine the benefits of both conventional and non-conventional, or renewable and other low-carbon generation technologies such as high-efficiency CHP-based systems.[58] Prospective microgrid DG includes conventional prime movers that convert fuel energy into mechanical shaft power, which can then be used to drive a generator to produce electricity. There are many types of prime movers that can be used in microgrid configurations including combustion turbines, micro-turbines, reciprocating engines, steam turbines and sterling engines. Non-conventional forms of DG that produce electric power through means other than mechanical shaft power include fuel cells, photovoltaics and wind turbines.

There are three types of electric generators – induction, synchronous and inverter-based. "Synchronous" generators can operate both in parallel and independently of the grid, as they have an autonomously powered “exciter,” which enables the generator to produce its own reactive power and regulate its own voltage. This contrasts with an “induction” generator, which cannot operate independently because it relies on the grid for its “excitation,” meaning the generator is effectively driven by current supplied by the grid and it follows the frequency of this current while operating. If the regional grid goes down, this generator goes down with it. The capability to operate independently of the grid has made synchronous generators an obvious choice for use as backup power in the event of a blackout.[59] This capability also makes these generators appropriate for use in a microgrid configuration. Examples of prime movers that are commonly configured with synchronous generation are combustion turbines and reciprocating engines.

Inverter-based generation uses a microprocessor-based controller to allow the system to operate in parallel while still synchronizing its power with the grid.[60] Inverter systems convert the direct current (DC) power that is produced by a generator into alternating current (AC) power. The controller can also detect fault conditions on the grid and stop the system from producing power much faster than other forms of generation, thereby contributing insignificant levels of fault current to the grid. Some types of inverters can also quickly and seamlessly switch a DG system into grid-isolated mode, allowing the system to safely provide power to a facility during a grid failure without the risk of back-feed that can jeopardize the safety of work crews trying to fix the fault.[61] This makes inverter based distributed generation particularly attractive to utilities, which are often concerned about the potential for stray current or unintentional islanding with synchronous systems. Examples of inverter-based generation include fuel cells, micro-turbines, photovoltaics and wind turbines.

2.2.1.1 Combined heat and power (CHP) and combined cooling, heat, and power (CCHP)

CHP and CCHP are applications of distributed generation, which involve the sequential or simultaneous production of multiple forms of useful energy (mechanical to drive a generator and thermal for process heat or space conditioning) in a single, integrated system. CHP and CCHP systems typically include specific components – prime mover, generator, heat recovery, absorption cooling, and interconnection – configured into an integrated whole. The

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[58] S. Chowdhury, S.P. Chowdhury, and P. Crossley, 2009

[59] Hammer, et al., 2007

[60] Inverter-controllers have also been developed to provide non-synchronous parallel operation of DG to the grid. For example, Pareto Energy’s “GridLink” power converter is capable of interconnecting multiple power sources and converting power flows from AC to DC and back to AC, as a “perfect” power signal to either the grid or to loads behind the meter.

[61] Hammer, et al., 2007

type of system is typically identified by the prime mover involved (i.e., gas turbines, micro-turbines, reciprocating engines, steam turbines, and fuel cells).[62]

Captured waste heat from CHP prime movers or generators can be used a number of ways, including for industrial processes or for space heating and cooling. Steam or hot water produced as a by-product of electric generation by the various prime movers (or possibly a boiler in the case of backpressure steam turbines) can be distributed in pipes to nearby heating loads or run through steam or hot water absorption chillers to produce cold water for cooling. Although the most efficient models are currently at high cost (i.e., double-effect chillers), absorption chillers allow the thermal output of the prime mover to be used across seasons, particularly during the summer when demand for steam or hot water might otherwise decrease. Through the simultaneous use of electricity and thermal energy, CHP systems can reach overall energy efficiencies of as high as 80%. These systems are most efficient if waste heat is used close to the source of production; losses will reduce overall efficiency if the heat must be transferred over long distances, even with heavily insulated pipes.[63]

It is important to note that while they may overlap in some respects, microgrids deploying CHP are not the same as district energy. District energy systems, which may involve cogeneration of electricity, typically use large boilers to produce and distribute steam or hot water for heating or cooling large districts. Con Edison's steam system in mid-town and downtown Manhattan is an example of a district energy system. This system, which consists of approximately 87 miles of distribution mains and 18 miles of service lines, serves approximately 1,800 customers. Nine plants supply steam to Con Ed's system with a combined steam capacity of approximately 12,500 lbs/hr including three large co-generation facilities capable of generating a total of 850 MW of electricity.[64] While it is possible that some large microgrids could be construed as providing district energy, most microgrids will be much smaller (e.g., less than 40 MW of electric capacity) and serve a much smaller number of customers with both electricity and thermal energy.

2.2.2 Energy Storage

To ensure uninterrupted supply to priority loads, manage intermittent renewable resources by providing fast-acting load following, provide reactive power support and allow optimal sizing and operation of DG units, it is likely that microgrid developers will want to employ some form of energy storage. Microgrids may incorporate a wide variety of electric and/or thermal storage technologies ranging from established battery storage systems to advanced flywheels or thermal ice storage to shave peak cooling demands.

Electric storage includes a range of commercial and developing technologies – including batteries, flywheels and super-capacitors – that may be used in microgrids for either energy or ancillary services (i.e., load balancing or frequency regulation). These technologies do not store electric current directly, but convert and store the electric energy using either mechanical, chemical or electric potential energy methods. Each of these storage methods provides particular operational range and capabilities, predisposing the storage technology to a particular set of applications for which it is best suited.

Advances in power electronics, or power converters that switch power from DC to AC, have helped make battery storage systems increasingly reliable.[65] Moreover, recent breakthroughs in battery development have demonstrated the ability to deliver an increasing number of charge/discharge cycles, which enhances their useful life and improves economics. The Zinc Bromide (ZnBr) "flow" battery, for example, has shown the ability to provide more than 10,000 charge/discharge cycles, which means that a system providing a daily cycle could last at least ten years (3,700-4,000 cycles) and perhaps as long as thirty (10,950 cycles).[66] NYSERDA is currently demonstrating a Premium Power 100 kW ZnBr flow battery at the Niagara Falls State Park. The project is intended to show how the

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[62] US EPA Combined Heat and Power Partnership, "Catalogue of CHP Technologies," December 2008, Available at: http://www.epa.gov/chp/basic/catalog.html (accessed on April 30, 2010)

[63] S. Chowdhury, et al., 2009

[64] Steam Business Development Task Force, *Steam Business Development Plan for the Consolidated Edison Steam System*, August 2005

[65] NETL, "Energy Storage – A Key Enabler of the Smart Grid," September 2009, Available at: http://www.netl.doe.gov/smartgrid/referenceshelf/whitepapers/Energy%20Storage_2009_10_02.pdf (accessed on April 30, 2010)

[66] Ibid.

100 kW battery can provide high-efficiency peak load shifting as well as the firming of a 30 kW photovoltaic system installed on the roof of one of the State Park facilities.[67]

Other battery technologies that could be deployed in microgrid configurations include the proven, yet low cycling lead-acid, sodium sulfur (NAS), lithium-ion (Li-ion) and other flow batteries (e.g., vanadium redox or VRB). NAS batteries are becoming common for utility-scale applications and may be useful for certain large-scale microgrid systems. New York State is currently testing a NAS battery at a Long Island bus depot. The Peak Reduction Demonstration project exhibits the use of a 1 MW NAS battery system to shift the load of a natural gas compressor from peak to off-peak and to provide emergency backup power. The natural gas compressor provides fuel for buses that will replace diesel-powered buses.[68] The characteristics of these different battery technologies and their suitability for microgrid applications vary. Table 2.2 below summarizes some of the important characteristics.

Table 2.2 – Selected Characteristics of Advanced Battery Storage Technologies

Battery Type	**Capital Costs $/kWh**	**Life Cycle (Number of charge/discharge cycled to 80% DOD)**	**% Round Trip Efficiency (from AC to AC)**	**Environmental Impact (i.e., ease of permitting)**
Li-ion	$600-$1,200/kWh (very high)	Medium (2,000-5,000)	Very High (85% - 95%)	Low
VRB	$350-$500/kWh (medium)	High (up to 10,000)	Medium (70% - 75%)	High
NAS	$350-$500/kWh (medium)	Medium (3,000-5,000)	High (85% - 90%)	Medium
ZnBr	$150-$250 kWh (low)	High (>10,000)	Medium (70% - 75%)	Low
Comments	Installation adds 20-30% to costs.	For storing wind or solar, life cycles of 10,000 or greater may be needed.	Efficiency is important for arbitrage (i.e., buying/producing at low cost and selling/using at high cost periods), but less so for peak shaving or frequency regulation	

Source: National Energy Technology Laboratory (2009)

Flywheel energy storage is another emerging technology that is viewed as useful for electric load leveling and frequency regulation and may be deployed in advanced microgrid applications to support system power quality and reliability. Flywheels consist of large rotating cylinders, accelerated to a very high speed, which is maintained within an enclosed system as rotational energy through the use of lightweight components and low-friction magnetic bearings. Electricity is used to accelerate the flywheel and add energy to the system. When energy is drawn from the system to produce electricity via a motor or generator, the flywheel's rotational speed is reduced. Flywheels have been deployed across the US in trials to provide power quality and reliability services and typically range in capacity from 150 kW to 1 MW. Their advantages include a long charging/discharging cycling life (tens of thousands of deep cycles) and fast charging/discharging times, while their disadvantages include low energy density.[69]

A large-scale flywheel is currently being built in Stephentown, NY to provide frequency regulation service to the New York State grid. The 20 MW Beacon flywheel project is the first of its kind in the world and is expected to

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[67] For more information on the ZnBr demonstration see the NYSERDA/DOE Joint Energy Storage Initiative Demonstration Projects at: http://www.storagemonitoring.com/nyserda-doe/ESS.shtml (accessed on July 31, 2010). Also see Premium Power for information on the PowerBlock 150 at: http://www.premiumpower.com/product/powerblock150.php (accessed on August 16, 2010)

[68] For more information on the NAS demonstration see the NYSERDA/DOE Joint Energy Storage Initiative Demonstration Projects at: http://www.storagemonitoring.com/nyserda-doe/battery.shtml (accessed on July 31, 2010)

[69] Electricity Storage Association, "Technologies – Flywheels," see: http://www.electricitystorage.org/ESA/technologies/flywheels/ (accessed on July 31, 2010)

provide 10% of the State's frequency regulation requirements. Although this is a large-scale project, the modularity of the technology – 4 MW was in place as of August 2010 – highlights its potential use in smaller-scale applications like microgrids.[70] For example, a 100 kW flywheel is currently being used at an industrial site in Amsterdam, NY to demonstrate frequency regulation, uninterruptible power supply and reactive power support.[71]

There are also several proven thermal storage technologies that could be valuable in microgrid systems, including hot or chilled water storage tanks and cool or "ice" storage. Thermal storage tanks store hot or cold water in an insulated repository for later use in space heating/cooling or domestic or process hot/cold water. For microgrids that deploy CHP, thermal storage tanks can provide a storage "sink" for thermal output of the DG when it may not be needed, for use during a period when demand would otherwise exceed supply. There are many examples of this, one being the University of California at San Diego where a 3.8-million-gallon chilled water storage system used for cooling shifts about 14% of its campus microgrid's load off-peak.[72] Additionally, in the Borough of Woking, United Kingdom, Thameswey Energy Limited stores excess hot water produced by its Woking Town Centre Energy Station during the day to operate absorption chillers at an interconnected nightclub in the evening. This system allows Thameswey to make use of excess heat produced during the day to reduce the cooling demand of the nightclub in the evening (see the Woking case study in the Appendix).

Ice storage systems use chillers (either electric or thermally driven) to create ice during off-peak periods to reduce cooling energy demands during peak periods. To cool buildings during the day, water is circulated through the chiller-produced ice to produce chilled water that would normally be the daytime output of the chillers, which is then run through the building's cooling system. By shifting loads to off-peak periods, ice storage can reduce peak demand on the microgrid, allowing DERs to be scaled down and operated 24-7, reducing capital cost and improving the system's load factor. There are several examples of ice storage deployments in New York State including at Morgan Stanley's corporate office building in Westchester where a Trane and Calmac ice storage system has lowered the building's peak electricity demand by 740 kW during the day and reduce overall electricity usage by 900,000 kWh. Similarly, the Bank of America tower in Manhattan uses a similar system to produce more than half a million pounds of ice at night, shifting 1,000 tons of cooling load to off-peak periods.[73]

2.2.3 Advanced Metering Infrastructure and Communications

Advanced metering infrastructure (AMI) refers to systems that measure, collect and analyze energy usage, and interact with advanced electricity meters, gas meters, heat meters, and water meters, through various communication media either on-demand or on pre-defined schedules. This infrastructure includes hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software, and supplier and network distribution business systems among other components. Due to the heightened importance of finely tuned load balancing on microgrids, AMI is important for rapid sensing, communications and response capabilities.

Smart meters at the customer premises are a cornerstone of AMI, providing a platform for a two-way communication network between the utility or microgrid operator and each participant's meter. Smart meters communicate with building systems, appliances or other demand generating devices through a wireless communication system, which in the case of residential customers is called the Home Area Network (HAN).[74] In

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[70] For more information see Beacon Power Corporation at: http://WWW.BEACONPOWER.COM/company/20100706-gallery.asp (accessed on August 17, 2010) and The Wall Street Journal's Market Watch, "Beacon Power Delivers First Power Electronics and Support Systems to 20 MW Flywheel Plant in Stephentown, NY," July 6, 2010 at: http://www.marketwatch.com/story/beacon-power-delivers-first-power-electronics-and-support-systems-to-20-mw-flywheel-plant-in-stephentown-ny-2010-07-06 (accessed on August 17, 2010)

[71] See: NYSERDA/DOE Joint Energy Storage Initiative Demonstration Projects at: http://www.storagemonitoring.com/nyserda-doe/flywheel.shtml (accessed on July 31, 2010)

[72] Lyn Corum, "The New Core Technology," *Distributed Energy*, January-February 2010

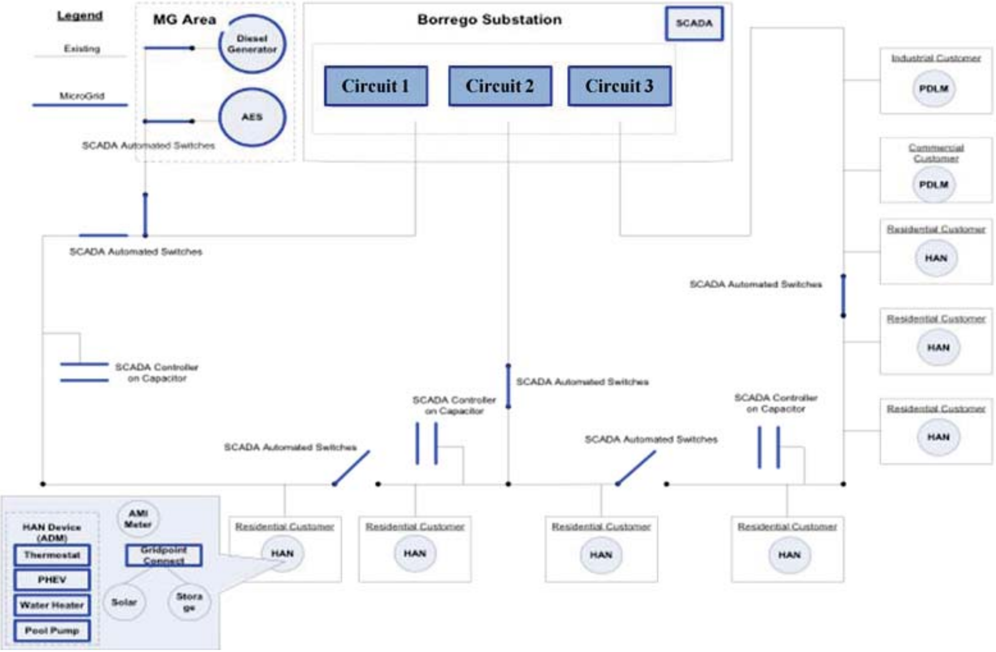
[73] Mark MacCracken, "Thermal Energy Storage and Peak Load Reduction," Presentation at NERUC Summer Meeting, July 2007, See: http://www.narucmeetings.org/Presentations/Off%20Peak%20Cooling_Thermal%20Energy%20Storage.ppt (accessed on August 17, 2010)

[74] A 2007 Federal Energy Regulatory Commission (FERC) staff report defines HAN as a network contained within a customer's home connecting "intelligent" digital devices including general appliances such as washer/driers and refrigerators, computers, heating and air conditioning, TVs and DVRs, home security systems or any other digital device that can communicate with the

the case of microgrids, a building's area network will link into a Local Area Network (LANs) to establish connectivity between network devices (e.g., smart meters) and the microgrid's central control system. The LAN will also use a communication system, such as wireless radio frequency (rf) mesh as SDG&E is deploying in its Borrego Springs microgrid demonstration, to establish connectivity between the electric meters and stand-alone cell relays that transmit signals to the central control system.[75]

Due to their small scale and likely incorporation of multiple sources of power supply as well as demand response, an advanced microgrid requires an active distribution system that can manage the influx of load and bi-directional flows of electricity. The installation of supervisory control and data acquisition (SCADA) at critical points on the microgrid distribution system (e.g., all circuit breakers and switches) can provide the necessary monitoring, communications and control capabilities for distribution automation. SCADA is a well-established technology for network management that has been deployed by utilities for more than thirty years to provide improved automation and control in the transmission system and at substations. SCADA consists of data acquisition (i.e., sensing and communications), data processing, remote control of mechanical devices (i.e., switches), event processing and other data analysis functions required to support the automated operation of a system. On a microgrid, SCADA may be deployed to monitor and control electric and/or heat generation, storage devices, distribution equipment and other ancillary services such as capacitors and other VAR-control devices. Figure 2.2 below provides one example of how SCADA is being incorporated by SDG&E into its microgrid system.

Figure 2.2 – Circuit Diagram Showing Use of SCADA on SDG&E Borrego Springs Microgrid



Source: San Diego Gas & Electric (2009)

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network. See FERC, "Assessment of Demand Response & Advanced Metering," September 2007, Available at: http://www.ferc.gov/legal/staff-reports/09-07-demand-response.pdf (accessed on April 7, 2010)

[75] An RF mesh is a wireless communications network made up of radio signal emitting and receiving nodes organized in a mesh topology; or a network where each node serves as an independent router regardless of whether its connected to another one or not, providing redundancy in communications pathways. Wireless mesh networks often consist of mesh clients (i.e., laptops, cell phones or other wireless devices) mesh routers (transmitting signals) and gateways, which are connected to the Internet or other data storage/processing system. An RF mesh network is sometimes called a mesh cloud and is dependent on the radio nodes working in harmony with each other. A mesh network is reliable and offers redundancy such that when one node fails, the rest of the nodes can still communicate, directly or through intermediate nodes. See: Ian. F. Akyildiz and Xudong Wang, "A Survey on Wireless Mesh Networks," IEEE Communications Magazine, vol. 43, no. 9, s23-s30, Sept. 2005

Typically, a combination of several communications circuits are used with SCADA, including fiber and copper circuits, wireless mobile phone and radio connections.[76] For example, to provide for local area communications on its project, SDG&E has licensed a 900 mHz rf solution, which will allow field SCADA devices and controls to communicate with substation controls and SDG&E distribution operators.

2.2.4 Microgrid Controls and Energy Management System

Microgrids require operating systems that are capable of managing loads and the operation of generators as well as determining when and how to transfer between grid-connected and islanded operating modes. This operation and management is achieved through the use of a combination of local micro-source controllers and a central controller. The micro-source controllers (also called "slave" controllers because they are subservient to the central controller) handle the operating functions of the local generators and storage devices (i.e., DERs) as well as the response of controllable loads and switches or breakers to local conditions. Micro-source controllers execute the response of DERs to real time changes in supply and demand as well as voltage, current, power and reactive power states.

The central controller provides executive control functions over aggregate system operation, including the individual micro-source controllers, DERs and power conditioning equipment. The central controller ensures that power quality and reliability on the microgrid are maintained through power-frequency control, voltage control, and protection coordination.[77] The central controller also manages economic dispatch of microgrid resources, including use of macro-grid power, which it will determine through an optimization process. The optimization takes into consideration variables including the cost of electricity, cost of gas or fuel inputs, weather, interconnected load forecasts, and microgrid DER characteristics and availability, among others.[78] The central controller is typically designed to operate in an automated fashion under several different operating modes (i.e., normal grid-connected mode or island mode), but has the capability of manual override if necessary.

New York is hosting an innovative project that involves the development of control systems for virtual microgrids. A collaboration between Innoventive Power, Con Edison, the telecommunications company Verizon and software firm Infotility, the project aims to demonstrate the interoperability of demand response and DERs, including backup generators, fuel cells and storage devices across a large number of dispersed sites in the Con Edison service territory. The linchpin of the project is the development of a demand response command center to aggregate multiple DR and DER resources at retail electric customer sites to supply critical services, under tariff-based and market-based programs, to the electric distribution company and to the regional transmission operator. Significantly, the command center facilitates remote control of both demand response resources and electric generating assets located at over 30 retail customer facilities. The control center will be capable of providing Con Edison with a 10-minute response time during network emergencies. Con Ed sends a signal to the aggregator control center for support in a particular sub-zone of its network and the control center operates the resources to deliver the requested load relief. In exchange, Verizon, the retail customer, is paid for making its assets available to the grid during peak periods.[79]

2.2.5 Self-healing Distribution

Self-healing distribution refers to circuits that incorporate feeder/circuit redundancy and smart switches to allow the flow of electricity to be reconfigured on the network. Substation feeder redundancy refers to when there are two or more feeders or distribution circuits that can supply power to end users' locations. For example, if one circuit feeding a customer location is compromised by a tree fall or other outage-inducing event, a section on the circuit can open and the customer can be supplied by the alternate feed. Smart switches allow these sections to be opened or closed remotely and automatically in cases where faults have been detected and communicated through SCADA.

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[76] S. Chowdhury et al., 2009

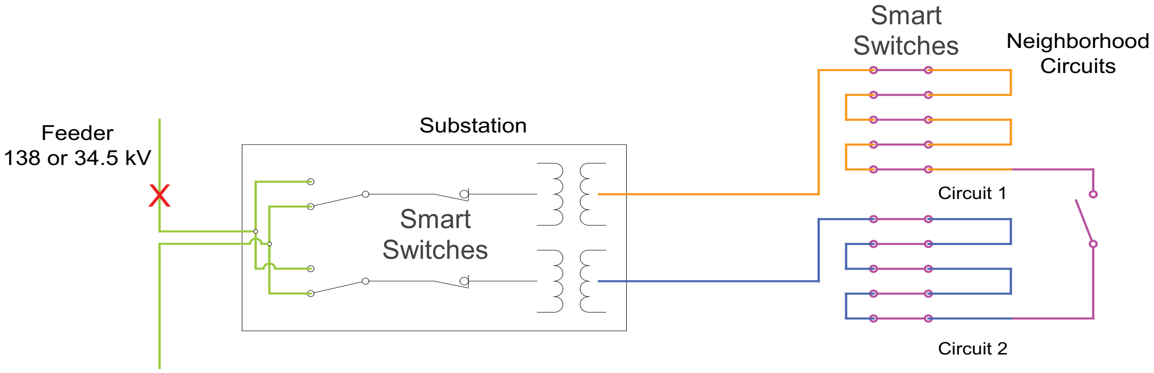
[77] Ibid.

[78] For an excellent and thorough description of microgrid control systems see: Galvin Electricity Initiative, "Master Controller Requirements Specification for Perfect Power Systems," February 2007, Available at: http://www.galvinpower.org/sites/default/files/documents/MasterController_VCRevision.pdf (accessed on May 19, 2010)

[79] Howard Fiebus, "Interoperability of Demand Response Resources in New York," Presentation to the International Microgrid Symposium, San Diego, CA, September 2009

Figure 2.3 below, provided by the Galvin Initiative, provides an example of a self-healing substation distribution area.

Figure 2.3 – A Self-healing distribution system with smart switches



Source: Galvin Electricity Initiative

Similarly, the circuit diagram of SDG&E's Borrego Springs microgrid area in Figure 2.2 above shows SCADA operated switches located on the circuits allow sections of the substation service area to be isolated, providing SDG&E with the capability of minimizing the extent of an outage due to a fault on part of a circuit.

2.2.6 Fast Switches

Fast switches enable quick intentional islanding and automatic re-synchronization of microgrid systems with the macro-grid. They are important components of the grid-connected electric microgrid system because they enable the system to detect conditions both on the utility and microgrid sides and are designed to make rapid decisions about whether to maintain connected to the macro-grid or to seamlessly separate and institute islanded operations. This contrasts with what is in place today for macro-grid-interconnected systems that can island, which require the on-site generation to trip, or shut down, if the macro-grid falters in order to protect utility workers. After a short period, the generators may then come back on line to serve some or all of the interconnected customers' load. With a fast switch, microgrids could electrically isolate themselves within milliseconds, preventing the need to trip connected generation. A similar process has to occur when the macro-grid comes back on-line and the microgrid reconnects – generation is tripped for a time period before re-synchronization can occur with the utility system.[80] The National Energy Technology Laboratory has reported that fast switches are currently available at a high cost, and estimates a time to market use of about 2-3 years (2011-2012).[81]

2.2.7 Microgrid Architectures and Characteristics

The technologies described above can be configured a number of ways to address a variety of different microgrid applications. As discussed above microgrids may consist of medium and low voltage distribution systems delivering power and/or thermal energy to loads in proximity served by DERs located on site. Microgrids can be interconnected to the macro-grid (interconnected microgrids) or designed to operate entirely as an island. Microgrids interconnected to the extant electric system at the point of common coupling can move between grid-connected and isolated grid modes, depending on circumstances. While grid-connected, the microgrid's control system may maintain a "grid dependent" or a grid-independent mode of operation, again depending on the circumstances. This flexibility allows interconnected microgrids to take advantage of grid resources yet maintain independence if needed.[82]

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[80] David Engle, "Microgrids Up and Running," *Distributed Energy*, May/June 2008

[81] NETL, "A Compendium of Smart Grid Technologies," July 2009

[82] Johan Driesen and Farid Katiraei, "Design for Distributed Energy Resources," *IEEE Power & Energy Magazine*, May/June 2008

Driesen and Katiraei identify three types of microgrid architectures that reflect different categories of applications, including utility microgrids, non-utility or industrial microgrids and remote or isolated microgrids.[83] Table 2.3 below is a general classification of different microgrid architectures and their characteristics based on different applications, ownership structures and load types.

Table 2.3 – Microgrid Architectures

		Utility Microgrids		**Non-Utility Commercial or Industrial Microgrids**	**Remote/Isolated Microgrids**
		Urban Networks	**Rural Feeders**	**Multi-facility**	
Application		Downtown areas	Planned islanding	Clusters of commercial and residential buildings; industrial parks; shopping centers; and university campuses	Remote communities and geographical islands
Main drivers		Outage management/improved reliability and control and renewables or CHP integration		Power quality enhancement, reliability and energy efficiency	Electrification of remote areas and reduction of fuel use
Benefits		Greenhouse gas reduction; supply/fuel diversity; congestion management; distribution/transmission upgrade deferral; and ancillary services		Premium power quality; service differentiation (i.e., reliability levels); CHP integration; and demand response management	Supply availability; renewables integration; greenhouse gas reductions; demand response
Operating modes		Grid dependent (GD); grid independent (GI); and isolated grid (IG)		GD, GI, IG	IG
Transition to GI and IG Modes	**Accidental**	Faults on adjacent feeders or at substation		Macrogrid power failure; power quality issues	
	Schedule	System maintenance		Energy prices (peak); utility maintenance	

Source: Driesen and Katiraei, 2008

Each of these architectures has a different set of drivers. The utility microgrid may be particularly valuable in a downtown urban network or along a rural feeder line where service capacity is resource-constrained and reliability and power quality may be compromised or in danger of being compromised. Efforts to increase the amount of renewable energy or use CHP may also be drivers of utility microgrids. Non-utility commercial or industrial microgrids may be driven by a desire to reduce costs through self-generation as well as provide greater control over site power quality and reliability. These loads, or a portion thereof, may not tolerate even momentary outages and a microgrids can be adapted to serve the different load requirements of multiple commercial or industrial facilities. Microgrids can also be designed to serve multi-facility residential customers or mixed use areas. Research conducted at Columbia University found, that due to their high demand for thermal energy relative electric, large multi-family buildings could serve as excellent hosts for CHP-based microgrid systems.[84] Although less applicable to New York State, remote or isolated microgrids serve to electrify areas either currently without power services or with limited access to fuel supplies (e.g., remote communities, state parks or resource extraction sites).

The range of benefits produced by a given microgrid will likely reflect the intended application, architecture, and resources deployed. A utility microgrid may be focused more on integration of renewable energy supplies and as a result, provide greater emissions benefits than a non-utility microgrid intended primarily to provide cost savings or highly reliable power services. These characteristics will in large part be driven by the microgrid ownership and service characteristics. Microgrid ownership and service models are examined further in Section 3.0 below.

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[83] Ibid.

[84] Lily Parshall, Hildigunnur Jonsdottir, Stephen Hammer and Vijay Modi, "Spactio-temporal patterns of energy demand in New York City and implications for cogeneration," Draft Working Paper, January 3, 2010, available at: http://sallan.org/EventPix_slideshow_Smart-Grid/resources/L-Parshall_NYC_Cogen_WorkingPaper_Jan2010.pdf (accessed on August 24, 2010)

3.0 MICROGRID OWNERSHIP AND SERVICE MODELS

Previous efforts to clarify and resolve some of the regulatory barriers to microgrid implementation have found that the environment for microgrids in the US is complex and uncertain.[85] Across the country, regulators' views of what a microgrid is and how one might operate differently (see Section 4.2 for more on other states). As a result, it is likely that the viability of a given microgrid within today's legal and regulatory structure will depend on how the project is framed, particularly with respect to who owns the microgrid infrastructure, which types of customers receive service from the microgrid, and how profits from those services are earned.[86] Below we provide a typology of microgrid ownership and service models to help identify the range of options for deployment and begin to shed light on the types of applications that may face the biggest hurdles. While we raise some general legal and regulatory issues here, a more complete discussion of these issues as they pertain to New York State and other parts of the country is provided in the next section.

In our research, we identified only two other efforts to define and categorize ownership and service models for microgrids. In its examination of the potential future market opportunity for microgrids for California, NCI identified four ownership models with "strong" business cases including utility, municipal (government), landlord (a single, non-utility and non-governmental owner) and renewable energy cooperatives (multiple non-utility owners). NCI also identified four scales of service these owners might provide including single facility (< 2 MW), multi-facility (< 5 MW), feeder (5-20 MW) and sub-station (20+ MW).[87]

King, in his research on the regulatory environment for interconnected microgrids across different US states, found that the way a microgrid is presented will have a significant effect on how regulators view it. "When framed as a small independent power producer," King explains, "a microgrid may yield a different reaction than when it is framed as a large distributed generator, or placed in the context of energy services or demand management." In order to reduce confusion and facilitate policy discussion and development, King proposed the following five models by microgrid ownership and business practice.[88]

1. *Utility model* – the distribution utility owns and manages the microgrid to reduce customer costs and provide special services (e.g. high power quality and reliability) to customers on the system.
2. *Landlord model* – a single landlord installs a microgrid on-site and provides power and/or heat to tenants under a contractual lease agreement.
3. *Co-op model* – multiple individuals or firms cooperatively own and manage a microgrid to serve their own electric and/or heating needs. Customers voluntarily join the microgrid and are served under contract.
4. *Customer-generator model* – a single individual or firm owns and manages the system, serving the electric and/or heating needs of itself and its neighbors. Neighbors voluntarily join the microgrid and are served under contract.
5. *District Heating model* – an independent firm owns and manages the microgrid and sells power and heat to multiple customers. Customers voluntarily join the microgrid and are served under contract.

As King observed, depending on the state in which a microgrid is located, regulators may interpret these models very differently. For example, he found that the Utility and Landlord models tend to be viewed most approvingly by regulators while the District Heating model is viewed least approvingly. These views are shaped by state electric industry regulation and law, which is generally designed to protect incumbent distribution utilities and their customers from the potential risks of competition. Even after industry restructuring, which focused on encouraging competition in generation, distribution utilities continue to be granted monopoly power to provide service to

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[85] M. G. Morgan and H. Zerriffi. (2002). "The Regulatory Environment for Small Independent Micro-Grid Companies." *The Electricity Journal*: 52-57

[86] King, 2006

[87] California Energy Commission and Navigant Consulting International, 2004

[88] King, 2006, p. 3

customers within a specified service territory. Service territories and franchises granted by municipal jurisdictions,[89] effectively uphold what is considered to be a natural monopoly designed to avoid the duplication of service wires, reduce utilities' financial risks, and assure customers they will receive electric service. By implying a merchant distribution function, where an independent microgrid firm can serve multiple independent customers that join voluntarily, the District Heating model may be viewed as conflicting with these existing protections for distribution utilities.[90]

The ability of a non-utility firm or cooperative to build and operate a microgrid revolves primarily around the following issues: how will the microgrid be interpreted under existing law, how heavily will it be regulated and will the incumbent attempt to block it from proceeding? If a proposed microgrid is defined by the regulator as a utility distribution company, it will likely face significant and probably insurmountable barriers to implementation, especially if it is located within the service territory or franchise area of an existing utility. Not only is it likely that regulatory authorities will be inclined to protect the incumbent distribution utility, but also the utility itself is likely to defend its franchise rights in court, if necessary. In many cases, the mere threat of tying up a potentially small enterprise such as a microgrid, in litigation over franchise rights could stop a project.

For example, in 1998, Pittsburg Electrical Insulation (PEI) Corporation proposed the construction of a cogeneration power park that would serve approximately 25 MW of load to a variety of customers on a campus it owned. The local utility opposed the project and petitioned the Pennsylvania Public Utility Commission (PUC) that the facility should be treated as a public utility under state law. Ultimately, the PUC issued a declaratory order exempting PEI's proposed project, partly on the basis that it owned the property on which it intended to serve. With this confirmation, PEI broke ground on the project and secured customer commitments to participate. Still, continued legal threats by the local utility in civil court and PEI's fear of ruining the business relationship it had with the utility, led the company to abandon its plans.[91] Ultimately, the PEI project went forward under an agreement with the local utility as an "exempt wholesale generator." PEI produces power and steam, but sells its electricity on the wholesale market. The PEI project is also not able to island from the utility system, reducing the potential reliability value of the system to its tenants.[92]

In addition to influencing its legal status, the economics of a given microgrid project – the incentives and practical considerations for building a microgrid – are also likely to differ depending on the ownership and service model. The extent to which the benefits derived from developing a microgrid can be captured by the developer will have a significant impact on the likelihood of it being built. For example, if utility or social benefits are large – and incremental to the estimated customer benefits – for a particular proposed micro-grid project, then that project under a non-utility model may not work, because the customers would not be able to realize the complete (i.e., social) value of their investment. This may be the case for a number of environmental and energy system benefits, such as reduced emissions, avoided line losses, and avoided generation and distribution system capacity investments. These issues are also addressed in Section 5.0.

In order to provide more granularity to New York State's consideration of microgrid opportunities and barriers, we developed a framework, following King, for thinking about *physical* and *virtual* microgrid ownership and service models. The framework includes nine models within two major categories of ownership: utility and non-utility (see Figure 3.1 below). The reason for proposing these categories is not to judge how a given microgrid would be interpreted under the law. Instead, we observe that there are two general types of entities that might want to pursue microgrids, existing utilities, and non-utilities (e.g., cooperatives, independent firms, and independent campuses). Within the utility and non-utility categories there are a number of variations that relate to the service orientation of

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[89] A franchise is the right conferred by the government to engage in a specific business. In New York State, the legislature has bestowed to cities, towns and villages the statutory authority to grant franchises or rights to use the streets, waters, waterfront, public ways and public places of the city to provide public services for private gain. For electric utilities, "use" encompasses occupying public rights-of-way and operation of the company's built infrastructure to provide the intended public service. See Section 5.1 for a more detailed explanation of utility franchises in New York State. See Section 5.0 for more information on franchises in New York State and how they may pertain to microgrids.

[90] King, 2006, p. 3-5

[91] King, 2006, p. 7

[92] Jay Apt and Granger Morgan, "Critical Electric Power Issues in Pennsylvania: Transmission, Distributed Generation and Continuing Services when the Grid Fails," Submitted to the Pennsylvania Department of Environmental Protection, July 2004

the microgrid as well as additional characteristics that might affect a given model's permissibility. We highlight these differences in the discussion of the nine ownership and service models below.

3.1 Utility owned physical microgrids

Existing electric distribution utilities may want to develop microgrids for various reasons, including to improve local reliability, differentiate their service offerings to customers or possibly to compete with non-utility microgrid service companies. In this context, we envision the potential for utilities to both fully owned (i.e., vertically integrated) and partially owned microgrids (i.e., unbundled). Although we do not address this issue in detail, utility-owned/operated microgrids could cover a range of scales including sections of distribution feeders, entire feeders or entire substation areas.

There are several important reasons for this distinction. First, under electric industry restructuring, most distribution utilities have been required or encouraged to sell their generation assets to third parties to facilitate competition.   As a result, utilities in states that have deregulated – such as New York – are generally not investing in new generation assets, but are leaving that to Independent Power Producers (IPPs) that build new generating units in response to wholesale market conditions. Meanwhile, states are encouraging customer investment in photovoltaics, fuel cells, and other forms of advanced clean distributed generation. Therefore, it is very likely that a microgrid that includes utility ownership of the distribution assets might also include customer or third party owned generating facilities. Implementing this type of microgrid will require regulatory and policy guidance and potentially the development of new markets for local energy and ancillary services. Alternatively, utilities may want to own the generation assets embedded within the microgrid (if they are allowed) so that they can exercise a greater degree of control over the system. Utilities already own backup generation, which is used for reliability purposes, and increasingly they are asking regulators for permission to own renewable assets, especially photovoltaics. Ultimately, this microgrid model may require policymakers to reconsider restrictions on utility ownership of generation assets.

A. *Vertically Integrated Utility Model*: An existing electric utility owns the microgrid distribution infrastructure and generation and storage technologies operating on the system, providing electric and/or thermal energy services to participating customers. It also operates the microgrid control system, determining which generating units run and directing customer demand response or the shedding of non-critical loads in the event of a macro-grid interruption or for economic reasons. The microgrid allows the utility to differentiate its product and services to customers in the form of varying reliability and/or power quality services at varying costs. The research team did not identify an example of a vertically integrated utility microgrid; however, aspects of this model are represented by a reliability project undertaken by Central Hudson Gas and Electric in New York and the City of Naperville's smart grid initiative in Illinois.[93]

B. *Unbundled Utility Model*: An existing electric utility owns and maintains the electric distribution facilities serving the microgrid, which provides electric and, possibly thermal energy, while generation or storage assets are owned by participating customers or third parties. The utility will likely operate or direct the microgrid control system, and possibly use a control scheme that can accommodate the interests of multiple DER asset owners (i.e., one that enables and can integrate multiple agents, or customers, acting on their own behalf).[94] In this model, the utility would be an active partner with customers and generators to

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[93] Central Hudson deployed a diesel backup generator on a feeder line serving a rural community to improve local reliability and reduce cost in one of its most troublesome distribution areas. The generator allows the utility to continue serving the community as an island even when the line goes down due to weather or for servicing. Similarly, the City of Naperville has undertaken a significant deployment of SCADA systems and automated controls across its distribution system to address deteriorating reliability issues. As a result of its investment, the municipal utility has reduced its annual average interruption time from 120 minutes to 18 minutes in 2010. Naperville recently received a smart grid grant from the DOE to deploy time-based pricing and introduce electric vehicles. More information on Naperville's smart microgrid initiative can be found in a case study produced by the Galvin Initiative available at: http://galvinpower.org/sites/default/files/Naperville_CaseStudy_Final.pdf (accessed on August 23, 2010)

[94] See for example Hassan Feroze, "Multi-Agent Systems in Microgrids: Design and Implementation," Thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University, August 2009 and Ramon Zamora and Anurag Srivastava,

facilitate and manage the aggregation of loads and the deployment of generation on the microgrid. An example of an unbundled or hybrid utility microgrid is the project San Diego Gas and Electric developing in Borrego Springs, California. While SDG&E will own generation and storage assets located at its substation, it is also encouraging customer-sited generation and developing a price-driven demand response program for residential customers. At least one circuit served by the substation area will be capable of islanding to improve local reliability (see SDG&E case study in the Appendix).

3.2 Non-utility owned physical microgrids

The development of non-utility owned microgrids providing lower cost, more reliable and cleaner energy services could become a significant new area of investment for distributed energy services. We distinguish non-utility microgrid ownership models based on whether the primary purpose is for self-service or for merchant service. From a regulatory perspective, it might make a difference if the microgrid owner receives most of the energy produced by the system, or if the owner uses little or none of the energy produced.[95] Therefore, we have identified three service sub-categories for non-utility owned microgrids: (1) own use, (2) own use with some merchant sales, and (3) merchant only.

J. *Landlord/Campus Model, Type 1*: A single non-utility owner operates the system and installs private wires and generation technologies on site, supplying electric and/or thermal power to multiple buildings also owned by the landlord-operator. Buildings and streets have the same owner and there are no previously unaffiliated parties receiving service from the microgrid. The system's wires and pipes do not cross a public way or utility franchise. An example of this type of microgrid is the Cornell University campus system (see the Cornell case study in the Appendix).

K. *Landlord/Campus Model, Type 2*: This model is the same as Type 1, but wires/pipes may cross a public way or utility franchise. An example of a Type 2 Landlord/Campus model is New York University's microgrid in the Washington Square Park area of Manhattan (see NYU case study in the Appendix).

L. *Landlord/Campus Model, Type 3*: This model is also the same as Type 1, but wires/pipes may cross a public way/utility franchise *and* previously unaffiliated neighboring customers may voluntarily join the micro-grid and be served under contract. The Burrstone Energy Center in Utica, NY, which provides electric and thermal energy to the Faxton-St. Luke's Hospital, St. Luke's Nursing Home and Utica College (across a public street) is an example of this model (see the Burrstone case study in the Appendix).

M. *Joint Ownership/Cooperative*: Multiple individuals or unrelated firms collectively own and operate the microgrid to serve their own electric and/or thermal energy needs. Other customers may voluntarily join the microgrid and be served under contract. The system's wires and pipes may cross a public way/utility franchise. The research team did not identify an operational microgrid that fit the cooperative description, but the Energy Improvement District initiative in Stamford Connecticut appears to contemplate the development of joint ownership microgrids (see the Stamford case study in the Appendix).

N. *Independent Provider*: An independent, non-utility firm owns and manages the microgrid and sells electricity and/or thermal energy to multiple unaffiliated customers. This business model is strictly commercial. The independent owner/operator does not produce primarily for its own consumption, which differentiates it from the Landlord/Campus and Joint Ownership models. The system's wires and pipes may cross a public way/utility franchise. The Woking Town Centre Energy Station, owned by Thameswey Energy Limited in Woking Borrough, United Kingdom, is an example of an Independent Provider microgrid system. The Woking project makes use of a law that allows private wires to interconnect previously unaffiliated customers to CHP and other clean energy systems, subject to a maximum capacity limit (see the Woking case study in the Appendix).

"Controls for microgrids with storage: Review, challenges and research needs," *Renewable and Sustainable Energy Reviews*, Volume 14, Issue 7, September 2010, Pages 2009-2018

[95] King, 2006

The Landlord/Campus Types 1 and 2 and the Joint Ownership/Cooperative models are categorized as "own use" microgrids because the primary function of these systems is to provide energy services to their owners. The unifying characteristic in all of the Landlord/Campus models is that the same: a single entity owns the microgrid and/or the majority of the buildings that receive service.[96] The distinction between Types 1 and 2 is whether or not the microgrid crosses a public way to deliver energy to a given building. This is significant because crossing a public street may lead to public utility designation or trigger conflicts over local franchise rights.

Because merchant sales may be viewed as inconsistent with policies that protect the monopolies of distribution utilities, we have established separate subcategories for systems that engage in retail energy sales. One is for microgrids that function primarily to provide energy services to their owners, but may also sell energy to unaffiliated customers. The Landlord/Campus Type 3 is a single-owner microgrid that provides energy primarily to tenants in buildings it owns, but may provide service to independent neighboring customers on a voluntary and contractual basis. This may also be the case for the Joint Ownership/Cooperative model. Allowing primarily self-serving microgrids to sell power or thermal energy to neighbors may be desirable from a public policy standpoint because it could allow for more optimal sizing/operation of generating facilities or allow the microgrid to take advantage of load diversity created by having a variety of customer types included. Finally, the Independent Provider model envisions a microgrid with an entirely merchant or retail service orientation. Because it is in some ways a new integrated "mini-utility," this kind of microgrid may require additional oversight, especially if residential customers are being served.

3.3 Virtual microgrids

A virtual microgrid, also referred to as "virtual private wires" or "virtual power plants," is a distributed energy resource-pooling model that uses existing electric or steam distribution systems to link multiple energy production resources and loads. Under a virtual microgrid scheme, locally sited energy resources supply multiple end users, but there is no separate physical connection between participating supply and load. Instead, power and/or thermal energy is produced and sold among different users using the existing utility distribution infrastructures. In addition to integrating customer-owned DER, virtual microgrids may aggregate demand response to provide virtual load balancing, or generate additional revenues through participation in organized energy markets or demand response programs. The microgrid owner/operator, which could potentially be a third party aggregator or a co-op, manages the "dispatch" of energy to meet the load requirements of participating customers. Virtual microgrid customers pay the utility distribution fees for power distributed to participating loads, but for the most part avoid, or can greatly reduce, transmission and grid commodity costs.

The United Kingdom's Office of Gas and Electricity Markets examined virtual microgrids as an alternative to private electric wires to support distributed energy investments.[97] Although not yet formally adopted, the virtual private wires would allow energy service providers to aggregate customer or third party-owned generation on the local distribution network for use by all participating customers. With the exception of limited energy purchases to balance supply and demand, participating customers share energy produced locally, avoiding the transmission and generation costs they would otherwise purchase from the grid. In exchange for "wheeling" the locally produced power to participating customers, virtual private wires schemes would continue to pay distribution costs to the local network operators.[98]

Thameswey Energy Limited (TEL), an energy services company in the UK already institutes a form of "virtual private wires" in the Borough of Woking. Under rules that allow the development of limited physical "private wires" schemes, TEL operates several community CHP facilities that directly serve multiple public and private

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[96] Although not addressed here, it is certainly possible that a Landlord/Campus microgrid system (i.e., the generation plant and distribution system) would be owned or operated by a third party under contract with the campus property owner. Such an arrangement is sufficiently different from the Independent Provider model we have identified, which is actually a merchant microgrid provider offering service to multiple end users that are not all tenants of a single property owner.

[97] OFGEM, "Distributed Energy – Initial Proposal for More Flexible Market and Licensing Arrangements," December 18, 2007, www.ofgem.gov.uk/.../DE%20con%20doc%20-%20complete%20draft%20v3%20141207.pdf (accessed on November 6, 2009)

[98] See Dave Miller, CE Electric UK. "Virtual Private Networks." August 2007. http://www.ofgem.gov.uk/NETWORKS/ELECDIST/POLICY/DISTGEN/DISENWG/Documents1/CE%20Electrics%20Paper%20-%20Virtual%20Private%20Networks.pdf (accessed on November 6, 2009)

customers. In at least one case, TEL also provides power to government and private buildings not physically connected to its private wires system. Instead, it has negotiated a wheeling tariff with the local distribution company, EdF Energy, to "deliver" excess electricity produced to its customers (see the Woking case study in the Appendix for a detailed discussion).

In a similar vein, the State of Massachusetts adopted a neighborhood net metering program in July 2009, which allows neighborhood-based renewable energy facilities to supply a group of ten or more residential customers in the same neighborhood and served by the same utility. Participating customers remain connected to the utility, which continues to deliver and meter energy use at each customer site. Nevertheless, in lieu of purchasing electricity from the utility, participating customers effectively share the output of the local qualifying generators. If generator output exceeds demand from participating customers, credits valued at retail prices may be carried forward indefinitely or, depending on the type of renewable facility, utilities can opt to make direct payments for excess. The maximum generating capacity for neighborhood net metering is 2 MW and all net metering is capped at 1% of the local utility's peak demand (see Section 4.2 for more information about the program in Massachusetts as well as on what other states are doing).[99]

Due to the fact that they do not have their own dedicated distribution systems, and very likely will not be capable of islanding all participating loads, virtual microgrids may not provide the same degree of reliability to local customers as physical microgrids would.[100] Still, virtual microgrids may be an attractive way to promote investment in distributed energy resources and develop the necessary institutional and policy frameworks to accommodate physical microgrids, particularly utility owned or managed systems, without developing separate distribution infrastructure. Moreover, virtual microgrids are consistent with the current framework for retail competition and should be able to accommodate customer departure from the scheme more easily than under a physical microgrid system.

The project team identified the following two general ownership and service models for virtual microgrids.

H. *Utility Aggregator*: The utility pools customer- or third party-owned DERs and manages output and loads on its distribution system. The utility also continues to meter and bill customers for energy services, possibly, but not necessarily under a combined bill. Participating customers share the benefits of the energy produced and receive either bill credits or direct payments for excess generation. The utility may continue to charge for use of the distribution system, but customers are able to avoid most transmission and grid-derived generation costs.

I. *Non-Utility Aggregator*: A private, cooperative or public entity pools together a group of customer- or third party-owned DERs, and manages output and loads on the utility's distribution system. The aggregator separately meters and bills the participating customers for energy used. Participating customers may benefit from aggregating demand response capabilities and earning revenue by bidding their collective load shedding capabilities into energy markets or demand response programs. From the utility perspective, the aggregated customer loads are one entity, under a single utility account. The pooled customers must pay distribution system charges, but otherwise avoid most grid transmission and energy costs. If necessary, the aggregator can procure energy services from the wholesale market to balance loads.

The utility aggregator model is similar to the neighborhood net metering concept. The utility continues to provide distribution, billing and metering services and energy produced by local generating units, or other DERs like battery storage, is shared by participating customers. The non-utility aggregator model is similar to the virtual private wires concept discussed in the UK, which would allow third parties to provide the pooling function and avoid transmission use charges. In both cases, if the customers are located where there is an existing district steam system and participants are using CHP, the virtual microgrid may also be able to also plug into this system to share excess

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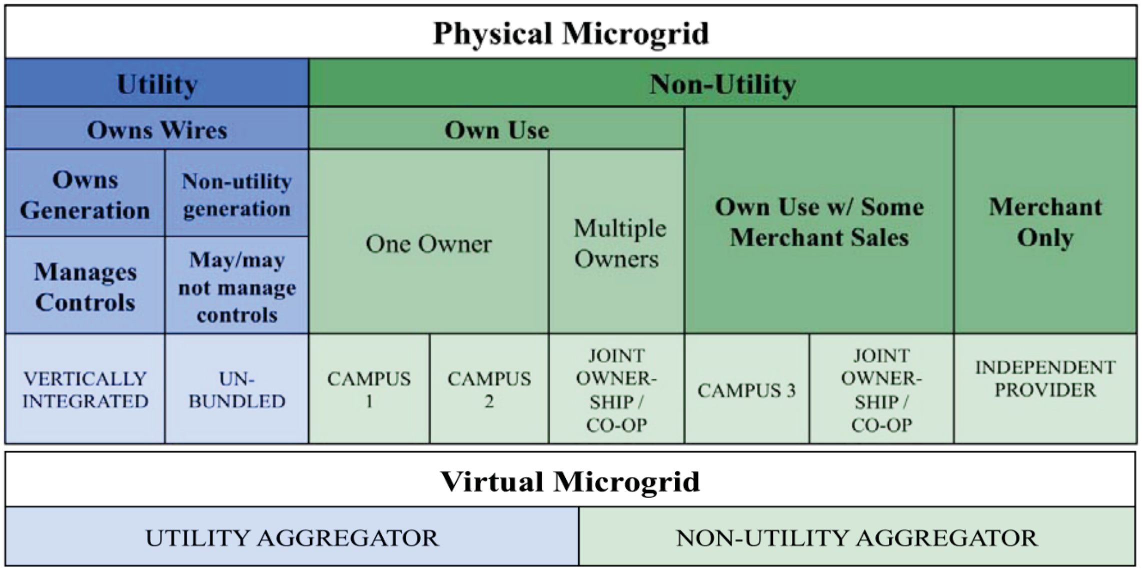
[99] Database of State Incentives for Renewables and Efficiency. "Massachusetts – Net Metering." http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA01R&re=1&ee=1 (accessed on November 6, 2009)

[100] However, customers located in close proximity to the DERs may be able to operate independently of the grid under certain conditions. Also, virtual microgrids like described here could serve as an excellent bridge to the unbundled utility-owned physical microgrid described above. With customer owned generation assets on the distribution network, it may only require certain utility upgrades to accommodate islanding and other forms of enhanced local control.

thermal output. Where district steam systems operate in New York, this kind of steam net metering could allow DERs to be sized and/or operated more optimally, especially if on-site thermal demands cannot support CHP systems scaled to meet on-site electricity demands.

Figure 3.1 – Microgrid Ownership and Service Typology



<table>
<tr><th colspan="8">Physical Microgrid</th></tr>
<tr><th colspan="2">Utility</th><th colspan="6">Non-Utility</th></tr>
<tr><th colspan="2">Owns Wires</th><th colspan="3">Own Use</th><th colspan="2" rowspan="3">Own Use w/ Some Merchant Sales</th><th rowspan="3">Merchant Only</th></tr>
<tr><th>Owns Generation</th><th>Non-utility generation</th><td colspan="2" rowspan="2">One Owner</td><td rowspan="2">Multiple Owners</td></tr>
<tr><th>Manages Controls</th><th>May/may not manage controls</th></tr>
<tr><td>VERTICALLY INTEGRATED</td><td>UN-BUNDLED</td><td>CAMPUS 1</td><td>CAMPUS 2</td><td>JOINT OWNER-SHIP / CO-OP</td><td>CAMPUS 3</td><td>JOINT OWNER-SHIP / CO-OP</td><td>INDEPENDENT PROVIDER</td></tr>
</table>

<table>
<tr><th colspan="2">Virtual Microgrid</th></tr>
<tr><td>UTILITY AGGREGATOR</td><td>NON-UTILITY AGGREGATOR</td></tr>
</table>

3.4 Additional considerations – benefits and challenges of utility microgrids

The advantages of utility microgrid ownership stem from the fact such systems would be 1) less encumbered by legal and regulatory uncertainty and 2) able to leverage the utility's own expertise and insight over its system, which could lead to investments in grid locations that provide the largest social benefit (see Section 4.0 for more discussion of this point). Moreover, aside from potential restrictions on utility ownership of generation, utility microgrids should be able to be deployed within the current regulatory framework – it is consistent with the traditional view that distribution service is a natural monopoly. Specific advantages of utility ownership include:

- Uninhibited customer recruitment and participation, consistent with current franchising and regulatory conditions (see Section 4.0), would allow DERs to be optimally sized to take full advantage of customer load diversity and scale economies.

- Cost savings by avoidance of duplicate wires investment (if participating customers were already connected to extant system) that might otherwise occur with a non-utility microgrid.

- Utility knowledge and expertise over its system may provide a better opportunity to strategically locate distributed resources and microgrid systems to maximize value to the grid (i.e., ideally the utility knows its distribution system, where capacity may be short and where investment is needed, whereas a non-utility provider may not).

- Microgrids provide an opportunity to the utility to differentiate its products and services to customers and keep up with the changing power quality requirements of the modern economy without extending such service to all loads, whether they need it or not. Microgrids can allow the utility to provide lower cost service to customers willing to accept lower reliability or shed load if needed, and superior reliability and power quality to customers willing to pay a premium.

Utility microgrid ownership also presents certain problems and challenges. A fundamental challenge would be encouraging utilities to consider microgrids. This is partly because it remains unclear whether a microgrid would be an attractive business proposition to a utility without changes to current regulatory policy. Currently, due to restructuring, utilities cannot capture the energy production benefits of generation through direct sales to customers; and while decoupling, which removes the historic link between utility revenues and sales, addresses the structural disincentive for utilities to facilitate customer generation, it does not necessarily incentivize them to encourage customer generation. Recent federal policy guidance and funding for smart grid development, however, may begin to change the way utilities view their business models and the management of their systems.

Other challenges that may be associated with utility microgrids include:

- New tariffs will likely need to be developed for a utility microgrid that provides varying service reliability and power quality. Examples of this are current interruptible tariffs that allow utilities to shut off all or a portion of a customer's service for system reliability reasons in exchange for lower average rates. Tariff design should be based on a fair division of the value and costs created by the microgrid. Depending on how microgrid benefits are monetized value transfers may need to be built into tariffs to ensure that both utilities and customers are effectively incentivized.

- Utility microgrid ownership could result in potential conflicts of interest. First, utility ownership of DER resources on the microgrid could lead the utility to act in an anti-competitive manner in order to limit non-utility ownership. This would clearly undermine any intended benefits associated with competition. Secondly, if non-utility or customer-owned generation is integrated into the microgrid, the question of how those resources are managed may become an issue. If the utility manages the microgrid control system the protocol for how internal resources are to dispatched should be clear, and preferably driven by market prices. In cases where non-utility resources are present, protocols should be in place to ensure that the utility manages those resources in a way that maximizes value for both microgrid customers and DER owners.

- If only the utility model is allowed, microgrids will likely not promote competition and could simply lead to a reinforcement of traditional vertically integrated electric utilities. Nevertheless, providing opportunities for non-utility entities to own and operate microgrids may push utilities to provide microgrid services fairly and efficiently.

Generally speaking, the unbundled utility model presents more complexity in terms of implementation than the vertically integrated model because of issues associated with customers owning generation on the microgrid. The utility must have a means of managing the potential uncertainty and impacts to the microgrid from the addition (and/or reduction) of customer generation. There should be clear policies in place for compensating customer or third party generators for power and other services they provide to the microgrid, including load curtailment, if required by the utility for local load balancing. This may require the development of more granular energy and ancillary service markets or other means of sending appropriate price signals to customer-generators. Moreover, if the microgrid is to maintain a policy of "open access" on the distribution system, terms and conditions as well as load management protocols for the addition of generation (and customer loads) will need to be developed.

Section 4.0 below, addresses the legal and regulatory barriers associated primarily with non-utility microgrids.

4.0 THE LEGAL AND REGULATORY ENVIRONMENT FOR MICROGRIDS

4.1 Global Legal Issues for Microgrids in New York

4.1.1 Introduction and Summary of Findings

Legal and regulatory uncertainty for microgrids presents a significant hurdle to their deployment in New York State. The risk associated with this uncertainty is compounded by the small-scale nature of microgrids. Many potential projects would be unable to bear the administrative burden attendant to full regulatory treatment as a distribution utility under State law. In tandem, the lack of legal identity and regulatory certainty presents a variety of obstacles for investors, utility customers, and engineers considering these types of projects.[101] These obstacles are problematic because the installation of such facilities has the potential to reduce costs to customers and to further public policy by improving the reliability and efficiency of power sources.

This section discusses the current structure of the electric industry, its regulatory framework, and how microgrids fit into that structure. Generators of electricity are subject to a complex set of federal and state laws that relate to property permissions, environmental protection, consumer rights, technical efficiency and administrative orders. The New York State Public Service Commission (PSC or Commission) enforces the Public Service Law (PSL) and regulations for electric corporations, which essentially means all companies owning electric plants. Although there are advantageous exemptions and privileges available to certain facilities under state and federal law, these facilities in many cases are not statutorily defined legal entities. They are currently regulated by *ad hoc* PSC rulings, and it is unclear how they will be regulated in the future.

While distinguishable, extant and proposed microgrid facilities share sufficiently common characteristics to be characterized and regulated as a distinct legal entity. We propose ways in which microgrids are or could be treated by analogy to entities regulated under existing PSL, and how they should be treated if this is a technology that New York State wishes to encourage.

Summary of Findings

General Legality

- Microgrids are not defined legal entities within existing New York State law governing the electric and steam industries. As a result, under current circumstances, microgrid developers will have to anticipate, based on the ownership and project service characteristics of a given project, how it will be viewed under the PSL and treated by state regulators.

- Based on the project team's research, there is nothing in the PSL suggesting that any of the microgrid ownership and service models identified in this report would be viewed, on their face, as illegal. However, the specific terms of regulation will vary depending on the particular features of the project, including the technologies deployed, whether the system is located entirely on private property, crosses a public way, serves multiple previously unaffiliated customers, serves residential customers, and the size of the distribution area.

Likely Treatment Under Existing State Legal and Regulatory Framework

- A physical microgrid will likely be characterized as an electric corporation by the PSC, particularly if it intends to serve multiple, otherwise unrelated, retail customers, cross a public way with power lines, and/or obtain a franchise from a local authority.

- If a microgrid is deemed by the PSC to be an electric corporation, it is likely that the specific terms of regulation will be determined by the PSC using a "realistic appraisal analysis," which evaluates the appropriateness of different provisions of electric corporation regulation for new entities. It is possible that

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[101] For example, investing even in preliminary stages of engineering feasibility studies will be uneconomical if the PSC ultimately denies an exemption for regulation, thus deterring the capital markets from backing these types of projects.

the PSC will determine that a lighter form of regulation is appropriate, but the specific terms will likely vary depending on the facts of the proposal.

- Microgrids using cogeneration and distributing thermal energy in the form of steam or hot/chilled water may be subject to state law relating to steam corporations. Regulation of steam corporations generally follows that of electric corporations and may include rate regulation, among other requirements. Due to their small scale, however, microgrids will likely fit within one of the state's exempt classes for regulation of steam service providers; this is particularly likely for microgrids that reflect the landlord/campus and cooperative models involving a non-profit entity.

- Virtual microgrids, which would use the wires of incumbent distribution utilities for distributing power among participants, would resemble energy service companies (ESCOs) in many respects. In contrast to ESCOs, which provide competitive generation service to retail customers that continue to pay for transmission and distribution service, virtual microgrids would likely seek to avoid transmission charges by pooling load and generation located on distribution systems. There are currently no provisions in state law that authorize virtual microgrids, however, nor are there regulations that obligate utilities to accommodate them.

Franchises and Other Consents to Distribute Energy

- All microgrids that intend to use public ways (i.e., deliver either power or thermal energy to a customer across a public street) must apply to the presiding municipal authority for permission, whether in the form of a franchise or another, lesser consent. Franchises, which represent contracts between a company or service provider and the local municipality, require specific legislative approval and are granted for a limited number of years.

- In municipalities where an incumbent electric utility currently operates under an existing franchise that is not by its terms exclusive, a subsequent franchise may be issued to a microgrid developer. Under state law, however, municipalities must provide a competitive process for determining the franchise grantee, thereby allowing incumbents and other service providers to bid against the microgrid developer for the franchise.

- Operation of a microgrid under a local franchise will require approval from the PSC in the form of a Certificate of Public Convenience and Necessity (CPCN), which is required by state law to exercise the rights granted under the franchise, including installation and subsequent use of electricity distribution facilities. A CPCN confirms that the exercise of a right, privilege or franchise to build and operate a major energy production or delivery facility is *necessary or convenient* for the public service. A microgrid developer seeking to operate under a local franchise must obtain the CPCN through a public hearing prior to commencing construction of a physical plant.

- A microgrid project may also have to obtain a CPCN if it is deemed to sell electricity via direct interconnection to retail customers. Some microgrids may qualify for exemption from this regulation, particularly those that use cogeneration or other facilities that qualify under state law.

- Due to their small scale and limited scope of service, it is unlikely—except in a limited number of circumstances—that microgrids will have to obtain a franchise to operate. In most cases it is likely that a lesser form of consent, such as a revocable consent, will suffice when a microgrid proposes to occupy public space to provide service. Operation under this lesser form of consent, in contrast to operation under a franchise requiring a CPCN, does not appear to trigger PSC jurisdictional authority.

Exemptions from Regulation as Steam and Electric Corporations

- A microgrid may be found to be exempt from state regulation as an electric corporation if it is deemed a qualifying facility under either federal or state law; qualifying facilities generally include either cogeneration or other clean small power production technologies that meet related criteria.

- Importantly, a microgrid that qualifies as a cogeneration facility, alternate energy production facility, or small hydro facility may be able to use the "related facilities" exemption to also qualify wires and pipes that would cross a public way and otherwise trigger electric corporation or CPCN requirements. While it is difficult to anticipate exactly how the PSC will rule in any given case, a microgrid that has characteristics similar to existing exempted facilities may be able to raise those similarities as persuasive precedent in seeking exemption.

Other Important Legal and Regulatory Considerations

- Any microgrid that provides service to residential customers will very likely have to comply with the statutory consumer protections as prescribed by the New York State Home Energy Fair Practices Act (HEFPA). Nevertheless, some microgrids, particularly those where residential customers are involved in the ownership of microgrid facilities, or are tenants of the microgrid owner, may not be subject to these requirements.

- If a microgrid is deemed an electric corporation (i.e., a distribution utility) or a steam corporation, there is a possibility that it will assume a statutory obligation to serve. An obligation to serve would require the microgrid to provide service upon the written or oral request of an applicant. This obligation may be more likely to attach to a microgrid if it serves an area that is otherwise electrically isolated from the local distribution company. If the microgrid provides service where a local distribution company provided service before, it is probably less likely that the microgrid would have this obligation. Ultimately, it may depend on the accessibility of the applicant to the local distribution company.

- The provider of last resort is a legal obligation traditionally given to utilities, to provide service to a customer when competitors have chosen not to or are unable to provide service. In New York's electricity market, distribution utilities maintain the obligation to serve and are the providers of last resort. For physical microgrids, the provider of last resort obligation will likely follow the obligation to serve; if the PSC determines a microgrid has an obligation to serve, it may also find that the microgrid is the provider of last resort. For microgrids that serve customers that were previously interconnected to the local utility, or that also continue to receive standby or back-up service from the utility, it is likely that the provider of last resort obligation will remain with the local distribution company.

- Microgrids that use thermal power production through the combustion of fossil fuels, biomass, or other materials, will be subject to state and federal laws governing air emissions. The need for a permit, and the associated conditions of operation, will depend on the particular features of the project, including its location and emissions level.

- During restructuring, in order to avoid discouraging competition, exit fees were generally prohibited in New York. The only exception to this was made for Niagara Mohawk (now National Grid), which is allowed to assess a competition transition cost charge. For departing load due to the installation of on-site generation, standby charges provide utilities with an opportunity to recover their fixed costs. Thus, it is unlikely that the customers of a microgrid, previously served by a local distribution utility, will be assessed exit fees upon departure, unless they do not take standby service and are located in Niagara Mohawk's service territory.

- Microgrids are not mentioned under existing provisions for net metering. It is very likely that microgrids – as defined in this report – would not be eligible because net metering is currently only available to single customers (i.e., excluding microgrids that involve multiple customers) and does not provide for hybrid systems that incorporate multiple technologies (e.g., solar and gas-fired reciprocating engines). As a result, it is likely that a microgrid owner or developer seeking to receive net metering service from a utility will either be rejected on these grounds or will require a voluntary agreement from the utility.

Below, we examine these issues in much greater detail. With the exception of Section 5.2, which provides an overview of the structure of the electricity industry in New York State and introduces the relevant bodies of law, a consideration of the direct applicability of these laws and regulations to microgrids is provided in text boxes following each section. The analysis is based on studied review of PSL and PSC decisions. The applicability of the legal and regulatory requirements will be as determined by the PSC in its exercise of jurisdiction over these issues.

4.1.2 Structure of the Electricity Industry and Relevant Regulatory Bodies and Codes

Industry Restructuring

As generally understood, a utility is a "business enterprise, as a public-service corporation, performing an essential public service and regulated by the federal, state, or local government."[102] In New York, legally distinct entities serve the public service functions in the market for electricity.

In the mid-1990s, New York restructured its electricity industry.[103] Restructuring the electricity industry involved the introduction of competition into a market previously dominated by vertically-integrated entities. This restructuring created a separation between the vertically-integrated entities' generation, transmission and distribution functions. Following restructuring, the generation entities can either sell their power into the competitive wholesale markets administered by the NYISO or sell their power directly to a utility or ESCO, which competes with the local distribution utilities as retail service providers. These local distribution utilities, sometimes referred to as New York Transmission Owners (NYTOs), continue to own the transmission facilities, to own and operate the distribution facilities, and to deliver electricity to retail customers. All are subject to regulation by the PSC.[104]

The restructuring of New York's electrical power industry enabled the emergence of new market participants that differed from traditional electric utility monopoly providers. These participants are described in Table 5.1, below.

Electricity Industry Participants in New York State

There are many types of entities participating in New York's electricity industry, but microgrids are not currently recognized as their own class of market participant. Table 4.1 describes the established types of electricity industry participants in New York.

Table 4.1 – Electricity Industry Participants in New York State

Entity	Description
Local distribution utilities, or New York Transmission Owners (NYTOs)	The local distribution utilities are New York State's eight legacy or incumbent transmission and distribution owners. Together, these companies own and maintain a network of high-voltage circuits, substations, and systems that work seamlessly to transmit electricity. The NYTOs are required to provide "open access" to their transmission networks to promote competition. In addition to owning the transmission system, the incumbent distribution utilities own and operate the distribution networks, which deliver electricity to virtually all business and residential consumers of electricity within New York State.
New York Independent System Operator (NYISO)	The NYISO is a non-profit corporation authorized by the Federal Energy Regulatory Commission (FERC) to oversee the New York State electric transmission system and administer wholesale markets where electricity generators compete to sell their output to utilities and ESCOs for resale. A primary function of NYISO is to maintain the reliability of the state electric transmission grid by keeping supply and demand in balance 24 hours per day, seven days per week. As such, it manages the scheduling of all electricity delivered to the grid, including transactions on its wholesale markets and direct, or bilateral, contracts between generators and a utility or ESCO.

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[102] Definition for "public utility" may be found at Dictionary.com at: http://dictionary.reference.com/browse/public+utility?db=luna (accessed on September 30, 2010)

[103] Many use the term "deregulation" for the process that took place in New York and elsewhere in the 1990s. Because the current scheme is not any less regulated, this paper will describe the electricity market as "restructured" rather than "deregulated." For more on the history of deregulation in New York, *see* Appendix A.

[104] Stephen P. Sherwin, Comment, Deregulation of Electricity in New York: A Continuing Odyssey 1996-2001, 12 Alb. L.J. Sci. & Tech. 263, 270 (2001).

Energy Service Companies (ESCOs)	An ESCO is a non-utility business that (1) provides gas or electric commodity and/or (2) installs energy efficient and other demand side management measures in facilities. Under the first function, ESCOs compete against utilities and other ESCOs to obtain and supply power to customers by offering creative service packages. With regard to commodity supply, ESCOs generally do not have a direct interest in generation assets; instead, they serve as a broker between merchant-owners of electricity generation facilities and end-use customers. With regard to delivery service, utilities deliver electricity to ESCO customers through their distribution lines and continue to meter and bill these customers for retail electric delivery service.
Independent Power Producers (IPPs)	The Independent Power Producers of New York defines IPPs as "private entrepreneurs who develop, own or operate electric power plants fueled by diversified energy sources such as biomass, cogeneration, coal, small hydro, waste-to-energy and wind facilities."[105] IPPs compete in the wholesale electricity markets to sell energy to ESCOs and utilities. IPPs have generation facilities throughout the state (including within the territories of host utilities) and do not have transmission facilities or retail sales.[106]

Relevant Bodies of Law

Any potential participant in New York's electricity industry must navigate a myriad of laws and regulations at the federal, state, and local levels. These laws vary in scope and applicability, sometimes overlapping and other times preempting each other. This section provides a brief overview of the bodies of law that are relevant to microgrid developers and operators.

New York Public Service Law

New York's Public Service Law (PSL) regulates the public service of utility companies in the state.[107] In particular, the PSL regulates many aspects of the provision of electric, gas and steam services. A primary purpose of the PSL is to guarantee that the public receives safe and adequate utility service at just and reasonable rates.[108] The PSL establishes the Public Service Commission and gives it broad powers to carry out the purposes of the PSL.[109]

If the PSC determines that a particular service is covered under the PSL, it can exercise a great degree of control over how the service is delivered and over the entity delivering the service. Of special relevance to microgrid developers, if the PSC determines that a microgrid is an electric corporation as defined by the PSL, the PSC has the ability to regulate the rates charged for electricity, the authority to approve construction of facilities, the power to inspect business records, and more.[110] The PSC may decide, however, to exercise only some of its authority over a given electric corporation, based on a realistic appraisal of the appropriate regulatory framework.[111]

New York Laws and Regulations Protecting Residential Customers

The PSC's quasi-judicial and legislative functions include representing consumer interests with regard to electric and gas services. Transactions between residential electricity consumers and suppliers are regulated through the PSL; HEFPA; the Energy Consumer Protection Act of 2002 (ECPA); the New York Codes, Rules and Regulations; utility tariffs and supplier contracts; and PSC Commission orders and opinions.[112]

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[105] Independent Power Producers of New York, "Glossary," http://www.ippny.org/power_industry/glossary.cfm (accessed on January 19, 2010)

[106] Energy Information Administration, "Electric Power Industry Overview 2007," available at: http://www.eia.doe.gov/cneaf/electricity/page/prim2/toc2.html#non (accessed on August 30, 2010)

[107] N.Y. Pub. Serv. Law §§ 1 to 230 (2009).

[108] Digital Paging Systems, Inc. v. Public Service Commission, 46 A.D.2d 92, 97 (3d Dep't 1974).

[109] N.Y. Pub. Serv. Law § 4 (2009).

[110] See Section 4(a), *infra*.

[111] See Section 4(a)(ii), *infra*.

[112] For more information, *see* www.narucpartnerships.org/Documents/Raj_Addepalli_Consumer_Protections_in_NY.pdf (accessed on March 20, 2010); www.consumer.state.ny.us; www.pult.tc; and http://liheap.ncat.org/news/Jan03/nyact.htm.

HEFPA, adopted in 1981 as New York Public Service Law Article 2, is New York's utility "consumer bill of rights." It is one of the most protective statutes for electric and gas customers in the country.[113] The law addresses, among other things, applications for termination of and restoration of service; deferred payment agreements; budget payment plans; service deposits; metering and billing requirements; late payment charges and interest rates; bill content; notification requirements; and complaints.[114] Following the passage of the ECPA, contracts between competitive power suppliers and residential customers had to comply with HEFPA and other New York PSC regulations.

Federal Public Utility Regulatory Policies Act

Congress enacted the Public Utility Regulatory Policies Act of 1978[115] to promote energy conservation and domestic energy production from renewable sources.[116] PURPA requires the Federal Energy Regulatory Commission (FERC) to prescribe rules to encourage two types of generating facilities: cogeneration and small power production facilities.[117] These facilities are known as "qualifying facilities" (QFs) when they satisfy prescribed regulatory requirements.[118] Requirements for qualification include, among other things, limitations on size of generating capacity, fuel-use criteria, and operating and efficiency standards.[119] Requirements also relate to ownership: a QF must be "owned by a person not primarily engaged in the generation or sale of electric power (other than electric power solely from cogeneration facilities or small power production facilities)." These statutory restrictions are constructed to mean that traditional electric utilities (e.g., NYTOs) are permitted to own up to a fifty percent equity interest in a cogeneration or small power production facility without jeopardizing the facility's qualifying status.[120]

QFs are entitled to receive special rate and regulatory treatments.[121] These preferential treatment rules include a requirement that electric utilities offer to sell or purchase electric energy to and from QFs.[122] Other rules ensure the operational integrity of QFs, rate-setting, and exemption from the Public Utility Holding Company Act (PUHCA), which imposes regulatory requirements on certain electric utility entities.[123] PURPA delegates substantial authority to the states with respect to how it is implemented within each state, including for example, the determination of avoided costs (the rate utilities are required to pay for the electrical output from QFs).[124] See Section 4.1.5.1 below for more detail on QFs and their applicability to microgrids specifically.

Property Law – Franchises and Lesser Consents

As a preliminary matter, all microgrid developers must obtain property rights for the physical plant and any auxiliary facilities, or else be liable as trespassers. Electric transmission and distribution facilities and pipes for distributing steam or other forms of thermal energy often traverse public space. This means microgrid developers must negotiate with the municipal authority that effectively holds the title to that public space – with the exception of permissions for major utility transmission facilities, which fall under the scope of Article VII of the PSL and the jurisdiction of the PSC. Permission can be obtained from the municipal authority in the form of a franchise or some lesser consent. Once obtained, these property-type rights may be subject to further regulation because of the type

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[113] Public Utility Law Project, http://www.pulp.tc/html/hefpa.html.
[114] Raj Addepalli, Presentation, Consumer & Utility Rights & Obligations (National Association of Regulatory Utility Commissioners, June 2007), available at www.narucpartnerships.org/Documents/Raj_Addepalli_Consumer_Protections_in_NY.pdf.
[115] Public Utility Regulatory Policies Act of 1978, 28 U.S.C. § 2601–2645 (2010), as amended by The Energy Policy Act of 2005, Pub. L. 109-58 (Aug. 8, 2005).
[116] 5-11 Treatise on Environmental Law § 11.02(4)(d) (Matthew Bender 2009).
[117] *Id.*
[118] Federal Energy Regulatory Commission, "What is a Qualifying Facility?" Available at: http://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp (accessed on March 30, 2010)
[119] 18 C.F.R. § 292.203, et seq. (2009).
[120] 3-70 Energy Law and Transactions § 70.04 (Matthew Bender 2009).
[121] Federal Energy Regulatory Commission, "What is a Qualifying Facility?" Available at: http://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp (accessed on March 30, 2010)
[122] 5-11 Treatise on Environmental Law § 11.02(4)(d) (Matthew Bender 2009).
[123] *Id.*; 42 U.S.C. § 16451, et seq. (2009).
[124] 5-11 Treatise on Environmental Law § 11.02(4)(d) (Matthew Bender 2009).

and purpose of the built infrastructure that is contemplated. See Section 5.1.3 below for a detailed discussion of these property rights.

Federal and State Environmental Laws

Microgrids are required to comply with federal and state environmental law. Of particular relevance are those laws and regulations related to air pollution. Air permitting and emission control requirements can be divided into four general categories: major source permitting, state minor source permitting, *de minimis* exemptions, and emergency generators. Microgrid systems that will require permits from state and federal authorities include those systems that use thermal power production and combust fossil fuels, biomass, or other renewable biofuels producing air emissions. Unless a source qualifies for an exemption, a permit is required. The need for a permit will depend on the unique features of a project, including its location (i.e., whether it is located within a "non-attainment" area under the Clean Air Act) and emissions levels. For additional information, see Appendix B, below.

4.1.3 Franchises and Lesser Consents

All entities that require the use of public ways (i.e., for transmission or distribution facilities) must be granted permission by the presiding municipal authority in the form of a franchise or some lesser consent, depending on the scope of the usage.[125] The cities, towns, and villages of New York have specific statutory authority to grant franchises: as provided by N.Y. Gen. City Law § 20(10), every city is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city.[126] "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[127] Municipalities typically provide for minor encroachments into public spaces by administering special permissions that may offer an alternative to the large-scale franchise. These permissions might be referred to as permits, right of way permits, revocable licenses, revocable consents, and similar instruments. Where the municipality does not use a standardized permitting process for conferring this type of property right, an authorized party, such as a mayor, counsel, or commissioner of public works must grant permission on an individual basis.[128] Once a company obtains a franchise or lesser consent, it must then obtain a CPCN, as explained in Section 4.1.4.3, below.

Individual franchises—contracts between a company and the municipal authority—require specific legislative authority and are granted for a limited term of years after a public bidding process.[129] Franchise rights are franchise-specific. In New York State, franchises are typically nonexclusive,[130] at least in principle, and the territory in which facility installation is permitted under a given franchise is the territory where the public service is provided.[131] In fact, except where a grant is by its terms exclusive, the grantor reserves the power to grant a subsequent, competitive franchise[132] and the subsequent grant does not violate the first franchisee's contractual or constitutional rights.[133] Monopoly is not an essential feature of a franchise, and in view of the competition-increasing changes in regulation, it is not a feature that is favored in New York.

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[125] It should be noted that the "franchise" granted by the state through municipal agents for the purpose of allowing a public service to be provided is distinct from the "franchise" granted by a company to an individual or group to market its service or products in a particular territory. BLACK'S LAW DICTIONARY (8th ed. 2004) ("franchise (fran-chIz), n. . . . 3. The sole right granted by the owner of a trademark or tradename to engage in business or to sell a good or service in a certain area. 4. The business or territory controlled by the person or entity that has been granted such a right.")

[126] N.Y. Gen. City Law § 20(10). (NYJUR Franchise s 4)

[127] *See*, *e.g.*, "Contract of April 7, 1887 between Hess et al. Commissioners & Consolidated Telegraph & Electrical Subway Co." (Con Tel and Electrical Subway Company Agreements 1886-1891.pdf)

[128] *See* Appendix C for further details regarding relevant permitting authorities in exemplary New York State municipalities.

[129] New York City Department of Transportation – Permits/Franchises, http://www.nyc.gov/html/dot/html/permits/franinfo.shtml.

[130] N.Y. Const. Art. 3, § 17. ("The legislature shall not pass a private or local bill in any of the following cases: . . . Granting to any private corporation, association or individual any exclusive privilege, immunity or franchise whatever.") *See also*, *Parfitt v. Furguson*, 38 N.Y.S. 466, 470-72 (N.Y.A.D. 2 Dept. 1896). (Stating that a provision in a contract between a municipality and gas company that no other company shall have consent to lay pipes or conductors for the term of the contract was void in view of the Constitutional provision against exclusive franchises.)

[131] See *Fayetteville Tel. Co. v. Pub. Util. Comm'n of Ohio*, 1 Ohio St.3d 167 (1982).

[132] *Syracuse Water Co. v. City of Syracuse*, 116 N.Y. 167 (1889).

[133] *Elec. City Ry. Co. v. City of Niagara Falls*, 48 Misc. 91, 95 N.Y.S. 73 (N.Y. Sup. 1905); *In re* City of Brooklyn, 143 N.Y. 596 (1894).

In the case of New York City, the City administers a formal, organized system through which applicants may obtain a revocable consent enabling them to install and use infrastructure within public space as a quasi-owner of that property. The New York City Department of Transportation (DOT) website provides that obtaining a revocable consent requires petitioning the Division of Franchises, Concessions and Consents and submitting a petition for the DOT's review.[134] The DOT then distributes the petition to appropriate City agencies, which, depending on the nature of the revocable consent structure proposed, may include the Department of Buildings, Department of City Planning, and various other agencies responsible for administering rules for safety, zoning, and preservation of landmarks.[135] The DOT next holds a public hearing regarding the merits of the petition, which is followed by a 10-day comment period.[136] Where no issues arise, the DOT executes a revocable consent agreement with the applicant subject to approval by the Mayor.

Other cities in New York State have systems that offer similar permits for use of public space. See Appendix C for references to procedures in place in a number of other cities.

Franchise and Consent Requirements for Steam Corporations

A "district steam corporation" is defined in the New York Transportation Corporations Law § 110 as "a corporation organized to supply steam to consumers from a central station or stations through pipes laid wholly or partly in the public streets." District steam corporations must obtain "the written consent of the local authorities" (i.e., a franchise or other permit) in order to "lay and maintain suitable pipes and conduits or other fixtures in and under the streets, parks and public places of the cities, villages, or towns mentioned in its certificate of incorporation."[137]

Steam corporations are required to apply for and attain revocable consents from the city in order to route pipes through the city's public property (e.g., streets and sidewalks), and the State does not have the statutory authority to grant permission.[138] In New York City, the Department of Transportation (DOT) requires a petition for revocable consent "to permit the use of public space for . . . steam pipes."[139] Such local permits can be secured from local authorities such as "in a city, a majority of the members of the local legislative body; in a village, a majority of the members of the board of trustees; in a town, outside of a village, the town superintendent of highways and a majority of the members of the town board."[140]

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[134] New York Department of Transportation – Revocable Consents: Information for Applicants, http://www.nyc.gov/html/dot/html/permits/revconif.shtml.

[135] *Id.*

[136] *Id.*

[137] Transportation Corporations Law (TCL) § 111.

[138] *TransGas Energy Systems, LLC v. New York State Board on Electric Generation Siting and the Environment*, 65 A.D.3d 1247, 887 N.Y.S.2d 99, 102 (N.Y.A.D. 2 Dept., 2009)

[139] New York Department of Transportation, "About DOT: DOT Consumer Service Center," Available at: http://www.nyc.gov/html/dot/html/about/onlineforms.shtml (accessed on March 30, 2010)

[140] TCL § 111.

Application to Microgrids

A franchise may be directly implicated when electric or thermal (i.e., steam) distribution lines cross public ways, and indirectly implicated by attempts to serve customers within the franchise area of an existing utility. If a microgrid project crosses public ways, it may need to seek a franchise and accompanying CPCN. Given the small-scale attendant to the microgrid structure, the operator of the microgrid will most likely not need to obtain its own franchise and may instead secure the necessary property use permissions through a lesser consent. If a microgrid project attempts to provide service within an existing franchise area, the current franchisee, as an interested party, may intervene or be invited to comment on proceedings between municipal authorities and the incoming microgrid developer over the grant of new property use permissions.

4.1.4 Regulation of Electric and Steam Corporations Under the PSL

4.1.4.1 The PSC's Regulatory Power Over Electric Corporations

The PSC will likely characterize microgrids as electric corporations

Under existing PSL, a microgrid is most likely to be characterized by the PSC as an "electric corporation," which is statutorily defined as "every corporation, company, association, joint-stock association, partnership and person…owning, operating or managing any *electric plant*."[141] An interviewed PSC official was fairly definitive on this matter: "[u]nless exempt, a micro-grid corporation is an electric corporation subject to [Public Service] Commission jurisdiction."[142]

Yet the characterization of a microgrid as an electric corporation does not provide much information about how the microgrid will be regulated. The PSC does not apply the same regulatory regime to all statutory electric corporations. Although the market participants described above at Section 0 differ in both form and function, nearly all fall within the sweeping statutory definition of "electric corporation." The PSC has responded by adopting a flexible, "realistic appraisal" approach to determine how to regulate different forms of electric corporations.

The PSC's "Realistic Appraisal" Analysis in Regulating Electric Corporations

Under existing PSL, a realistic appraisal determines which PSL requirements should be imposed on new electric service providers that differ in character from traditional utility providers. In *Carr Street*, a case in which a facility previously operated as a cogenerator, but sought to sell electricity products into the wholesale market, the PSC undertook to perform a realistic appraisal to determine the regulatory regime that would apply to the proposed operations.[143] The PSC's realistic appraisal consisted of a three-prong analysis: 1) whether a particular section of the Public Service Law is inapplicable on its face (i.e., evident without need for proof or reasoning); 2) if a provision is facially applicable, whether it is possible for an entity to comply with its requirements; and 3) whether imposing the requirements on an entity is necessary to protect the public interest, or whether doing so would adversely affect the public interest.[144]

A realistic appraisal yields different results depending upon the provider's characteristics. For example, the PSC's application of the PSL to generating facilities that intend to operate as merchant plants in a wholesale market will result in a different outcome than applying the statute to ESCOs that do not own a generating plant, but instead market electricity services to retail customers.[145]

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[141] N.Y. Pub. Serv. Law §2(13) (2008) (emphasis added). The two specific exemptions provided by the statute are discussed below at Section 4.1.5.

[142] Leonard Van Ryn, Assistant Counsel, NYS Department of Public Service response to Survey of State Regulatory Officials *cited by* King at 162.

[143] In re Carr St. Generating Station, PSC Case 98-E-1670, Order Providing for Lightened Regulation, at 4–5 (issued April 23, 1999) [hereinafter *Carr Street*].

[144] *Id.* at 5.

[145] *Carr Street*, supra note __ at __

Application to Microgrids

Since the electric industry restructuring of the 1990s, the PSC has repeatedly used a three-prong realistic appraisal analysis to determine how to apply the PSL to emerging market participants that do not neatly fit into previously regulated categories of "electric corporations." The PSC is likely to use this analysis to identify and resolve any novel regulatory issues created by microgrids.

Regulatory Requirements for Electric Corporations

While the applicability of specific requirements to a given electric corporation will depend on PSC's realistic appraisal of the entity, Table 4.2 provides an overview of the extent of PSC's regulatory power and the expanse of regulatory hurdles that an electric corporation may need to overcome before providing electric service.

Table 4.2 – The PSC's Regulatory Powers Over Electric Corporations

Area of Authority	Description of Power
General Supervision	The PSC has the power of general supervision over all electric corporations, which includes the powers to investigate the manufacture, distribution and transmission of electricity; to order improvements and provision of service; and to perform five-year audits to investigate the efficiency and customer response (i.e, quality of service) to the corporation's operations. [146]
Rates	The PSC determines the rates that electric corporations are permitted to charge. Charges made by electric corporations are required to be just and reasonable,[147] and the PSC has the authority to require electric corporations to disgorge revenues in excess of the corporation's authorized annual rate of return.[148]
Quality of Service	Electric corporations are required to furnish safe and adequate service. The PSC has the power to determine the safety and adequacy of service.
Billing	The PSC has control over all aspects of the billing process, including the format and informational requirements of bills.
Administration and Public Reports	The PSC has power over the financial and recordkeeping requirements of electric corporations. The PSC may prescribe methods of accounting and record keeping and inspect all records; require an annual report of stock, bonds and property; and order reports of charged rates to be filed and made publicly available.[149]
Corporate Finance and Structure	An electric corporation must apply for the PSC's approval before issuing stock, bonds and other forms of indebtedness and must provide information about the amount of stock, proceeds and the purposes for which proceeds will be used. The PSC must also approve mergers, consolidations, and reorganizations by electric corporations.[150]
Incorporation, Franchises, and Certificates[151]	An electric corporation may not construct a plant without PSC's permission and approval. A corporation may not exercise a right or privilege under a granted franchise without the PSC's permission and approval. Before a franchise is issued, an electric corporation must file a certified copy of its charter, with a verified statement of the president and secretary of the corporation, showing that it has received the required consent of the proper municipal authorities. The PSC has the power to grant its permission and approval after a hearing and determination that construction or such exercise of the right, privilege or franchise is necessary or convenient for the public service.

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[146] PSC § 66

[147] PSL § 65.

[148] PSC § 66.

[149] PSC § 66; § 68-a.

[150] PSC § 69.

[151] PSC § 68. Franchises, revocable consents and certificates of public necessity and convenience are discussed in detail *infra* at Part 3.b., c., and d.

Residential Service	New York state's policy on the provision of electric service to residential customers provides that "the continued provision of all or any part of such gas, electric and steam service to all residential customers without unreasonable qualifications or lengthy delays is necessary for the preservation of the health and general welfare and is in the public interest."[152] Transactions between residential electricity consumers and suppliers are regulated through the PSL, HEFPA and ECPA. HEFPA and ECPA are discussed in detail below at Section 4.1.4.6.

4.1.4.2 PSC's Regulatory Power Over Steam Corporations

A microgrid that incorporates thermal energy distribution in the form of steam may be regulated as a "steam corporation." Two statutes govern steam corporations in New York State: Public Service Law Chapter 48, Article 4-A ("Provisions Relating to Steam Corporations; Regulating the Price of Steam") and the New York Transportation Corporations Law Chapter 63, Article 9 ("District Steam Corporations").

Under the Public Service Law, the Public Service Commission's jurisdiction, supervision, powers and duties extend to the "manufacture, holding, distribution, transmission, sale or furnishing of steam for heat or power, to steam plants and to the persons or corporations owning, leasing or operating the same."[153] "Steam plant" includes "all real estate, fixtures and personal property operated, owned, used or to be used for or in connection with or to facilitate the generation, transmission, distribution, sale or furnishing of steam for heath or power."[154]

A "steam corporation" is "every corporation, company, association, joint stock association, partnership and person, their lessees, trustees or receivers appointed by any court whatsoever, owning, operating or managing any steam plant." There are three exceptions to this designation: (1) "where steam is made or produced and distributed by the maker, on or through private property solely for the maker's own use or the use of the maker's tenant and not for sale to others";[155] (2) "where steam is made or produced by the maker solely [sic] from one or more of such facilities to users located at or near a project site"; and (3) "where stream is made or produced and distributed solely for the use of its members by a non-profit cooperative corporation organized under the cooperative corporations law."[156] The powers of the Commission over steam corporations generally mirror those of electric and gas corporations and are outlined in PSL § 80.

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[152] PSL § 30.

[153] PSL § 5(c).

[154] PSL § 2(21).

[155] *See also*, People ex rel. Cayuga Power Corp. v. Public Serv. Commn., 226 N.Y. 527, 124 N.E. 105 (N.Y.A.D. 3 Dept., 1996) (where the corporation was a private business, with energy produced and distributed exclusively on private property, and not an electric corporation under PSL, and therefore the PSC had no authority to consider its application)

[156] PSL § 2(22).

Application to Microgrids

Because some microgrids will use cogeneration technology, their operation--particularly the distribution of thermal energy--may implicate the regulations that are in place for steam corporations. Cogeneration requires the use of "steam plants" as defined above, but the smaller scale of certain microgrid models will likely allow those microgrids to fall into one or more of the exceptions to the "steam corporation" designation, thus excluding them from the PSC's jurisdiction.

The terms of the relevant regulations suggest that the nature and location of users, non-profit status, and use of public property are key features to consider in understanding the potential for exclusion and the level of oversight that microgrids will be subject to as steam/thermal energy producers.

4.1.4.3 Certificates of Public Convenience and Necessity

As discussed above, microgrids that require the use of public ways to lay distribution lines or pipes must obtain a franchise or lesser consent. A franchisee that is also an electric corporation or steam corporation within the meaning of the PSL must obtain a CPCN from the PSC in order to exercise the rights granted under its franchise, including both installation and consequent use of electricity or steam distribution facilities.[157] The Commission is empowered to grant such permission and approval whenever, after due hearing, it determines that such exercise of the right, privilege or franchise is *necessary or convenient* for the public service.[158] Note that this section requires the PSC's approval before construction of the physical plant may begin. Where installing the microgrid requires installation of a "major utility transmission facility"[159] (e.g., a gas line such as in the case of Cornell University's campus microgrid, discussed in Section __ of this Report), a certificate of environmental compatibility and public need is required.[160]

Also, microgrids that use cogeneration and distribute thermal energy offsite necessarily incorporate steam facilities. Franchises for steam corporations are subject to approval by the Commission pursuant to PSL § 81. The process mirrors that of gas and electric corporations under PSL § 66. The corporation must submit a "certified copy of the charter with a verified statement of the president and secretary of the corporation, showing that it has received the required consent of the proper municipal authorities."[161] Then the Commission makes a determination on whether the "exercise of the right, privilege or franchise is necessary or convenient for the public service."[162]

The PSC also imposes a CPCN requirement on "electric corporations that intend…to sell electricity via direct interconnection to retail customers."[163] Certain facilities, such as QFs, are exempted from the PSL requirement.[164] When a former QF began to sell electricity through direct interconnection, however, the PSC "concluded that [the facility's] retail sale of electricity was subject to PSC regulation and declared that a certificate of public convenience

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[157] Public Service Law § 68.

[158] N.Y. PUB. SERV. LAW § 86 (2009). The "convenience and necessity" principle is the standard for PSC approval and was recognized in *Penn-York Natural Gas Corp. v. Maltbie. Penn-York Natural Gas Corp. v. Maltbie*, 164 Misc. 569, 576 (N.Y. Sup. 1937).

[159] N.Y. PUB. SERV. LAW § 120(2) (2009). ("Major utility transmission facility" means: (a) an electric transmission line of a design capacity of one hundred twenty-five kilovolts or more extending a distance of one mile or more, or of one hundred kilovolts or more and less than one hundred twenty-five kilovolts, extending a distance of ten miles or more, including associated equipment, but shall not include any such transmission line located wholly underground in a city with a population in excess of one hundred twenty-five thousand or a primary transmission line approved by the federal energy regulatory commission in connection with a hydro-electric facility; and (b) a fuel gas transmission line extending a distance of one thousand feet or more to be used to transport fuel gas at pressures of one hundred twenty-five pounds per square inch or more, excluding appurtenant facilities, but shall not include any such transmission line that is located wholly underground in a city or wholly within the right of way of a state, county or town highway or village street as those terms are defined in article one of the highway law and article six of the village law, or that replaces an existing transmission line, including appurtenant facilities, and extends a distance of less than one mile.)

[160] N.Y. PUB. SERV. LAW § 121(1) (2009).

[161] PSL § 81

[162] PSL § 81.

[163] *Carr Street*, *supra* note 10, at 7–8 (citation omitted).

[164] In re Sithe/Independence Power Partners, PSC Case 94-E-0136, Order Denying Petition for Rehearing, at 8 (March 16, 1995).

and necessity was required."[165] Thus, a CPCN was required for a facility to sell electricity to a *single* retail customer, even though the remainder of its capacity was sold wholesale and its other operations were exempt from PSC jurisdiction as a QF.

4.1.4.4 Certificates of Environmental Compatibility and Public Need

Article VII of the New York State Public Service Law describes the necessary application process for the siting of major utility transmission facilities. The applicability of Article VII hinges on the definition of major utility transmission facility. Fuel gas transmission lines extending over 1,000 feet and transporting fuel gas at pressures equal to or greater than 125 lbs/in^2 are regulated under Article VII.[166] For electric transmission lines to qualify, they must either extend a distance of one mile or more with a design capacity of 125 kilovolts, or extend for at least ten miles with a capacity of 100-125 kilovolts.[167] Underground transmission lines located in a city whose population exceeds 125,000 are exempt from Article VII regulations. A full environmental, public health, and safety impact review is required for all in-state major transmission facilities.[168]

A certificate of environmental compatibility and public need must be obtained prior to the preparation of a site for major utility transmission facility construction.[169] To receive a certificate, an application must be filed with the PSC with proof of service to interested individuals and bodies.[170] This application is required to include the location of the site and any reasonable alternatives, a description of the proposed facility, and a summary of studies made on the potential environmental impacts.[171] Certain fees apply to transmission lines greater than ten miles in length.[172]

In order to grant a certificate, the Commission must make several findings, including the basis of the need for the facility; the probable environmental impact; that the facility represents the minimum adverse environmental impact; that the proposed location conforms to applicable state and local laws; and that the facility will serve the public interest.[173]

Application to Microgrids

Because microgrids deploy small-scale generation at the distribution level and likely will not seek to install major electric transmission lines, it is unlikely that Article VII will apply to most microgrid facilities. Microgrids that construct new transmission facilities likely would be limited to new commercial or residential developments in rural or otherwise isolated areas and that seek to interconnect to the transmission network. Other possible cases where Article VII would apply include larger microgrids that may require access to natural gas fuel supplies and must build a new pipeline connecting to the regional gas transmission system, as Cornell University recently did for its system. In the event Article VII applies to a given microgrid project, then a certificate of environmental compatibility and public need must be obtained prior to the preparation of a site for major electric or gas transmission facility construction.[174]

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[165] 637 N.Y.S.2d 987, at 988.

[166] *Id.*

[167] N.Y. Public Service Law § 120(2).

[168] NEW YORK STATE PUBLIC SERVICE COMMISSION, THE CERTIFICATION REVIEW PROCESS FOR MAJOR ELECTRIC AND FUEL GAS TRANSMISSION FACILITIES 2 (2004).

[169] N.Y. Public Service Law § 121(1). Projects for which the federal government has exclusive jurisdiction are exempt. See N.Y. Public Service Law § 121(4)(c).

[170] See N.Y. Public Service Law § 122(2).

[171] N.Y. Public Service Law § 122(1).

[172] N.Y. Public Service Law § 122(5).

[173] *Id.*

[174] N.Y. Public Service Law § 121(1). Projects for which the federal government has exclusive jurisdiction are exempt. *See* N.Y. Public Service Law § 121(4)(c).

4.1.4.5 Issues Related to Default Service Providers

Obligation to Serve

In New York State, electric corporations have a statutory obligation to serve customers. The PSL requires *every electric corporation* to "provide residential service upon the oral or written request of an applicant, provided that the commission may require that requests for service be in writing under circumstances as it deems necessary and proper as set forth by regulation, and provided further that the applicant" can pay.[175]
As the default service provider, a local distribution utility has a legal obligation to provide electric service to any customer who requests it and is willing to pay the rates established for such service.[176] This obligation arises from both common and statutory law. Early case law provides that a business of a public character has an "obligation to serve all equally within its power and to make connections, in the absence of any restraining order," which "rests upon a common law duty, on the contract obligation of its franchise and on the statutory duty imposed by section 65 of the Public Service Commission's Law."[177] If a building is not supplied with electricity, an electric corporation is "obligated to provide service to such a building, provided however, that the commission may require applicants for service to buildings located in excess of one hundred feet from gas or electric transmission lines to pay or agree in writing to pay material and installation costs relating to the applicant's proportion of the pipe, conduit, duct, or wire, or other facilities to be installed."[178]

Provider of Last Resort

Market deregulation generated legal challenges as to which entities in the competitive market would continue to have an obligation to serve. This debate also implicates which entities will serve as the provider of last resort (POLR), which is a legal obligation, traditionally given to utilities, to provide service to a customer when competitors have chosen not to provide service.[179]

In New York's electricity market, the distribution utilities, or NYTOs, both maintain the obligation to serve and are the POLR. Currently, service by the distribution utilities is the default electricity service; customers may elect to have service provided by an ESCO.[180] The PSC initially recommended that ESCOs be bound by the obligation to serve "within the geographic area and with respect to customer classes (residential, commercial, industrial, etc.) they elect to serve," to obviate the need to designate a single POLR.[181] Still, the PSC was concerned that "imposing such an obligation could unduly constrain ESCOs and thereby impede development of the market."[182] Moreover, it found the Legislature's exemption of the ESCOs from the HEFPA requirement that they serve all customers who request service controlling.[183] The PSC further determined that a designated POLR may no longer be needed once an unspecified critical mass of customers migrates from NYTOs to ESCOs.[184]

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[175] N.Y. P.S.L. §31(1) (2009).
[176] New York State Public Service Commission Energy Glossary http://www.dps.state.ny.us/enegloss.htm.
[177] *Park Abbott Realty Co. v. Iroquois Natural Gas Co.*, 102 Misc. 266, 270 (1918).; *see also People ex rel. New York & Queens Gas Co. v. McCall*, 171 A.D. 580, 583 (**"**the obligations owing by a public service corporation to serve well the entire community through which it has a franchise").
[178] PSL §31(4) (2009).
[179] New York State Public Service Commission Energy Glossary, Available at: http://www.dps.state.ny.us/enegloss.htm (accessed on March 30, 2010)
[180] Gerald A. Norlander, "Electricity Deregulation in New York State, 1996-2002," Available at: http://pulp.tc/NYDeregulation_1996-2002Draft.pdf (accessed on March 30, 2010)
[181] PUBLIC SERVICE COMMISSION, CASE 00-M-0504- Proceeding on Motion of the Commission Regarding Provider of Last Resort Responsibilities, the Role of Utilities in Competitive Energy Markets and Fostering Development of Retail Competitive Opportunities. STATEMENT OF POLICY ON FURTHER STEPS TOWARD COMPETITION IN RETAIL ENERGY MARKETS, 49 August 25, 2004, Available at: http://www3.dps.state.ny.us/pscweb/WebFileRoom.nsf/0/F4746B665D1C642685256EFB00622E91/$File/201a.00m0504.pdf?OpenElement (accessed on March 30, 2010); *see also* http://www.pulp.tc/html/archive_2001_46.html (accessed on March 30, 2010)
[182] *Id.* at 49-50.
[183] *Id.* at 50.
[184] *Id.*

Application to Microgrids

If the PSC classifies a microgrid as an electric corporation, it may also establish that the microgrid is the default provider to a group of customers and has an obligation to serve those customers. For example, this obligation may attach to a microgrid if the customers served were otherwise electrically isolated from a local distribution utility. This could occur if a microgrid was deployed on a greenfield development or other area that previously did not receive service from a distribution utility. Nevertheless, if the microgrid provides service where a local distribution utility had provided service before, and the customers served maintain some type of connection to the utility, it is not likely that a microgrid will have this obligation.

The PSC has not yet considered the applicability of the POLR requirement to microgrids, so it will not have any precedent to guide its decision when it first reaches the issue. Factors that may influence its treatment of microgrid POLR obligations could include whether it is interconnected to the transmission network and whether it or its customers continue to receive service, such as standby service, from the utility.

Under current PSL, the PSC requires "any electric corporation" "to provide supplemental or back-up power to any alternate energy production, small hydro or cogeneration facility on a non-discriminatory basis and at just and reasonable rates."[185] Thus, a microgrid that is exempted from regulation as an electric corporation (see Section 4.1.5 for a discussion of exemptions) could rely on an electric corporation to serve as the POLR.

An additional issue is whether microgrids that serve residential customers can be islanded (i.e., severing connection to the grid) if a distribution utility is the responsible POLR. PSL §31(4) (2009) indicates that residential customers can build structures that are not connected to the grid and are responsible for paying for the infrastructure that will connect them to the grid if they subsequently desire electric service from the regional utility. Thus, islanded microgrid service is unlikely to relieve the distribution utility of its role as default provider and a disconnecting customer will probably be financially liable for any costs to reconnect to the grid if it so desires.

Exit Fees[186]

National Grid (formerly Niagara Mohawk) is the sole utility in the State of New York given authority by the PSC to assess a fee to recover stranded costs (i.e., for divested generation assets or uneconomic power contracts) upon customers who exit the grid.[187] While "exit fees" were generally prohibited by the PSC during restructuring, an exception was made for Niagara Mohawk to discourage total bypass of the Company's retail *distribution services* and charges where such bypass is not economic from society's standpoint and to prevent the shifting of the Company's Competition Transition Costs to other stakeholders.[188]

The exit fee does not apply if: 1) a self-generating customer completely isolates itself from the National Grid system, or 2) if its electricity is supplied by an on-site third party that installed its generating capacity after January 1, 2000 and serves only a single customer. If a third party elects to be connected to National Grid's system, it must deliver excess energy to the grid in addition to entering into an agreement under S.C. No. 7, National Grid's standby tariff for retail service. Standby tariffs elucidate the terms and conditions for back-up or supplemental electric

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[185] PSL 66-c(1)(b). It should be noted, however, that the PSC does not require any such electric or steam corporation to construct any additional facilities for such purposes unless such facilities are paid for in full by the owner or operator of the co-generation, small hydro or alternate energy production facility.

[186] National Grid, Niagara Mohawk Power Corporation Schedule for Electric Service applicable in All Territory Served by Company, Available at: https://www.nationalgridus.com/niagaramohawk/non_html/rates_psc207.pdf (accessed on March 30, 2010)

[187] *See* Niagara Mohawk Power Corporation, P.S.C. Tariff No. 207 Electricity, section 52 (Leaves Nos. 71 - Z13 through 71 - Z15).

[188] Competition Transition Costs are those costs associated with the previously vertically-integrated utility's divestiture of generation assets required as a condition of restructuring to encourage more competition in the market for generation; it may also include lost revenues from the sale of above-market power contracts no longer required due to the reduction in the number of customers served.

service a utility provides to a self-generating customer.[189] A third party's failure to pay the standby tariff will result in the collection of a lump sum payment of transition costs.

For other utilities, customers that self-generate electricity similarly pay for utility stranded investments in distribution infrastructure through standby tariffs. Typically, this cost recovery is part of the demand charge assessed.

Application to Microgrids

Exit fees are intended to keep a utility, which is the default service provider, financially indifferent to the departure of customers from its system. Inasmuch as the PSC generally prohibited exit fees during restructuring, this is not likely to be an issue of concern for microgrid developers unless the proposed microgrid is located in the former service territory of Niagara Mohawk, now operated by National Grid. Most utilities (including National Grid) will recover stranded costs by embedding them within the demand charges of standby tariffs charged to self-generators like microgrids. To the extent microgrids remain interconnected to the utility and take standby service to meet peak demands on the microgrid or as back-up, any potential utility stranded costs will be included in standby fees instead of through a separate "exit fee." A microgrid that was either never connected or disconnects from the utility distribution system, may be able to avoid such charges, unless they are located in the former service territory of Niagara Mohawk.

There may be instances where microgrids themselves will want to assess exit fees. For microgrids that have been deemed electric corporations and are assigned by the PSC an obligation to serve, exit fees may need to be charged to participating customers if they decide to leave the microgrid system at a later date. In fact, a cost recovery mechanism, like exit fees, which allow microgrid developers to recover costs, could be a necessary condition for raising capital. Rather than an exit fee mechanism authorized by the PSC, however, microgrids will likely implement this cost recovery mechanism through the terms and conditions of long-term contracts required from participating customers.

4.1.4.6 Service to Residential Customers

Statutory protections afforded to residential customers apply whenever an electric corporation or other entity "in any manner, sells or facilitates the sale or furnishing of gas or electricity to residential customers."[190] A residential customer is any person who, pursuant to an application for service or an agreement for the provision of commodity supply, is supplied directly with all or any part of the gas, electric, or steam service at a premise used in whole or in part as his or her residence where: 1) the distribution utility's effective tariff specifies a residential rate for such service or 2) such service is primarily used for his or her residential purposes, and the customer has so notified the utility.[191]

New York State Multiple Dwelling and Multiple Residence Law define what constitutes a residence. A dwelling is a building or structure, which is occupied in whole or in part as the home, residence, or sleeping place of one or more persons.[192] A "multiple dwelling" is a dwelling that is either rented, leased, let or hired out, to be occupied, or is occupied *as the residence or home* of three or more families living independently of each other. A "class B" multiple dwelling is a multiple dwelling that is occupied, as a rule transiently, including hotels, lodging houses, rooming houses, boarding houses, boarding schools, furnished room houses, lodgings, club houses, college and school dormitories.[193] A "multiple dwelling" does not include a hospital, convent, monastery, asylum or public institution, or a fireproof building used wholly for commercial purposes.[194]

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[189] Standby service may be required for a self-generating customer for purposes of meeting peak demand or to provide full electric service when on-site power supplies are undergoing maintenance or repairs.

[190] N.Y. Public Service Law § 53 (2009).

[191] 16 NYCRR § 11.2 (2009)

[192] NY CLS Mult R § 4 (13) (2009).

[193] NY CLS Mult D § 4(9) (2009).

[194] NY CLS Mult D § 4(7) (2009).

With regard to submetered residential buildings, "[f]or purposes of HEFPA, a landlord who submeters electricity . . . must provide submetered customers the same rights and protections that utilities are required to observe."[195] On the other hand, master-metered residential rental units owned or operated by private or government entities are permitted by the PSC, upon application. An application must include, among other things, the method for calculating rates to tenants with a rate cap not to exceed the utility's tariffed residential rate; complaint procedures and tenant provisions consistent with HEFPA; provisions for tenant notice and comment; and an enforcement mechanism for plaintiffs to ensure that their rights are protected under the law.[196] Still, a conversion from submetering to master metering may not be permitted by the PSC, which has stated a policy preference for improving the amount of information residential customers have about their energy use through practices like submetering.[197] The PSC has used its broad discretion in such instances to deny applications for master metering on these grounds, as it did in an application filed by NYU in 2007 (see the NYU case study in the Appendix).

As contrasted with residential customers, the relevant PSL does not provide non-residential customers the same degree of procedural protections as afforded to residential customers.[198] A nonresidential customer is a person, corporation or other entity, supplied by a utility with gas, electric or steam service under the utility's tariff, and pursuant to an accepted application for service, who is not a residential customer as so defined.[199] Provision of service to non-residential customers is also regulated by the PSL and governs, among other things, application and termination of service, billing, and complaint-handling procedures.

Application to Microgrids

The rate structure as established by the PSC and charged by the distribution utility will likely govern whether a given microgrid model will be required to comply with statutory customer protections under existing PSL. Because any residential customer who purchases electricity from any provider is entitled to statutory protections, a microgrid that serves residential customers will likely be required to comply with these requirements and cannot be exempted by the PSC.

Nevertheless, it appears that in the "single landlord/campus model" of microgrids, *e.g.* the case studies of Cornell University and NYU, provision of electric commodity to dormitories does not trigger statutory customer protections even though the dormitories are likely Class B Multiple Dwellings, and thus residential. Many dormitories are master metered and residents do not pay their energy bills directly; instead, dormitory residents are charged the average cost of energy service to a dorm room, which is included in the rent. Accordingly, service under a campus model, where the microgrid is serving loads all under the control of a single owner, may be afforded different treatment under the PSL than direct service to other residential customers under an independent provider model.

4.1.5 Exemptions to Regulation of Steam and Electric Corporations

4.1.5.1 Privileged Status Under Federal Law

PURPA establishes "qualifying facilities", which receive special rates and regulatory treatment, in two general categories: qualifying small power production facilities and qualifying cogeneration facilities.[200] PURPA and its attendant regulations at 18 C.F.R. §292.100 et seq., exempt federal QFs from state rate, financial and organizational regulation.[201]

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[195] Public Utility Law Project, "Residential Submetering," Available at: http://www.pulp.tc/html/residential_submetering.html (accessed on March 30, 2010)

[196] 16 NYCRR § 96.2.

[197] Case No. 07-E-0820, Petition of New York University to Remove the Individual Apartment Meters and Consolidate the Meters Pursuant to Service Classification SC-9 Located at 334 East 26th Street Dormitory in the Territory of Consolidated Edison Company of New York, Inc., Order Denying Petition for Waivers. (Issued February 21, 2008).

[198] 16 NYCRR §13.1-.16 (2009).

[199] 16 NYCRR § 13.1 (2009).

[200] 42 U.SC. § 134 et seq.

[201] 18 C.F.R. §292.100

QFs enjoy certain benefits under federal, state, and local laws, in three general areas: right to sell energy to a utility,[202] right to purchase certain services from utilities (i.e, standby service),[203] and relief from certain regulatory burdens.[204] Eligible QFs include cogeneration facilities of any size and small power production facilities that are 1) 30 MW or less, 2) "eligible" under section 3(17)(E) of the Federal Power Act, or 3) generating geothermal and biomass power. QFs are exempt from provisions of PUHCA,[205] state laws or regulations respecting rates or the financial or organizational regulation of electric utilities,[206] and most provisions of the Federal Power Act[207] (except §§ 205 and 206, which exempts only QFs smaller than 20 MW, making sales pursuant to a contract executed before March 17, 2006, or made pursuant to state regulatory authority's implementation of section 210 of PURPA[208]).

Cogeneration Facilities

PURPA defines a "cogeneration facility" as "equipment used to produce electric energy and forms of useful thermal energy (such as heat or steam), used for industrial commercial, heating, or cooling purposes, through the sequential use of energy."[209] To be classified as a QF, a cogeneration facility must meet the criteria in 18 CFR § 292.205.

For top-cycle facilities[210], which produce electricity and provide useful thermal energy with excess heat, the useful thermal energy output of the facility must be at least 5% of annual production.[211] In terms of efficiency, the useful power output plus half of the useful thermal energy[212] must be at least 42.5% of total annual energy input of natural gas and oil to the facility.[213] For bottom-cycle facilities[214] (those producing useful thermal energy, with excess heat producing power), the useful power output must be no less than 45%of the natural gas or oil input.[215] For both types, there is no efficiency standard if "none of the energy input as supplementary firing is natural gas or oil," or installation began before March 13, 1980.[216]

All new cogeneration facilities larger than 5-MW,[217] not certified as QFs on or before August 8, 2005 (nor filed notice of self-certification, recertification, or application prior to February 2, 2006), and seeking to sell electric energy pursuant to § 210 of PURPA must show that the "thermal energy output of the cogeneration facility is used in a productive and beneficial manner,"[218] and that the "electrical, thermal, chemical and mechanical output of the cogeneration facility is used fundamentally for industrial, commercial, residential or institutional purposes and . . . not . . . for sale to an electric utility."[219] The fundamental use test in (d)(2) is satisfied if at least 50% of annual output is used for "industrial commercial, residential or institutional purposes."[220]

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[202] 18 CFR § 304.

[203] 18 CFR § 292.305. Included is the same right to just and reasonable rates as other customers, and the right to interconnect (see 18 CFR § 292.306).

[204] Federal Energy Regulatory Commission, "What is a Qualifying Facility?" *available at* http://www.ferc.gov/industries/electric/gen-info/qual-fac/benefits.asp

[205] 18 CFR §292.602(b).

[206] 18 CFR § 292.602(c)(1).

[207] 18 CFR § 292.601(c).

[208] 18 CFR § 292.601(c)(1).

[209] 18 Code of Federal Regulations § 292.202(c)

[210] 18 CFR § 292.202(d)

[211] 18 CFR § 292.205(a)(1)

[212] Unless the useful thermal energy output is less than 15% of the total energy output, in which case the efficiency must be 45% of annual total energy input of natural gas and oil. 18 CFR § 292.205(a)(2)(i)(B)

[213] 18 CFR § 292.205(a)(2)(i) & (i)(A).

[214] 18 CFR § 292.202(e)

[215] 18 CFR § 292.205(b)(1).

[216] 18 CFR § 292.205(b)(2), 18 CFR § 292.205(a)(2)(ii).

[217] 18 CFR § 292.205(d)(4).

[218] If a thermal host previously supplied the thermal energy the new cogeneration facility will now supply, the new thermal output will be presumed to be "productive and beneficial" under (d)(1).

[219] 18 CFR § 292.205(d), (d)(1) & (d)(2).

[220] 18 CFR § 292.205 (d)(3).

Finally, a new cogeneration facility must either file "with the [Federal Energy Regulatory] Commission a notice of self-certification, pursuant to §292.207(1)" or have "filed with the Commission an application for Commission certification, pursuant to § 292.207(b)(1), that has been granted."[221]

Small Power Producers

PURPA defines a small power production facility as "a generating facility of 80 MW or less whose primary energy source is renewable (hydro, wind or solar), biomass, waste, or geothermal resources."[222] In order to be classified as a QF, a small power production facility must meet the criteria in 18 CFR § 292.204. First, the "power production capacity . . . together with the power production capacity of any other . . . small power production facilities that use the same energy resource, are owned by the same person(s) or its affiliates, and are located at the same site, may not exceed 80 megawatts."[223] Same site is defined as "within one mile of the facility for which qualification is sought," measured from the electrical generating equipment.[224] There is no size limitation for "eligible solar, wind, waste or geothermal facility" as defined in the Federal Power Act 16 U.S.C. § 796(17)(E), mainly certain facilities certified prior to 1995.[225]

Second, the "primary energy source of the facility must be biomass, waste, renewable resources, geothermal resources, or any combination thereof, and 75 percent or more of the total energy input must be from these sources."[226] Use of "oil, natural gas, and coal by a facility, under section 3(17)(B) of the Federal Power Act, is limited to the minimum amounts of fuel required for ignition, startup, testing, flame stabilization, and control uses . . . to alleviate or prevent unanticipated equipment outages, and emergencies . . . [s]uch fuel use may not, in the aggregate, exceed 25 percent of the total energy input."[227]

Finally, like cogeneration facilities, a new small power production facility must either file "with the Commission a notice of self-certification, pursuant to §292.207(1)" or have "filed with the Commission an application for Commission certification, pursuant to § 292.207(b)(1), that has been granted."[228]

Fuel Use

Both small power production facilities and cogeneration facilities are required to provide annual hourly energy input in terms of British thermal units (Btu) for fossil fuel energy inputs and the percentage of the total average annual hourly energy input to the facility. Cogeneration facilities and small power production facilities are required to provide data for use of natural gas and oil while only small power production facilities are also required to provide data for coal use.[229]

To qualify, a small power production facility must meet set ratios for the usage of renewable and fossil fuel inputs. The criteria for qualifying small power production facilities provide that "The primary energy source of the facility must be biomass, waste, renewable resources, geothermal resources, or *any combination thereof*, and *75 percent or more of the total energy input* must be from these sources."[230] Use of oil, natural gas and coal by a small power facility "is limited to the minimum amounts of fuel required for ignition, startup, testing, flame stabilization, and control uses, and the minimum amounts of fuel required to alleviate or prevent unanticipated equipment outages, and emergencies, directly affecting the public health, safety, or welfare, which would result from electric power outages" and may not exceed "*25 percent of the total energy input of the facility* during the 12-month period

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[221] 18 CFR § 292.203(b)(1) & (2).
[222] Federal Energy Regulatory Commission, "What is a Qualifying Facility?" Available at: http://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp (accessed on March 30, 2010)
[223] 18 CFR § 292.204(a)(1).
[224] 18 CFR § 292.204(a)(2).
[225] 18 CFR § 292.204(a)(1).
[226] 18 CFR § 292.204(b)(1)(i).
[227] 18 CFR § 292.204(b)(2).
[228] 18 CFR § 292.203(b)(1) & (2).
[229] 18 CFR 131.80 Pt A(5).
[230] 18 CFR § 292.204 (b)(1)(i) (emphasis added).

beginning with the date the facility first produces electric energy and any calendar year subsequent to the year in which the facility first produces electric energy."[231]

While cogeneration facilities are required to report their use of oil and natural gas as fuel inputs, their qualification status is not contingent on fuel inputs. Instead, a cogeneration facility seeking QF status must meet the operating, efficiency, and ownership criteria described in this section.

Ownership

The statutory terms "qualifying small power production facility" and "qualifying cogeneration facility" each include the requirement that the facility be "owned by a person not primarily engaged in the generation or sale of electric power (other than electric power solely from cogeneration facilities or small power production facilities)." These statutory restrictions are construed to mean that electric utility interests are permitted to own up to a 50 percent equity interest in a cogeneration or small power production facility without jeopardizing the facility's qualifying status.

Wholesale Generation

The NYISO administers the wholesale power market for New York State. While the NYISO is not involved in the retail market for electricity, the companies that provide retail electricity (utilities and ESCOs, for example) procure power through the NYISO's wholesale electricity markets.[232]

Although wholesale generators are subject to the PSC's jurisdiction by virtue of their ownership of electric plant, they may receive lightened regulatory treatment. The PSC has found that "[i]mposing [certain PSL] requirements could unnecessarily hinder competitive wholesale generators by interfering with their flexibility in structuring the financing and ownership of their facilities."[233] Therefore, many transactions subject to PSC review would be afforded "reduced scrutiny" when required by the public interest.[234] In the *Carr Street* and *AES Orders*, the PSC concluded that new forms of electric service providers participating in wholesale markets would be lightly regulated.[235] In recent proceedings, the PSC continues to rely upon these findings as the basis for lightened regulation of wholesale generators.[236]

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[231] 18 CFR § 292.204 (b)(2).

[232] New York ISO, "Wholesale vs. Retail Electricity," Available at: http://www.nyiso.com/public/about_nyiso/understanding_the_markets/wholesale_retail/index.jsp (accessed on March 30, 2010)

[233] *Id.*

[234] *Id.*

[235] *Carr Street*, supra note __; Case 99-E-0148, AES Eastern Energy, L.P., Order Providing For Lightened Regulation (issued April 23, 1999) (AES Order).

[236] *See, e.g.*, Rensselaer Cogen. Order, *supra* note.

Application to Microgrids

Many microgrids will employ cogeneration facilities or will be small facilities using renewable fuels. Therefore, it is of particular interest to microgrid operators to design their facilities to meet the eligibility requirements to be a QF under PURPA. For example, a microgrid that has a cogeneration facility should ensure that it meets the relevant efficiency requirements, that less than 50% of its output is sold to the utility, and that all other QF requirements are met. Similarly, a microgrid that employs renewable technologies or fuels should ensure that it meets the fuel use requirements, as well as the other operating and ownership requirements.

If a microgrid can meet all the requirements to be a QF under PURPA, it will be exempt from many state and federal regulatory requirements. In particular, the microgrid will be exempt from state laws and regulations with respect to the rates and financial and organizational aspects of utilities. Also, microgrids that are primarily engaged in wholesale transactions (i.e., through the NYISO) can expect lighter regulation than other market participants. Similarly, lighter regulation may also extend to microgrids that provide service only to customers that own a stake in the system (i.e., Landlord/Campus Models 1 & 2 and Cooperatives), as "self-service" could be interpreted to approximate a wholesale transaction. There is no specific PSC precedent supporting this particular interpretation, however.

4.1.5.2 Privileged Status Under State Law

Pursuant to PSL §§ 2(2-d) and 2(13), and separate from what is allowed under PURPA, facilities that "qualify" under NY state law are exempt from PSC regulation except for PSL Article VII.[237] As discussed above, Article VII includes, among other things, the process of applying for and obtaining certificates of environmental compatibility and public need. For example, such a facility is exempt from regulation as a person or electric corporation under the PSL.[238]

Unlike the privilege under federal law, greater than 50% ownership by an electric utility will not jeopardize a facility's status under state law. The PSC has determined that an entity regulated as an "electric corporation" or "person" under PSL can own a facility exempt from such treatment without destroying its exemption status. In a case on the issue, the PSC ruled that a utility's ownership of an exempt facility would not destroy its exemption. According to the PSC's analysis, pertaining to Central Hudson Enterprise Corporation ("CHEC"), the Commission determined that the facility at issue (Lyonsdale) would not be subject to regulation as a result of CHEC's ownership of it, even though CHEC is an electric corporation for other purposes. The PSC stated that "[n]othing in the PSL prevents an electric corporation from owning a facility that is not subject to regulation, and it is public policy, under PSL §66-c, to promote the development of exempt facilities. That policy accomplished in part through the exemption from PSL regulation extended to exempt facilities."[239]

Moreover, the PSL explicitly contemplates that service may be provided to multiple users: the statutory language states "transmission or distribution facilities as may be necessary to conduct electricity, gas or useful thermal energy to *users* located at or near a project site."[240] In the *Burrstone* case, the PSC found that "furnishing electric service to multiple users" is "specifically contemplat[ed]" in PSL §2(2-d) "by providing that electricity may be distributed to 'users,' in the plural.[241]"

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[237] CASE 08-E-0738 IPP Energy LLC and Standard Binghamton LLC, Available at: http://documents.dps.state.ny.us/public/Common/ViewDoc.aspx?DocRefId={F3AEB8CC-C894-4F00-8C44-4F56F13DC54F; CASE 05-E-1423 Central Hudson Enterprises Corporation, Available at: http://documents.dps.state.ny.us/public/Common/ViewDoc.aspx?DocRefId={DAAF039C-1613-44E5-A0BB-E8540B69D8C2 (accessed on March 30, 2010)

[238] CASE 09-M-0776 Griffiss Utility Services Corporation ("In the alternative, GUSC argues that the facility is a qualifying facility (QF) under both PSL §2(2-a) and §2(2-b) that is exempt from regulation under PSL §2(4) and §2(13)."

[239] CASE 05-E-1423 Central Hudson Enterprises Corporation, Available at: http://documents.dps.state.ny.us/public/Common/ViewDoc.aspx?DocRefId={DAAF039C-1613-44E5-A0BB-E8540B69D8C2 (accessed on March 30, 2010)

[240] N.Y. Pub. Serv. Law §2(13) (2008) (emphasis added).

[241] See Case 07-E-0802, *Burrstone Energy Center LLC*, Declaratory Ruling on Exemption from Regulation (issued August 28, 2007)

4.1.5.3 Types of Exemptions from Regulation as an Electric Corporation

As described above, the PSL generally provides that an electric corporation is a corporation “owning, operating or managing any electric plant.” This general treatment is subject to two exemptions: [(1)] “where electricity is generated or distributed by the producer solely on or through private property … for its own use or the use of its tenants and not for sale to others”; and [(2)] “where electricity is generated by the producer solely from one or more co-generation, small hydro or alternate energy production facilities or distributed solely from one or more of such facilities to users located at or near a project site.”[242] In order to qualify under the first form of exemption, a microgrid facility would be precluded from crossing public ways.

The second form of exemption is more likely to come into play in the case of microgrids. Each of the categories of facilities falling within this exemption is statutorily defined. Table 5.3 details the types of power supply and other characteristics a microgrid would need to have in order to qualify for an exemption from regulation as an electric corporation.

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[242] N.Y. Pub. Serv. Law §2(13) (2008) (emphasis added).

Table 4.3 – Statutory Categories of Privileged Facilities Under State Law

Exemption Category	Statutory Definition
Cogeneration Facility	"[A]ny facility with an electric generating capacity of up to eighty megawatts, and including any facility with an electric generating capacity of up to one hundred twenty megawatts located at a project site within an air terminal operated by the Port Authority of New York and New Jersey and wholly contained within a city having a population of one million or more, which produces electricity and useful thermal energy solely for sale to the Port Authority of New York and New Jersey, for use at the airport, for sale to an electric utility, and/or for sale to the Power Authority of the State of New York, together with any related facilities located at the same project site, which is fueled by coal, gas, wood, alcohol, solid waste refuse-derived fuel, water or oil, to the extent any such oil fueled facility was fueled by oil prior to the effective date of this subdivision and there is no increase in the amount of oil used at the facility or to the extent oil is used as a backup fuel for such facility, and which simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy that is used solely for industrial and/or commercial purposes"[243]
Alternate Energy Production Facility	"[A]ny solar, wind turbine, fuel cell, tidal, wave energy, waste management resource recovery, refuse-derived fuel or wood burning facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy."[244] There is an 80 MW generation limit for an alternate energy production facility to be an exempt facility under the PSL; this limit applies to the aggregation of several sources of power generation.[245]
Small Hydro Facility	"[A]ny hydroelectric facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts."[246]
Related Facilities	"[A]ny land, work, system, building, improvement, instrumentality or thing necessary or convenient to the construction, completion or operation of any co-generation, alternate energy production or small hydro facility and also include such transmission or distribution facilities as may be necessary to conduct electricity, gas or useful thermal energy to users located at or near a project site."[247]

4.1.5.4 Related Facilities and the "at or near" Exemption

As described in Table 4.3, a related facility that is necessary or convenient to any of the other categories of facilities that qualify for exemption from regulation as an electric corporation is also exempt if it is "at or near" the project site. "[T]ransmission or distribution facilities...necessary to conduct electricity, gas or useful thermal energy to uses located at or near a project site," are considered "related facilities," and therefore part of the cogeneration plant and within the scope of the QF exemption.[248] The PSC will make a finding of fact to determine whether the facility is "necessary or convenient" and whether it is located "at or near" a project site. For example, the PSC considered service on a 1,000-acre campus "at or near" a QF. In a later case involving a 3,500-acre campus, however, the PSC

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[243] NY CLS Pub Ser **§** 2-a.

[244] NY CLS Pub Ser **§** 2-b.

[245] CASE 07-E-0674 DECLARATORY RULING ON ELECTRIC CORPORATION JURISDICTIONhttp://documents.dps.state.ny.us/public/Common/ViewDoc.aspx?DocRefId={7ABB76EC-28BC-4E2C-BF7D-0372DF7F62C3} "Petitioners appear to argue that the generating capacities of all four wind energy projects in question should be aggregated such that the total capacity would exceed the 80 MW limit specified in PSL §2(2-b). Generating capacities of physically separate projects proposed by affiliates however, have not previously been aggregated in determining whether a facility is a State qualifying facility under PSL §2(2-a), (2-b), or (2-c). Moreover, while WFP's project is only about two miles from that of its nearest affiliate, WFP does not indicate that the projects will be interconnected. Indeed, if they were interconnected, WFP's project would lose qualifying facility status under § 2(2-b)."

[246] **NY CLS Pub Ser §** 2-c

[247] NY CLS Pub Ser **§** 2-d.

[248] PSL § 2(2-d)

reserved judgment on the issue, stating that a finding of fact would need to be made whether the related facilities were "at or near" the project site over such a large acreage.[249] In the context of steam lines, the PSC has interpreted "at or near" the project site to include "steam transmission lines, of up to 1.9 miles in length and crossing public streets."[250]

The "at or near" exemption may also cover facilities that run wires and pipes in public ways. In *Burrstone*, the PSC found that the "lines distributing electricity and steam from Burrstone's cogeneration facility . . . including some that cross public streets" are "related facilities that are part of the cogeneration project" and therefore the project "qualifies for the exemptions from regulation set forth at PSL §§2(3), 2(4), 2(13), and 2(22)" and is "not . . . a corporation, person, electric corporation or steam corporation for the purposes of the PSL."[251]

Application to Microgrids

Current PSC precedent indicates that a microgrid that incorporates certain features will likely be exempted from nearly all PSL regulation. Importantly, a microgrid that qualifies as a cogeneration facility, alternate energy production facility, or small hydro facility may be able to use the "related facilities" exemption to also qualify wires and pipes that would cross a public way and otherwise trigger franchise and consent requirements. While it is difficult to anticipate exactly how the PSC will rule in any given case, a microgrid that has characteristics similar to existing exempted facilities may be able to cite those similarities as persuasive precedent in seeking exemption.

Additionally, the broader definition that qualifies facilities for exemption under the PSL includes utility-owned systems. While the risk of regulation may not be a major issue for an already-regulated utility that seeks to develop a microgrid, these exemptions may provide a pathway for utilities to make investments in new distributed generation deployed in microgrid structures, which might otherwise be prohibited or discouraged under the terms of electric restructuring.

4.1.6 ESCOs and Virtual Microgrids

Unlike the "physical" microgrids discussed in the sections above, a "virtual microgrid" is one that uses the existing utility's distribution wires and aggregates locally sited distributed generation to offset a group of customers' energy needs. Because the sources of supply are embedded within the distribution system, close to customer loads, the participating customers may avoid all or most transmission and generation costs (i.e., supplemental grid purchases may be required), but must pay utility distribution fees. There is currently no provision in the PSL that requires utilities to accommodate or provide services that enable the operation of virtual microgrids. Still, based on the functions of existing electricity market participants, the aggregating function of a virtual microgrid could be viewed as very similar to what some ESCOs do today.

As explained above, one type of ESCO serves as a broker between owners of electricity generation facilities and end-use customers. These ESCOs focus on the provision of the commodity portion of electricity service, but do not distribute electricity; rather, they use the existing distribution utilities, or NYTOs, to deliver electricity to their customers as well as provide metering and billing (in many cases). While ESCOs are regulated by the PSC, they are not subject to the same degree of oversight as distribution utilities. Unlike utilities, ESCOs can generally charge and structure their rates however they wish without PSC approval or review. Instead, ESCO rates are determined by or based upon the wholesale market for generation and competition between other ESCOs and utilities. Any ESCO that provides service must also be certified by the utility in whose territory they operate, typically to demonstrate

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[249] CASE 09-M-0776 Griffiss Utility Services Corporation ("GUSC asserts that its CHP facility is a qualifying facility (QF) because it is a cogeneration facility under PSL §2(2-a) and an alternate energy production facility under PSL §2(2-b).").

[250] Case 93-M-0564, *In re Nissequogue Cogen Partners*, Declaratory Ruling (issued November 19, 1993) (Nissoquogue's steam lines, under 1.5 miles long and entirely on their own property, are exempted QFs) (citing Case 89-E-148, *Nassau District Energy Corporation*, Declaratory Ruling (issued September 27, 1989)); see also Case 06-E-1203, *Steel Winds Project LLC and Steel Winds LLC,* Declaratory Ruling (issued December 13, 2006) (users located approximately 0.6 miles from wind turbines, one mile from substation); Case 07-E-0802, *Burrstone Energy Center LLC*, Declaratory Ruling on Exemption from Regulation (issued August 28, 2007) (50 feet).

[251] Case 07-E-0802, *Burrstone Energy Center LLC*, Declaratory Ruling on Exemption from Regulation, 5-6 (issued August 28, 2007).

that the ESCO has the capability to do business with the utility, such as the exchange of data and other important operating activities. Typically, ESCOs enter into contracts with customers for the commodity electricity portions of their bills; the delivery portion of the bill is typically paid by ESCO customers directly to the distribution utility.

Inasmuch as virtual microgrids have some similar features to ESCOs, it is possible that virtual microgrids would also be subject to utility certification and charges. There are no provisions in the state statutes or in PSC decisions that would indicate to a "virtual" microgrid provider that such a service is legal. Moreover, utilities do not have an obligation to cooperate with virtual microgrid providers.

4.2 Other Regulatory Issues for Microgrids in New York State

4.2.1 Net metering

Net metering is a policy for electricity customers that generate their own power from qualifying renewable and distributed energy sources. Net metering requires electric utilities to compensate such customers for surplus power delivered to the grid, where it joins other electricity and is made available for general consumption.[252] Typically, provisions require utilities to measure the flow of electricity using bi-directional electric meters capable of rotating either forward or backwards so that, for accounting and billing purposes, only a consumer's net electricity consumption is measured and any excess electricity generated is credited towards grid-sourced electricity consumed. Customer-generators receive multiple benefits from the arrangement:

> Under a net metering program, customers can use their generation to offset their consumption over the entire billing period, not just the instant that there is a demand. The arrangement allows the customers to use the utility grid to "bank" their electricity produced at one time and consume it at another time. This form of energy exchange is especially useful for intermittent renewable energy generation. It allows for a substantially bigger portion of the customer-generated electricity to the [sic] receive the retail price and thus increases the value of small renewable energy technologies for customers. The ability to "bank" affords customers greater flexibility in self-generating. Customers do not have to alter their consumption or install energy storage devices to maximize the value of their generation.[253]

The benefits designed to incentivize private investment in renewable energy represent a cost to utilities and ratepayers, which effectively pay retail rates for customer-generated electricity. These rates "include costs of transmission and distribution, administration, and profits in addition to a utilities' energy cost," which means that net metering represents a subsidy for distributed generation at the utility and other ratepayers' expense. Nevertheless, distributed energy resources also provide benefits to utilities and ratepayers (see Section 5.0) and net metering is the "cornerstone of state energy policies encouraging private investment in renewable energy sources." It is the "principal mechanism employed by the states to encourage decentralized and renewable energy technologies ."[254] Currently, 44 states and the District of Columbia, local governments and some individual utilities provide for some level of legislatively enacted net metering.[255]

In New York, net metering is available on a first-come, first-served basis to customers of the state's major investor-owned utilities (and the Long Island Power Authority), subject to technology, system size, and aggregate capacity limitations. Currently solar, farm waste (e.g., agricultural biogas), wind, micro-CHP and fuel cell systems qualify for net metering. Solar and wind systems may not exceed 25-kW for residential and non-demand metered

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[252] See the Database of State Incentives for Renewable Energy (DSIRE), "Incentives for Renewable Energy," available at: http://www.dsireusa.org/ (accessed on March 30, 2010)

[253] Yih-huei Wan & H. James Green, *Current Experience With Net Metering Programs*, National Renewable Energy Laboratory, 1-2 (1999).

[254] Steven Ferrey, *Nothing but Net: Renewable Energy and the Environment, Midamerican Legal Fictions, And Supremacy Doctrine*, 14 Duke Envtl. L. & Pol'y F. 2, 3 (2003).

[255] DSIRE,"Summary tables: Rules, Regulations and Policies for Renewable Energy," available at: http://www.dsireusa.org/summarytables/index.cfm?ee=1&RE=1 (accessed on March 30, 2010)

commercial customers and 2-MW for demand metered commercial customers. Farm waste projects may not exceed 500-kW in electric power capacity. Micro-CHP systems must have a rated electric capacity of at least 1-kW, but no more than 10-kW, and must produce at least 2-MWh of electricity annually.[256] Fuel cell systems must have a combined rated capacity of not more than 10-kW.[257] Micro-CHP and fuel cell systems only receive the avoided utility energy cost – as opposed to bundled retail – for excess generation net of grid-based power usage. By comparison, customer net excess generation in a given month from most solar, farm waste, and wind systems is credited to the customer's next bill at the bundled retail rate. Table 4.4 below provides a summary of the current net metering rules, organized by technology and eligible sector.

Application to Microgrids

Microgrids are not mentioned under existing provisions for net metering. It is very likely that microgrids – as defined in this report – would not be eligible because net metering is currently only available to single customers (i.e., possibly excluding microgrids that involve multiple customers) and it does not provide for hybrid systems that incorporate multiple technologies. As a result, it is likely that a microgrid owner or developer seeking to receive net metering service from a utility will be rejected on these grounds. Because microgrids are not specifically identified in net metering regulations, any microgrid project wishing to receive such service will require a voluntary agreement from the utility.

Extending net metering to microgrids may not require significant changes to the existing program. Regardless of the number of customers participating, microgrids with a single point of common coupling with the macro-grid, will appear as a single load – or a single customer – from the perspective of the utility. A more challenging issue for microgrids that deploy multiple technologies may be determining which generating facilities are exporting to the grid and which are supplying microgrid loads and then applying the correct net metering terms and conditions. While individual generators in a microgrid will be separately metered, if a microgrid is designed with a single point of common coupling to the macro-grid, exported electrons may not be distinguishable from one another. This is important particularly for microgrids that deploy fossil fueled combined heat and power applications in addition to qualifying renewables.

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[256] PSL § 66-j (1)(f)
[257] PSL § 66-j (1)(g)

Table 4.4 – Summary of New York State Net Metering Rules

Eligible Technologies	**Solar**		**Farm Waste**	**Wind**		**Micro-CHP and Fuel Cells**
Applicable Sectors	Residential and Non-Demand Commercial	Demand Commercial	Farm-Based Residential and Non-Residential Farms	Residential and Non-Demand Commercial	Demand Commercial	Residential
System Size Limit	25 kW	Up to two MW[258]	500 kW	25 kW Residential; and 500 kW Farm-Based	Up to two MW	10 kW
Limit on Overall Enrollment[259]	1.0% of utility's 2005 electric demand			0.3% of utility's 2005 electric demand		1.0% of utility's 2005 electric demand with solar and farm waste
Treatment of Net Excess	Residential - net excess will roll over monthly. At the end of 12 month period, any excess will be converted to a cash value and paid to the customer at SC6 avoided cost rates. Non-Demand Commercial customer's net excess will roll over monthly on an ongoing basis. Demand Commercial customer's excess is converted to its equivalent value and applied as a direct credit to the customer's next utility bill for outstanding energy, customer, demand and other charges on an ongoing basis.[260]		Residential/Non-Demand – net excess will roll over monthly. Demand customer's excess is converted to its equivalent value and applied as a direct credit to the customer's next utility bill for outstanding energy, customer, demand and other charges. For both demand and non-demand customers, at the end of the net metering year, any excess will be converted to a cash value and paid to the customer at SC6 avoided cost rates.	Residential/Farm-based – net excess will roll over monthly. At the end of 12 month period, any excess will be converted to a cash value and paid to the customer at SC6 avoided cost rates. Non-Demand Commercial customer's net excess will roll over monthly on an ongoing basis. Demand Commercial customer's excess is converted to its equivalent value and applied as a direct credit to the customer's next utility bill for outstanding energy, customer, demand and other charges on an ongoing basis.		Credited to customer's next bill at avoided utility energy cost for micro-CHP and fuel cells; annual excess generation may be carried over indefinitely.

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[258] The lesser of 2,000 kW or such DG Customer's peak load as measured over the prior twelve month period, pursuant to New York State Public Service Law §66-j and §66-l. If no prior history is available, utility will determine the limit of the size of generator based on an analysis of comparable facilities. Customer has the right to petition the PSC if not in agreement with the Company's analysis.

[259] Net Metering is available on a "first come, first serve" basis determined by the date the utility notifies the DG Customer that it has received a complete project application.

[260] Demand customers will be subject to applicable actual metered demand charges consumed in that billing period. The Company will not adjust the demand charge to reflect demand ratchets or monthly demand minimums that might be applied to a standard tariff for net metering.

4.2.2 Interconnection

Microgrids may be designed to be electrically isolated from the macro-grid, in which case interconnection to the macrogrid is avoided. Still, in most cases, developers will want to interconnect to the macrogrid for supply of back-up or supplementary energy and, when possible, to participate in regional energy markets (i.e., sell excess power or participate in demand response programs). Microgrids connecting directly to the transmission system will follow the standardized procedures established by FERC and the NYISO.[261] In cases where microgrids are connecting to the distribution system, the microgrid operator must seek approval from the local electric utility, which will first ensure that interconnecting will not have an adverse impact on the distribution system or on other customers. In such instances, it is very likely that the local electric utility will treat the microgrid similar to a standalone DG system, and will follow the established procedures for interconnecting such systems to the macrogrid.

The process for interconnecting DG to the distribution system varies depending on the type of DG unit (i.e., induction, synchronous or inverter-based), generating capacity and the type of interconnection (i.e., island or parallel). DG systems larger than 20-MW generally cannot connect to the distribution system; rather they must connect directly to the transmission system following the NYISO procedures. For DG systems smaller than 20-MW but larger than 2-MW, each of New York's six local electric utilities – Central Hudson Gas and Electric (Central Hudson), Consolidated Edison, New York State Electric & Gas (NYSEG), National Grid, Orange and Rockland Utilities and Rochester Gas and Electric – has its own processes and requirements for interconnection. For DG systems smaller than 2-MW, however, the PSC has established Standardized Interconnection Requirements (SIR), which contains processes and requirements that all six local electric utilities must follow.[262] The SIR establishes an expedited application procedure for certain small DG systems and a standard application procedure for all other DG facilities it covers. Generation that is not designed to operate in parallel with the utility's electrical system is not subject to the SIR requirements.

The SIR's expedited application procedure is for DG systems that are under 25-kW, as well as certain certified, inverter-based systems from 25-kW to 200-kW. Inverters, or static power converters, provide the interface between DC energy sources or variable high frequency sources and the 60 Hz power distribution system. Examples of inverter-based systems include photovoltaic arrays, fuel cells, battery storage systems, some micro-turbines, and some wind turbines. Equipment "certified" for inverter-based systems should be selected from the PSC's "Certified Equipment" list. The expedited process includes: (1) the Initial Communication by Potential Applicant; (2) Review by Utility; (3) Filing of Application; (4) System Installation; (5) Facility Testing in Accordance with SIR; and (6) Final Acceptance. Potential applicants filing for non-inverter-based systems up to 200-kW may, at the utility's discretion, use the expedited process.

The SIR's standard application procedure is for DG systems up to 2-MW. After initial communication, utility review, and filing an initial application, the utility will develop a cost estimate for the Coordinated Electric System Interconnection Review (CESIR). After parties agree to proceed, the utility completes the CESIR, which consists of two parts: (1) a review of the impacts to the utility system associated with interconnection of the proposed system and (2) a review of the system's compliance with criteria included in the SIR. Following this, the utility will provide the results of the study to the applicant in writing. The results will include system impacts, notification of compliance with criteria, a detailed estimate of the total costs of the completion of the interconnection of the proposed system, and a statement of cost responsibility for required interconnection equipment including required modifications to the utility system, administration, metering, and on-site verification testing.

The SIR also include technical guidelines on the following system characteristics: (1) Design Requirements; (2) Operating Requirements; (3) Dedicated Transformer; (4) Disconnect Switch; (5) Power Quality; (6) Power Factors; (7) Islanding; (8) Equipment Certification; (9) Verification Testing; and (10) Interconnection Inventory.

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[261] See NYISO's Open Access Transmission Tariff at: http://www.nyiso.com/public/webdocs/documents/tariffs/oatt/body_oatt.pdf (accessed on September 5, 2010)

[262] *New York State Standardized Interconnection Requirements and Application Process for New Distributed Generators 2 MW or Less Connected in Parallel with Utility Distribution Systems* (Revised 2/11/10), available at http://www.dps.state.ny.us/Modified_SIR_2-11-10_Clean.pdf

The SIR does not cover DG systems larger than 2-MW, so operators of these large DG systems must follow the application procedure and requirements established by its local electric utility. Con Edison uses the SIR procedures for DG systems up to 5-MW and uses similar procedures, albeit with an extended timeline, for DG systems larger than 5-MW.[263] Similarly, Central Hudson has its own process for larger facilities that closely mirrors the 11-step SIR application procedure.[264]

NYSEG and RG&E have a process which begins with a Preliminary Technical Review, which can take up to four months and results in a list of deficiencies in the proposed design, a list of required system modifications, and an estimate of the cost for the completion of the application process.[265] If the applicant decides to proceed, the utility will perform a Final Technical Review, which can take up to six months and results in a formal acceptance of the proposal for interconnection.

4.3 Regulatory Environment for Microgrids in Other States

Very few studies have been undertaken that examine the regulatory environment for microgrids in the United States. King (2006) conducted the most comprehensive study on the subject thus far. King's work builds upon a survey carried out by Morgan and Zerriffi (2002), which initially observed that regulatory barriers inhibit the development of microgrids. After conducting a more comprehensive survey of regulatory officials from approximately thirty states, King confirmed that the regulatory environment for microgrids is varied and complex. King concluded that existing conditions for microgrids in the US were "clouded in considerable uncertainty," impeding the deployment of this energy delivery architecture.

Our research, while not attempting to replicate the extensive work of the King study, nonetheless sought to see if its conclusions were still a general reflection of the regulatory environment for microgrids. Semi-structured telephone interviews were conducted with staff at regulatory agencies and legislative offices in eleven jurisdictions: Arizona, California, Connecticut, Delaware, Illinois, Maryland, Minnesota, Oregon, Pennsylvania, Texas, and Washington DC. These particular states were selected in order to create a group with geographic and market diversity. California and Illinois were chosen for pilot initiatives already underway, and Connecticut because the development of a microgrid is being pursued in the city of Stamford. The interviews with state officials focused on the legal status of microgrids from the perspective of state public utility commissions, which regulate investor owned utilities, but typically not municipally owned utilities. Consequently, discussions were also held with staff at the American Public Power Association (APPA) to ascertain whether microgrids were on the agendas of public power entities and if so, how they were approaching them.

Interviews were sought with those knowledgeable on electricity matters in the various state regulatory agencies and legislative offices to address four main issues: (1) whether microgrids are defined in state law or administrative rules; (2) whether microgrids would have a right to exist today and under what constraints; (3) whether policymakers are thinking about microgrids; and (4) whether existing policies with respect to distributed generation (i.e., net metering, interconnection, etc.) might also apply to microgrids. In some cases, interviews were conducted with the directors or members of the electricity divisions at the regulatory agencies; in other cases, referrals were made to distributed generation experts within the regulatory agency, legislative advisors or others familiar with regulatory issues applicable to microgrids. Interviews were supplemented with additional research on state public utilities law as well as on policies related to distributed generation (i.e., net metering) that may be valuable for consideration in New York State microgrid policy.

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[263] Con Edison, "Application Process Overview," available at: http://apps.coned.com/dg/_CommonLib/Dialog.asp?url=/dg/applications/overview.asp (accessed on August 15, 2010)

[264] Central Hudson Gas and Electric, "Interconnection Application Process," available at: http://www.centralhudson.com/dg/Interconnection%20Application%20Process.pdf (accessed on August 15, 2010)

[265] NYSEG, "Requirements for Independent Power Producers of Electricity" (Bulletin 86-01), available at: http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/Shared/SuppliersPartners/PDFs%20and%20Docs/Bulletin%2086-01(March%2031%202005).pdf (accessed on August 15, 2010)

4.3.1 Findings

For the purposes of the interviews, we shared our general definition of a physical microgrid – a small, integrated energy system of interconnected loads and distributed energy resources (producing electric, both electric and thermal energy, or just thermal energy), which if electric, can operate in parallel with the grid or in an intentional island mode. We then offered the descriptions of the various ownership and service models analyzed in our study, to determine whether and how these characteristics might affect the legality of microgrid projects in certain states. The major findings from the interviews conducted with state regulatory officials and supplemented by additional research are summarized below.

4.3.1.1 The overwhelming response from those interviewed was that microgrids fitting our definition are either not being considered, or are just beginning to be discussed at the regulatory level.

The interviewees affirmed King's conclusion that there is a general unfamiliarity among regulatory agencies regarding the concept of microgrids, and a lack of clarity as to how microgrids should be regulated. Multiple interviewees described the concept of microgrids as being "off the radar screen." Even in Illinois and Connecticut, where a major microgrid test project and the development of an actual microgrid are underway, respectively, regulators we spoke to were unfamiliar with the current status of these projects. Regulatory staff members from Pennsylvania and Delaware expressed the view that there were "so many legal issues" to be surmounted in developing a microgrid that such projects would likely not be economically feasible, and therefore were not a regulatory priority.

4.3.1.2 In some jurisdictions, discussion of specifically including microgrids into the legal and regulatory framework had recently transpired, but was either never transposed into law or was done so in a limited, or vague fashion.

In Washington DC, discussion of microgrids occurred in the context of Bill 17-492, the *Clean and Affordable Energy Act of 2008*, which addressed issues related to energy independence, demand response, distributed generation, and the promotion of renewable resources. According to the Deputy Executive Director for Regulatory Matters, microgrids were considered for inclusion as part of the bill, but were ultimately excluded from the text because they seemed too expensive and too "esoteric" a concept at the time.[266]

In Pennsylvania, proposed legislation expressly referred to microgrids in several instances in 2007 and was ultimately included in new net-metering legislation. The first, House Bill (HB) 1201, proposed to codify a definition of a microgrid as "a small power generation and distribution network directly serving multiple consumers with the electric generating facility located near or on the same site as the consumers, that may be interconnected to the transmission and distribution system, but [is also] capable of operating independently from it."[267] The law would have allowed microgrids to serve up to four customers without approval and more than four customers with approval from the Pennsylvania Public Utility Commission, on a case-by-case basis. HB 1201 would also have directed the Commission to issue rules regarding fees related to microgrid interconnection to utility distribution systems, standby power and other services, and clarified that microgrids could sell excess power either via net metering arrangements or into wholesale markets. For reasons staff of the bill sponsor could not recall, after being narrowly voted out, if this particular bill was re-committed to the House Rules Committee where it was never resurrected.[268]

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[266] Jeanene Mitchell, personal communication with Joseph Nwude, Deputy Executive Director for Regulatory Matters, Washington DC Public Service Commission, 2009

[267] The General Assembly of Pennsylvania, House Bill No. 1201, Session of 2007, Introduced by Representative George. Bill text is available at: http://www.legis.state.pa.us/cfdocs/billinfo/BillInfo.cfm?syear=2007&sind=0&body=H&type=B&bn=1201 (accessed on March 10, 2010)

[268] Michael Hyams, personal communication with staff of Representative Bud George, April 2010. Also see: Pennsylvania General Assembly, House Bill 1201, Regular Session 2007-2008, voting history available at: http://www.legis.state.pa.us/cfdocs/billinfo/BillInfo.cfm?syear=2007&sind=0&body=H&type=B&bn=1201 (accessed on April 29, 2010)

The second instance, a proposed amendment to Senate Bill (SB) 1134, which addressed various electric ratemaking and policy matters, would have exempted a microgrid that served four or fewer customers from public utility status. In testimony before the Pennsylvania Department of Environmental Protection, Secretary Kathleen A. McGinty noted that the law would simply codify "current interpretations of what constitutes a public utility" and "provide the certainty financial institutions need to fund these projects. Micro-grids," she continued, "have proven to be a vital and successful part of the Commonwealth's strategy to retain and expand manufacturing operations in the state. Landfill gas micro-grids in the south-central and southwest parts of the state are delivering substantially below market gas to industrial off-takers and are thereby supporting thousands of good jobs." Arguing the need for legislative clarity, Ms. McGinty complained "red tape and lawyers fees currently hamper these projects… so a clarification of the law as provided here is vital to realizing the full potential of these under-developed energy resources."[269]

While the proposed amendment to SB 1134 with the microgrid language never went to vote in committee, microgrids were eventually included in a modified definition of "customer generator" provided in HB 1203. This bill, which was signed into law by Governor Rendell as Act 35 of 2007, expanded the state's net metering program.[270] Under the new law, customer generator includes "a nonutility owner or operator of a net metered distributed generation system… not larger than 3,000 kilowatts… except for customers whose systems are above three megawatts and up to five megawatts, who make their systems available to operate in parallel with the electric utility during grid emergencies as defined by the regional transmission organization or where a *microgrid* is in place for the PRIMARY OR SECONDARY purpose of maintaining critical infrastructure, such as homeland security assignments, emergency services facilities, hospitals, traffic signals, wastewater treatment plants or telecommunications facilities…" (emphasis added).[271] Significantly, the inclusion of microgrids in this definition of customer generator made them eligible to net meter with the local electric distribution company and receive credits for exported generation at the full retail rate.[272] Nevertheless, this is the only reference to microgrids in state law and it appears to refer to existing facilities. Since the term microgrid itself is left undefined and rather vague (aside from the 5-MW cap), it appears to provide no additional certainty or encouragement for the development of new microgrid systems.

4.3.1.3 In some states, developers or owners of existing generation had inquired about whether they might be able to serve multiple unaffiliated sites across public ways, but no formal applications were submitted; in these cases, laws forbidding private wires to be strung across public ways preempted potential microgrid projects.

The regulator from Oregon expressed that there was specific interest at the Oregon Public Utility Commission to further explore the regulatory issues posed by microgrids, and that there have been several inquiries to the Commission about the legality of microgrids. One such inquiry came from a 45 MW cogeneration facility in Albany, which was looking into trying to deliver power to a neighbor across the street. The plant was a "qualifying facility" under PURPA and had been providing power to a containerboard facility, which provided the plant's biomass fuel. The year prior, plant owners had decided not to enter into a long-term contract with the local utility at prevailing avoided costs when subsequently, the short-term wholesale rates dropped to uneconomic levels. The plant never submitted a formal request to regulators for approval to deliver power directly to the additional customer. In October 2009, the paper mill and plant announced that it would shut down within a month's time.[273]

Other accounts of attempts to deploy microgrids come from Louisiana and California. A pair of chemical companies in Franklin, Louisiana investigated developing a plant that would capture residual gas from the

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[269] Secretary Kathleen A. McGinty, Pennsylvania Department of Environmental Protection. Testimony on Senate Bill 1134, Committee on Consumer Protection and Professional Licensure, Pennsylvania Senate. November 20, 2007.

[270] Michael Hyams, personal communication with Bruce McLanahan, Office of State Senator Tommy Tomlinson, 2010.

[271] Pennsylvania Public Utilities Commission, Implementation of Act 35 of 2007; Net Metering and Interconnection; Final Rulemaking Order, L-00050174, May 22, 2008

[272] Ibid.

[273] Steve Lathrop, "International Paper to Close Albany Paper Mill; decision will cost 230 jobs," *Albany Democrat-Herald,* October 22, 2009, Available at: http://www.democratherald.com/news/local/article_7465af12-bf47-11de-baff-001cc4c03286.html (accessed on February 07, 2010)

production of carbon black (a heavy petroleum-based powder used to produce printer ink and tire rubber) to generate electricity.[274] Most of the electricity would be used on site and approximately one-third would be sold to another industrial facility down the road at a discount compared to the facility's existing service. Nevertheless, due to restrictions on the installation of "private wires" serving multiple loads across a public street, this approach had to be abandoned.[275] Additionally, since the terms the local utility offered the plant to purchase excess generation were too low for the project to be economic, the project never went forward. Similarly, Real Energy, a developer of distributed energy projects attempted to develop a microgrid project that would serve two buildings in San Francisco, California. As with the chemical plants in Louisiana, this particular project could not be undertaken because it was also not allowed to lay a private electric line linking the two buildings across a public street. Still, Real Energy was able to install a distributed energy system linking multiple buildings owned by the California Public Employees' Retirement System in San Diego because they were located on a single campus and the road separating them was privately owned.[276]

4.3.1.4 Other states indicated that while discussion had not yet been seriously extended to accommodating physical microgrids, policies to encourage distributed generation, particularly those related to net metering, such as meter aggregation and community net metering, were beginning to be implemented at the regulatory level.

The State of Oregon conducted a detailed study on DG regulatory barriers in 2005. Though the report did not refer specifically to microgrids, the fact that microgrids link multiple DG resources and usually interconnect with the utility grid as a form of distributed generation means that barriers to DG are often barriers to microgrids as well.[277] Recommendations from the Oregon study included the development of interconnection standards, exploration of how to include distributed generation in utility planning processes, and consideration of how a customer-generator could use the electric distribution system to provide power to another of the customer's locations – in essence, the development of a "virtual microgrid" scheme.[278] An Oregon regulatory official who had worked on the study said that microgrids were a topic that the Commission was interested in addressing, but that more practical barriers to DG deployment were more immediate priorities.[279]

Subsequently, in 2007 the Oregon Commission took a significant first step toward accommodating "virtual microgrid" development by authorizing meter aggregation for customer generators. The rule allows a customer generator with multiple *contiguous* accounts on the same rate schedule and served by the same feeder line to take advantage of excess generation, which is then applied to the customer's other property.[280] Although the number of customers with multiple, contiguous accounts may be few, the policy allows these customers to size their DG systems to meet the demand of their contiguous properties free from the constraint that the system only serve load behind a single meter. As is common with other net metering policies, the systems must be intended primarily to offset part or all of the customer's electricity requirements and must generate electricity using solar, wind, hydropower, biomass or fuel cells. Meter aggregation applies to both residential and non-residential customers and capacity limits on individual systems are 25-kW and 2-MW, respectively. There is no limit on the number of net metering facilities per customer, as long as the capacity of net-metered facilities on a customer's contiguous property does not exceed the applicable customer class capacity limit. Obligated utilities may request approval from the Commission to collect a fee to cover the administrative costs associated with meter aggregation.

While Oregon's meter aggregation rule is limited to contiguous loads under the control of the customer generator, other states have gone much farther with net metering policies that encourage group or "community" net metering.

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[274] Bradford Plumer, "Drunk with Power," *The New Republic*, October 2, 2009

[275] Ibid.

[276] The Galvin Electricity Initiative, "Microgrid Workshop," June 27-28, 2006, Available at: http://www.galvinpower.org/sites/default/files/documents/Final_Microgrid_Workshop_with_changes.pdf (accessed on February 15, 2010)

[277] King (2006) even describes microgrids as "an extended form of distributed generation."

[278] Lisa Schwartz. "Distributed Generation in Oregon: Overview, Regulatory Barriers and Recommendations." Oregon Public Utility Commission, February 2005. p. 40.

[279] Michael Hyams, personal communication with Lisa Schwartz, November 2009.

[280] Oregon Public Utilities Commission, Available at: http://apps.puc.state.or.us/orders/2007ords/07-319.pdf (accessed on February 15, 2010)

To date, Vermont, Massachusetts, Rhode Island and Maine have all adopted laws that require utilities to offer group or community net metering. Although the programs vary in their specific terms and administrative details, in some way they all allow multiple customers or customers with multiple locations to benefit from the output of a DG unit, installed behind a customer's meter. Rhode Island's meter aggregation policy, for example, allows customers within certain classes – cities, towns, schools, farms, non-profit affordable housing agencies and state agencies – to apply excess credits produced at one location toward use at up to ten other locations. Both Maine and Vermont require the utility to provide joint billing (or group net metering), whereby the utility aggregates the bills of all designated customers in the net metering group and applies the electricity production from the eligible generator against a group bill. Participating customers may come from different classes and must designate a single representative that handles billing and collection responsibilities.[281] Maine requires that customers participating in the group have an ownership stake in the eligible generation unit, and caps the number of participating accounts at ten.[282]

Massachusetts' "neighborhood net metering" program, which was part of the 2008 Green Communities Act, requires that the group consist of at least ten residential customers located in a single neighborhood and served by a single utility. Commercial customers may join groups as long as there are ten or more residential customers. Because the arrangement may require the utility to "wheel power" from the generating site across its distribution facilities to participating loads, neighborhood net metering credits do not include distribution charges (i.e., credits equal the bundled rate less the distribution component). Significantly, under the Green Communities Act, net metering credits are now also transferable, allowing a given customer generator to provide credits from power produced to another customer located within the same utility service territory.[283]

Table 4.5 below summarizes the community and virtual net metering policies that are in effect in states today.

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[281] In order to set up group net metering, the participants must file with the Public Service Board and other relevant parties (i.e., the utility) the specific meters that are part of the group, a method for adding/removing meters, the contact person responsible for communications and the aggregate bill, and a dispute resolution process.

[282] Dana Hall, James Rose and Laurel Varnado, "Investing in Solar as a Community" and Kevin Fox, "Getting the Policies Right," *Solar Today*, Vol. 24, No. 2, March 2010

[283] Ibid

Table 4.5 – Summary of Selected State Virtual or Community Net-Metering Policies

State	**Type of Policy**	**Ownership Requirement?**	**Multiple Customers Allowed?**	**Eligible Technologies & Capacity Limits**	**Selected Terms & Conditions**
Oregon	Virtual Meter Aggregation	No, third party ownership allowed	No	Applies to qualifying "renewable" technologies up to two MW for non-residential and 20 kW for residential customers	Net excess generation carried over to next bill as a credit for a 12-month period. Any credits remaining at the end of a 12-month period will be credited at the utility's avoided-cost rate to customers enrolled in Oregon's low-income assistance programs
Pennsylvania	Virtual Meter Aggregation	No	No	Applies to qualifying "renewable" technologies and CHP up to three MW for non-residential customers and 50-kW for residential customers	Meter aggregation allowed on properties owned or leased and operated by a single customer. Aggregation is limited to meters (in a single utility's service territory) that are located on properties within two miles of the customer's property
Maine	Group Net Metering	Yes, participants must have ownership stake	Yes, up to 10 customers per group allowed	Applies to qualifying "renewable" technologies up to 660 kW including micro-CHP[284]	Net excess generation is credited at retail rate to the following month for up to 12 months; any remaining credits are granted to the utility w/out compensation.
Vermont	Group Net Metering	No, but a binding dispute resolution process is required	Yes, group must elect single representative to allocate credits among participants	Applies to qualifying "renewable" technologies up to 250-kW and micro-CHP up to 20-kW	Net excess generation credited at retail rate shall be used within 12-months of the month generated, if not, it is granted to the utility w/out compensation
Massachusetts	Neighborhood Net Metering	No, third party ownership allowed	Yes, must include at least 10 residential customers; can include commercial customers	Applies to qualifying "renewable" technologies up to two MW; system must be behind a customer's meter	Treatment of net excess generation varies by technology; utilities are not required to credit customers for distribution costs in compensation for "wheeling" power. Credits may be applied to customers outside the "neighborhood" as long as they are in the same utility service territory
California	Virtual Net Metering	No, third party ownership allowed	Yes, but only applies to a building or group of buildings that can be classified as low-income (20% of units) multi-family residential housing	Applies only to photovoltaics up to one MW in capacity (maximum allowed at each site determined by cumulative peak demand at service point)	Participants receive a bill credit that is equivalent to the full "bundled" retail rate as either a percentage or a kilowatt-hour allocation of the output from the eligible generating facility. Utility administers allocation of bill credits to eligible customers. Excess generation is credit to subsequent monthly billing periods, however credits remaining after a 12-month period are granted to utility w/out compensation.

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[284] The 660 kW capacity limit applies to customers located in the service territories of investor owned utilities. Publicly owned utilities are only required to provide net-metering for systems up to 100 kW, but can provide it to larger systems on a voluntary basis. Qualifying micro-CHP systems must meet a specified efficiency threshold. For systems less than 30 kW, systems must demonstrate an overall energy efficiency of 80%; for systems over 30 kW and less than 660 kW, efficiency must be at least 65%. To see which renewables qualify under the state program see the Database of State Incentives for Renewables and Efficiency at: http://www.dsireusa.org/ (accessed April 29, 2010)

4.3.1.5 Of all the states contacted for this study, California has probably taken the most coordinated approach to addressing microgrids, by adopting a functional definition and funding research and development through its Public Interest Energy Research program. The state has also implemented policies that may be encouraging for the development of virtual microgrids, including virtual and multi-facility net metering.

Among the states contacted for this study, only California had put extensive thought into the development of a microgrid definition and committed funds to support research and pilot projects. In 2006, a comprehensive study by NCI, commissioned by the California Energy Commission (CEC) and the DOE, examined the value proposition and market for microgrids.[285] In 2008, the CEC and DOE separately awarded demonstration grants to San Diego Gas and Electric Company to pursue its Beach Cities Microgrid Project. At a total cost of approximately $15 million this demonstration will explore microgrid islanding of an entire substation area. The goals of the project are to reduce feeder peak load by 15% through the integration and control of multiple distributed generation and electrical energy storage devices, while improving substation area reliability in a cost-effective manner.[286] SDG&E will also be working with the University of San Diego to identify regulatory and policy issues associated with deployment of microgrids. The utility is expected to submit pilot tariffs designed to encourage customer generators to participate in the microgrid to the California Public Utilities Commission for approval sometime in 2010. While this work is only just beginning (the demonstration is expected to be completed in 2012), as it progresses new insight regarding the regulatory implications of utility microgrid investments will emerge as will a more practical understanding of how to institute utility-owned microgrids in restructured electricity markets.

As noted in Table 4.5 above, California adopted virtual net metering for low-income multi-family residential buildings and complexes. This program allows customers that might not otherwise be able to receive the benefits of on-site generation to join together to install a larger system that can serve the group. Additionally, to accommodate locations with multiple generation sources, including both net metering eligible and non-eligible technologies (i.e., solar and natural gas-fired CHP), served through a single point of common coupling, California also allows net metering for what it calls "multiple tariff facilities." Under multiple facility net metering, billing credits are based on the proportional contribution of the energy production (in terms of kWh) of each net metering-eligible generator over the applicable billing period.[287] This is an important policy for facilitating microgrids in the sense that it provides clarity to facilities that use multiple forms of generation and/or fuel sources.

4.3.1.6 In general, our research indicated that microgrids operating on a single customer's site – and would not attempt to sell electricity to previously unaffiliated entities, cross property lines or a public right-of-way, or would always operate in island mode – would be perceived as being less problematic from a regulatory perspective than those that would attempt to sell electricity to others or extend beyond private property lines.

Since microgrids did not exist as a fully-fledged concept within the regulatory framework of any state contacted, we attempted to determine what characteristics a microgrid should or should not possess in order to be considered permissible within existing structures. Most state officials interviewed agreed that the Utility and Landlord/Campus Type 1 ownership models would be least problematic from a regulatory perspective – because of the fact that no property lines or right-of-ways were being crossed, and that no previously unaffiliated customers were being sold electricity. In fact, many states have statutory exemptions from designation as public utilities for systems that deliver electricity to customers, if the system is located entirely on private property. The Landlord/Campus Type 2,

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[285] Navigant Consulting. "Mirogrids Research Assessment – Phase 2." May 2006. http://der.lbl.gov/new_site/2006microgrids_files/Navigant%20Microgrids%20Final%20Report.pdf. Accessed 15 August 2009.

[286] Presentation by San Diego Gas & Electric. "Smart Grid OIR Workshop 2." 5 June 2009. http://www.cpuc.ca.gov/NR/rdonlyres/B1CA46CE-68B9-4626-AB1A-D995795BF74B/0/SDGEDistributionWorkshop.pdf. Accessed 15 August 2009.

[287] For an example see Pacific Gas and Electric Company, "Electric Schedule NEM, Net Energy Metering," Available at: http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_NEM.pdf (accessed on April 29, 2010)

which crosses a public way to serve property owned by the microgrid owner, and Joint Ownership microgrids that don't serve unaffiliated customers, would likely also be allowed assuming local permits to occupy public space were available. On the other hand, the Landlord/Campus Type 3 and Independent Provider models would likely raise problematic issues from a regulatory perspective. In many instances, the problem was that selling electricity to previously unaffiliated entities on a retail basis, as could be interpreted to be the case under the latter service models, requires approval from the state utility regulatory body or public utility designation (most states); in other cases, state policy is that distribution utility areas may not overlap, so constructing private wires to serve unaffiliated customers within an existing utility franchise area would not be permissible (this was the case in Maryland and Oregon).

4.3.1.7 The most frequently cited barrier to microgrids was the requirement to have electricity marketer or public utility status to be able to sell electricity to others.

Definitions of a public utility vary widely among states, ranging from furnishing electricity to more than 25 "persons" in Minnesota[288] to any entity selling electricity to retail customers, regardless of the amount of kWh or number of customers, as is the case in Arizona, Connecticut, Delaware, Texas, and Illinois. The definition in Minnesota suggests that microgrids serving 25 or fewer people would not be treated as a public utility, regardless of whether those customers were otherwise unaffiliated or the system crossed public ways to do so. The law also clearly exempts persons providing services only to tenants or cooperative or condominium owners as well as owners of manufactured home or trailer parks. Also, the state's practice of assigning exclusive service areas to utilities to "avoid unnecessary duplication of facilities," could raise doubts about how an incumbent would respond to a microgrid project proposing to provide services using new private wires and whether the incumbent might try to preempt such service, particularly if the project involves some of its existing customers.

Some state public utility definitions, such as in Texas for example, include exemptions covering PURPA qualifying facilities and systems providing self-service or service to tenants.[289] Arizona noted that while public utility status would be necessary for microgrids selling any electricity to other customers at retail, the permissibility of both private wires schemes and of microgrids selling electricity as wholesale transactions was unclear from a regulatory perspective. The regulator from Illinois brought up concerns that selling electricity at wholesale rates could require regulation by FERC, which has jurisdiction over such transactions as they pertain to interstate commerce. Nevertheless, microgrid transactions would likely only become a FERC issue if they were selling power into the wholesale market administered by the Midwest Independent System Operator. Although not clear from discussions with our interviewees, a likely distinguishing feature between wholesale and retail service from the standpoint of a microgrid that serves multiple unaffiliated customers, is whether those customers hold ownership stakes in the system; service to owners may approximate a wholesale transaction (i.e., self-service) while service to customers without an ownership stake will likely be interpreted as a retail sale.

4.3.1.8 Franchise violations when selling electricity to customers within a utility's existing service territory, and when running wires across public rights-of-way, were the other primary barrier to the development of microgrids.

In Maryland, for example, the system put in place during restructuring granting electric suppliers (i.e., ESCOs) the right to sell electricity within a particular area can only be bypassed by individuals wishing to sell solar, wind, or other renewables up to 2-MW. Still, this system only applies to customer-sited and utility grid connected systems; it does not provide for installing private wires to share power produced by the systems with other neighboring customers. While Illinois does not have exclusive franchises per se, it does have a "first in the field" franchise clause, meaning that new market entrants – such as a microgrid selling electricity to other customers – must prove that the existing franchise is not meeting its public service requirements before operating within the existing franchise's territory. The regulator from Minnesota pointed out that since franchises are granted at the municipal level, municipalities would be the ones to decide whether a microgrid violated a franchise or not, though if the microgrid was deemed to be a public utility, its rates would be approved at the Commission level. Regardless, the

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[288] Douglas E. King, "The regulatory environment for interconnected electric power micro-grids: insights from state regulatory officials," Carnegie Mellon Electricity Industry Center Working Paper CEIC-05-08

[289] See Texas Public Utility Regulatory Act, 1999, Sec. 31.002(6)

exclusive service territory provisions in Minnesota would likely prevent a microgrid located within an existing utility's service territory from providing service as a franchised public utility. The one exception to this might be if the microgrid is located in an area that did not already have access to the utility system (i.e., a new development).

4.3.1.9 In general, the interconnection of microgrids to the distribution grid was not perceived as posing a greater problem from a technical or regulatory perspective than the interconnection of any other type of distributed generation.

Stated differently, the process of interconnection for a microgrid was not expected to dramatically differ from the process of interconnecting a single form of distributed generation. Some interviewees raised caveats such as that as the total generating capacity of microgrid increased, the interconnection review process may also become increasingly stringent. Others stated that there was no legal limit to the amount of DG that could be interconnected to the grid; however, utility authority over the technical requirements associated with interconnection to distribution systems could result in a *de facto* limit through the imposition of expensive grid protection schemes or limitations on the system's operating characteristics (e.g. whether it can export power).

4.3.1.10 Lastly, while several state officials expressed that non-utility owned microgrids should be un-necessary if the local distribution utility was effective at its job, we observe that microgrids are receiving an increasing amount of national interest, particularly in the context of smart grid.

Though not a regulatory issue per se, the perception among employees of regulatory agencies on the future potential for microgrids provides one view on the direction that the regulatory environment for these systems may be heading. In Connecticut, Pennsylvania, Illinois and Maryland, officials noted that a major impediment to microgrids was the lack of economic incentives to pursue them – they did not see the value-added for the development of such systems, and one stated that there should be no need for a microgrid if incumbent utilities were "doing their job." This perception of the political and economic reality surrounding microgrids would appear to indicate that, at least in these states, it is unlikely that microgrids or incentives to encourage microgrid investment will soon be on the policy agenda. Still, in light of the increasing focus across the country on building a smart grid (or smart grids), and particularly a focus on investments that allow distribution systems to accommodate increasing amounts of distributed generation, this perspective may quickly change. As noted above, the DOE indentified microgrid deployment as a metric for assessing the progress of smart grid in the United States. It also funded seven utility- and non-utility-owned microgrid demonstration projects in 2007 as part of its Renewable and Distributed Systems Integration program.[290] Consequently, it is very possible that microgrids will increasingly be viewed as opportunities to test smart grid technologies and capabilities without costly – and risky – installation or application across an entire service territory.

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[290] These projects include microgrid demonstrations at the Santa Rita Jail in Alameda County, California (non-utility); ATK Space Systems in Promontory, Utah (non-utility); City of Fort Collins, Colorado (utility); Illinois Institute of Technology in Chicago (non-utility); Borrego Springs in San Diego County, California (utility); University of Nevada at Las Vegas (non-utility); and Allegany Power in Morgantown, West Virginia (utility). See Merrill Smith, "Overview of the U.S. Department of Energy's Research and Development Activities on Microgrid Technologies," Presentation at the 2009 San Diego Symposium on Microgrids, September 2009

5.0 INTEGRATED ANALYSIS OF MICROGRID VALUE STREAMS

This section articulates a basic taxonomy of benefits, or value streams, microgrids may provide to New York State. The benefits generally fall under four broad categories: 1) economic, 2) reliability and power quality, 3) environmental and 4) energy security and public safety. The taxonomy illustrates the interactions between benefits and the contribution they make to the microgrid value proposition. The analysis draws from the case studies as well as recent research on microgrids and distributed generation to present these value streams wherever possible in quantitative terms. Opportunities for monetizing the value streams in New York as well as the impact different ownership structures might have on value realization are also considered. While the net gains (or losses) likely to result from an assumed level of penetration of microgrids in New York State is beyond the scope of this report, one of the objectives of this section is to identify the attributes or operating circumstances where the net private and social gain from development of a microgrid is likely to be maximized.

To this end, the first part of this Section catalogs and describes the specific microgrid benefits that fall under each of the four umbrella categories mentioned above. The second part addresses the impact of microgrid ownership structures and geography on the allocation and magnitude of benefits while the third part describes these benefits in more detail and examines opportunities for capturing microgrid value streams within New York State. Finally, we conclude with a discussion of the potential costs associated with microgrids and their treatment under extant regulations.

5.1 Microgrid Value Streams Framework and Summary

The value streams produced by microgrids are derived primarily from two sources: (1) the benefits provided by the specific DER applications that are deployed within a given microgrid and (2) the additional benefits created by the unique configuration of DERs into the microgrid architecture. As small networks that use distributed generation, energy storage and system control technologies, microgrids will provide benefits associated with the particular DER applications and energy distribution design and control schemes deployed. Contextual factors – such as the geographic location of the microgrid on the extant electric grid, local gas and electricity rates, regulatory policies or energy markets, and regional macro-grid power supply mix – will also influence the realization and magnitude of certain microgrid value streams.

A substantial body of research has established the benefits associated with distributed generation and DERs. While many of these benefits flow directly to system owners or hosts – energy cost savings and improved reliability, for example – other benefits are more diffuse and frequently may not be captured by system owners (e.g., the value of reduced CO_2 emissions or electric distribution system deferrals). Unlike single-site applications of DG, a microgrid may create additional value through the exchange of power or heat across multiple sites. By using appropriate electronic controls and aggregating multiple end-user loads a microgrid can combine some of the benefits of the macrogrid (e.g., load diversity and economies of scale associated with aggregated demand) with the benefits of DERs.[291]

The potential benefits provided by microgrids can be bundled into four principal categories: economic, environmental, reliability, and security.[292] Figure 651 provides a basic schematic of these categories and the benefits typically associated with each. These categories are fluid in the sense that certain benefits commonly spill over into multiple categories. For example, reduced line losses simultaneously deliver both economic and environmental benefits and reduced power interruptions can provide both economic (e.g., uninterrupted productivity) and security/safety benefits. A summary description of each category and type of value stream follows below.

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[291] Douglas E. King and M. Granger Morgan, “Customer-Focused Assessment of Electric Power Microgrids,” *Journal of Energy Engineering,* September 2007

[292] See EPRI, Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects (2010).

Figure 5.1 – Microgrid Value Stream Taxonomy

Economic

- ***Direct***
  - Energy cost reductions
    - Reduced purchases of electric generation, transmission & distribution services
    - Reduced purchases of fuel for on-site thermal energy demand
    - Reduced purchases of ancillary services
  - Sales of excess electricity to the macro-grid
  - Participation in demand response programs
  - Provision of ancillary services to the macro-grid
- ***Indirect***
  - Reduced electric T&D losses
  - Deferred electric T&D capacity investments
  - Utility option value for long-term planning purposes
  - Enhanced electricity price elasticity
  - Support for deployment of renewable generation

Reliability & Power Quality

- Reduced power interruptions
- Enhanced power quality

Environmental

- Reduced emissions of greenhouse gases
- Reduced emissions of criteria pollutants

Security and Safety

- Safe havens during power outages

Economic Value Streams

The economic benefits potentially created by microgrids are commonly the critical factor driving deployment decisions. One of the most attractive aspects of a microgrid is the ability to optimize the generation and consumption of electric power and thermal energy over multiple sites, generation resources and loads. While traditional combined heat-and-power systems are optimized across a single facility, microgrids allow CHP systems to be optimized over multiple facilities. Microgrids offer the promise of matching diverse multiple building load and generation profiles into systems that markedly improve overall energy efficiency.

Reduced overall energy costs: depending on the generating technologies deployed, microgrid participants may benefit from reduced overall energy costs in several ways including:

- *Reduced purchases of grid-sourced electricity and utility transmission and distribution services:* through the use of DERs and sharing of power among multiple customers, microgrids may allow participants to eliminate most, if not all, purchases of macro-grid power, avoiding electric generation, transmission and distribution as well as other electric utility bill charges (i.e., reactive power charges, competitive transition charges or other surcharges). Moreover, if employing fuel-free renewable resources like solar PV or wind, participants may benefit from reduced energy market price volatility. Ultimately, the realization of energy cost benefits will depend on the installed and operating costs of microgrid DERs deployed.

- *Reduced fuel purchases for on-site thermal energy supply:* for microgrids that use CHP, an important value stream will come from the useful recovery of waste heat produced by generation sources. Recovery of heat from exhaust or engine cooling jackets for productive purposes such as hot water or space heating, process heat or steam, or as input to a thermally activated cooling system, significantly improves the overall fuel efficiency of an onsite electric power generation facility. This allows microgrid participants to avoid or reduce thermal energy production from on-site boilers, which in New York State typically burn natural gas, coal, or distillate fuel.

Sales of excess power to the macrogrid: microgrids that are interconnected to the extant electric distribution and/or transmission system may be able to capture the value of sales of electric generation either directly to utilities or other electric customers, or into wholesale energy markets managed by the NYISO. Sales of excess electricity to the macrogrid may help microgrids optimize their energy production, particularly if CHP is included and the heat-to-power ratio of microgrid electric and thermal supply is not coincident with microgrid electric and thermal demand.

Participation in organized demand response markets: by virtue of their ability to precisely control sources of supply and demand in response to market or other signals, interconnected microgrids may be able to participate in organized demand response markets. In New York State the NYISO manages both reliability- and economic-based demand response programs. These programs pay customers (or microgrids) with the ability to curtail their electricity consumed from the grid on demand either by shutting off non-essential equipment or by using on-site DG. Reliability-based programs call on participating customers to shed load during emergency periods when power supply may not be able to keep up with demand. Economic-based programs allow customers to bid their demand reduction into day-ahead energy markets to compete directly with power supply resources.

Reduced purchases or provision of transmission and distribution ancillary services: broadly speaking, ancillary services are functions performed by electrical generating, transmission, system-control, and distribution- system equipment and people to support the basic operations and services of electric generating capacity, energy supply, and power delivery. Ancillary services can include reactive power[293] and voltage control, energy loss compensation, scheduling and dispatch, load or demand following, and energy imbalance, among others. In New York State, the NYISO administers markets for ancillary services at the transmission level including regulation, voltage support and black-start service, while utilities manage ancillary services at the distribution level.

The ability of microgrids to precisely control interconnected loads and manage customer voltage profiles can reduce the distribution utility's cost of providing reactive power and voltage control at microgrid participants' locations.[294] Moreover, microgrid participants may be able to avoid utility reactive power charges, which are now being implemented in New York to encourage customer power factor improvement to reduce electric system line losses. Microgrids may also be able to provide certain ancillary services to the macro-grid. In some cases, such as regulation service, reserves and black-start support, microgrids with the proper configuration may be able to receive financial remuneration from utilities or the NYISO for providing these services to the grid.[295] The provision of these services, however, may come at the expense of using microgrid capacity for serving internal loads and should be assessed on a case-by-case basis.

Reduced electric transmission and distribution losses: when electric current moves through the power distribution system, it encounters resistance from every system component it flows through, which produces heat and results in efficiency losses. In New York, these losses average 5-10% of power delivered to the transmission system from generating stations (i.e., net electricity produced), depending on the age of the system and the degree of electric loading on the lines. By removing load that would otherwise be served by the macrogrid, microgrids can help reduce these losses, providing indirect social benefits in the form of capacity market savings. While microgrids have the potential to reduce losses when compared with typical grid supply, they will not eliminate them entirely as losses are inherent in all devices electric current passes through. Microgrids can reduce T&D losses to about 3% of

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[293] Reactive power is that portion of electricity that does not perform work in an alternating current circuit, but that must be available to operate certain types of electrical equipment, such as motors. Reactive power compliments real power (work-producing electricity), which is measured in units of watt-hours. Reactive power consumed by motors and other magnetic equipment during distribution of electricity, must be replaced on the grid, typically by generators or capacitors, in order to avoid causing current and voltage to be out of phase resulting in system losses. See: Pacific Gas and Electric, *Resource: an encyclopedia of energy utility terms*, Second Edition, 1992.

[294] S. Chowdhury, S.P. Chowdhury, and P. Crossley, *Microgrids and Active Distribution Networks,* Institution of Engineering and Technology: London, United Kingdom, 2009

[295] Information on ancillary service markets managed by the NYISO is available at: http://www.nyiso.com/public/markets_operations/market_data/ancillary/index.jsp (accessed on March 30, 2010)

net power produced with the amount of the reduction varying with the distance the power must be transmitted to loads.

Deferred or avoided electric transmission and distribution capacity investments: Electric utilities must invest in the transmission and distribution system so that there is always enough physical capacity to reliably deliver the amount of power required by interconnected customers. Utility T&D capacity investments – high-voltage transmission lines, lower-voltage feeders or transformers to expand substation capacity, for example – are typically "lumpy" (i.e., occur in relatively large segments of capacity) and can come at significant capital cost. It has long been recognized that DERs and other customer demand reducing activities, like energy efficiency investments, can be used to avoid or defer these investments. By removing load that would otherwise be served by the macrogrid, microgrids can help to reduce peak demand or system load growth and similarly help utilities avoid or defer new power delivery capacity investments. Such deferrals can produce financial value to both utilities (e.g., reduced capital budget, lower debt obligations, a lower cost of capital) and ratepayers (i.e., lower rates).

Concern about modernizing the nation's infrastructure has become a critical priority in the United States and is likely to remain so for some time into the future. This concern is especially acute for several electric utilities in New York State, which is likely to require large capital investments in infrastructure upgrades over the next two decades. For example, Con Edison has increased its capital expenditure spending from about $1.4 billion per year in 2005 to $2.5 billion per year in 2008.

> The five percent rate increase in the 2008 rate decision included a 9.1 percent return on equity and some capital expenditure disallowances. Wall Street has reacted by dropping the Company's stock price to the lowest among peers, and in March 2009 was only trading at about the stock's book value. CECONY's [Consolidated Edison Company of New York] credit rating has also been reduced. A $2.5 billion (or greater) capital budget is probably not sustainable unless rates are increased by more than 5 percent per year . . .With CECONY's asset base growing at close to 10 percent per year, annual rate increases of substantially more than five percent would be required to ensure long-term access to market funding.[296]

Utility option value for long-term planning purposes: Utility transmission and distribution capital investment decisions are made as a consequence of demand forecasts that have a certain degree of risk. If the projected demand does not materialize, the utility and its ratepayers may have invested in an uneconomic asset. Because of the nature of utility revenue recovery, ratepayers will absorb much of the costs of uneconomic capital investments. Using microgrids to defer utility investment provides the utility (and ratepayers) greater control over its exposure to changing market conditions in the future. The longer lead times required for most non-utility owned microgrids, however, may diminish this value.

Enhanced electricity price elasticity: Through the use of dispersed generation, microgrids may be able to provide value to all ratepayers in the form of enhanced electricity price elasticity. By reducing its consumption of electricity from the macrogrid, particularly when system demand is high, microgrids may be able to reduce the output from high marginal cost or "peaking" plants, thereby reducing the clearing price for electricity in wholesale energy market or reducing the marginal cost of energy consumed (in a vertically integrated, cost of service environment). Given the uniform pricing principles adopted across organized US power markets (i.e., each customer within a given customer class pays the same rates), this means that other consumers – including ratepayers of utilities - will benefit too. Other wholesale "power" market benefits include mitigating capacity shortages and minimizing peaking plant owners' market power (effectively by expanding the pool of competition that existing plant owners face). Microgrids can receive compensation for providing these services in the NYISO's Installed Capacity (ICAP) and demand response programs.

Enable greater use of renewable generation: through the use of advanced control systems, demand response and other generating sources that have good load following capabilities (e.g., reciprocating engines or fuel cells), microgrids may enable greater use of intermittent distributed renewable technologies both within the microgrid and possibly for separate grid-connected systems. Microgrids located near utility-scale renewable power facilities may be able to support the NYISO in managing variations in output from typically intermittent resources, such as wind or

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[296] The Liberty Consulting Group, "Final Public Report to the Management Audit of CECONY New York Public Service Commission," CASE 08-M-0152, June 16, 2009

solar. Additionally, by improving energy efficiency and reducing the amount of electricity delivered by utilities, microgrids may reduce the cost of meeting the state's renewable energy target of 30% by 2015. Microgrid participants may benefit from the integration of renewables particularly if net-metering policies that provide microgrids with retail-level credits for exports apply or if the renewable energy credits produced by the microgrid may be sold into either voluntary markets or for use by regulated entities in the renewable portfolio standard program. Additionally, the integration of renewable technologies and fuels into a microgrid could reduce participant exposure to future carbon regulation and cost.

Reliability and Power Quality Value Streams

Sophisticated electronics are playing an increasingly important role in business and our everyday lives. This equipment is sensitive to power quality (i.e., voltage fluctuations or imbalances and harmonics) and requires more reliable sources of power. Still, while higher overall power quality and reliability is arguably an economic good, not all consumers of electricity require or are willing to pay for the same high level of service. It may also be that only a portion of a customer's electricity demand is considered "uninterruptible" or particularly sensitive to power quality conditions. With the capability of providing varying and customized levels of power quality and reliability to interconnected loads, microgrids may be able to deliver tailored power quality and reliability to these loads at a lower overall cost than providing it at high levels universally.

Reduced power interruptions: Power reliability is a critical issue for many electricity consumers, representing a significant business, safety and health risk to their operations. There are also social costs to unreliable power with estimates for lost productivity ranging from $80-120 billion per year nationally and as much as $9 billion per year in New York. For many power customers, the risk of losing power at critical times, even if just momentarily, compels them to install uninterruptible power systems or back-up generation. Thus, an important potential benefit of microgrids to participants – and a frequent driver of investment – is the improved electric reliability that comes with the ability to isolate internal loads from the macro-grid during outages or other events. The magnitude of this value to participants will vary depending on the type of customers involved. In fact, the incorporation of a range of reliability requirements into a microgrid can enhance the economics of reliability by allowing shedding of low priority loads in favor of high-value critical loads reducing the capacity required to serve internal loads when operated independent from the grid. Additionally, microgrids may also provide reliability benefits to the macro-grid by reducing loads in areas with limited capacity or that are suffering from transmission or distribution congestion.

Enhanced power quality: Power quality typically refers to the characteristics of voltage delivered to end-users. When voltage or current levels deviate from specified standards, equipment can be damaged or fail resulting in economic losses to customers. It has been demonstrated that through the use of modern power electronics (i.e., static power converters and rectifiers that convert "raw" power into a precisely regulated waveform), microgrids can provide integrated power supply with different levels of power quality, including carefully controlled voltage and frequency levels or different classes of alternating current or direct current power.[297] This kind of control over the quality of power delivered to end-users can provide valuable benefits to loads with little tolerance for voltage deviations. Additionally, in certain circumstances and with the appropriate generating sources and power quality control devices, microgrids may be able to provide voltage support by injecting reactive power into the local distribution system. This may be particularly beneficial to distribution systems that use long radial feeders, which frequently suffer from voltage or frequency irregularities.[298]

Environmental Value Streams

Microgrids have the potential to reduce the environmental impact of energy use through the integration of low or zero emissions generating technologies and by increasing the overall efficiency of the energy delivery system. As noted above, producing power closer to the point of consumption reduces electric system losses and the emissions associated with those losses, which are a function of the regional power supply mixture that microgrid load would otherwise be reliant upon. Similarly, microgrids can facilitate the use of waste heat produced by some generating

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[297] Afzal Siddiqui, H. Asano, N. Hatziargyriou, C. Hernandez and C. Marnay, "Microgrids: Engineering and Economics," SPIN Springer, May 2008

[298] Robert Lasseter et al., *Integration of Distributed Energy Resources: The CERTS MicroGrid Concept*, LBNL-50829, Berkeley: 2002

units, which effectively doubles the efficiency of primary energy use and can lead to the avoidance of thermal energy supplies from on-site boilers. We've identified two specific environmental value streams associated with the potentially improved emissions profiles of microgrid systems.

Reduced emissions of carbon dioxide (CO_2): The potential and magnitude of microgrid CO_2 emissions reductions will be a function of the fuels and overall efficiency of supply technologies deployed within the microgrid as compared to the power and thermal energy supplies the microgrid is displacing. Because CO_2 is largely an unregulated pollutant, the value of reductions represents a positive externality (i.e., a benefit to society for which the microgrid does not receive direct compensation). Until CO_2 is a more broadly regulated pollutant (i.e., through the establishment of a national cap-and-trade program or a carbon tax) reduced emissions will not represent a significant or reliable value stream for microgrid owners or participants. Investment in a low-carbon microgrid, however, can reduce the risk to participants associated with potential near- or medium-term regulations on carbon emissions. Microgrids may also be a valuable near-term pathway to deliver CO_2 reductions to achieve public policy objectives (e.g. New York City's goal of reducing local government emissions by 30% from 2006 levels by 2017).

Reduced emissions of criteria pollutants: Criteria pollutants are air pollutants – notably ozone, particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), and sulfur dioxides (SO_2) – that are federally regulated, using human health or environmentally based criteria for setting permissible levels. At certain concentrations these pollutants can have deleterious effects on human respiratory systems (i.e., asthma) or the environment (i.e., acid rain and global warming). To the extent microgrids incorporate CHP that displaces the use of building boilers burning coal or residual fuel (No. 4 or 6 oil), which is common in New York State, microgrids can provide significant local reductions in emissions of NOx, SO_2 and PM. Namely because more energy is being produce on site, microgrids using combustion technologies that burn fossil fuels may, in some cases, result in a net increase site emissions. Still, the extent of the increase will depend on the fuel sources and combustion technologies used.

Security and Safety Value Streams

Microgrids have the potential to provide public security and safety benefits in the form of improved overall electricity system resilience while also serving as safe havens during extended power outages. Facilities that receive energy from microgrids capable of separating and operating independently from the macro-grid can serve as community refuges during emergencies or long-term grid outages. Similarly, by reducing reliance on the macrogrid and remote sources of power, microgrids may make it a less appealing target for terrorist attacks. Finally, a high penetration of microgrids could improve the robustness of the macro-grid by containing disruptions and possibly limiting cascading outages. These benefits, while highly valuable, appear infrequently and are extremely difficult for microgrids to monetize.

5.2 Influence of Microgrid Ownership and Geography on Value Realization

5.2.1 Microgrid Ownership and Benefits

Microgrids benefits may accrue to the project owner, participants or hosts, non-participating electric customers located nearby on the distribution system, the utility, the regional grid, or society as a whole. Table 6.1 below identifies, for illustrative purposes, the distribution of selected microgrid value streams to either participants/owners, utilities and society.

Table 5.1 – Microgrid Value Stream Distribution (illustrative)

Benefit Class	Participant	Utility	Society	Specific Benefit
Power Reliability	X			Reduced power outages on-site
Power Quality	X			Voltage stability
Economic (indirect)	X		X	Lower demand and energy losses
Economic (indirect)		X	X	Reduced system congestion costs
Economic (indirect)		X	X	Higher T&D capacity use

Economic (indirect)		X		Reduced operating reserves
Environmental			X	Lower SOx, NOx, CO2 emissions
Security & Safety	X		X	Avoided major system outages

The ability of a microgrid owner or developer to capture certain value streams will have a direct bearing on the decision to invest. For example, non-utility microgrids will be driven primarily by the opportunity to improve electric reliability and reduce or control the direct energy costs to participants. They may also provide valuable emissions reductions benefits to interconnected users that fit into customers' long-term strategic plans or public relations efforts. Due to the high transaction costs and immature markets for emissions credits, the economic benefits of these environmental value streams may be difficult for microgrid owners to capture, resulting instead in uncompensated social benefits. Similarly, the benefits that interconnected non-utility microgrids may provide to the macrogrid, in terms of deferred utility capital expenditures may also result in uncompensated social benefits.

The Burrstone Energy Center located Upstate in Utica, NY provides 80% of the annual electrical usage of participants and reduces peak macro-grid demand by more than half for all three of the customers tied to the microgrid. Economic benefits in the form of avoided grid-sourced power purchases and on-site thermal energy fuel expenditures were a major driver of the Burrstone project, but this benefit is shared by the Independent Owner/Provider through an energy services agreement. The magnitude of the direct economic benefit in terms of energy cost savings might be greater if it was cooperatively owned by St. Luke's and Utica College, but third party ownership relieves these entities of the significant capital expense of microgrid development – approximately $15 million in this particular case. Table 6.2 below highlights the distribution of some of the value created by the Burrstone project.

Table 5.2 – Burrstone Microgrid Participant Benefits

Participant	**Peak Demand Reduction**	**Annual Energy Cost Savings**	**Reliability and Security**
Hospital	98%	**$500,000**	**Operated system during six-hour forced outage**
College	60%	**$300,000**	
Nursing Home	50 to 60%	**$500,000**	

Green = Society Benefit **Blue** = Participant Benefit **Orange** = Mutual Benefit

Utility owned microgrids, by comparison, may be driven primarily by the desire to deliver more reliable or better quality power (i.e., premium power) to certain end users or accommodate increasing amounts of renewable generation on distribution networks. Nevertheless, unless utilities can find a way to capture the energy supply benefits of DERs, they are unlikely to make investments in vertically integrated microgrid systems (see Section 4.0 above). Con Edison has identified this inability capture energy benefits as a major impediment to utility investments in DERs, a barrier that translates to microgrids as well.

A more likely form of utility owned microgrid would be unbundled, where utilities own the distribution facilities and interconnected customers or third parties own generating assets. Still, the business case for this kind of utility system has yet to be fully developed, and raises issues regarding utility control of multiple non-utility generating assets on their system. A system of this type is being demonstrated in Borrego Springs, California, where SDG&E is in the process of developing a microgrid with advanced battery storage, customer-sited photovoltaics and price-driven demand response to solve a rural T&D constraint (see SDG&E case study in the Appendix). A major goal of the project is to test whether microgrids make economic sense as an alternative to traditional utility T&D investments.

5.2.2 Distribution of Benefits By Geography

Generally speaking, the distribution of benefits can be expressed as a series of rings of expanding geographic distance around the microgrid, which correspond to specific value streams at each level – the microgrid site, the network that the microgrid is interconnected to (if it is), the utility service territory, the regional power grid, and so on. At the microgrid site benefits include energy cost savings, reduced power interruptions and enhanced power quality. Microgrid projects operating at the right times and at the right locations of stressed portions of the distribution system may also provide capital cost reduction benefits. This should be an attractive benefit for certain areas of New York, particularly downstate, as distribution capital costs in are a key factor driving utility revenue requirements and retail rates. This type of benefit is presently an uncompensated gain for the local utility and ratepayers that occurs as a positive side effect in the locality of the microgrid.[299] Other "localized" microgrid benefits that would potentially accrue to end-users other than the site owner include enhanced power quality and reduced power outages.

Another set of benefits accrues beyond the immediate locale but remains within a specific region. This set includes potential air quality benefits from the reduction in criteria pollutants that are regionally transported, reduced energy demand that would put downward pressure on zonal wholesale prices, increases in utility asset usage that improves the productivity of the entire system and so on. Finally, there are national and international benefits, particularly greenhouse gas reductions, which can be separately identified and in some cases quantified.

The magnitude of benefits that flow from microgrids is also a function of the deployment context and geographic location. For example, the magnitude of electric generation cost savings for participants will be a function of local and regional energy markets and the pool of generation resources on which these markets rely. On average, these costs are higher downstate than upstate. Similarly, the environmental benefits of a microgrid will partly be a function of local or regional generation. Due to transmission constraints and the need for electric generating capacity to be located within the New York City load pocket, downstate New York is more reliant on fossil fueled generation than areas upstate. This may mean that a MWh displaced by a microgrid downstate will be more valuable in terms of reduced air emissions than a similar microgrid situated Upstate; however, the emissions reductions achieved will also depend on the production resources deployed by the microgrid. To illustrate this point, Table 5.3 below shows the carbon dioxide equivalent emissions factors of the EPA's eGrid sub-regions for New York State for total resources, combustion-only resources and non-baseload resources.

Table 5.3 – CO_2 Equivalent Emissions Factors for eGrid Sub-regions in New York State (2005)

eGrid Sub-region	Carbon Dioxide (CO2) equivalent (lb/MWh)		
	Overall	Combustion	Non-baseload
NPCC NYC/Westchester	817.9	1,456.32	1,529.06
NPCC Long Island	1,544.83	1,544.83	1,514.46
NPCC Upstate NY	724.79	1,561.44	1,520.77

Source: EPA (2010)

While the scale of microgrid benefits tends to be much greater downstate in dense urban centers, there are also potentially valuable applications for rural locations. For example, Central Hudson recently installed a diesel-fueled reciprocating engine to allow islanding of a substation area serving a rural community via a single radial feeder. Although it produces more air emissions that central station power plants, locating the engine in this area allows Central Hudson to keep the village's lights on during periods of maintenance or when sections of the line are interrupted. It also allows the utility to avoid expensive overtime work schedules to repair a downed line to restore service; now the community can receive continuous service and repairs can be made at a lower cost to the utility. Similarly, the SDG&E project mentioned above, is intended to reduce peak load on the feeder serving the community and demonstrate intentional islanding of at least one of the substation area circuits. If the initial phase of the demonstration is successful, SDG&E intends to add enough DER capacity and customer demand response to

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[299] The DLRP and demand response programs were supposed to provide opportunities to monetize the value of T&D deferral. The program's design – specifically, the 100% physical assurance requirement—has effectively precluded DG/DER projects and microgrids from participating in these programs.

island the entire substation area, allowing crews to work on the feeder without disrupting power service to Borrego Springs.

5.3 Opportunities to Monetize Microgrid Value Streams

As indicated above, the value streams created from the deployment of microgrids are not universal, but reflect various site-specific factors like location, operating schedules, system design and so forth. Below we examine the range of potential benefits microgrids may bring to New York State and discuss the opportunities for developers and/or owners to monetize these benefits. By "monetize" we mean that there are either markets or mechanisms in place through which benefits that create value can be captured by microgrid owners – such as through the receipt of payment for a service provided, or by avoiding costs microgrid participants or owners would otherwise incur. Where possible, we use examples from the case studies and other research to demonstrate whether and how certain microgrid values streams are materializing for specific projects.

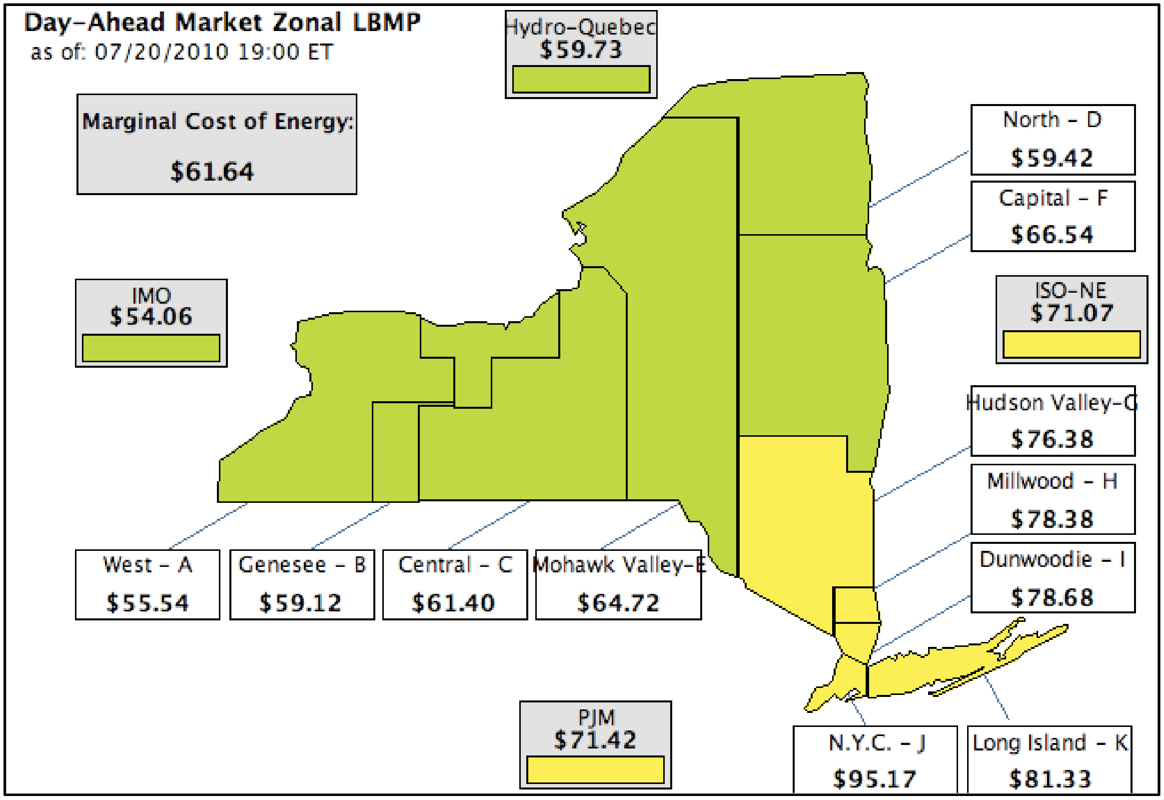
5.3.1 Economic Value Streams

5.3.1.1 Reduced purchases of grid-sourced electric generation, transmission & distribution services

From the perspective of participating customers, one of the most important value streams associated with microgrids is the avoidance or reduction in purchases of macro-grid electricity and transmission and distribution services. Microgrids produce savings to their participants when the average cost of internally generated power is less than grid-sourced power. The ability of microgrids to deliver economic value to participants and/or system owners by bypassing or reducing purchases of grid-derived power will depend on a number of factors including: the cost and performance characteristics of the generating technology used by the microgrid; fuel costs (if any); capital carrying costs; and the cost of grid-based power and utility tariffs, which will vary by utility service territory and the microgrid's location within the state electric system.

In New York State, electricity is traded through the NYISO, which manages both day-ahead and real-time energy markets across 11 zones (designated A through K). The price of energy within each zone is set by a location-based marginal price (LBMP), which reflects the cost of the last unit of electricity traded in the market. As with any competitively traded commodity, the price of electricity in NYISO markets is a reflection of available supply and demand – the generators with the lowest operating costs are dispatched first and as demand increases, power plants with increasingly higher marginal costs are called on to supply power to the market. The marginal cost of the last plant called on to supply power to the market sets the price for all generators. The current or projected (e.g., day-ahead) commodity price of electricity can be used to ascertain a given microgrid's avoided generation value on an hourly basis. Higher average electricity prices – partly due to transmission constraints and a limited ability to build new facilities within the New York City and Long Island areas – make avoided electricity consumption downstate more valuable on a $/MWh basis than avoided purchases upstate. Figure 5.2 below, which shows NYISO zonal prices for day-ahead wholesale energy, illustrates this point.

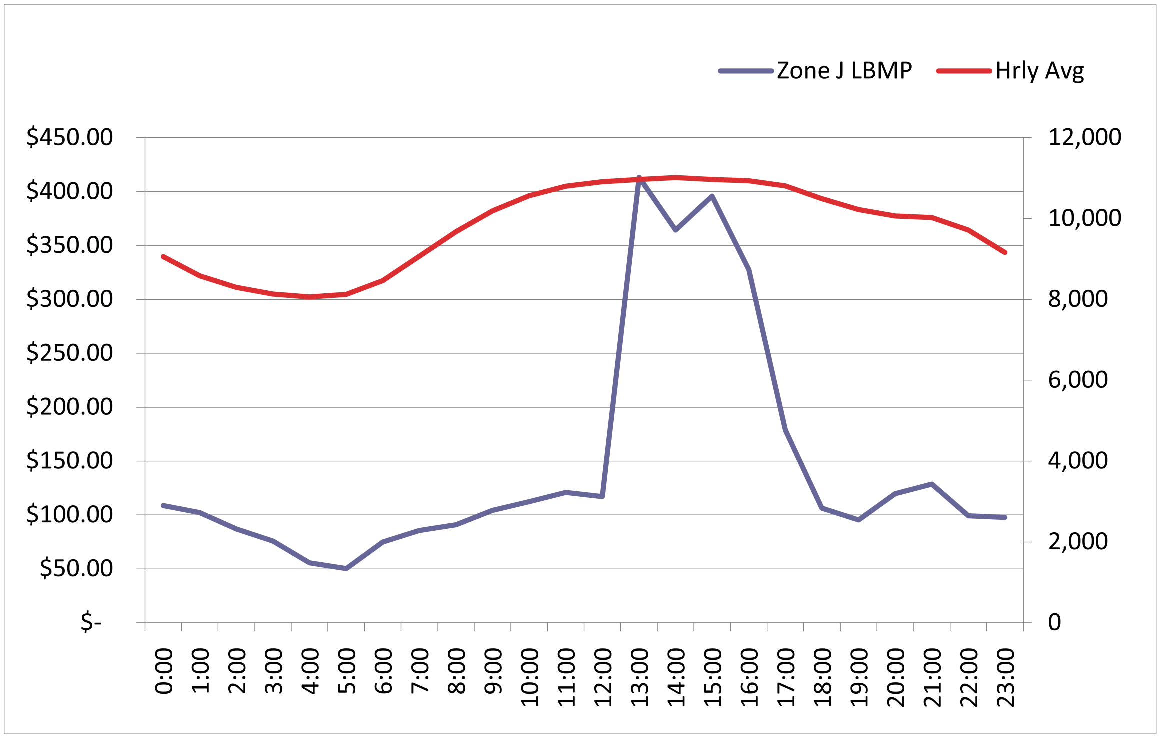
Figure 5.2 – NYISO Day-ahead Zonal Energy Prices



Source: NYISO (2010)

Day ahead prices for a mid-week day in July shows a price differential for energy delivered into New York City that is $30-40/MWh more than power delivered into NYISO zones upstate. For microgrids that are interconnected to the macrogrid and capable of importing power, operation of generating and other assets (e.g., storage and demand response) can be coordinated to maximize the value of the cost differential between internally produced power and purchases from the grid. Because grid power prices peak during the day when demand is greatest, microgrids may benefit most by self-generating during these periods and purchasing electricity from the macro-grid during off peak periods. Figure 5.3 below shows the hourly real time price of energy in NYISO Zone J (NYC) on a recent hot summer day when peak prices were eight times higher than off peak.

Figure 5.3 – Zone J (NYC) Hourly Average Demand and Real Time Electricity Price (July 7, 2010)



Source: NYISO (2010)

Princeton University in western New Jersey, which operates a campus microgrid system, uses predictive pricing to determine when its generating resources should be dispatched, or when and how much power to self-generate or purchase from the grid. Princeton's system incorporates a number of factors including hourly wholesale electricity prices in the PJM interconnection, NYMEX fuel prices (e.g., natural gas), real time campus load, and weather forecasts. The University purchases power from the grid when prices are low (i.e., there are excess supplies on the grid) and generates power when prices are high (i.e., supply is limited and the grid is stressed).[300] By arbitraging its microgrid assets against fuel and real-time power prices, Princeton University has reduced its overall energy costs by an estimated $2.5 to $3.5 million annually.[301] It has also reduced demand on the grid when supplies are most scarce and prices highest, providing an indirect benefit to other consumers (see Figure 5.4 below).

5.3.1.2 Reduced purchases of fuel for on-site thermal energy demand

In the process of generating electricity, as much as 70% of the primary energy consumed ends up as heat, which is often vented into the environment. A major source of economic value for microgrids today will come from capturing and using the "waste heat" produced by integrated fuel-based generators, typically burning natural gas. Microgrids that employ CHP can create value for participating loads in the form of avoided purchases of fuel or electricity for on-site thermal energy demand (i.e., both heating and cooling). By capturing the heat by-product of thermal electric generation, CHP-based microgrids can offset all or a majority of site hot water and space heating loads, and if using heat activated air conditioning (i.e., absorption chillers) site space cooling loads. The latter is particularly important in New York if a microgrid is to make use of waste heat during the summer months.[302]

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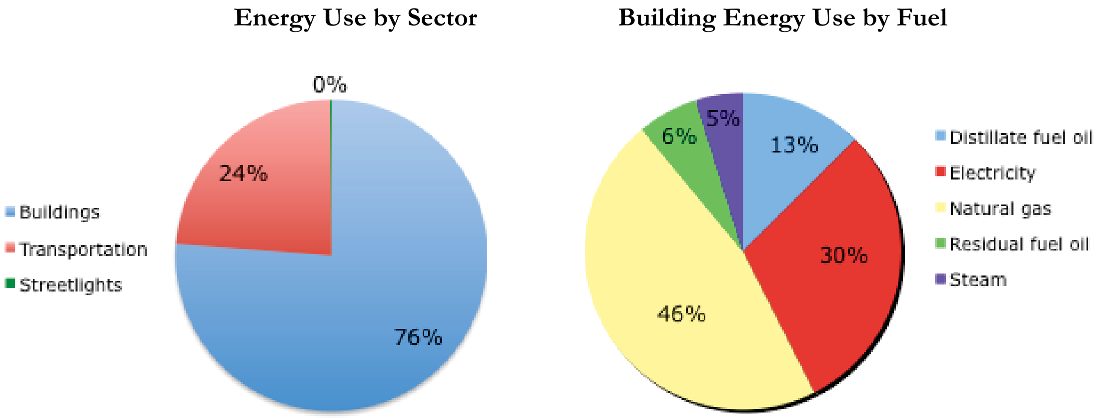
[300] Thomas Nyquist, "Princeton University and the Smart Grid, CHP, and District Energy," Presentation at *US EPA Combined Heat and Power Partnership*, October 2009.

[301] Nyquist, Princeton's CHP System, p. 13.

[302] Lily Parshall, Hildigunnur Jonsdottir, Stephen Hammer and Vijay Modi, "Spactio-temporal patterns of energy demand in New York City and implications for cogeneration," Draft Working Paper, January 3, 2010.

There are significant opportunities for microgrids to displace traditional building thermal energy supplies in New York, particularly downstate. In New York City, buildings use more than three-quarters of the total energy consumed.[303] As Figure 5.4 below indicates, only 30% of this energy is electricity, meaning that the majority of building energy demand – particularly space heating and hot water - is supplied by fuels combusted in boilers on-site.

Figure 5.4 – Energy Use in New York City (MMBtu)



Source: New York City Mayor's Office (2009)

A recent review of the number of buildings with on-site boilers burning distillate oil (i.e., No. 2 oil), residual oil (i.e., either No. 4 or No. 6 oil) or coal in the Northeast region indicated there were over 10,000 such units registered in New York State.[304] Moreover, more than 90% of these boilers are located in New York City, where they consume approximately 87,000,000 MMBtu/year. While the burning of coal has long since been phased out in New York City, most of the nearly 10,000 boilers identified in the study (99%) burn either No. 4 or No. 6 fuel oil, both of which are highly polluting and increasingly expensive when compared to natural gas. Today, prices for these fuels hover around $20/MMBtu and the EIA forecasts average residual and distillate oil prices between $15 and $20/MMBtu over the 2010-2020 period. By comparison, the EIA forecasts natural gas rates (firm) of approximately $11/MMBtu over the 2010-2020 period.[305]

EPRI has estimated that 35% to 40% of the value of displaced fuel can be captured through the use of CHP, depending on the technology and application.[306] For example, at a fuel cost of $10/MMBtu and recovery of 40% of the energy input as heat produced by the prime mover, an additional $0.05/kWh of value may be captured.[307] Moreover, with gas prices currently around $5/MMBtu (New York City Gate Spot), switching primary heating fuels from fuel oil to natural gas can provide even greater savings. Microgrids using combined cooling, heating and power have an even greater potential to provide these kinds of savings than traditional CHP/CCHP applications. While traditional CHP systems are frequently designed to meet the thermal energy requirements of a single facility, microgrids allow thermal and electric power production to be optimized over multiple facilities, which can provide scale economies and allow higher percentages of useful heat recovery. The Burrstone Energy Center in Utica, NY, for example, provides energy services to Faxton-St. Luke's Hospital, St. Luke's Nursing Home and Utica College (see Figure 5.5).

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[303] New York City Mayor's Office of Long Term Planning, *Inventory of New York City Greenhouse Gas Emissions, 2008*, September 2009

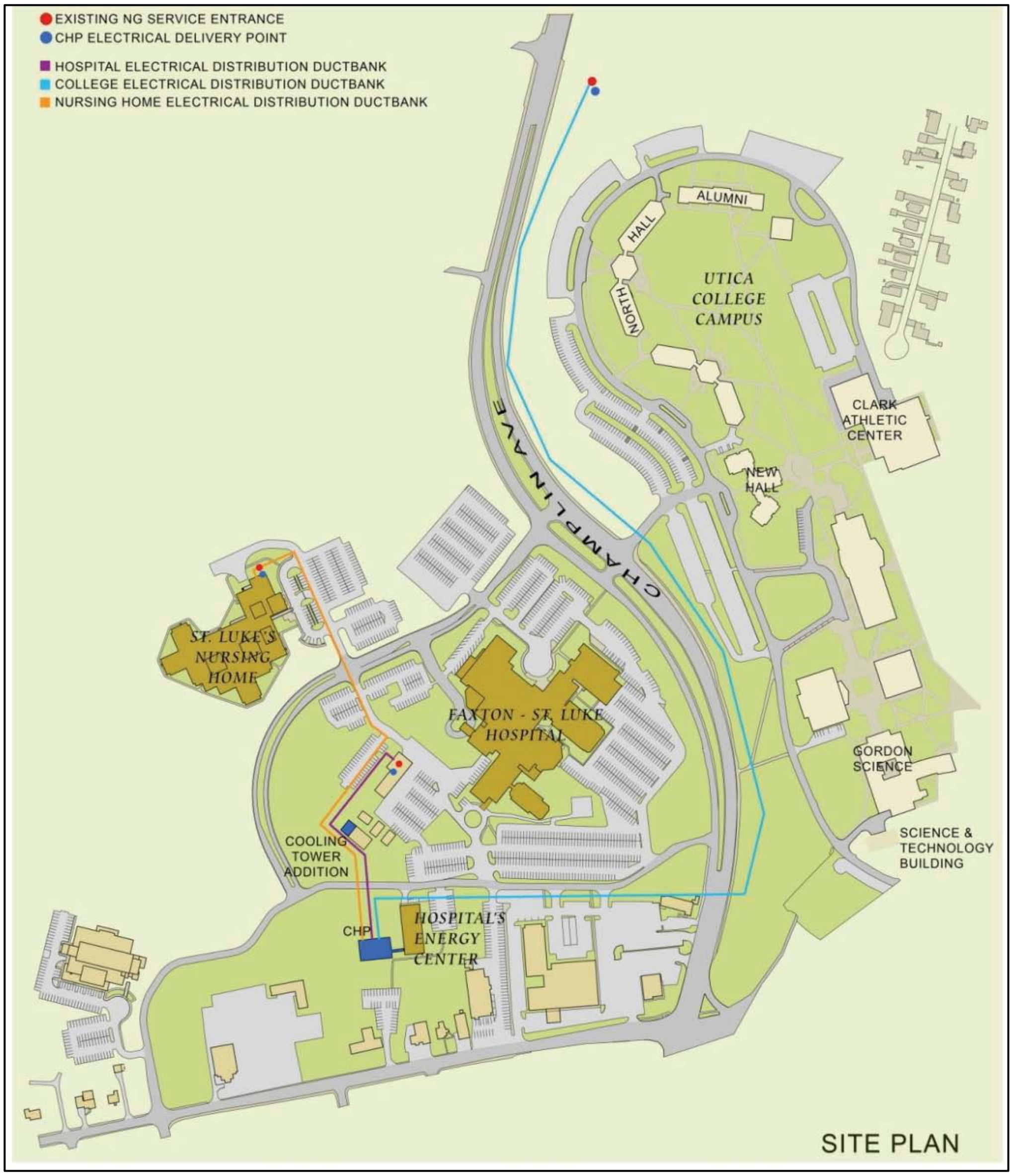
[304] This is approximately four times the total number of permitted boilers in both New Jersey and Connecticut and almost ten times the number in Massachusetts. See: ICF International, "Expanding Small-Scale CP Opportunities Through the More Efficient Use of Trading Programs: An Analysis of Market Opportunities and Regulatory Issues," Prepared for the New York State Energy Research and Development Authority, August 2009.

[305] Environmental Defense Fund and the Urban Green Council New York, "The Bottom of the Barrel: How the Dirtiest Heating Oil Pollutes Our Air and Harms Our Health," December 2009

[306] EPRI, *Economic Costs and Benefits of Distributed Energy Resource: Technical Update,* Palo Alto, CA, 2004. 1011305, p. 30

[307] Ibid.

Figure 5.5 – Burrstone Energy Center Site



Source: Burrstone Energy Center (2010)

The thermal demand of the hospital is large enough to be able to use all of the waste heat generated by the microgrid's four gas-fired internal combustion engines, which supply power to all end users. The Burrstone Energy Center is expected to provide participants savings of 15-20% from their annual utility energy costs. Such microgrids allow for matching multiple and diverse building thermal and electric load profiles into systems that can markedly improve the overall efficiency of energy use and displace fuel purchases for on-site thermal loads.

5.3.1.3 Reduced purchases of ancillary services

Ancillary services are required to hold the operation of the grid – generation, transmission and distribution – in balance. They are critical for maintaining the integrity, quality and operational security of electric service.

For microgrids interconnected at the distribution level, reactive power and voltage support is an ancillary service of increasing significance. Reactive power is that portion of electricity that does not perform work in an alternating current circuit, but that must be available to operate certain types of electrical equipment, such as motors and the ballasts of fluorescent lights. Reactive power, which is measured in units of volt-ampere-reactive (Var) compliments real power – the work-producing electricity, measured in units of watts. Inductive loads like wires, motors and transformers make electric current lag behind voltage, consuming reactive power and reducing the "power factor." The power factor is the fraction of delivered power that can do work (i.e., it measures how much power being drawn by a load is "real" power) with 1.0 the ideal. Power factors less than 1.0 can cause voltage drops and increase grid losses. As a result, utilities must replace the reactive power consumed in their systems, usually with capacitors or certain types of generators.[308]

In 2008, the PSC established a proceeding to examine how the state's utilities could reduce such electric system losses. Under that proceeding, the PSC directed the utilities to file amended tariffs implementing reactive power rates and provisions. In separate decisions issued in September 2009 and February 2010, the PSC approved revised tariff filings for Niagara Mohawk Power (d/b/a National Grid), New York State Electric and Gas Corporation, Con Ed, Orange and Rockland Utilities, Central Hudson Gas and Electric Corporation and Rochester Gas and Electric Corporation. The utilities' new tariff provisions require large customers in their service territories, beginning in 2010, to pay a reactive power charges if the customer's power factor is below a certain threshold (e.g., 95%). The charges for the different utilities, based on the avoided marginal cost to each utility of installing capacitor banks to supply reactive power, are as follows in Table 5.4. Some utilities charge for reactive power based on the monthly demand (kVar) whereas others charge based on the metered hourly reactive power usage (kVar-h).

Table 5.4 – PSC Jurisdictional Utilities' Reactive Power Charges

Utility	Applies to Customers with…	Applicable Service Classifications	Reactive Power Demand Charge(s)
New York State Electric and Gas Corporation	Peak monthly demands >200 kW and power factors <97%	Service Classifications 2 (General Service with Demand Billing), 3 (Primary), 7 (Large TOU)	$0.00078/kVar-h
Niagara Mohawk Power Corporation	Peak monthly demands >500 kW for three consecutive months and power factors <95%	SC-3 (Large General Service)	$0.85/kVar
		SC-3A (Large General Service TOU)	$1.02/kVar
Rochester Gas and Electric Corporation	Peak monthly demands >1,000 kW (year 1), >500 kW (year 2) and >300 kW (year 3) and power factors <97%	SC 8 (General Service TOU) and SC 14 (Standby Service)	$0.00127/kVar-h
Central Hudson	Peak monthly demands >1,000 kW and power factors <95%	S.C. No. 3 (Primary) and S.C. No. 13 (Substation & Transmission)	$0.83/kVar
Orange and Rockland Utilities	Peak monthly demands >1,000 kW (year 1) and >500 kW (year 2) and power factors <95%	Service Classification Nos. 2, 3, 9, 15, 20, 21, 22, and 25	$0.40/kVar
Consolidated Edison	Peak monthly demands >1,000 kW (year 1) and >500 kW (year 2) and power factors <95%	SC 8, 9, and 13	$1.10/kVar

The purpose of these charges is to encourage electric customers to take responsibility for the use of reactive power. Electric customers can mitigate these costs several ways. One method involves the use of power factor correction capacitors or self-commutated inverters (which can perform at a wide range of power factors) installed on customer premises to re-align voltage and current so they are in phase.[309] Some energy efficiency projects, such as high

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[308] Pacific Gas and Electric, *Resource: an encyclopedia of energy utility terms*, Second Edition, 1992

[309] For example, Allied Converters, Inc. in New Rochelle, NY, installed power factor correction capacitors to supply reactive power to machinery in its factory. This has improved its power factor significantly, stabilized voltage allowing its on-site generation to operate continuously without risk of over voltage shutdown and reduced its consumption of reactive power from the

efficiency motors designed to achieve better power factors, can also directly improve a customer's power factor. In a microgrid environment, these devices can be used in concert with generators (i.e., those that use inverters such as photovoltics or fuel cells) or electricity storage devices to manage reactive power demand through central controllers.[310]

The cost of self-supplying reactive power includes the capital costs of the correction equipment and signaling devices and, in the case of generators, the foregone supply of real power to interconnected loads.[311] The production of reactive power from a generator comes at the expense of the production of real power, so the use of microgrid generators in this way depends on the economic values of real and reactive power at a particular time. The potential avoidance of new reactive power charges for participating microgrid loads, particularly loads with low power factors, represents a value stream that can contribute to the overall microgrid value proposition. Interconnected microgrids may also create value for their owners/participants by providing similar services to the macro-grid; this is discussed more below.

5.3.1.4 Sales of excess electricity to the macro-grid

If configured properly, and utility interconnection requirements are not too onerous, microgrids may be able to generate valuable revenues by exporting power into the macro-grid. For microgrids employing CHP, the ability to sell surplus power to the grid facilitates greater usage of microgrid installed capacity and can increase the system's overall energy efficiency. Similar to avoided purchases of electricity, the value of excess sales will depend on the location of the microgrid and the time of export.

Since it is likely that the heat and power demand of interconnected loads will not always be consistent with the heat and power output of microgrid production units (i.e., heat-to-power ratio), being able to use the grid as a sink for surplus power can facilitate consistent usage of prime mover thermal output. This is the case for Cornell University's campus microgrid, which was built primarily to provide thermal energy to campus loads. The Cornell microgrid is electrically interconnected to the state transmission system at 115 kV, but because the power output of the University's system follows steam production, which can be highly variable, it cannot participate in NYISO wholesale energy markets without potentially facing under-generation charges (i.e., for not delivering power as scheduled in advance).[312] Still, as a qualifying facility under PURPA, Cornell is able to receive payments from NYSEG based on the LBMP during the hours that it delivers power to the utility (see Cornell case study in the appendix).

While the macro-grid can serve as a useful "sink" for surplus power produced from thermal supply-oriented systems, microgrids that are able to dispatch their generating units in response to energy price signals may be able to earn higher revenues from power sales. For example, Burrstone Energy Center – a microgrid with 3.6 MW of electric generating capacity in Utica, New York – sells excess power to National Grid under a power purchase agreement. Under the agreement, National Grid pays Burrstone the wholesale energy price (i.e., LBMP) that is equivalent to what other generators delivering power in Burrstone's location receive, from the NYISO hourly day-ahead market. Currently, Burrstone's export price is tied to the real time price of imports from West Canada Hydro, which is published by the NYISO.[313]

To operationalize the microgrid's interaction with the wholesale power market, Burrstone developed an algorithm that governs the microgrid control system.[314] Using market prices fed into the algorithm, the microgrid control

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utility. See: Richard Ellenbogen, "Distributed Generation, Customer Premise Loads and the Utility Network – A Case Study," February 2008

[310] The Galvin Initiative, "Master Controller Requirements Specification for Perfect Power Systems," February 2007

[311] Amory Lovins et. al., 2002

[312] Federal Energy Regulatory Commission, "Order Granting in Part and Denying in Part the Application to Terminate Purchase Obligation," New York State Electric and Gas Corporation and Rochester Gas and Electric Corporation, Docket No. QM10-3-000, March 18, 2010

[313] Burrstone believes it is the first cogeneration project to structure this type of "buy-back" contract with a utility, where it is receiving hourly prices as opposed to average LBMPs.

[314] An algorithm is a mathematical method for solving a problem using a process that performs a sequence of operations following a series of instructions.

system will provide signals to the units indicating when to run and when not to run. Similar to Princeton University's system mentioned above, Burrstone's control system will check the NYISO's day-ahead prices and compare against hourly data, unit operating costs and a forecast load profile to determine the strategy the units will operate under. Burrstone's algorithm makes hourly operational decisions that are automatically implemented by the microgrid's Energy Management System.

5.3.1.5 Participation in demand response programs

Demand response refers to changes in typical electric demand patterns by end-use customers in response to: 1) changes in the price of electricity or 2) incentive payments designed to encourage reductions at times of high wholesale market prices or when the reliability of the electric grid is at risk. With the proper controls and ability to quickly shed load or operate generators in response to either internal or external signals, microgrids can receive payments for their participation in New York State's demand response programs.

The NYISO operates two types of demand response programs statewide – reliability and economic-oriented programs. The reliability-oriented programs, including the Installed Capacity/Special Case Resource (ICAP/SCR) program, the Emergency Demand Response Program (EDRP), and the Targeted Demand Response Program (TDRP), are intended to support grid reliability during periods of high system demand. Participants in these programs must be able to provide at least 100 kW of response capacity. Two economic-oriented programs – the Day Ahead Demand Response Program (DADRP) and the Demand Side Ancillary Service Program (DSASP) – allow customers to bid their demand response capabilities into NYISO markets to compete directly with wholesale generators. Minimum size to participate in these programs is 1-MW.

The ICAP/SCR program requires participants to provide demand response for specified contract periods in exchange for both monthly capacity (based on an ICAP auction) and energy payments when grid reliability is at risk. In exchange for these payments, participants are required to curtail their committed loads when called on with at least two hours' notice, if they were notified the day ahead. Interconnected microgrids can commit demand-reducing capacity through the use of integrated generation and/or reducing grid-connected electricity consumption. For example, New York University plans on committing the back-up generating capacity of its Washington Square Park microgrid system to the SCR program, which will provide an additional revenue stream to fund its $125 million upgrade. According to the NYISO, the New York City region has averaged only 15 hours of SCR-eligible events per year over the 2001-2008 period.[315] During this same period, the average energy payment for SCR events was $461/MWh, which is provided on top of the monthly capacity payments. Participants in the ICAP/SCR must provide committed load reductions or face financial penalties for deficiencies.

Similarly, participants in the EDRP program receive payments for curtailing demand on the grid in response to event notification from the NYISO. In contrast to the ICAP/SCR, the EDRP pays only an energy payment – the greater of the real-time LBMP or $500/MWh with a guaranteed 4-hour minimum – and does not penalize enrolled customers for not responding to a call. Microgrids can participate in the EDRP or the ICAP/SCR, but not both. Table 5.5 shows the level of EDRP, ICAP/SCR and TDRP participation and compensation over the 2001-2008 period.

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[315] Donna Pratt, "NYISO's Demand Response Programs," September 2009, Available at: https://www.nyiso.com/public/webdocs/services/market_training/workshops_courses/nymoc/8_demand_response_01_2009.pdf (accessed on March 22, 2010)

Table 5.5 – EDRP, ICAP/SCR and TDRP Event and Payment Summary

Summer	No. of Resources (& Registered MW)	Events	Avg. Hourly Load Curtailed	Payments	Avg. Payment per MWh
2001	292 (712 MW)	23 hours downstate 18 hours upstate	361.2 MWh	$4.2 million	$502
2002	1,711 (1,591 MW)	22 hours downstate 10 hours upstate	319.5 MWh	$3.3 million	$500
2003	1,419 (1,531 MW)	22 hours statewide	635.3 MWh	$7.2 million	$537
2004	2,030 (1,570 MW)	No events	N/A	N/A	N/A
2005	2,356 (1,605 MW)	4 hours downstate	207.5 MWh	$0.8 million	$976
2006	2,575 (1,720 MW)	35 hours downstate 5 hours upstate	357.8 MWh	$8.5 million	$678
2007	2,705 (1,802 MW)	20 hours downstate (TDRP only)	10.91 MWh	$0.11 million	$500
2008	3,711 (2,108 MW)	No events	N/A	N/A	N/A

Source: NYISO (2009)

The TDRP is a newer reliability program (available since 2007) that incentivizes existing EDRP and SCR resources, at the request of a transmission owner, to participate in targeted subzones. Currently, the program is only offered in nine subzones designated by Con Edison in Zone J (New York City). This program allows utilities to only call on resources in specific subareas that are facing reliability problems instead of calling on all resources within an entire zone, even if they are not required.

In contrast with the reliability-oriented programs described above, the DADRP allows customers (or microgrids) to bid load reduction capability into wholesale energy markets. To participate, customers bid their load-reducing capacity, on a day-ahead basis, into the wholesale electricity market, in direct competition with wholesale generators' bids. DADRP participants are treated like a generator bidding into the day-ahead market; winning bidders receive either the settled marginal energy price (LBMP) or their offer price, whichever is greater. Only curtailable load (i.e., no local generation) may participate in this program and non-compliance with a bid is penalized at the greater of the day-ahead or real-time price.

The DSASP program allows microgrids to bid both load reduction and generation into the NYISO reserve market in exchange for the market-clearing price for reserves. Participants are notified by 11:00 AM the day before an event. Participants in the DADRP and DSASP must have at least 1-MW of load reduction or generation capacity available to participate in either of these programs. The penalty for non-compliance with a call to curtail is either the greater of the day-ahead or real-time energy price for the DADRP and the real-time reserve price for the DSASP.

Con Edison is currently the only electric utility to offer separate demand response programs at the local level – the Distribution Load Relief Program (DLRP) and Direct Load Control Program (DLCP). The DLCP is a thermostat-control program operated by Con Edison that offers participating customers one-time incentive payments. The DLRP program provides compensation for demand response provided during network-specific (i.e., substation area) load relief periods designed by Con Edison. The program has both voluntary and mandatory load reduction options. The voluntary option provides an energy payment of $0.50/kWh or the LBMP, whichever is greater, while the mandatory option provides both an energy and a capacity payment. The capacity payment has two tiers - $3/kW and $4.50/kW – with the higher payments to loads located in areas designated by Con Edison as high priority.[316] To participate in these programs single customers must be able to provide at least 50 kW, while aggregated loads must be able to provide 100 kW. While not specifically identified as aggregators, it is likely that microgrids that consist of multiple end use customers will be treated as such for participation in these programs, particularly if they are coordinating their load shedding capabilities.

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[316] Nextant, *DLRP Program Evaluation, Interim Report*, Submitted to Con Edison, February 2008, Available at: http://www.dps.state.ny.us/08E0176_ConEdison_DLRP_ProgramEvaluationInterimReport.pdf (accessed on July 15, 2010)

5.3.1.6 Provision of ancillary services to the macro-grid

In addition to self-supplying ancillary services, microgrids can create value to both owners/participants and the state by providing these services to the grid. In its Order 888, FERC identified six ancillary services required to support the transmission of power from generators to end users including system control, voltage and reactive power supply and control, regulation, spinning reserves, supplementary reserves, and energy imbalance.[317] In New York State, the NYISO manages markets for the following categories of ancillary services.

- *Regulation Service* is the continuous balancing of resources with load (supply with demand) to assist in maintaining the grid's scheduled interconnection frequency at 60 Hz. Regulation service is managed by the NYISO through the dispatch of various resources including generators, Limited Energy Storage Resources and Demand Side Resources.[318] Output or demand is adjusted – mostly through the use of Automatic Generation Control (AGC) – as necessary to follow instantaneous changes in load on the macro-grid. Qualified Regulation Service providers with AGC capability bid into the market and the NYISO selects bidders on a day-ahead basis to provide Regulation Services. Information required from bidders includes the response rate (MW/minute), bid price ($/MW) and availability of response direction (e.g., a bid of 5-MW is a bid to provide 5-MW of regulation up and regulation down). As noted above, microgrids with at least 11MW of regulation capability can participate as a demand side resource.
- *Voltage Support Service (VSS), or Reactive Supply and Voltage Control Service*, is the ability to produce or absorb reactive power and the ability to maintain a specific voltage level. VSS is required to support all transactions on the New York State transmission system and the amount supplied is determined based on the amount of reactive power required to keep the system within specific voltage limits. Resources providing VSS to the NYISO must be able to produce and absorb reactive power. Generally speaking, if a resource cannot absorb reactive power (i.e., operate in "lead" mode), it is not eligible to provide VSS. Aside from large microgrids that are interconnected to the transmission system, most microgrids will not be able to participate in NYISO VSS programs. Microgrids interconnected to distribution systems, however, may be able to provide useful reactive supply and voltage support, but currently there are no markets or programs to facilitate such transactions.[319]
- *Operating Reserve Service* provides rapid backup generation and/or demand response in the event that the NYISO experiences a real time power system contingency, requiring emergency corrective action. There are several types of operating reserves classified by the time required to change output levels (i.e., 10 or 30 minutes) and whether the resource is already synchronized with the grid (i.e., "spinning reserve"). All suppliers of operating reserves must be under the NYISO's operational control and must be able to supply power or curtail demand when called upon. It is possible for microgrids to provide Operating Reserve Service to the grid if they are configured properly and have the load response or generating assets capable of ramping up or down rapidly in response to a NYISO automated control signal.
- *Black Start Capability* is the ability of a generating unit to go from a shutdown condition to an operating condition, and start delivering power without assistance from a power system.[320] If a partial or system-wide blackout occurs, these generating units are called on by the NYISO or the local utility to assist in grid restoration. The NYISO selects black start resources based on location, generator start-up time, maximum response rate (MW/minute) from minimum output, and maximum generating capacity or output. Microgrids may be capable of providing black start services in New York, but due to their typically small scale it is likely important that they be located close other generators to support the restoration of these units.

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[317] U.S. Federal Energy Regulatory Commission, *Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities*, Docket RM95-8-000, Washington, DC, March 29 1995. Also see: Eric Hirst and Brendan Kirby, *Ancillary Services*, Oakridge National Laboratory, 1996

[318] Limited Energy Storage Resources are a new class of resources that the NYISO is beginning to incorporate into its energy service markets. Their key features include that they are consumers of electricity when they store energy and suppliers when they release energy. Their main benefit is the speed of their response to a signal to dispatch energy, not the duration of their response, which makes them valuable as a resource for regulation services. For more information see: NYISO, "Energy Storage in the New York Electricity Market," Discussion Draft, December 2009

[319] S. Chowdhury et. al., 2009

[320] NYISO, *Ancillary Services Manual*, October 2009

Participation in the NYISO ancillary service markets is complicated and typically favors large-scale resources. Moreover, the provision of ancillary services may involve a tradeoff between participating in certain markets and using microgrid assets to supply power to microgrid loads. Also, while unconventional resources such as electricity storage systems and demand side resources are just beginning to be formally incorporated into ancillary service markets, there is no clear role for microgrids.[321] There is little reason, however, why advanced microgrids of sufficient size, with automated controls, electric storage and demand response capabilities should not be able to participate in these markets and earn revenues for services rendered. For more information on the requirements for participants see the *NYISO Ancillary Services Manual* and the *NYISO Accounting and Billing Manual*.

Table 5.6 – NYISO Ancillary Services Summary

Ancillary Service	**Is Service Location Dependent?**	**Pricing Method for Service**
Voltage Support	No	Embedded Cost-Based Rates
Regulation and Frequency Response	No	Market-Based Rates
Energy Imbalance	No	Market-Based Rates
Operating Reserve	Yes	Market-Based Rates
Black Start Capability	Yes	Embedded Cost-Based Rates

Source: NYISO (2010)

5.3.1.7 Enhanced electricity price elasticity

While microgrids may be able to earn additional revenues by participating in organized ICAP or demand response programs, they may also provide social benefits in the form of lower peak power prices. Through the use of dispersed generation and demand response, microgrids that are interconnected to the macro-grid may be able to provide value to all ratepayers in the form of enhanced electricity price elasticity. By reducing consumption of electricity from the macro-grid, particularly in response to market price signals when system demand is high, microgrids may be able to reduce the output from high marginal cost or "peaking" plants, thereby reducing the clearing price for electricity in wholesale energy market or reducing the marginal cost of energy consumed (in a vertically integrated, cost of service environment). Given the uniform pricing principles adopted across organized US power markets (i.e., each customer within a given customer class pays the same rates), this means that other consumers – including ratepayers of utilities - will benefit too. Other wholesale power market benefits include mitigating peaking plant owners' market power (effectively by expanding the pool of competition that existing plant owners face). It's unlikely that a single microgrid will have a noticeable impact on wholesale power prices. Nevertheless, at large scale and in concert with other distributed and demand side resources, microgrids could provide this potentially valuable social benefit.

5.3.1.8 Reduced electric T&D losses

Energy losses are inherent in the transmission of electricity due to resistance from electrical equipment (e.g., cables, transformers). Still, losses can be minimized through various measures, including better reactive power and voltage management as well as production closer to the point of consumption. The PSC has found that the reduction of lost energy on the T&D system is a potentially significant source of savings and would benefit system operations. In New York State, total losses vary from one electric utility's system to the next, but are estimated to be between 6% and 10% depending on the system.[322] In aggregate, the annual losses in New York are equivalent to the output of approximately 2,000-3,000 MW of generating capacity, or roughly the annual output of the Indian Point nuclear power facility.

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[321] NYISO, "Energy Storage in the New York Electricity Market," 2009

[322] State of New York Public Service Commission, "Order Adopting Reactive Power Tariffs with Modifications," Case 08-E-0751, September 22, 2009, See: http://documents.dps.state.ny.us/public/Common/ViewDoc.aspx?DocRefId=%7B486BF06D-D65D-4150-918E-F9C1F94E7DC8%7D

The NYISO reports that approximately 14,000,000 MWh were lost in 2006 in the transmission and distribution of electricity in New York (about 8.4% of total delivered).[323] In a report to the PSC, Con Edison calculated that its total electric power delivery losses in 2007 amounted to 6.64% of net generation and purchases, or 4,156,218 MWh. The utility calculated the value of these losses at $446 million (in 2007 dollars), or approximately $107/MWh. Similarly, Orange and Rockland Utilities reported losses of 4.64% in 2007, or nearly 290,000 MWh with an estimated value of $24.1 million ($82.46/MWh).[324]

Generally speaking, electric system losses are reduced when power is generated closer to loads. Although it is impossible to eliminate electric power delivery losses entirely, microgrids by definition involve the production of electricity close to loads, allowing line losses to be reduced to approximately 2-4% for power consumed internally.[325] In its filing for QF status before the FERC, the Burrstone Energy Center estimated its distribution losses to be approximately 3%.[326] Moreover, by reducing consumption from central station generation on the macro-grid, microgrids also contribute to the reduction of system losses by 6-10% for every MWh of energy reduced. If microgrids self-supply power during periods of hot weather or high system demand, which is when the grid is most strained and losses are highest, they may contribute even more to reductions in system losses.

5.3.1.9 Deferred T&D capacity investments for specific locations

DERs sited in the right locations, of sufficient scale and operating at the right times may serve as a substitute for certain utility investments in T&D infrastructure. By removing load from a utility service area (e.g., feeder, substation or circuit) that is at or near capacity, DERs may extend the ability of the existing T&D facilities to serve load. As aggregations of DERs, microgrids also have the potential to provide this benefit by removing large amounts of load from utility networks in one coordinated system.

The value that microgrids may provide in deferring investments in traditional T&D facilities varies markedly across the state and within utility service territories. This value is place and time specific and depends on several factors including the rate of load growth on a network or substation area and that network's capacity to meet peak demand over a particular planning horizon.[327] While microgrids could provide T&D deferral benefits either upstate or downstate, in rural areas or in dense urban centers, on average, the value of distribution deferral is far greater downstate. For example, the PSC estimates the average value of avoided transmission and distribution capital costs is $55/kW per year for upstate and $110/kW per year for downstate.[328] Avoided distribution capital costs have also been reported to be as high as $800/kW-year in certain parts of the Con Edison service territory.[329] The difference between regions is due to both the higher property acquisition costs as well as the higher construction costs associated with underground distribution, which predominates downstate.

For DERs – and by extension microgrids – to provide an electric T&D deferral function, they should satisfy certain criteria. Specifically, the DER/microgrid must be:

1. In the right location
2. Of sufficient scale/capacity
3. Operational in the time frame required

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[323] New York Independent System Operator, "Comments of the New York Independent System Operator, Inc. On the Installation of Capacitors on the New York Power System to Reduce Real and Reactive Power Losses," Case 08-E-0751, December 23, 2008

[324] Consolidated Edison, "Report of Consolidated Edison Company of New York, Inc. on Electric System Line Losses," Submitted to the Public Service Commission of the State of New York in Case 08-E-0751, December 23, 2008 and Orange and Rockland Utilities, "Report of Orange and Rockland Utilities, Inc. on Electric System Line Losses," Submitted to the Public Service Commission of the State of New York in Case 08-E-0751, December 23, 2008

[325] S. Chowdhury et. al., 2009

[326] Burrstone Energy Center, *Certification of Qualifying Facility Status for an Existing or Proposed Small Power Production or Cogeneration Facility,* FERC Form No. 556, June 29, 2007

[327] Dana Hall, James M. Van Nostrand, and Thomas G. Bourgeois, "Capturing the Value of Distributed Generation for More Effective Policymaking," White Plains, NY, 2009

[328] EEPS Staff Team, *March 2008 DPS Staff Report on Recommendations for the EEPS Proceeding* (Albany: 2008)

[329] Hall et. al., 2009

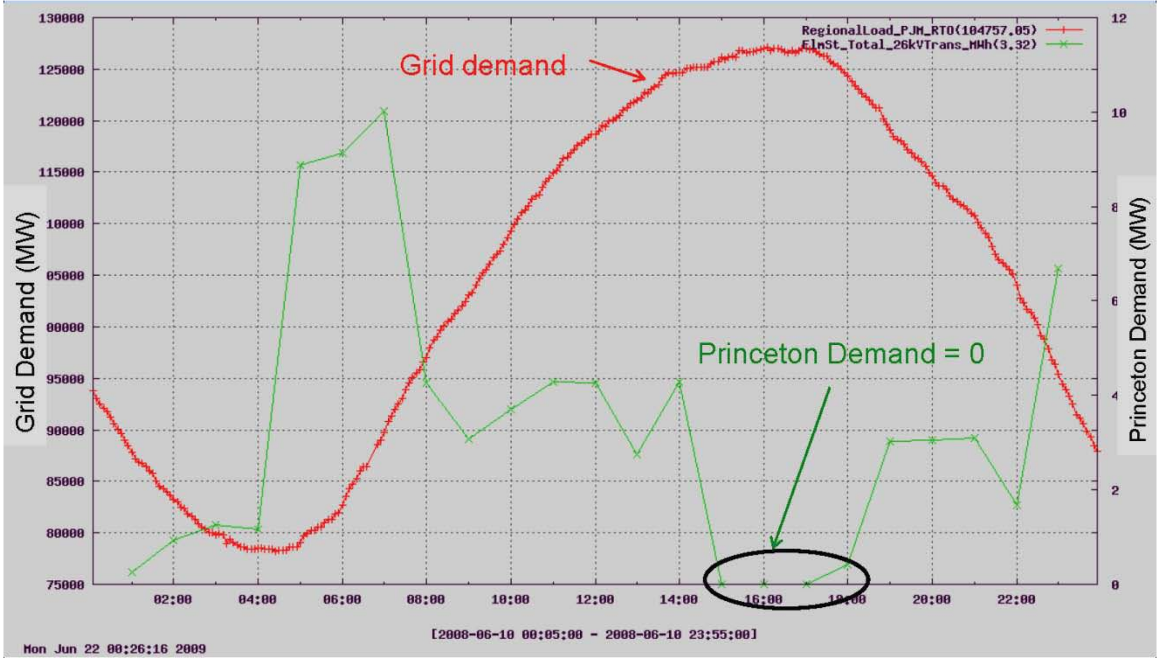
4. Offering a level of reliability that is comparable to what the utility would expect from the alternative solution

With respect to the issue of location, formal consideration of demand side measures – such as DERs and customer energy efficiency – in distribution planning processes is critical to identifying where microgrid deployment can provide substation area load relief and capital investment deferral benefits. Identifying these areas requires analysis and communication from utilities regarding the conditions on their network and their forecast of network level load growth. This can be done by sharing the results of regularly conducted system load analysis and soliciting customer investments to defer utility capital expenditures. With respect to satisfying the required timing of investment and operation of the DER or microgrid, advanced notice must be provided. This is due to the required lead times for coordinating the development of a microgrid, which can be two or more years depending on scale, location, ownership and service characteristics.[330]

By aggregating the resources and loads of multiple end users, microgrids address the issues of scale and reliability in a manner that individual DG projects cannot. The pool of single building projects that are both economically viable and of sufficient scale to serve the distribution deferral need is likely a small one. By permitting the aggregation of proximate sites into microgrids, the pool of available opportunities is likely to grow.

For example, Princeton University's microgrid in New Jersey provides value to the local distribution system by essentially removing nearly all, or in some instances all of the universities load from the nearby substation during peak hours.[331] Figure 5.6 illustrates this load reduction against the system demand profile of a typical day.

Figure 5.6 – Demand Profiles of Princeton University and the Grid



Source: Nyquist (2009)

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[330] The projects examined in the case studies section of this report indicate lead-times of 2-4 years from conception to commissioning.

[331] Thomas Nyquist, Presentation at EPA/CHP Partnership Meeting in New York City, October 1, 2009

Aside from Con Edison's Targeted Demand Side Management (TDSM) program, which at the time of this report faces funding uncertainty, there are no formal markets where microgrids can get paid for load relief that defers T&D system investments.[332] In this case, the ownership and service structure of the microgrid likely plays a determining role in whether or not the benefits are recognized and captured. To non-utility microgrid owners, such value streams are uncompensated benefits to ratepayers. A utility-owned and operated microgrid, on the other hand, may be in a better position to internalize the distribution deferral benefits of such investments. Still, the overall business case for such systems is less clear due to the inability of distribution-only utilities to capture the energy benefits of production assets. Generally speaking, the combination of a lack of information regarding where these investments are most needed and the absence of a market that might allow customers to internalize these benefits inevitably results in an under-provision of this service.

5.3.1.10 Utility option value for long-term planning purposes

Utility transmission and distribution capital investment decisions are made as a consequence of demand forecasts that have a certain degree of risk. If the projected demand does not materialize, the utility and its ratepayers may have invested in an uneconomic asset. Because of the nature of utility revenue recovery, ratepayers will absorb much of the costs of uneconomic capital investments. Using customer-owned DERs and microgrids to defer utility investment provides the utility (and ratepayers) an additional resource to manage exposure to changing market conditions.[333] If the anticipated demand conditions never materialize, societal resources have been saved by avoiding uneconomic capital investments. Once the option to invest has been exercised, the utility has given up the alternative of waiting for more information about demand conditions or the state of technology.

Microgrids may permit the utility to defer an investment in transmission or distribution system assets, thereby giving the utility more time to observe demand conditions or to take advantage product or process changes that offer a less expensive or more productive solution. Still, the ability of a given microgrid to deliver this benefit is highly site specific and dependent on local utility investment needs.

5.3.1.11 Support For Deployment Of Renewable Energy

Microgrids have the potential to facilitate the deployment of renewable energy in several ways that could support state policy and prove valuable to microgrid participants, utilities, and grid operators. Microgrids may directly integrate renewables into internal supplies and support Renewable Portfolio Standard program goals. Microgrids may offer rapid demand reduction or load response to support greater integration of variable production grid-connected renewable supplies (see Figure 6.7 below). Moreover, by reducing load on the macro-grid, microgrids may reduce the overall amount of purchases required to meet the state RPS target, saving ratepayer funds.

Although most existing grid-connected microgrid systems primarily use gas-fired engines or turbines in a CHP configuration, the integration of renewables into microgrid configurations is a major driver of microgrid research, development and demonstration initiatives. State-of-the-art control technologies and modern inverters make integration of renewables, such as photovoltaics and wind energy systems, in a microgrid possible. These systems

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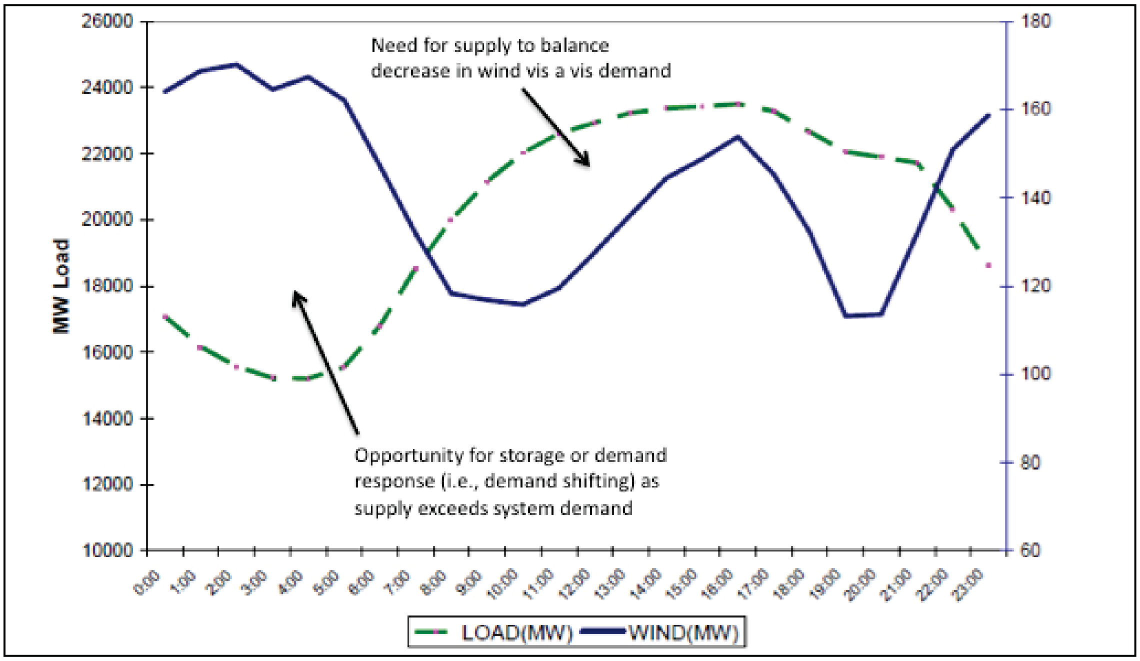
[332] The Distribution Load Relief Program and Con Edison's Targeted Demand Response Program (TDSM) were supposed to provide opportunities to monetize the value of T&D deferral. Still, the program's design to date – specifically, the 100% physical assurance requirement—has effectively precluded DG/DER projects and microgrids from participating in these programs. According to Navigant Consulting evaluation of the TDSM program for the PSC, "the use of DG to offset networks peak load has not been pursued due to "physical assurance" obligations, a contractual requirement vendors are unwilling to pursue due to added cost and potential for customer load disruption. Physical assurance involves use of communication and control systems that would interrupt customer load in amounts equal to contracted firm DG delivery if the generator was unavailable when needed to reduce load." Navigant Consulting, "Evaluation of TARGETED DEMAND SIDE MANAGEMENT PROGRAM," MAY 30, 2009.

[333] Utility customers may interconnect distributed generation (DG) to their utility system. As such, DG customers are given some options that can be valued by option theory. Real option theory can be used to value options that a customer receives when they interconnect DG with a utility system using Black-Scholes option pricing model. See: M.Pati, et. al., "Real Option Valuation of Distributed Generation Interconnection," Edison Electric Institute, March 2001 and Charles Feinstein, Ren Orans, and Stephen Chapel, "The Distributed Utility: A New Electric Utility Planning and Pricing Paradigm," Annual Review of Energy and Environment, 1997. 22:155-85

will likely use demand response, battery storage and/or other generation with good load following capabilities to help smooth out the intermittent generation common from certain types of renewables. San Diego Gas and Electric's Beach Cities microgrid in Southern California, which is using reciprocating engines and advanced battery storage to support islanding of a distribution circuit with high penetration of customer-owned photovoltaics, is a good example of this.

By quickly moving from grid parallel to islanded operation mode in response to signals from the grid microgrids may, in certain cases, also be able to provide valuable support for the integration of large-scale renewables, particularly wind power. New York State's RPS program, which requires 25% of in-state electricity supplied to come from renewable energy by 2015, is expected to result in the addition of an estimated 4,000 MW of nameplate wind capacity as early as 2013. Moreover, wind power facilities are being sited in New York State to produce power to support the renewable energy programs of neighboring states; as a result it is very likely that New York's wind-power capacity will significantly exceed 4,000 MW in the next 5-10 years. In 2008, the NYISO's interconnection queue contained requests from over 7,700 MW of new wind projects.[334] Finding a way to integrate this influx of variable wind power into the regional grid will be a significant challenge and finding good solutions is a major priority of the NYISO.[335]

Figure 5.7 – Average Hourly Wind Versus Load Profile in New York State (June 2008)



Source: NYISO (2009)

Compounding the challenge of integration is the fact that most of the proposed wind plants are seeking to interconnect in concentrated clusters located in the northern and western regions of the New York State. While expanding transmission capacity will be required to bring the wind resources into load centers, balancing the wind on the grid will require the availability of both sinks and sources of power. A recent study found that overreliance on thermal generating units to meet increased regulation requirements could actually increase emissions of CO_2, NOx and other pollutants, defeating one of the intended benefits of the RPS program.[336] NYISO has recognized the need for new technologies to provide regulation and reserves to address this concern.[337] With their ability to shed or

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[334] NYISO, "Transmission Expansion in New York State," November 2008

[335] Ibid.

[336] Jay Apt and Warren Katzenstein, "The Character of Wind Power Variability and its Effects on Fill-in Power," Carnegie Mellon University, June 25, 2008.

[337] NYISO, *Integration of Wind Into System Dispatch*, October 2008

absorb load rapidly, physical microgrids located at strategically significant areas of the grid could be valuable resources to the NYISO in this regard, as could aggregated demand response and advanced energy storage systems.

In addition to providing sink/source benefits to help accommodate variable sources of renewable energy on the macro-grid, microgrids would likely benefit the state by reducing the amount of renewable energy that would be needed to satisfy the RPS goals. Currently, the RPS program requires 25% of annual energy deliveries (i.e., MWh) to be supplied by renewable energy by 2015. As the central procurement administrator for the RPS Program, NYSERDA issues solicitations on a periodic basis to procure RPS attributes, or RECs from new qualifying renewable energy supplies. In exchange for a competitively priced incentive award to renewable project developers, the renewable generator provides NYSERDA with all rights and/or claims to the RECs associated with each MWh of energy produced by the facility.

Over the course of three solicitations spanning 2004 to 2007, the average incentive price awarded by NYSERDA to developers for RECs ranged from $14.75/MWh to $22.90/MWh. Every MWh of energy reduced from the system through energy efficiency or self-supply reduces purchases of RPS-eligible power by 0.25 MWh. Thus, based on historical REC prices, every 4-MWh of energy supplied directly to end use customers by microgrids provides a $14.75-$22.90 benefit to ratepayers, who fund the RPS program through the System Benefits Charge. By 2015, a microgrid like Cornell University's, which supplies approximately 200,000 MWh/year to its campus loads, provides value to ratepayers in avoided RPS purchases of approximately 50,000 MWh, or $735,000-$1,450,000 per year based on historical REC prices.

5.3.2 Reliability and Power Quality

The reliability of the electricity system is measured by the percentage of time per year an average customer can expect to have service. The US power system is typically reliable 99.9-99.99% of the time, or in the vernacular of the electric industry, three to four "nines." Three to four nines of reliability equates to approximately 1-9 hours per year without power for the average customer (see Table 5.7 below for how the degrees of reliability equate to time without power). While this level of reliability may be acceptable for most residential customers, many commercial and industrial customers require reliability that verges on perfect. For example, microprocessor-based industries, such as telecommunications and brokerage firms, can require up to "nine nines" of reliability, or electric service that is 99.9999999% reliable (i.e., less than one second of outage time per year). As a consequence, even brief outages or power quality disturbances can cause production losses or equipment malfunctioning that can add up to millions of dollars annually.

Table 5.7 – Degrees of Reliability and Time Without Power

Reliability	Time Without Power
99.0% (two nines)	3.7 days per year
99.9% (three nines)	9 hours/yr
99.99% (four nines)	53 minutes/yr
99.999% (five nines)	5 min/yr
99.9999% (six nines)	32 seconds/yr
99.99999% (seven nines)	3 sec/yr
99.999999% (eight nines)	0.32 sec/yr
99.9999999% (nine nines)	0.032 sec/yr

A lack of reliable data on the duration and frequency of reliability and power-quality events, as well as the cost of those events to particular end use customers, makes it difficult to draw firm conclusions about the costs of power interruptions to consumers in New York State. Still, estimates in recent years suggest that the aggregate cost to New York State ranges from approximately $7 billion to $11 billion annually.[338]

Microgrids using state-of-the-art technology have the capability of providing higher levels of reliability and power quality to participating loads than can currently be offered by electric utilities.

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[338] Primen, "The Cost of Power Disturbances to Industrial and Digital Economy Companies," Consortium for Electric Infrastructure to Support a Digital Society, June 2001

5.3.2.1 Reduced Power Interruptions

Microgrids interconnected to utility systems can reduce disruption to critical loads during system-wide outages, providing a significant value to participants, particularly those with mission critical or uninterruptible loads. Through the application of uninterruptible power supplies and fast transfer switches that allow microgrids to seamlessly move from grid parallel to islanded operation, microgrid participants may capture the potentially high value of extremely reliable power supplies.

The value electric customers place on reliability of service can be understood both in terms of the value of economic losses caused by power interruptions and measurements of customer's willingness-to-pay to avoid outages or their willingness-to-accept compensation for outages.[339] These values vary significantly both across and within electric customer classes (i.e., residential, commercial and industrial). The duration of the interruption as well as the time of day are also important factors in determining the cost to specific end users. For example, Hewlett-Packard has reported that a 20-minute outage at a circuit fabrication plant would result in a day's worth of lost production at an estimated cost of $30 million (in 2000 dollars).[340] Table 5.8 below shows the average cost of electricity outages by customer type and duration as estimated in a recent report issued by Lawrence Berkeley National Laboratory.

Table 5.8 – Average Electric Customer Interruption Costs by Class and Duration (U.S. 2008 Dollars)

	Interruption Duration				
	Momentary	30 minutes	1 hour	4 hours	8 hours
Medium & Large Commercial & Industrial					
Cost per Event	$11,756	$15,709	$20,360	$59,188	$93,890
Cost per Avg kWh	$173.10	$38.50	$25.00	$18.20	$14.40
Cost per Avg kW	$14.40	$19.30	$25.00	$72.60	$115.20
Small Commercial and Industrial					
Cost per Event	$439	$610	$818	$2,696	$4,768
Cost per Avg kWh	$2,401.00	$556.30	$373.10	$307.30	$271.70
Cost per Avg kW	$200.10	$278.10	$373.10	$1,229.20	$2,173.80
Residential					
Cost per Event	$2.70	$3.30	$3.90	$7.80	$10.70
Cost per Avg kWh	$21.60	$4.40	$2.60	$1.30	$0.90
Cost per Avg kW	$1.80	$2.20	$2.60	$5.10	$7.10

*All figures refer to a summer weekday afternoon

Source: Sullivan, Mercurio and Schellenberg (2008)

The value of reliability varies significantly by end user. Table 5.9 illustrates the range of average cost of power interruptions to a number of customer types that place a high value on reliable service.

Table 5.9 – Average Cost of Outages for Selected Industries

Industry	Average Cost Per Hour of Downtime
Cellular Communications	$41,000
Telephone Ticket Sales	$72,000
Airline Reservations	$90,000
Credit Card Operations	$2,580,000
Brokerage Operations	$6,480,000

Source: Arthur D. Little (2000)

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[339] Michael J. Sullivan, Matthew Mercurio, and Josh Schellenberg, "Estimated Value of Service Reliability for Electric Utility Customers in the United States," LBNL-2132E, June 2009

[340] Arthur D. Little Consulting, "Reliability and Distributed Generation," 2000

5.3.2.2 Power Quality

When the nation's central power grids were built more than a century ago, "power reliability" was synonymous with "availability of power." Electric power was electric power and consumers either had it or didn't have it. The proliferation of sensitive electronic equipment throughout society is rapidly reframing this perception. Electronic equipment is commonly designed for power supplies with specific voltage and current characteristics. When voltage or current levels deviate from specified quality standards, electronic equipment can be damaged or fail. On the typical power delivery circuit, voltage and current variations occur fairly frequently. EPRI makes the following observation with regard to the significance of power quality in modern healthcare.

> Before the introduction of electronic medical equipment, common electrical disturbances were inconsequential to healthcare operations. Today, however, common electrical disturbances may cause high-tech medical equipment to malfunction, which is a problem given the intimate connection between this equipment and the patients that hospitals serve. Much of this equipment incorporates sensitive electronic power supplies and microprocessors—possibly resulting in extended patient discomfort, misdiagnoses, increased equipment downtime and service costs, and even life-threatening situations. Moreover, equipment damage and malfunctions can jeopardize patient safety and increase the cost of healthcare. Electrical disturbances can result in repeated diagnostic tests, wasted medical supplies, and expensive service and repair calls.[341]

As a result, expectations about reliability for services providing power have expanded from simply "availability of service" to "availability *and* quality of service."

Regulations have only begun to adapt to this fundamental shift in the nation's energy economy. In most jurisdictions, "service standards" for voltage levels, frequency controls, current characteristics and so forth have not appreciably adapted to the evolving needs and expectations of power consumers, forcing consumers to implement increasingly elaborate and expensive power conditioning schemes to reduce their exposure to power-quality events.[342] These events – voltage sags and spikes, frequency and harmonic stability, imbalances, for example – have direct financial consequences for the value received by end users.

Voltage sags – also called undervoltages, are the most common and costly power quality disturbance. Voltage sags are partial reductions in voltage levels lasting from 0.5 to 30 cycles (the US electric system operates at a frequency of 60 Hertz (Hz), or 60 cycles per second). They occur as a result of a large momentary overload or fault in the power system or when large loads begin drawing power from the system. Although a voltage sag of short duration will generally not cause problems for lighting or small motors, it can interrupt computers or other sensitive equipment. The cost of sags varies by customer and can range from zero to several million dollars per event.[343]

Harmonics – while the US power system is designed to operate at a frequency of 60 Hz, some equipment that customers connect to the macro-grid generate currents and voltages at frequencies other than 60 Hz (e.g., personal computers, compact fluorescent lighting, televisions and variable frequency drives), creating what are called harmonics. Harmonics cause distortions in the quality of grid power and can both increase local line losses and reduce equipment lifetimes.

Spikes – also called transients, spikes are very brief surges in voltage (e.g., milliseconds) caused by lightning strikes or the switching of large loads, network circuits or capacitor banks. They can disrupt and damage sensitive electronic equipment (i.e., personal computers, variable frequency drives, televisions).

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[341] EPRI, "Power Quality Issues in Health Care Facilities," *Power Quality Watch*, November 2008.

[342] Electric service voltages vary throughout the day. This is because almost every customer draws different amounts of power from hour-to-hour and day-to-day. To counter the problem, utilities have operating and design standards that limit the range of service voltage variance. The American National Standard Institute (ANSI) has developed Standard C84.1, which recommends specific voltage ranges for utilities and their customers.

[343] National Energy Technology Laboratory, "Smart Grid Principal Characteristics – Provides Power Quality for the Digital Economy," October 2009

Imbalances – voltage imbalances are long-term "stead-state" problems that only affect three-phase electric power systems. Imbalances are caused by defective transformers or uneven loading of grid phase wires, which can happen when large single phase electric loads are on the system. Some motors are designed to tolerate only small voltage imbalances and can fail prematurely as a result of exposure to imbalances.

Power quality problems such as these can cause a negative cash flow either continuously (through reduced equipment life) or in discrete events (i.e., acute power quality disturbances). Typical losses related to PQ events include:

- Losses due to reduced equipment life
- Energy losses
- Production interruption or reduced throughput
- Data losses
- Cost of staff not producing or working
- Malfunctioning equipment
- Equipment damage
- Extra O&M costs

Unfortunately, there is currently very little data available regarding the cost of these kinds of events to the economy. The demand for power quality and reliability varies markedly across economic sectors and end users. For some the cost of even infrequent momentary interruptions can result in catastrophic losses, while others experience little more than a minor inconvenience (e.g. re-setting clocks).

By locating generation close to the source of demand, microgrids can potentially provide so-called "gourmet" or premium power customers with finely calibrated power flows more cost-effectively than possible relying exclusively on conventional, macro-grid solutions. For example, healthcare facilities with extremely sensitive electronic equipment and extremely high reliability needs are increasingly recognizing the limitations or traditional solutions to the increasing and increasingly costly occurrence of power-quality problems. Again, as EPRI observes,

> Even though electric utilities try to provide as many nines of reliable power to a healthcare facility as possible, healthcare providers must realize that their facilities are also fed from typical power distribution networks. Utilities will make every effort to ensure that a direct service feed (service entrance) to a hospital is properly maintained and that second feeds are provided from a second substation whenever possible. Nevertheless, redesigning distribution systems or making other investments in the utility's power delivery infrastructure may also be prohibitively costly.[344]

Unlike most macro-grid power solutions, microgrids can be tailored to the specific needs of an end-user. Moreover, the advancement of power electronics and control technologies will likely make it possible to develop microgrids that provide a comprehensive solution to the full spectrum of power-quality issues across a complex and interconnected end-user environment like hospitals or data centers.

5.3.3 Environmental Value Streams

Microgrids have the potential to deliver environmental benefits to New York State in the form of reduced emissions of CO_2, the primary greenhouse gas, and criteria pollutants, particularly NOx and SO_2. A microgrid's ability to deliver these benefits will vary with the types of generation that are deployed. Microgrids that provide CO_2 reductions will use either renewables (e.g., PV or small wind), low emission DG units – likely in a CHP configuration, – or both. The magnitude of CO_2 savings will depend on the regional system mix of electric generation resources and, if CHP is incorporated into the microgrid, the type of fuel used to provide on-site thermal energy.

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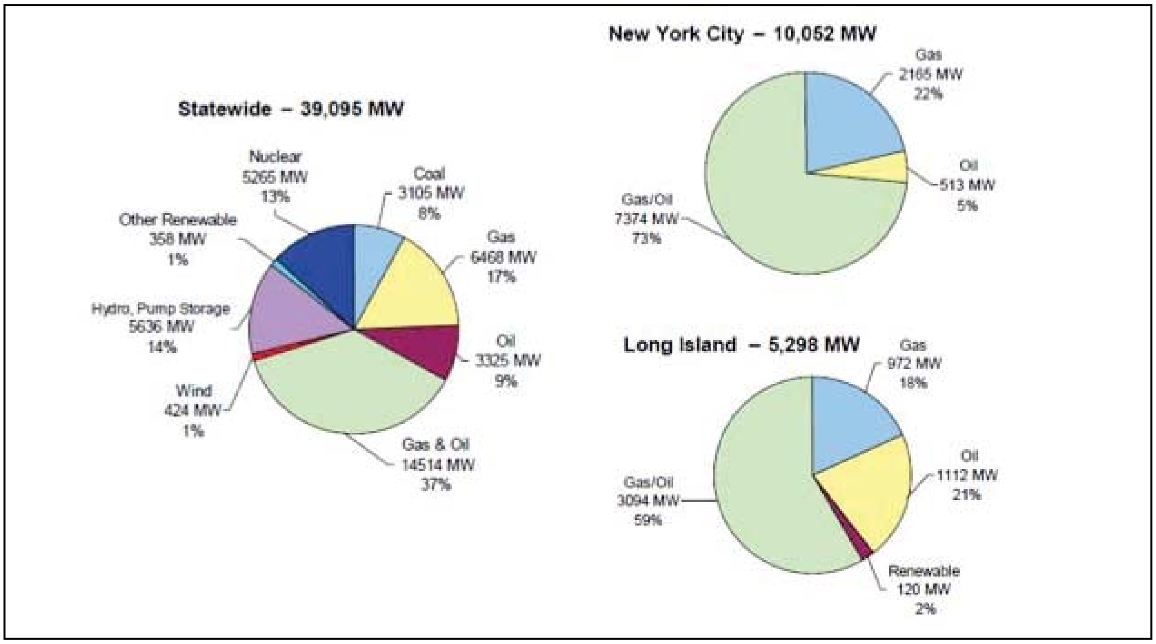
[344] Philip Keebler, "Power Quality for Healthcare Facilities," *EPRI PQ TechWatch*, December 2007.

5.3.3.1 Reduced CO_2 Emissions

Microgrids may be well positioned to reduce CO_2 emissions as compared to macro-grid electricity and thermal energy supply from the combustion of fuels in boilers onsite. New York University's repowering and expansion of its CHP-based microgrid system will reduce campus use of #6 fuel oil by 1.7 million gallons per year and will eliminate use of #2 diesel fuel entirely.[345] The microgrid expansion alone will reduce NYU's annual CO_2 emissions by roughly 44,000 tons, or nearly 25% from 2006 levels. The expanded microgrid will easily serve as the largest wedge in NYU's efforts to meet its commitment to reduce its greenhouse gas emissions by 30% from 2006 levels by 2017. Cornell University's CHP-based microgrid is also an essential component of its long-term climate action plan.[346] Approximately 65,000 tons of coal and nearly 75,000 tons of associated GHGs will be avoided as a consequence of Cornell's investment.

Carbon dioxide and other greenhouse gas emissions create impacts that transcend state, regional and national boundaries. As a result, reductions in CO_2 have equal value in upstate and downstate New York. Still, because the generation mix that a microgrid displaces differs across the regions (or utility service territories) as well as by time of day and seasonally, the location and timing of microgrid supply will affect the magnitude of CO_2 reductions. In order to accurately ascertain the net CO_2 reduction benefits of microgrids it is important to understand the composition of displaced power generation. Below, the mix of power generation resources that supply downstate and upstate load centers are provided in Figure 5.8.

Figure 5.8 – Power Generation Capacity in New York State by Resource Type



The Regional Greenhouse Gas Initiative (RGGI) is an active market to reduce CO_2 emissions. RGGI is an initiative of ten states in the Northeast (including New York) to reduce GHGs from power plants. RGGI uses a cap-and-trade system and quarterly auctions of emissions allowances, applicable to fossil-fueled power plants with 25 MW or more of capacity. Power plants can use allowances issued by any of the ten states to satisfy their compliance with the program. The value of RGGI allowances – shown in Table 5.10 below – is one proxy for the value of reduced GHG emissions.

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[345] No. 4 and 6 fuels are also referred to as residual fuel oil, and are heavy and thick fuel oils and often contain high concentrations of sulfur and other contaminants. No. 2 fuel is considered a distillate fuel, which is less viscous and has a lower energy content per gallon that residual fuels. Nevertheless, distillate fuels also have fewer contaminants and lower sulfur.

[346] See: Cornell University Sustainable Campus, "Energy," at: http://www.sustainablecampus.cornell.edu/energy/energy.cfm (accessed on July 31, 2010)

Table 5.10 – Value of RGGI Emissions Allowances (Auction 7, March 10, 2010)

Metric Ton of CO_2 Emissions	Bid Prices	
	2010	2013
Minimum	$1.86	$1.86
Maximum	$5.00	$2.06
Average (Median)	$2.06	$1.90
Average (Mean)	$2.07	$1.94
Clearing Prices	$2.07	$1.86

Source: RGGI (2010)

While most microgrids would not be subject to RGGI and not capable of monetizing CO_2 emissions reductions through the initiative, the auctions do provide one point of reference for the value of allowances in an active market. Using the RGGI auction price as a measure of the value of carbon reductions in New York State is controversial and likely to represent a significant understatement of the societal value. As a result, the Public Service Commission currently uses a figure of $15.00/ton of CO_2 for purposes of conducting cost effectiveness tests for energy efficiency programs.[347] Still, the Commission has not formally adopted that number and has encouraged parties to come forward with alternative estimates and their supporting rationale.[348]

5.3.3.2 Reduced Criteria Emissions

Due to their deleterious effects on the environment and human health, the EPA regulates criteria pollutants, including nitrogen oxide, sulfur dioxide, and particulate matter. The EPA currently classifies the downstate area as a severe non-attainment zone for NO_X while the upstate region is classified as moderate non-attainment.[349] To facilitate the most economically efficient reductions, emissions trading markets for NO_X and SO_2 encompass much of the Eastern United States. The Clean Air Interstate Rule (CAIR) became effective in 2009 and permanently capped NOx and SO_2 emissions in 28 states and the District of Columbia. It replaced and expanded the geographical coverage of the NOx Budget Trading Program, which had been administered from 2003-2008 under the NOx State Implementation Plan, or SIP, Call (promulgated in 1998).[350]

There are also more localized markets for certifying and selling Emission Reduction Credits (ERCs). These markets are operated by the states, with each state having a somewhat different program and protocols. Microgrids operating in New York State could certify and sell ERCs, if the circumstances of the situation permitted it. Microgrids operating in adjoining states (CT, MA) could also certify and sell NO_X allowances into the CAIR market as part of the Renewable Energy/Energy Efficiency allowance set-aside. In New York State the allowance set aside is held by NYSERDA.[351]

Similar to RGGI allowances, regional markets for criteria pollutants do not reflect the full societal costs leading to depressed trading prices. These issues are addressed in great detail in a February 2010 report prepared by Pace Energy & Climate Center for NYSERDA and the U.S. Department of Energy.[352] New York and other states may attempt to capture some of the societal cost of avoided emissions in proceedings that are used for valuing ratepayer investments in energy efficiency and renewable energy programs.

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[347] Public Service Commission, *Proceeding on Motion of the Commission Regarding an Energy Efficiency Portfolio Standard*, Case 07-M-0548 (2008)

[348] Ibid.

[349] Thomas Bourgeois et al., *Guidebook for Small Combined Heat and Power Systems Seeking to Obtain Emissions Reduction Credits in New York State* (2006)

[350] US EPA Clean Air Markets, "Emission, Compliance, and Market Analyses," Available at: http://www.epa.gov/airmarkt/progress/NBP_2.html (accessed August 23, 2010)

[351] Bourgeois et al*,* 2006

[352] ICF International, "Expanding Small-Scale CHP Opportunities Through the More Efficient Use of Trading Programs: An Analysis of Market Opportunities and Regulatory Issues," February 2010

This study found that system owners often do not sell their allowances in markets to create additional revenues. In some cases this may be due to high transaction costs for microgrids, which are relatively small projects, but not in all cases. In fact, at least two New York microgrids – NYU and Cornell University – noted that they intended to retain and retire allowances created by their projects, in effect "donating" the value of these reductions to society.

5.3.4 Security and Safety

Microgrids have the potential to provide security and safety benefits through delivery of reliable and resilient electric service to locations of important social value. By facilitating integration of distributed resources across the macro-grid, microgrids can reduce the risk of reliance on remote sources of power, particularly for high-security and strategic locations. There are few users of electricity more important to public security and safety than the military, and the U.S. Department of Defense has championed microgrids as a key strategy for improving the energy security for national defense services.[353] For example, the U.S. Navy has installed a geothermal-based microgrid at the Naval Air Warfare Center in China Lake, California[354] and projects are currently being carried out at Twenty-nine Palms, the large Marine Corp Base in California, and Wheeler Air Base in Hawaii.[355] While the value of this energy security is clearly very high, it is also difficult to quantify and isolated to a very specific and limited set of circumstances.

When deployed on a larger scale or in key locations, however, microgrids could have a material effect on the overall security of our power supply by limiting the potential for large area interruptions. The U.S. power grid covers vast distances, which makes it difficult to protect from malicious attacks. Studies have identified critical nodes, representing less than 5% of the national electric grid, where redundancies do not exist.[356] Equipment failures at these critical junctions would result in regional power failures. The blackout that struck the Northeast in 2003 involved the loss of approximately 61,800 MW of power to over 50 million people and resulted in significant economic losses estimated at $6-$10 billion with approximately $1 billion for New York City alone.[357] While a few individual microgrids would likely do very little to prevent a major blackout of this nature, distributed resources deployed at a large scale or at critical nodes could prevent or at least limit the extent of such cascading outages.

5.3.4.1 Safe Havens During Power Outages

A more local safety benefit that microgrids might provide to New York State is reliable power to public facilities that can serve as safe havens during regional blackouts or periods of extreme weather or other emergencies. Microgrids have proven to be extremely resilient in the face of natural disasters, enduring the impact of earthquakes in Haiti, hurricanes in Louisiana and similar catastrophes where the central power grid collapsed.[358] In these circumstances, microgrids have provided power to health-care facilities and other critical infrastructure systems. Blackouts often strike New York State during the summer when temperatures are high and the grid is strained. These are also times when people of all ages are vulnerable to heat-induced health risks, including exhaustion and

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[353] Naval Inspector General Report to DASM, "Utilities Privatization Study," March 15, 2005

[354] Naval Inspector General Report to DASM, "Utilities Privatization Study," March 15, 2005

[355] Tina Casey, "US Military is Developing Smart Microgrids with Solar Power," *Scientific American*, June 18, 2010, Available at: http://www.scientificamerican.com/article.cfm?id=us-military-is-developing-smart-mic-2010-06 (accessed on July 30, 2010)

[356] These critical nodes usually involve transformers that are specially made for a particular application and fabricating new transformers requires more than a year. These transformers are large and expensive. As long as they are in good operating order power companies are reluctant to invest in back up capability, since transformers of this size tend to have high reliability under normal condition. A major concern is that these transformers could be subject to malicious attack by determined terrorists. Replacement transformers that could take as much as "…1.5 years to build, transport, and install." See: Massoud Amin, "North America's Electricity Infrastructure: Are we ready for more perfect storms?, IEEE Security and Privacy, Sept/Oct 2003, and Amin "Balancing Market Priorities with Security Issues," July 2004.

[357] ICF International, "The Economic Cost of the Blackout: An Issue Paper on the Northeastern Blackout, August 14, 2003," and Electricity Consumers Resource Council, "The Economic Impacts of the August 2003 Blackout."

[358] Alyssa Danigelis, "Greentech Lights the Way in Haiti," *Discovery News*, July 12, 2010, Available at: http://blogs.discovery.com/news_tech_nfpc/2010/07/green-tech-lights-the-way-in-haiti.html (accessed on August 23, 2010). See also World Association for Decentralized Energy, "Security Via Decentralized Energy," December 2007; Energy and Environmental Analysis, Inc., "Assessing the Benefits of On-Site Combined Heat and Power during the August 14, 2003 Blackout," June 2004.

even stroke. New York City's Office of Emergency Management operates approximately 400 cooling centers across the city to provide shelter to the public during these times. During a heat wave in July 2008 more than 200 cooling centers served nearly 30,000 New York City residents.[359] Microgrids located in public facilities such as these can provide reliable safe havens and cooling center services that protect the public during emergencies such as extreme weather, blackouts or even terrorist attacks. Although it is difficult to quantify the benefits of public safe havens, there is little doubt that microgrids providing reliable power service to such facilities during emergencies would prove very valuable from a societal perspective, but likely very difficult to monetize for microgrid owners.

5.4 Allocating the Costs of Microgrids

While the focus of this Section is microgrid benefits, microgrids are not always an unambiguous gain for all parties involved. There are private and social costs that result from deployment of microgrids.

In New York State, potential macro-grid costs created by microgrid deployment – particularly microgrids interconnected to the macrogrid – are typically imposed on the microgrid owner through a host of regulatory mechanisms, including stand-by rates, interconnection requirements and similar policies. While regulations and markets currently fail to compensate microgrid owners for several of the benefits they may provide, the converse is more commonly true for microgrid costs. In other words, regulations, especially those like stand-by rates, which allow a significant amount of discretion, may be applied in a manner that overestimates the costs imposed by microgrids.

Benefits and costs do not flow in equal measure to all affected parties as a result of microgrid development. The existing utility is likely to lose revenues and suffer a decline in capacity uses, particularly if non-utility owned microgrids were to proliferate on their system. As existing capital costs of the utility are spread over a declining base of customers, or across an aggregate end-user load profile that is less attractive, then rates for remaining customers may rise. Depending on the regulatory status and legal form of the utility, these losses may be borne by shareholders, ratepayers, or the public generally.

Large-scale deployment of microgrids may impact utility revenues and increase utility stranded costs. Revenue erosion for utilities from microgrids, DG or other smart-grid services or systems begs for serious thought from within the industry regarding the long-term role of electric utilities and the kind of business model that will allow them to survive or transition. On the other hand, microgrids are a symptom rather than the underlying source of revenue erosion for utilities in competitive power markets like New York State. Market forces are ultimately the cause of demand destruction. If microgrids do not destroy a utility's traditional sources of demand, energy efficiency, ubiquitous distributed generation or other smart grid systems may. The rationale for deregulation in New York State is beyond the scope of this White Paper, but it is important to emphasize that deregulation, or competition – not microgrids – will likely be the reason for demand destruction and any related revenue erosion experienced by utilities.

Ironically, and as discussed above, microgrids may provide at least a partial solution for utilities trying to develop new revenue streams that offset losses to their traditional base by providing a portfolio of services and products that utilities can offer customers. These may include providing services targeting electric vehicles, products monetizing various environmental attributes, or utility owned or directed microgrids that provide differentiated energy services to customers (i.e., varying levels of power quality and reliability). Many forward-looking utilities have already begun exploring strategies to pursue these emerging market opportunities as new sources of revenue.[360] The structural and technical similarities of microgrids to today's electricity grid may provide utilities with a significant competitive advantage in developing and deploying microgrids. Still, moving toward a distributed services business model will require a significant shift in the thinking at most utilities, where the paradigm of the centralized grid has become entrenched over the past one-hundred years.

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[359] For more information see the NYC Office of Emergency Management, "NYC Hazards: Cooling Centers," at: http://www.nyc.gov/html/oem/html/hazards/heat_cooling.shtml (accessed on August 1, 2010)

[360] CERES, "The 21st Century Electric Utility: Positioning for a Low-Carbon Future," July 2010.

6.0 ROADMAP FOR FACILITATING MICROGRIDS IN NEW YORK STATE

The 2009 New York State Energy Plan articulates five key objectives for the state's energy system over the next 10 years:

- Maintain reliability
- Reduce greenhouse gas emissions
- Stabilize energy costs and improve economic competitiveness
- Reduce public health and environmental risks
- Improve energy independence

As this report addresses in detail, microgrids have the potential to contribute to each of these policy objectives. Although the types of energy technologies and configurations will vary from one application to the next, microgrids have demonstrated the ability to: improve the efficiency of overall energy use; reduce GHG emissions; provide energy cost savings to participants and macro-grid customers; reduce the environmental and public health risks attendant to current modes of energy production and delivery; and improve local energy independence by reducing reliance on the macrogrid.

While several microgrid systems have been deployed in New York State over recent years, and interest continues to grow, the ability to develop microgrids remains clouded in uncertainty. Much of this uncertainty is in regard to how the microgrid is organized and to whom it provides service. If microgrids are to serve a role in achieving New York State's long-term energy policy objectives, however, the state must take action to clarify the right to organize microgrids and the responsibilities attendant with different types of systems. Similarly, incentives or other policies designed to help finance microgrids and properly compensate owners for the positive externalities they provide would go a long way toward helping some of these projects get off the ground. Our recommendations regarding legal and regulatory issues, financing and incentives, and research and development are below.

RECOMMENDATIONS ON LEGAL AND REGULATORY ISSUES

RECOMMENDATION: Enact a Statutory Definition of "Microgrid" to Formalize the Elements of this Legal Entity.

Microgrids are not defined legal entities under the Public Service Law. As a result, microgrid developers are subject to substantial uncertainty regarding the regulatory treatment prescribed by the Public Service Commission, which typically determines the applicability and extent of regulatory oversight for particular microgrids on a case-by-case basis. A statutory framework governing microgrids could formalize the elements of this legal entity which, in turn, would reduce some of the uncertainty associated with regulatory treatment. The statute should prescribe the principle characteristics of a microgrid. For example, as provided in Section 3.1 above, a microgrid could generally be defined as a "small, local energy system of integrated loads and distributed energy resources – producing electric or both electric and thermal energy – which can operate connected to the grid or autonomously from it, in an intentional island mode." The statute could also address restrictions on size (*e.g.*, no greater than 40 MW interconnected capacity); maximum number of participating customers; limitations on the overall percentage of a utility's load that may be served by microgrids (similar to the aggregate limitation applicable to net metering in New York State); compliance with energy efficiency and renewable resource requirements; and form of ownership (*i.e.*, non-profit or for-profit, and the possibility of utility ownership of microgrids).

RECOMMENDATION: Provide Statutory Authorization for Sharing of Electric and Thermal Resources and Loads Among Previously Unaffiliated Utility Customers.

Statutory authorization should provide an exemption for microgrids from regulation as an "electric corporation," notwithstanding the ownership, operation or management of "electric plant" by a microgrid. Similarly, authorizations should exempt microgrids that distribute thermal energy in the form of steam, hot or chilled water as "steam corporations," notwithstanding similar ownership, operation or management of "steam plant." The exemption should apply whether the microgrid is jointly owned by the participating customers or by a third-party, such as an ESCO. The statute should also provide guidance on the circumstances under which utility customers are permitted to share electric and thermal resources and loads, such as geographical boundaries (if any), the applicable criteria for granting the necessary operating rights to occupy or cross public space, and limitations (if any) on the service class or number of utility customers permitted to participate in a microgrid arrangement.

RECOMMENDATION: Statutory Authorization Should Also Address the Respective Legal Obligations of Microgrids and the Interconnecting Distribution Utilities.

Although microgrids are proposed to be exempt from regulations as "electric corporations" under the Public Service Law, it is recommended that microgrids remain subject to legal requirements designed to protect the interests of participating customers as well as the broader public interest. Governing agreements among the microgrid participants would be filed with the PSC, for example, and the PSC would be authorized to resolve any disputes among microgrid participants. In the case of third-party ownership of a microgrid, statutory provisions would address the protections afforded to participating customers including, in the case of residential customers, the applicability of the Home Energy Fair Practices Act. Statutory guidance should also address any obligation to serve that may arise in connection with a microgrid arrangement, as well as the obligation of utilities to connect with and serve microgrids on reasonable terms and conditions including, for example, suitable interconnection standards; reasonable, cost-based rates for standby service that reflect the value of services provided by microgrids to the macro-grid, such as avoided or deferred transmission and distribution infrastructure investment and ancillary services (*e.g.*, voltage support); and standard terms and conditions for utility control of customer-owned distributed energy resources.

RECOMMENDATION: Statutory Authorization Could Include Measures that Would Encourage Development of Microgrids, such as Net Metering, Virtual Net Metering, or Retail Wheeling.

As a policy matter, New York State could properly decide to include various measures in the statutory authorization that would stimulate the development of microgrids. These incentive measures could include the availability of net metering (including size limitations, if any) for sales of any excess generation from the microgrid to the macro-grid; retail wheeling[361] for microgrids under common ownership but not located on contiguous properties; and virtual net metering, which would allow microgrid participants to jointly share in the benefits of electricity generation, regardless of the actual flow of electrons. Alternatively, such incentive measures could be limited to microgrids meeting specified technology requirements, such as use of renewable resources, high-efficiency CHP, or complementary electrical generation and thermal capture/storage technologies that optimize microgrid or macrogrid performance.

RECOMMENDATION: Statutory Authorization Could Include an Explicit Recognition of Community-based or Cooperative Microgrids as Eligible to Receive Property-Assessed Clean Energy (PACE) Financing or other Forms of Public Financing.

PACE financing allows property owners to borrow money to pay for energy improvements. The amount borrowed is typically repaid via a special assessment on the property over a number of years. In 2009, New York State enacted two separate bills – Assembly Bill (AB) 8862 and AB 40004A – authorizing local governments to offer these types of programs using different mechanisms. AB 40004A, authorizes counties, towns, cities and villages (or "municipal corporations") to offer sustainable energy loan programs. Loans may be used to pay for energy audits; cost-effective, permanent energy efficiency improvements; renewable energy feasibility studies; and the installation of renewable energy systems.[362]

AB 8862, on the other hand, allows towns to offer energy efficiency programs as part of the town's general authority to create garbage improvement districts and collect fees for related services. The programs must be designed for

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[361] Retail wheeling is the movement of electricity, owned by a power supplier and sold to a retail consumer, over transmission and distribution lines owned by neither one. In this case, the power supplier could be a microgrid under any of the ownership and service structures identified in this report. A "wheeling" fee is charged by the owner of the lines for distributing power from one location to the other. This type of transaction is referred to as retail wheeling and the wheeling charge is levied by the transmission and distribution utility for use of its lines.

[362] For a good summary of New York State's PACE financing program, see the Database of State Incentives for Renewables and Efficiency at: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY68F&re=1&ee=1 (accessed on September 13, 2010)

"the prevention or reduction of waste matter consisting of carbon components or energy waste from residential properties and the performance of energy audits and the purchase and installation of energy efficiency improvements on such residential properties." Towns offering such programs are permitted to enter into contracts for energy efficiency improvements on behalf of participating residents.

Statutory authorization for microgrids could include specific recognition of community-based or cooperative microgrids as eligible for financing under the programs established by AB 8862 and 40004A, or another mechanism. PACE could be made available to cooperative or jointly-owned microgrid systems that use multiple distributed energy systems located at different properties. Similarly, municipalities could be authorized to form special energy improvement districts (i.e., similar to the program authorized in Connecticut and described in the Stamford case study), which allow the local entity to use public financing to procure energy, specify distribution system upgrades and deploy clean and efficient energy production under a long-term local energy supply strategy.

RECOMMENDATION: Statutory Authorization Could Include Options for Municipalities to Adopt Property Tax Credits for New or Redeveloped Areas to Integrate High Efficiency, Advanced Microgrid Systems Into their Development Plans.

Historically, municipalities and state governments have offered a variety of incentives, including property tax abatements, credits against state tax liability for property or sales taxes paid, investment tax credits for buildings and equipment and other state and local tax breaks for qualifying development and redevelopment projects. These incentives have been provided as a general mechanism for spurring economic development and job creation and also as a mechanism to target development to particular zones (see for example the Empire Zones Program[363]). More recently certain state and local governments have provided tax incentives for Green Buildings typically differentiated by various levels of certification achieved (silver, gold, platinum).[364] Property tax abatements for local or county taxes, credits against state tax liability for property or sales taxes paid, or investment tax credits for capital investment in buildings and equipment at qualifying facilities are all mechanisms that might be employed to improve the economic viability of high efficiency advanced microgrid systems. Targeting these incentives to areas undergoing new or re-development, that can demonstrate the use of low-carbon energy supply services, could be an appropriate way to encourage microgrids.

RECOMMENDATION: Irrespective of Statutory Authorization, the PSC Should Adopt Policies to Encourage Microgrids in New York State.

Ideally, the legal definition of "microgrid" and the necessary exemption from regulation as "electric corporations" for microgrids owning "electric plant" would be affected through statute, which provides greater certainty – and thus reduced risk – for developers of microgrid projects in New York State. In the absence of legislative action, however, the PSC retains substantial authority to promote microgrid development using its broad authority over the electric utility industry and the public service companies that are subject to PSC jurisdiction. The restructuring of the electric utility industry, for example, was accomplished in New York State without benefit of any express statutory authorization, as was the imposition of a System Benefits Charge (SBC) on utility customers' bills, the establishment of a RPS, and the collection of RPS surcharges on utility customers' bills.

Using this broad regulatory authority over the electric utility industry and the public service companies over which the PSC has jurisdiction, the PSC could adopt through administrative action many of the recommended statutory authorizations recommended above. For example, rather than determining the applicability and extent of PSC regulation of non-utility microgrids on a case-by-case basis – as is currently the practice – the PSC could commence a generic proceeding focused on the development of necessary guidelines and policies governing the regulatory treatment of microgrids in New York State. The proceeding could also address the issues surrounding utility microgrids, particularly utility ownership of generation and storage assets and tariffs for provision of differentiated services (i.e., uninterruptible service), among other matters. Given the PSC's authority to require utilities to submit tariff filings implementing its policy decisions, the PSC could reshape the regulatory landscape governing

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[363] For details please see Empire Zones program tax benefits at: http://www.tax.state.ny.us/sbc/qeze.htm (accessed on September 16, 2010)

[364] See, for example, the U.S. Green Building Council's Summary of LEED Incentives at: http://www.usgbc.org/ShowFile.aspx?DocumentID=2021 (accessed on September 16, 2010)

microgrids through administrative actions implementing the guidelines and policies developed in a microgrid-focused generic proceeding. While not having the durability of statutory provisions, the administrative actions of the PSC could substantially clarify the regulatory treatment of microgrids, and thereby reduce the uncertainty and delay associated with the case-by-case approach. These administrative actions could provide necessary and helpful guidance for the development of microgrid arrangements in New York State.

RECOMMENDATION: The PSC Should Commence a Proceeding to Examine the Issues Associated with Microgrid Development in New York State, and to Adopt Design Guidelines for Maximizing Performance and Efficiency of Microgrids.

In addition to initiating an administrative proceeding to develop the necessary guidelines and policies governing the regulatory treatment of microgrids in New York State, the PSC should initiate a second phase of that proceeding to focus on identifying the best practices for designing microgrid architecture to maximize performance and efficiency. This proceeding should consider, among other things, the use of incentives to encourage deployment of such best practices, through specification of performance standards that would trigger eligibility for financial incentives. Specific recommendations regarding the design of incentives are provided below.

RECOMMENDATIONS ON FINANCING AND INCENTIVES

RECOMMENDATION: Inventory the Current System of State Energy Incentives As They Relate to Creating Favorable Conditions for Microgrid Project Development.

A thorough review of the current system of incentives available for renewable energy, energy efficiency and targeted Demand-Side Management programs (such as those funded by SBC revenues or by RPS surcharges[365]) should be undertaken to ascertain how well suited they are to a more aggressive development of high value microgrids and supporting technologies. This effort is particularly timely as a new set of SBC IV programs are now under development for implementation in 2011.

RECOMMENDATION: Provide Incentive Resources for both Development and Demonstration Type Microgrid Projects.

NYSERDA operates several categories of research, development and deployment projects on behalf of the State's ratepayers. In the Development category are projects designed to test the viability of new concepts, improve upon the design of current products, and risk share with technologists.[366] The State should consider setting aside funding to test the viability of promising new microgrid designs, supporting equipment and energy production/storage/consumption configurations through development type programs. The objectives of the Demonstration projects include selection of promising technologies for in-field testing, scrutinizing technologies by progressing from simple to complex scenarios, and risk sharing with early adopters.[367] The State should also consider funding some promising microgrid pilot projects through the Demonstration category.

RECOMMENDATION: Develop a Multi-Stakeholder, Peer Reviewed Process for Identifying a Set of Screening Criteria for Optimizing the Investment of State Funds in Microgrid Pilots.

In previous sections of this report, we have identified a substantial set of benefits that could be derived from microgrids strategically sited at high value locations on the grid and incorporating a set of technologies that provide one or more important system services. At the same time, microgrids may be located and operated in such a manner

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[365] New York's System Benefits Charge supports energy efficiency, education and outreach, research and development, and low-income energy assistance. The state's six investor-owned electric utilities collect funds from customers through a surcharge on customers' bills. On an annual basis, each utility collects and remits to NYSERDA a sum equal to 1.42% of the utility's 2004 revenue. This percentage may be adjusted slightly each year based on updated utility revenue. The RPS surcharge is a separate surcharge that is assessed on each kilowatt-hour sold by the state's investor-owned utilities (except for certain excluded customer classes) to support an RPS fund managed by NYSERDA. This fund supports payments associated with the Main Tier solicitations for renewable energy credits for the RPS program as well as payments to support customer investments in distributed renewable energy systems associated with the Customer-Sited Tier.

[366] NYSERDA, *Combined Heat and Power Program Guide*, 2009

[367] Ibid.

as to provide little or no benefits to ratepayers. We recommend that prior to investing in pilot projects, the State should create a rigorous set of screening criteria and performance goals designed to maximize return on investment of public resources in early stage projects. For example, the Galvin Initiative has developed what it calls a “Perfect Power Prototype” that includes a checklist of technical characteristics that would deliver elements of “perfect power.” These characteristics include, but are not limited to the following:

- Redundant Distribution
- Substation Automation
- Self-Healing Distribution
- On-site Generation
- Building Automation with Load Reduction Capability
- Building Efficiency
- Renewable Infrastructure and Technologies
- Cyber Security
- Smart Meters
- Intelligent Utility or Microgrid Energy Manager
- Minimal Environmental Impact
- Energy Storage
- Power Quality Correction or Protection

The screening criteria developed by New York might include similar technical characteristics as well as other location and operational characteristics that would provide the most value to ratepayers. Ultimately, the screening criteria should support the direction of ratepayer funds to projects that demonstrate either significant public benefit or advance the development of innovative energy supply and delivery services.

RECOMMENDATION: Create an Expert Advisory Board and Stakeholder Process to Ascertain the Role that Microgrids Might Play in Addressing Concerns Regarding the Level of Geographical Balance in the RPS Program.

While the RPS has increased the overall amount of renewable energy supplying New York State, a geographical discrepancy exists with regard to the amount of renewable capacity installed through the program with most of the capacity installed upstate. Although ratepayers downstate contribute significantly to the RPS program, higher costs and other logistical challenges associated with developing projects in the region have limited the effectiveness of the program there.

One potential benefit of microgrids is the ability to optimize the operation of a set of generation and demand-side resources at a suite of buildings, potentially with complementary load and supply profiles. In so doing, renewable resources operating at microgrids might offer greater value to ratepayers than investing in building-by-building, individually sited renewables. When combined in a microgrid with dispatchable generation or CHP and demand response, larger-scale and intermittent renewable resources could be more easily integrated into congested load areas downstate. By linking these resources into a coordinated system, microgrids may be able to accommodate distributed renewables at the megawatt or multiple-megawatt scale without concern for export to the macro-grid, which is still a limiting factor for DG in many parts of Con Edison’s service territory.

In the downstate area, Con Edison in particular, should be encouraged to experiment with microgrid configurations that demonstrate a significant efficiency benefit when operating an integrated system of renewable energy resources in combination with CHP, DR and/or energy storage assets. Development and Demonstration programs that use microgrids with a significant renewable energy capital investment should be considered as a mechanism for addressing the concerns about the level of geographic balance in the RPS program.

RECOMMENDATION: Conduct State Supported Research Studies Creating Protocols for Incorporating Microgrids Into Existing and Prospective Energy Markets.

There are currently NYISO System-wide capacity and ancillary markets in existence that could benefit from (and provide compensation to) microgrids for system benefits that they create. NYSERDA is currently supporting a project in Con Edison's service territory that is demonstrating the interoperability of demand response and distributed generation resources, including how those resources might participate in existing demand response and ancillary service programs. In addition, Con Edison has in existence (i.e., the Targeted Demand Side Management program), and under design, distribution load relief programs that could provide a revenue stream for microgrid projects that provide local area system support. The State should work with NYISO, Con Edison and other distribution utilities where appropriate to create protocols that would encourage the expansion of these existing programs to include microgrids – and other forms distributed energy resources – that are capable of providing the services required by these energy market programs.

RECOMMENDATION: Identify Near-Term, High Return R&D Needs For the Microgrids Industry.

The SBC IV funding referred to above, could support the identification, demonstration and deployment of new technologies that will improve upon the internal efficiency and effectiveness of microgrids as well as insuring a much higher level of benefit to the outside macro-grid. We recommend an investigation into promising product innovation and refinements of controls/management systems for the optimization of the suite of resources operating within the microgrid as well as important new designs to maximize the value at the interface of the microgrid and the macro-grid.

RESEARCH & DEVELOPMENT RECOMMENDATIONS

RECOMMENDATION: Conduct a National Survey of Microgrid R&D That Identifies Critical R&D Funding Gaps and Research the Available Resources for Filling Those Gaps in New York.

Microgrids have attracted significant research funding in recent years, but most of this research has concentrated on specific components of microgrid systems rather than "microgrids" per se. For example, research related to energy storage, utility interconnection devices, power electronics, energy management systems and advanced control technologies will likely influence the development of microgrids directly or indirectly. By mapping the status of microgrids-related R&D activities in the United States, New York State can target critical R&D funding gaps in the microgrid value chain and possibly attract new in-state economic development or investment from this emerging sector.

RECOMMENDATION: Facilitate Integration of Microgrid's Power-Electronic Components into Modules or Building Blocks with Defined Functionality and Interfaces that Serve Multiple Applications.

Power electronics interfaces are a key enabling technology for microgrids. Power electronics interfaces modules coordinate power conversion, power conditioning, protection, DER and load control, ancillary services, and monitoring and control services for microgrids. They offer the potential of lower costs, higher reliability and improved performance. Rather than improving the components, devices and circuits of power electronics individually, the U.S. Navy's Office of Naval Research and the Center for Power Electronics Systems have adopted an alternative approach focusing on modularization, standardization and integration to achieve economies of scale. New York State should endorse and contribute to these efforts by funding research designed to develop modeling standards and benchmark models for improving the design process.

RECOMMENDATION: Enhance Technology Transfer by Expanding Collaboration Interfaces Among Researchers, Entrepreneurs, Investors and Other Parties Involved in Commercialization of Microgrid Technologies.

Many of the most promising microgrid technologies are being pursued by researchers in academic institutions and federal laboratories. In addition, researchers developing these technologies may not fully appreciate the implications of their research for microgrids. As a result, the success or failure of the technology-transfer process for moving intellectual property into the private sector will have a significant impact on the commercialization of microgrids. Enabling new interfaces between researchers and potential investors would improve the technology transfer process. For example, the U.S. Department of Energy recently launched the "Technology Commercialization Portal" to accelerate the commercialization of clean-energy technologies developed in federal laboratories.

RECOMMENDATION: Institute a Collaborative Process for Streamlining the Development of Standards and Protocols for Microgrids.

New York State should institute a collaborative process for utilities, technology providers, researchers, policymakers, consumers and other electric-grid stakeholders to define, implement, test and verify emerging microgrid architectures, components and control systems. In particular, the collaborative should include key federal agencies like the U.S. National Institute of Standards and Technology or the National Renewable Energy Laboratory and critical standard-setting organizations like Underwriters Laboratory or Institute of Electrical and Electronics Engineers. The collaborative would develop protocols and processes for expediting the certification or verification of new microgrid technologies related to performance, reliability or other issues.

RECOMMENDATION: Promote Public-Private Partnerships for Accelerating Development and Deployment of Critical Microgrid Technologies.

New York State should promote partnerships among universities, trade associations, professional societies, equipment manufacturers and other stakeholder groups that facilitate access to information, enhance market feedback, leverage financial and intellectual resources, encourage early adoption and implement comprehensive strategies for accelerating the commercialization of microgrid technologies. An illustrative example is that of a technology cluster[368] that would encompass all aspects critical to the process of development and deployment including technology supply chain, systems integrators, design/build capabilities, financing expertise and legal counsel. The public role in part is one of facilitating the productive interaction of interconnected companies, system integrators and the service providers that are critical to entire chain of product development. The Public-Private entity may have additional authority to provide financial capital in support of specific ventures as specified in articles of incorporation.

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[368] Technology clusters are a concept popularized by Harvard Business School Professor Michael Porter. See for example the Clusters and Innovation Initiative http://www.isc.hbs.edu/econ-clusters.htm (accessed on September 16, 2010)

APPENDIX A CASE STUDIES

A.1 SAN DIEGO GAS AND ELECTRIC'S BEACH CITIES MICROGRID

Project Name: San Diego Gas & Electric's Beach Cities Microgrid
Location: Borrego Springs, California
Owner/Developer: San Diego Gas & Electric
Ownership Model: Unbundled Utility
Status: Planning

Microgrid Typology

<table>
<tr><td>Project originator</td><td colspan="2">[✓ Private sector]</td><td colspan="2">Government</td></tr>
<tr><td rowspan="2">Microgrid system owner</td><td colspan="3">Single</td><td rowspan="2">Multiple</td></tr>
<tr><td>[✓ Utility]</td><td colspan="2">Property owner</td></tr>
<tr><td>Energy users</td><td>Self</td><td colspan="2">Self + others</td><td>[✓ Others]</td></tr>
<tr><td>Cross public street?</td><td colspan="2">[✓ Yes]</td><td colspan="2">No</td></tr>
<tr><td>Form of energy distributed</td><td>[✓ Power only]</td><td colspan="2">Power + thermal</td><td>Thermal only</td></tr>
<tr><td>Limits on microgrid size?</td><td>[✓ None]</td><td colspan="2"># of customers</td><td>Volume of sales</td></tr>
<tr><td>Interconnected at voltage?</td><td colspan="2">LV</td><td colspan="2">[✓ HV]</td></tr>
<tr><td>Operate independently of grid?</td><td colspan="2">[✓ Yes]</td><td colspan="2">No</td></tr>
<tr><td>Multiple resources</td><td colspan="2">[✓ Yes]</td><td colspan="2">No</td></tr>
<tr><td>Certified QF?</td><td colspan="2">Yes</td><td colspan="2">[✓ No]</td></tr>
</table>

Microgrid Summary Statistics

- **Number of district customers**: 2,500 residential customers, 300 businesses
- **Customer classes served**: Residential, commercial, industrial and water district
- **Technologies employed**:
  - Two Caterpillar 3516 prime diesel generators rated at 1.825-MWe each
  - One MWe advanced battery storage with discharge capabilities of between three to eight hours
  - Customer-owned distributed photovoltaics (PV), approx. 50 installations totaling 500 kW
  - Advanced metering infrastructure featuring Itron OpenWay™ Solution technology (2,800 smart meters)
  - Microgrid master controller
  - Outage management system/Distribution management system
  - Automated distribution control, Feeder Automation, SCADA controllers on existing distribution system capacitors
- **Substation peak distribution capacity**: approximately 14.5-MW
- **Substation peak electric demand**: approximately 13-MW
- **Target feeder peak load reduction**: 15%

Ownership & Service Model Explanation

San Diego Gas and Electric Company's (SDG&E) "Beach Cities" project an example of a planned unbundled utility microgrid.[369] SDG&E, a state-regulated investor owned utility, is in the process of deploying several technologies to create a demonstration microgrid system in the community of Borrego Springs, which is located in northeast San Diego County, California (see Figure A1 in the Appendix for a map). The microgrid service area will include all of the approximately 2,800 customers served by SDG&E's Borrego substation. The utility will own generation and storage assets located adjacent to the substation as well as additional sensing and control devices installed on its

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[369] We define the Unbundled Utility model as a microgrid for which the distribution facilities are owned by an existing electric utility, but some or all of the DERs on the microgrid are owned by participating customers or third parties. In this model, the utility is an active partner with customers and generators to facilitate and manage the aggregation of loads and deployment of generation on the microgrid.

three distribution circuits serving the community. An important part of the demonstration will be SDG&E's integration of customer-owned and sited distributed generation (DG) and price-driven demand response (DR) as resources available to the microgrid. The inclusion of customer-owned resources makes SDG&E's project an example of an "unbundled" utility-owned microgrid, as opposed to a vertically integrated model, which would only include utility-owned resources.

Background/Project Objectives

As one of Sempra Energy's[370] regulated business units, SDG&E provides power to approximately 1.4 million residential and business accounts (approximately 3.4 million people) in a 4,100 square-mile service area.[371] Due to the large footprint of its service territory and location of loads in rural areas inland, the utility has encountered service reliability challenges and sought innovative solutions to address them. Additionally, as one of three investor owned utilities directed by the California Public Utilities Commission (CPUC) in 2007 to deploy Advanced Metering Infrastructure (AMI)[372], the utility has been at the forefront of smart grid development efforts in California.[373]

In 2008, SDG&E's Beach Cities proposal was one of nine microgrid demonstrations selected by the U.S. Department of Energy (DOE) to receive federal grant funding under the Renewable and Distributed Systems Integration (RDSI) program. The goal of the RDSI is to demonstrate the use of renewable and distributed generation in decreasing peak loads on distribution feeder lines, while providing both grid parallel and islanded operating capability for the generation and connected loads. That same year, SDG&E was awarded a grant from the California Energy Commission (CEC) to deploy a "sustainable communities microgrid." With a focus on customer-oriented issues, such as interoperability, AMI and integration of customer-sited distributed energy resources (DER),[374] the CEC grant complements the RDSI, which is focused more on utility-side applications and distribution feeder load reduction. The CEC-funded part of the Beach Cities microgrid will support the integration of remote controlled demand response devices, such as thermostats, solar panels, plug-in hybrid electric vehicles (PHEVs) and grid-friendly appliances.

To identify substation areas that they could use for the demonstration, SDG&E put together an internal team representing a broad array of company divisions. The team rank ordered twenty substations based on various criteria and Borrego Springs was one of several finalists (see Table A1 in the Appendix for a summary of the substation selection criteria). SDG&E ultimately selected the Borrego substation because it provides a unique opportunity to explore potential microgrid islanding of an entire substation service area; this project will demonstrate islanding of a single circuit within the substation area. The community is located at the end of a single 69 kilovolt (kV) radial feeder making it vulnerable to service interruptions and ideal for DERs. On average, Borrego Springs suffers about nine outages per year, some of which are required whenever the utility does work on the feeder.[375] The substation area already includes a significant amount of distributed photovoltaics installed on customer premises that could be integrated into the microgrid and the excellent solar resources of southern California makes Borrego Springs and ideal location for adding more. The Borrego substation is itself attractive

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[370] Sempra Energy (NYSE: SRE) is a Fortune 500 energy services holding company based in San Diego.

[371] San Diego Gas & Electric, "Our Service Territory," Available at: http://sdge.com/aboutus/serviceTerritory.shtml (accessed on April 3, 2010)

[372] AMI refers to systems that measure, collect and analyze energy usage, and interact with advanced devices such as electricity meters, gas meters, heat meters, and water meters, through various communication media either on-demand or on pre-defined schedules. This infrastructure includes hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management (MDM) software, and supplier and network distribution business systems among other components.

[373] California Public Utilities Commission, "Opinion Approving Settlement on San Diego Gas & Electric Company's Advanced Metering Infrastructure Project," Application 05-03-015, Decision 07-04-043, Issued on April 17, 2007, Available at: http://docs.cpuc.ca.gov/published/FINAL_DECISION/66766.htm (accessed on April 3, 2010)

[374] DER is a term that includes small-scale, distributed generation technologies such as photovoltaics or various types of combustion engines as well as energy storage technologies and electromechanical control devices including inverters and power conditioning systems.

[375] California Energy Commission. "Public Interest Energy Research 2009 Annual Report". http://www.energy.ca.gov/2010publications/CEC-500-2010-018/CEC-500-2010-018-CMD.PDF

because of its remote location and plenty of space. The approximately two acres on which the substation sits can accommodate the installation of utility assets that may be difficult to site in more dense areas, particularly generators and large utility-scale batteries.

SDG&E's overall goal is to conduct a pilot scale "proof-of-concept" microgrid test from which conclusions may be drawn regarding how information-based technologies and DER could be applied to increase utility asset use and reliability.[376] The demonstration has several objectives including:

- Achieving a greater than 15% reduction in feeder peak load through the integration of multiple, integrated DER, including generation, energy storage and price-responsive load management
- Demonstrating the capability of volt-ampere reactive (VAR) management[377]
- Developing a strategy for and demonstrating the following:
    - Integration and value of advanced metering infrastructure (AMI) into a microgrid
    - Integration of Feeder Automation System Technologies (FAST)[378]
    - Integration of an Outage Management System
    - Islanding of customers in response to emergencies
    - Coordinating and controlling multiple technologies[379]

Detailed Microgrid Description

Borrego Springs is a small, unincorporated resort, retirement and agricultural community in northeast San Diego County with a population of approximately 3,000, mostly part-time residents. Perched on the north-westernmost extent of the Sonora Desert, Borrego Springs experiences mild winters with temperatures between 44 and 70 degrees Fahrenheit (°F), which attract its residents and visitors. The population declines, however, during summer months, when temperatures average well over 100°F and can get as high as 122°F during the day. As the Borrego Springs Community Plan recently explained, high summer temperatures combined with high electricity costs have a "significant negative economic impact on the community." In fact, "many businesses close during the summer months because they cannot operate profitably with low demand and excessive electrical costs," limiting the community's ability to market year-round tourism. The Plan further states "service reliability for SDG&E is poor, especially during the summer 'monsoon' season," which is attributed to above ground utility distribution lines that are susceptible to damage in frequent high winds.[380]

SDG&E provides power to the entire community through its Borrego substation, which feeds three circuits with capacities of approximately 4.5 MW each, serving approximately 2,500 residential electric customers and 300 commercial and industrial customers. Among the commercial uses of power include water-pumping loads from Borrego Irrigation District, several golf courses and local agriculture. Peak load on the substation is approximately 13 MW and typically occurs between 7:00 and 8:00 PM during the month of August. Due to its high summer

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[376] Tom Bialek, "SDG&E Beach Cities MicroGrid Project," presentation at the Symposium on Microgrids, San Diego, CA, Sept 17-18, 2009.

[377] In power transmission and distribution, volt-ampere reactive (VAr) is a unit used to measure reactive power in an AC electric power system. Reactive power is that portion of electricity that does not perform work in an alternating current circuit, but that must be available to operate certain types of electrical equipment, such as motors. Reactive power complements real power (work-producing electricity), which is measured in units of watt-hours. Reactive power consumed by motors and other magnetic equipment during distribution of electricity, must be replaced on the grid, typically by generators or capacitors, in order to avoid causing current and voltage to be out of phase resulting in system losses. See: Pacific Gas and Electric, *Resource: an encyclopedia of energy utility terms*, Second Edition, 1992.

[378] Advanced Feeder Automation is an automatic power restoration system that uses distributed intelligence (i.e., sensors) and peer-to-peer communication to switch and isolate a faulted line section and restore power to the unfaulted line sections. Vendors of FAST technologies include ABB, GEPower and S&C among others. National Energy Technology Laboratory, "A Compendium of Smart Grid Technologies," July 2009

[379] Terry Mohn, "SDG&E RDSI Project Overview," Available at: http://events.energetics.com/rdsi2008/pdfs/presentations/wednesday-part1/8%20Mohn%20Sempra%20SDG&E.pdf (accessed on March 20, 2010)

[380] County of San Diego, "Borrego Springs Community Plan," July 2009, Available at: http://www.borregospringschamber.com/BSCSG/BorregoSprings_CP_2009-07-01.pdf (accessed on April 4, 2010)

temperatures and steady demand for air conditioning, Borrego's load is relatively flat. This contrasts with SDG&E's system-wide peak, which occurs earlier in the day, normally between 3:00 and 4:00 PM, in late August or September, and is driven largely by mid-day building air conditioning.

These conditions make Borrego Springs an ideal place to test the value of an advanced utility-led microgrid system. Its excellent solar resource makes it ideal for both rooftop and utility-scale solar applications and its vulnerability to service interruptions makes a microgrid with islanding capabilities attractive, particularly as an alternative to building additional transmission capacity. The installation of utility assets such as back-up generation, storage and distribution automation will complement the large number of existing customer-owned distributed PV systems, which SDG&E hopes will increase in number as part of this project.

The important design elements and technologies SDG&E plans on integrating into the Beach Cities microgrid are summarized below under four categories: AMI and smart meters; utility-side DER and distribution automation; customer-side DER and price-responsive demand; and microgrid control and energy management system.

AMI and Smart Meters
In response to direction from the CPUC in 2007, SDG&E is installing AMI for all customers in its service territory. AMI provides the backbone for utility smart grid deployments – including advanced microgrid systems – by providing a network of measurement and two-way communications devices that allows collection and distribution of information to customers, electricity suppliers, utility companies, and other service providers.

As part of a settlement agreement between SDG&E and the Utility Consumers' Action Network (UCAN), a non-profit consumer advocacy, the CPUC approved $572 million in ratepayer funds to allow SDG&E to deploy 1.4 million new, AMI-enabled, solid-state electric meters and 900,000 AMI-enabled gas meters.[381] The meters will allow, among other things, time-differentiated measurement of energy usage. SDG&E is currently in the process of installing the new meters and expects to be finished some time in 2012. The approximately 2,800 electric customers in Borrego Springs will be outfitted with their electric smart meters during 2010 (there is no utility gas service in the area). As the CPUC explained,

> This decision is part of our effort to transform California's investor-owned utility distribution network into an intelligent, integrated network enabled by modern information and control system technologies… The deployment will improve customer service by providing customer premise endpoint information, assist in gas leak and electric systems outage detection, transform the meter reading process and provide real near-term usage information to customers. AMI will also support such technological advances as in-house messaging displays and smart thermostat controls.[382]

Under an agreement approved by the CPUC, Itron will provide its OpenWay™ electric meters and gas modules and Itron Enterprise Edition™ Meter Data Management software, as well as implementation, project management and installation services for SDG&E's service territory-wide smart meter project.[383] Itron's OpenWay™ system provides a platform for smart metering and supports smart transmission and distribution grids by providing a two-way communication network between the utility and each customer's meter. OpenWay™ provides interval data collection, time-of-use metering, remote disconnect and reconnect, outage detection, net metering capability and ZigBee®-based[384] wireless Home Area Network (HAN)[385] communication system. The theory is that real-time

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[381] CPUC, D.07-04-043, 2007

[382] Ibid., p. 2

[383] CPUC, "Resolution Authorizing SDG&E to Enter into Contracts with Private Vendors to Implement Phase 1 of its AMI Project," Resolution E4201, Available at: http://docs.cpuc.ca.gov/published/Agenda_resolution/93159-01.htm (accessed on April 7, 2010)

[384] ZigBee is a wireless communications specification for a suite of communications protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks. For more information see: ZigBee Alliance at: http://www.zigbee.org/ and IEEE 802.15 WPAN™ Task Group 4 at: http://www.ieee802.org/15/pub/TG4.html (both accessed on May 10, 2010)

[385] A 2007 Federal Energy Regulatory Commission (FERC) staff report defines HAN as a network contained within a customer's home connecting "intelligent" digital devices including general appliances such as washer/driers and refrigerators, computers, heating and air conditioning, TVs and DVRs, home security systems or any other digital device that can communicate with the

information to consumers about their energy use will empower them to participate in energy management and conservation. Moreover, installing devices capable of communicating with and responding to signals will empower the utility to better manage its distribution networks while accommodating greater interaction with customers.

SDG&E's AMI will include a Wide Area Network (WAN), which will link Local Area Networks (LANs) – such as the Borrego Springs area – together, to establish connectivity between network devices (e.g., smart meters) and the utility's software headend, or central control system. The LAN will use a radio frequency (rf) mesh system to establish connectivity between the electric meters and stand-alone cell relays.[386] Finally, a ZigBee Smart Energy or HAN communication network will establish connectivity between the smart meters and HAN devices (i.e., smart appliances and customer-sited DER technologies) located at customer premises.

The AMI will serve as the grid awareness and communications backbone for both SDG&E's system wide smart grid initiatives and the Borrego Springs microgrid demonstration.

Utility-side DER and Automated Distribution

While the AMI portion of the Beach Cities microgrid is part of a larger SDG&E smart grid development, the deployment of utility-side DERs as well as investments to enable distribution automation are specifically associated with the DOE-funded RDSI demonstration project. The DOE portion of the project emphasizes distribution system operation and will integrate utility-owned distributed generation, storage and VAR compensation devices, which provide fast-acting reactive power on distribution networks.

With respect to generation, SDG&E is installing two four-stroke diesel-fueled generator sets – Caterpillar 3516 reciprocating engines rated at approximately 1.8 MW peak generating capacity each. The engines will provide dispatchable power to the microgrid to support islanded operation in response to feeder outages. The load-following capabilities of the generators will also help SDG&E manage the influx of intermittent resources (i.e., photovoltaics) and customer demand on the distribution system. Although they will likely have a negative impact on project emissions, SDG&E selected diesel generators because there is no access to natural gas in the Borrego Springs area, and diesel can be stored on site in sufficient quantities to accommodate generator operation during an extended outage.[387] In a previous proposal to install a small peaking unit at the Borrego substation, SDG&E noted an interest in procuring biodiesel to run that plant; however no such plans have yet been discussed for the microgrid's diesel generators.[388] SDG&E will be installing selective catalytic reduction on the two generators to mitigate emissions in order to obtain a stationary emission source permit from the San Diego Air Pollution Control District.

As of the time of writing, SDG&E was negotiating with a vendor for the advanced battery storage system, so it was not able to divulge the identity of the manufacturer or the model it intends to purchase. Still, the utility has stated that it is seeking a system with approximately 1-MW of capacity and six to eight hours of discharge capabilities. One battery type that fits this general description, and is receiving a lot of interest from utilities, is the sodium-sulfur (NAS) battery. Currently, NGK Insulators, Ltd is the leading manufacturer of NAS batteries, of which 165 MW have been deployed in Japan for various utility applications. Current capital cost estimates for NAS batteries range

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network. See FERC, "Assessment of Demand Response & Advanced Metering," September 2007, Available at: http://www.ferc.gov/legal/staff-reports/09-07-demand-response.pdf (accessed on April 7, 2010)

[386] An RF mesh is a wireless communications network made up of radio signal emitting and receiving nodes organized in a mesh topology; or a network where each node serves as an independent router regardless of whether its connected to another one or not, providing redundancy in communications pathways. Wireless mesh networks often consist of mesh clients (i.e., laptops, cell phones or other wireless devices) mesh routers (transmitting signals) and gateways, which are connected to the Internet or other data storage/processing system. An RF mesh network is sometimes called a mesh cloud and is dependent on the radio nodes working in harmony with each other. A mesh network is reliable and offers redundancy such that when one node fails, the rest of the nodes can still communicate, directly or through intermediate nodes. See: Ian. F. Akyildiz and Xudong Wang, "A Survey on Wireless Mesh Networks," IEEE Communications Magazine, vol. 43, no. 9, s23-s30, Sept. 2005

[387] According to the California Climate Action Registry, the CO_2 emissions factor for electricity sales to SDG&E customers in 2007 was 806 lbs/MWh, see: http://www.climateregistry.org/tools/members-only/reporting-tips.html (accessed May 12, 2010). By contrast, the emissions from the Caterpillar diesel engines will be approximately 1,615 lbs CO_2/MWh, about double SDG&E's system average in 2007. The diesel engine emissions are calculated using the following assumptions: 22.2 lbs CO_2/gallon, 133 gallons/hr at full load, and 1.825 MW output at full load.

[388] San Diego Gas and Electric, *Sunrise Powerlink Project, Draft EIR/EIS, E.6 In-Area All-Source Generation*, See "Borrego Springs Peaker," January 2008

from \$350-\$500/kWh plus installation, which adds approximately 20-30% to the cost.[389] At Borrego Springs, the storage device will be instrumental in achieving the desired substation peak load reduction of 15% or more; it will also provide critical, instantly available capacity to support transitions to/from islanded operation. The battery will be charged during off-peak periods, using grid-sourced power, and discharged during peak periods to reduce load on the substation area. Similarly, during extended island operation, the battery may be charged by the diesel generators to provide additional peak capacity to the microgrid during these times.

Among the capabilities SDG&E will demonstrate with the Beach Cities project is VAR management on the distribution system to improve power quality to end use customers. VAR management can be provided using VAR compensators, or a suite of technologies capable of providing reactive power and restoring or stabilizing voltage on a circuit. The need for additional reactive power on the distribution system is greatest during periods marked by increased use of large air-conditioning units, irrigation pumping loads or industrial motor loads. When local sources are not available to meet reactive power demands, the voltage on the transmission line or circuit drops or sags. Generally speaking, a decrease in voltage can lead to a blackout unless capacitors or generators are locally available and able to quickly increase their supply of reactive power. VAR compensation devices located on the distribution circuits will allow the utility to maintain distribution voltage at the desired levels.[390]

An increase in DER penetration on utility distribution circuits necessitates the development of an active distribution system that can manage the influx of load and bi-directional flows of generation. To provide monitoring, communications and control capabilities on the Borrego Springs substation area, SDG&E is installing supervisory control and data acquisition (SCADA) at all circuit breakers, switches and capacitor banks. SCADA is a well-established technology for network management that has been deployed by utilities for more than thirty years to provide improved automation and control in the transmission system and at substations. Still, to a large extent, SCADA has not been deployed within utility distribution systems. SCADA consists of data acquisition (i.e., sensing and communications), data processing, remote control of mechanical devices (i.e., switches), event processing and other data analysis functions required to support the automated operation of a system. On a microgrid, SCADA may be deployed to monitor and control electric and/or heat generation, storage devices, distribution equipment and other ancillary services such as capacitors and other VAR-control devices. Typically, a combination of several communications circuits are used with SCADA, including fiber and copper circuits, wireless mobile phone and radio connections.[391] To provide for local area communications, SDG&E has licensed a 900 MHz rf solution, which will allow field SCADA devices and controls to communicate with substation controls and SDG&E distribution operators. Motorola is a project partner and will provide additional communications services to SDG&E as required.

SDG&E is also instituting self-healing distribution circuit concepts including substation feeder redundancy and smart switches. Substation feeder redundancy refers to when there are two or more feeders or distribution circuits that can supply power to end users' locations. For example, if one circuit feeding a customer location is compromised by a tree fall or other outage-inducing event, a section on the circuit can open and the customer can be supplied by the alternate feed. Smart switches allow these sections to be open or closed remotely and automatically in cases where faults have been detected and communicated through SCADA. A circuit diagram of the Borrego substation is provided in Figure A3 in the Appendix. It shows that SCADA operated switches located on the circuits allow sections of the substation service area to be isolated, providing SDG&E with the capability of minimizing the extent of an outage due to a fault on part of a circuit.

Customer-side DER and Price-Responsive Capabilities

At the customer level, the Beach Cities project will integrate remote-controlled demand response devices (e.g., thermostats) and appliances such as smart water heaters and pool pumps, distributed generation (e.g., solar panels), and distributed battery storage, including PHEVs. Integration of these resources will be critical to microgrid islanding operation. With approximately 4.6 MW of utility-owned and dispatchable resources expected to be available, customer or third party owned assets that are capable of contributing another five to six MW would be required to enable islanded operation during the substation peak.

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[389] National Energy Technology Laboratory, "Energy Storage – A Key Enabler of the Smart Grid," US DOE, September 2009

[390] S. Chowdhury, S.P. Chowdhury, and P. Crossley, *Microgrids and Active Distribution Networks*, Institution of Engineering and Technology: London, United Kingdom, 2009

[391] Ibid.

After the AMI backbone is in place, SDG&E will work closely with customers located in the area to secure their participation in the microgrid DER and demand response programs. SDG&E reports that the Borrego Springs substation area currently has more than thirty customer-owned solar photovoltaic systems with an approximate aggregate capacity of 500 kW, or nearly 4% of the area peak demand. To encourage customers with solar panels and other generation to make those resources available and under the control of the utility new tariffs may need to be designed and approved by the CPUC. These tariffs, furthermore, will likely need to provide at least the level of remuneration that existing tariffs such as net metering already provide for eligible technologies such as solar PV (see "Permissions and Regulatory Matters" below).

SDG&E will implement price-driven load management in the second phase of the project. To accomplish this, customer-owned, controllable and grid-friendly appliances (i.e., automated demand response capable) will be integrated with the HAN-enabled electric meter, which serves as the local communication hub. With two-way communications capability, the HAN can measure and verify energy use as well as dispatch demand response. It can also provide feedback to the customer through an in-home display that shows the billing effects associated with usage of various appliances.

SDG&E's customer service group will work closely with customers to help manage the transition to new programs as well as encourage the purchase of new appliances that can plug into the system and receive signals from the smart meters. Once the AMI and customer resources are in place and integrated with SDG&E's systems, the HANs will also be able to communicate directly with the utility. Price signals will be communicated to residential customers (i.e., their home energy management systems) through SDG&E's event management system, which will also be able to receive signals indicating home area appliance operating characteristics. To simulate real-time prices, SDG&E will use wholesale energy prices published by the California Independent System Operator (CAISO). Commencement of price-responsive demand programs will be the final stage of the demonstration.

Microgrid Control and Energy Management System

All of the components discussed above will be tied together by a central microgrid control system, which will communicate with generators and storage and provide automated control capabilities over the system at all times. When the microgrid goes in and out of islanded operation, the energy management system will assess conditions on the substation circuits providing the basis for controller signals to start the generators and the storage unit and/or engage demand response to manage loads. SDG&E noted that due to their infancy and limited deployment, these systems are currently not available "off the shelf," but must be custom designed to a particular microgrid application.[392]

Project Development Process

SDG&E completed the project and program design phases for the Beach Cities demonstration in 2009 and is currently at the beginning stages of project development. The full-scale demonstration is slated for completion sometime during 2012.

SDG&E assembled two teams, one for the DOE portion and another for the CEC portion (see Figure A4 in the Appendix for an illustration identifying the project team and roles). Two of those team members are working on both portions of the project including IBM (project management) and Horizon Energy Group (functional architecture, business process, and system integration). On the DOE side, project participants include Motorola (network communications and security), Pacific Northwest National Labs (DER design), Oracle (outage and distribution management functions), an advanced energy storage vendor (TBD), University of San Diego (regulatory design) and Lockheed Martin. On the CEC side, Gridpoint will design the home area networks and demand response program while Xanthus will serve as systems integrator.

The major project milestones and approximate completion dates for the project, divided by the DOE and CEC components, are as follows:

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[392] Michael Hyams and Thomas Kelly, personal communication with Thomas Bialek, SDG&E, April 2010

DOE

Program Initiation and Design……………………………………………January 2009-May 2009

- Project site selection
- Project management team setup

Phase 1: Baseline Assessment and Technology Procurement..………………June 2009 - July 2010

- AES vendor selection
- Pilot Network Analysis & Baselines
- Obtain permits for DER installation

Phase 2: Equipment Integration and Operations Testing……………Sept. 2009 – December 2011

- DER Integration and Testing
- Feeder Automation Systems Technology Integration and Testing
- AES Integration and Testing
- Receive CPUC approval for experimental customer DER tariffs
- Outage Management and Distribution Management Systems Integration and Testing
- Price-Driven Load Management Integration and Testing

Phase 3: Data Collection and Analysis……………………..…………January 2011 - June 2012

- Cost-benefit Analysis and Final Report

CEC

Phase 1: Program Design………………………………………………..June 2009 - September 2010
Phase 2: Demonstration……………………………………………..October 2010 - December 2011

- AMI deployment
- Resource integration
- Operational testing
- Evaluation

Permissions and Regulatory Matters

As a utility-driven microgrid that will integrate both utility- and customer-owned assets, SDG&E's Beach Cities project will be among the first of its kind. From a regulatory standpoint, its challenges have much less to do with its fundamental legality – as might be the case with a non-utility owned system – than with other regulatory issues such as cost recovery, customer integration and participation, and cost-effective program design. SDG&E owns and operates the distribution system in Borrego Springs and has the authority to reconfigure or enhance that system to include microgrid features, such as self-healing circuits and automated controls. Normally such investments would be subject to cost-recovery approval by the CPUC, but because this is a demonstration largely funded by government grants and intended to test the benefits of microgrids, this project will not have to stand up to the scrutiny of CPUC prudency tests. Still, future utility-led projects will likely have to receive regulatory approval for cost recovery of microgrid investments.

Another set of hurdles faced by the Beach Cities project – and likely other utility-led microgrids in restructured electricity markets – is the design of demand response programs as well as the development of new tariffs to encourage customers with their own generating assets to participate. Because both involve the establishment of new rates and programs for retail customers, the terms and conditions as well as design of this program will require CPUC approval. Although California has restructured its electric industry and required the investor-owned utilities to divest most of their generating assets to promote competition, in the aftermath of the electricity market crisis of the early 2000s, the CPUC now allows utility ownership of generation.[393] This flexibility to own distributed

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[393] In several instances, the CPUC has authorized the state's investor-owned utilities to develop new utility-owned generation in addition to supplies it contracts for with third parties. In its Decision 09-06-049, the CPUC authorized Southern California Edison to build and own up to 250 MW of utility-owned solar photovoltaic capacity. Similarly SDG&E has applied for

generation assets removes one potential regulatory barrier for SDG&E that other utilities in restructured markets might face when instituting microgrid systems.

Below, we further address the permissions and regulatory matters that SDG&E will have to address as it moves forward with the Beach Cities demonstration and other future microgrid projects.

Cost Recovery

Since the Beach Cities project is a federal and state-funded demonstration project, it has not had to go through the traditional cost recovery approval process at the CPUC that utility investments would normally require. DOE and CEC demonstration grants cover more than 50% of the estimated total cost of the Borrego Springs microgrid; the remainder will be met through cost sharing from SDG&E and its project partners, meaning SDG&E ratepayers will only cover a small portion of the total cost. Nevertheless, as discussed above, the installation of smart meters and other AMI infrastructure in Borrego Springs is part of the utility's wider AMI program, which already received regulator approval.

Depending on whether the Beach Cities project is successful in demonstrating it can achieve its objectives cost-effectively, SDG&E will likely seek full cost-recovery for future microgrid projects. As a result, the utility, in collaboration with its project partners, will be conducting a detailed cost-benefit analysis of the project consistent with the methodology developed by the Electric Power Research Institute (EPRI) for the Department of Energy for evaluating smart grid projects (see Cost/Benefit Discussion below).

CPUC Approval of Trial DG and Real Time Pricing Tariffs

A major challenge of instituting an unbundled utility-driven microgrid is developing the terms and conditions as well as price structures to encourage customer participation. The CPUC currently requires that customer involvement in demand response programs be voluntary. As a result, tariffs will need to offer incentives that attract customers and ensure there is adequate demand response. SDG&E expects to file experimental tariffs with the CPUC that would afford Borrego Springs' customers an opportunity to participate in price-driven demand response programs sometime during 2010. The experimental tariffs will use wholesale energy prices published by the CAISO as a proxy for real time prices. Participating retail customers' electric generation prices will track CAISO organized whole prices in real time at the appropriate pricing points in SDG&E's service territory. In theory, as wholesale prices increase in real-time and are communicated to customers via their smart meters, microgrid participants will adjust their demand (likely automatically through a home energy management system) and reduce the amount of power that must be imported into the substation area. Although SDG&E couldn't provide specific details at this time, these separately filed tariffs may also cover special terms and conditions for participation of customer-owned DG in the microgrid, which may be important to allow the utility to exercise direct control over customers' DG assets. While SDG&E tests the program, it will only be available for Borrego Springs' customers.

Air and Construction Permits

In order to proceed with the installation of the two diesel generators, SDG&E is working with the San Diego County Air Pollution Control District (APCD). APCD is responsible for implementing and enforcing air pollution regulations covering mobile and stationary sources.[394] SDG&E is seeking permits for the two generators based on the limited amount of time the generators are expected to operate. Still, regulations in California generally discourage the use of internal combustion diesel engines for non-emergency use, particularly when cleaner burning natural gas can be used as a fuel instead. Since Borrego Springs does not have access to natural gas supplies SDG&E was granted the permit, but it will have to install the Best Available Control Technology including selective catalytic reduction (SCR) to remove nitrogen oxides.

Although presently built upon approximately two acres of a larger 4.5-acre parcel, the addition of the two generators and the battery required more of the substation area to be fenced for security to accommodate the approximately three tractor trailer sized installations. An additional challenge for the project occurred when the utility discovered

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authorization to own up to 52 MW of photovoltaic capacity located at various substations throughout its utility service area. For addition information, see CPUC, "Distributed Generation in California: Utility Solar and Fuel Cell Procurement," Available at: http://www.cpuc.ca.gov/PUC/energy/DistGen/ (accessed on May 8, 2010)

[394] California Air Resources Board, "Mission," Available at: http://www.arb.ca.gov/html/mission.htm (accessed on April 5, 2010)

that the expanded area of the substation would be located on a 100-year floodplain. As a result, SDG&E's site development plans had to include provisions to mitigate any potential flooding risk posed to the location.

Cost/Benefit Discussion

The Beach Cities microgrid demonstration is expected to cost approximately $15.3 million over three years. This cost will cover the procurement and integration of utility assets and systems. The DOE RDSI grant covers approximately $7.2 million of this amount and the CEC is funding $2.8 million. The remaining $5 million will be covered by in-kind contributions from SDG&E and its partners.

Since the demonstration project is not yet complete, a detailed cost/benefit picture is not available at this time. However, as noted above, the project will be assessed using the cost/benefit methods developed by EPRI for the DOE RDSI program and described in its report "Methodological Approach for Estimating Benefits and Costs of Smart Grid Demonstration Projects."[395] The EPRI methods provide a standardized and uniform approach for assessing Smart Grid projects that have similar elements.[396]

Under the EPRI methodology, four categories of benefits are examined – economic; reliability and power quality; environmental; and security and safety. Each of these categories is treated as mutually exclusive in terms of accounting for various benefits that may materialize from RDSI projects. Nevertheless, within each category are several types of benefits, which may lead to additional cross-category benefits. For example, reduced line losses associated with integration of distributed generation in microgrids as opposed to central station power can produce both economic (i.e., reduce losses) and environmental benefits (i.e., reduced emissions associated with reduced losses).[397] Table A2 in the Appendix summarizes the benefits that will likely be assessed for SDG&E's Beach Cities project.

SDG&E staff indicate that the cost/benefit assessment for the Beach Cities project will be comprehensive and thorough. Regardless of the outcome of the cost/benefit analysis, the successful completion of the project will provide valuable information regarding real-world deployment of an advanced utility-led microgrid. The project will provide knowledge regarding the design, operations, and economic considerations of a microgrid that integrates both conventional and non-conventional energy sources as well as how various distributed and "smart" technologies may be applied to allow for two-way power flows in existing distribution systems.[398] The intention is that lessons learned will provide a foundation upon which recommendations for future SDG&E distribution network operations will be built, particularly for systems integrating distributed generation and price-driven demand response. It will also provide important information regarding managing these resources on a distribution network where both customer and utility assets co-exist with the goal of providing a high degree of reliability. The experience gained from this project should prove valuable to utilities across the country as they begin to deploy smart grid systems.

Project Contacts

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[395] EPRI, "Methodological Approach for Estimating Benefits and Costs of Smart Grid Demonstration Projects," January 2010, Available at: http://my.epri.com/portal/server.pt?open=512&objID=243&&PageID=496&mode=2&in_hi_userid=2&cached=true (accessed on April 7, 2010)

[396] Ibid.

[397] Ibid.

[398] EPRI, "SDG&E RDSI Demonstration Project – Utility Integration of Distributed Generation," Available at: http://www.smartgrid.epri.com/doc/SDGE%20RDSI%20%20Final.pdf (accessed on May 12, 2010)

Figures and Tables

Figure A1: Borrego Springs in San Diego County, CA

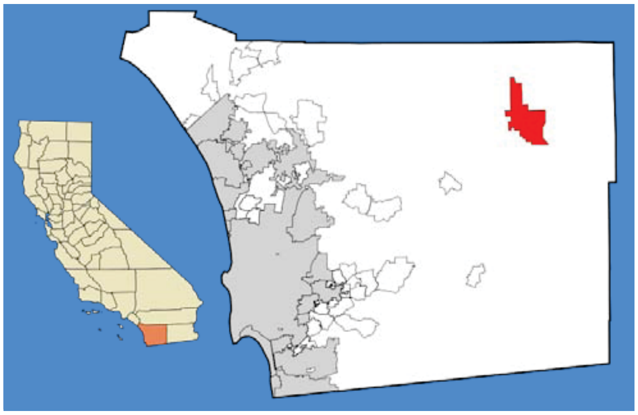
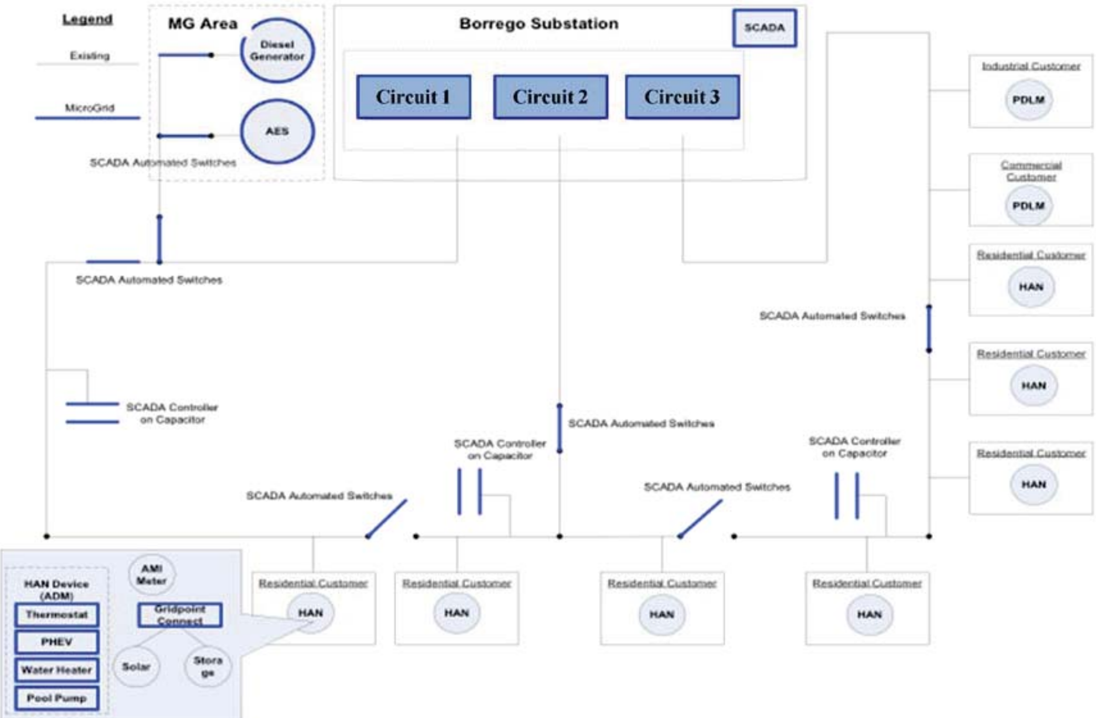


Figure A2: SDG&E's Borrego Springs Substation

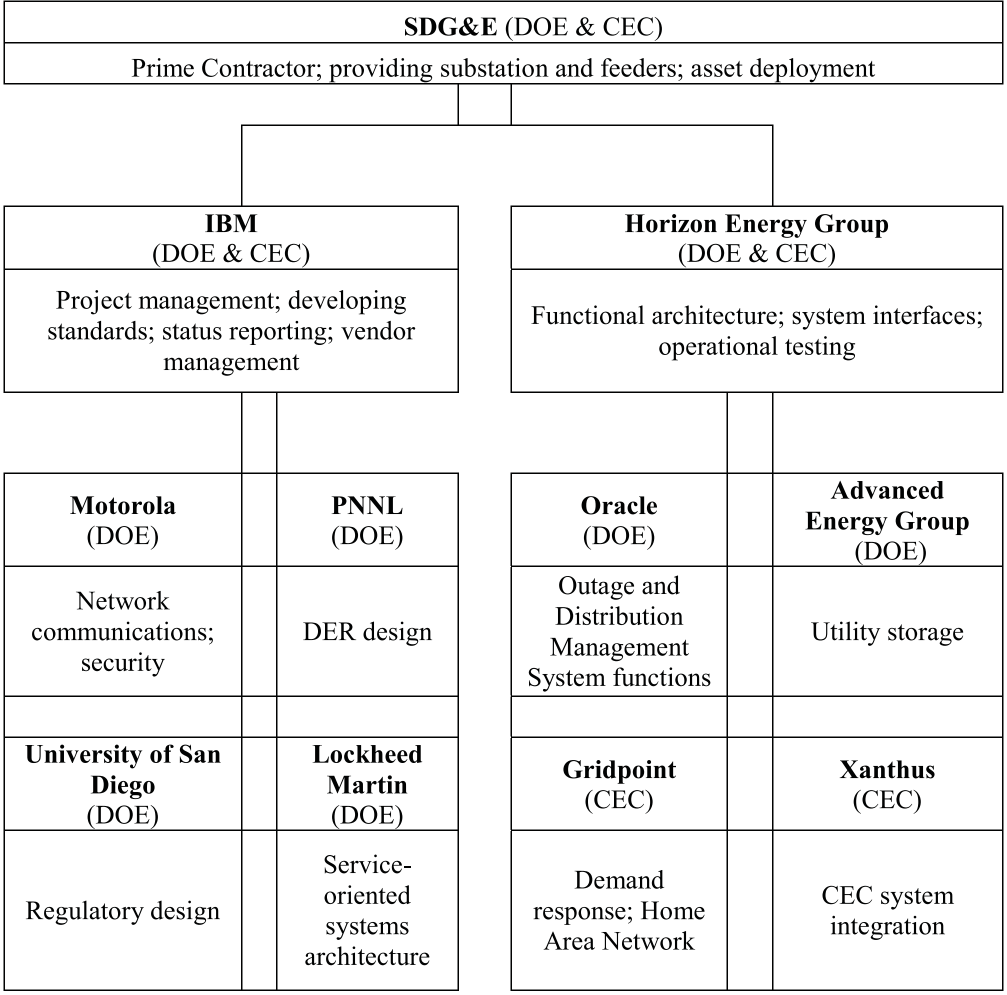
Source: San Diego Gas and Electric

Figure A3: Borrego Substation Circuit Diagram with Microgrid Features



Source: San Diego Gas & Electric

Figure A4: Proposed Beach Cities Microgrid Demonstration Project Team



Source: San Diego Gas and Electric

Table A1: Summary of Microgrid Substation Area Selection Considerations

Key Features	**Selection Criteria**
Substation	
	Survey and analyze baseline feeder characteristics, including: Loads - Historical (one year) - Planned (five years) System Configuration Existing Advanced Technology Devices Existing Measurement Devices Existing Control Capabilities Upgrade and Reconfiguration Potential as Required Customer Characteristics (residential, commercial, industrial, government)
	Identify potential customer clusters with installed resources that are favorable to a microgrid in terms of generation and consumptions loads. Identify areas where proactive developers or owners have implemented zero energy homes, sustainable communities and/or commercial power parks. Screen customer account information on the feeder to identify customers participating in California Solar Initiative, Self Generation Incentive Program, demand response programs, or have energy storage devices (thermal energy storage or batteries). In the case that the analysis indicates that there are insufficient customer resources in terms of generation, storage and load control, investigate the potential for the installation of new resources (customer-side and/or utility-side) to be implemented or scaling the number of participants down to a workable group that will meet the load balance requirements of the smart grid operation when it operates in an islanding mode.
	Assess communications and protocol capabilities of equipment on feeders being analyzed, including possible upgrades, including whether the International Electrotechnical Commission's (IEC) 61850 standards for Distribution Automation could or should be implemented on the feeder(s).[399] Assess options for various communications media to determine the most practical and/or cost-effective system to use for accessing the feeder equipment. Assess the communications and protocol capabilities and requirements for integrating customer equipment, including generation, storage and AMI. Determine whether the IEC 61850-7-420 DER protocol standard could or should be implemented for customer DER systems.[400] In addition, different communications media will be assessed to determine the most practical and/or cost-effective media to use for accessing the customer equipment, including an AMI system or a non-AMI communications network.

Source: California Energy Commission

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[399] The IEC 61850 is a standard for the design of distribution substation automation and is part of the IEC's reference model for electric power systems. For more information see the IEC's website at: http://www.iec.ch/ or the following informational site at: http://iec61850.ucaiug.org/default.aspx (accessed on May 12, 2010)

[400] IEC 61850-4-420 is a protocol that specifies information models to be used in the exchange of information between distribution substation automation systems with distributed energy resources (DER), which comprise dispersed generation devices and dispersed storage devices, including reciprocating engines, fuel cells, microturbines, photovoltaics, combined heat and power, and energy storage. For more information see: http://www.iec.ch/cgi-bin/procgi.pl/www/iecwww.p?wwwlang=E&wwwprog=pro-det.p&He=IEC&Pu=61850&Pa=7&Se=420&Am=&Fr=&TR=&Ed=1 (accessed on May 12, 2010)

Table A2: Potential Benefits of SDG&E's Beach Cities Microgrid Demonstration

Benefit Category	**Benefit Sub-category**	**Benefit**	**Potential Sources of Benefits (Smart Grid functions and resource integration – not all apply to microgrids)**
Economic	Improved asset use	Optimized generator operation (avoided grid-connected generator start-up and improved performance from better heat rate efficiency)	From improved monitoring, visualization and control of grid resources and the integration of stationary electricity storage and PHEVs
		Deferred generation capacity investments	From customer electricity use optimization; and deployment of DG, storage and PHEVs
		Reduced ancillary service cost	From automated VAR control; improved monitoring and visualization of grid conditions; and deployment of DG, storage and PHEVs
		Reduced congestion cost	Same as above, plus improved power flow controls
	Transmission & Distribution capital savings	Deferred transmission capacity investment	From fault current limiting; wide area monitoring, visualization and control; dynamic capability rating; flow control; customer electricity use optimization; and deployment of DG, storage, and PHEVs
		Deferred distribution capacity investment	From dynamic capability rating; flow control; real-time load measurement and management; customer electricity use optimization; and deployment of DG, storage, and PHEVs
		Reduced equipment failures	From fault current limiting; dynamic capability rating; enhanced fault protection; and diagnosis and notification of equipment conditions
	T&D O&M savings	Reduced distribution operations cost	From improved diagnosis and notification of equipment conditions
		Reduced distribution equipment maintenance cost	From automated feeder switching and automated voltage and VAR control
		Reduced meter reading cost	From real-time load measurement and management
	Improved utility System awareness	Reduced electricity theft	Same as above
	Energy efficiency	Reduced electricity losses	From automated voltage and VAR control, real-time load measurement and management; real-time load transfer; customer electricity use optimization; DG and storage
	Electricity cost savings	Reduced electricity cost	From customer electricity use optimization; and deployment of DG, storage, and PHEVs
Reliability	Power interruptions	Reduced sustained outages	From automated islanding and reconnection; diagnosis and notification of equipment conditions; enhanced fault protection; real-time load measurement and management; and deployment of DG, storage, and PHEVs
		Reduced major outages	From wide area monitoring, visualization and control; automated islanding and reconnection; real-time load measurement and management and load transfer
		Reduced restoration cost	From adaptive protection; automated feeder switching; diagnosis and notification of equipment conditions; and enhanced fault protection
	Power quality	Reduce momentary outages	From enhanced fault protection and storage
		Reduced sags and swells	From enhanced fault protection and storage
Environmental	Air emissions	Reduce CO2 emissions	From flow control; automated feeder switching; voltage and VAR control; real-time measurement and management; customer electricity use optimization; and deployment of DG, storage, and PHEVs
		Reduced SOx, NOx, and PM-10 emissions	Same as above
Security	Energy security	Reduced oil usage	From automated feeder switching; diagnosis and notification of equipment conditions; real-time load measurement and management; and PHEVs
		Reduced wide-scale blackouts	From wide area monitoring and visualization; dynamic capability rating; and enhanced fault protection

Source: EPRI, 2010

A.2 CORNELL UNIVERSITY'S COMBINED HEAT AND POWER CAMPUS MICROGRID

Project Name: Cornell Combined Heat and Power Project (CCHPP)
Location: Ithaca, New York
Owner/Developer: Cornell University
Ownership Model: Landlord/Campus Type 1
Status: Operating

Microgrid Typology

Project originator	[✓ Private sector]	Government	
Microgrid system owner	Single		Multiple
	Utility or ESCO	[✓ Property owner]	
Energy users	[✓ Self]	Self + others	Others
Cross public street?	Yes	[✓ No]	
Form of energy distributed	Power only	[✓ Power + thermal]	Thermal only
Limits on microgrid size?	[✓ None]	# of customers	Volume of sales
Interconnected at voltage?	LV	[✓ HV]	
Operate independently of grid?	[✓ Yes]	No	
Multiple resources	[✓ Yes]	No	
Certified QF?	[✓ Yes]	No	

Microgrid Summary Statistics

- **Number of distinct customers**: 1 (150 buildings electric and thermal; 75 district cooling)
- **Types of end uses served**: Administrative offices, classrooms, residential dormitories, research laboratories, athletic facilities, and food services operations
- **Production technologies employed**:
    - 2 Solar Titan Model 130 combustion turbines (duel-fuel units, 14.7 MW each)
    - 2 Turbodyne back-pressure steam turbo-Generators (1986 vintage generators, 1.7 MW and 5.7 MW each)
    - 2 Rentech heat recovery steam generators (58,000 lbs/hr)
    - 2 emergency diesel generators (1 MW each)
    - 2 Ossberger run-of-river hydroelectric generators (1981 vintage, 800 kW and 1 MW)
    - 2 coal fired stoker boilers (170,000 lbs/hr and 90,000 lbs/hr)
    - 2 dual fuel (natural gas/#2 ultra low sulfur diesel) package boilers (100,000 lbs/hr each)
    - 1 natural gas fired package boiler (100,000 lbs/hr)
- **Peak electric capacity**: 37.9 MW[401]
- **Electric demand**: Peak – 34 MW (2008); Minimum – 13.5 MW (2008)
- **Annual total energy usage**: 2,500,000 MMBtus (fuel for electricity and boilers)
- **Annual electric usage**: 201,000 MWh (2008)
- **Peak thermal capacity**: 680,000 lbs/hr (without duct firing) and 860,000 lbs/hr (with duct firing) **Peak thermal demand**: 400,000 lbs (winter, 2008) and 47,700 lbs (summer, 2008)
- **Peak cooling capacity**: 20,000 tons
- **Annual cooling**: 40,000 ton-hours
- **Annual thermal**: 600,000 tons (short)/year
- **Annual CO_2 reductions**: 50,000 tons per year (40% reduced from 2007)
- **Annual SO_2 reductions**: 800 tons per year (65% from 2007)
- **Annual NOx reductions**: 250 tons per year (70% from 2007)

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[401] This total is not "dispatchable" capacity as the Hydro is run of river and the steam turbo generators follow steam production. Emergency generators are only used for black-starts.

Ownership & Service Model Explanation

Cornell University's combined cooling, heat and power system is an example of a Landlord/Campus Model 1 microgrid.[402] The University owns and operates the system, which is intended for self-service to the school's various buildings. Cornell does not provide service to unaffiliated customers and the microgrid does not cross a public right of way to deliver energy to any of the campus' buildings.

Background/Project Objectives

Cornell University has been generating power on-site since the 1880s, when the University built a hydropower facility in Fall Creek gorge in the center of campus.[403] At roughly the same time the University installed a central heating distribution system, which would eventually grow into separate delivery systems fed by boilers from three independent plants located in different quarters of campus. After World War I, the University replaced the separate plants with a centralized district heating plant to serve the entire campus. This system was completed in 1922.

Today Cornell has over 19,000 undergraduate and graduate students and more than 11,000 faculty and staff housed in 150 buildings covering 14 million square feet of space. Much of this space shelters advanced research with a need for highly reliable electricity services. Loss of energy to labs for even relatively short periods could result in loss of research with significant financial consequences.

Cornell has forecast its campus demand for steam to outgrow its existing capacity in upcoming years. To satisfy forecast future demand, Cornell is in the midst of a significant expansion of its central heating plant and microgrid system.[404] Currently, the University provides all of its heating requirements principally though the combustion of coal in several boilers. This system supplies all of the campus' annual steam requirements used for space heating and other processes. It also generates some of the electricity used on campus – about 15% – using its run-of-river hydroelectric facility and two back pressure steam turbo-generators that are part of its existing central heating cogeneration plant. The University purchases the remaining 85% of its electricity requirement from New York State Electric and Gas (NYSEG). Cornell also has a separate lake source district cooling system serving the campus. By the end of 2009, the central heating plant will be expanded to increase the campus' self-supply of electricity to approximately 80% of its needs with the balance purchased from NYSEG. The plant will also be able to island from the macrogrid in order to ensure continuous service to the University's critical loads. These changes will increase the efficiency of Cornell's power and thermal operations, and improve its environmental performance.

Detailed Microgrid Description

On an annual basis, Cornell's Ithaca campus consumes approximately 240 GWh of electricity, 1.2 million klbs of steam and 40 million ton-hours of chilled water. With a peak electric demand close to 35 MW, the University consumes approximately 2.5 trillion Btus of energy (fuel and electricity) emitting 270,000 tons of CO_2 per year. To supply the University's demand for energy, Cornell has, over time, devised two separate, but complementary campus energy systems: a combined heat and power system (which generates electricity and produces steam for building heating) and a district cooling system which uses Cayuga Lake, two miles to the north, as an efficient heat exchanger. While these two systems are technically separate, they work together to provide highly efficient power, heating, and cooling services to the University.

District/Lake Source Cooling

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[402] The Landlord/Campus Type 1 microgrid model has a single non-utility owner that installs and operates the system to supply electricity and/or thermal energy to multiple buildings also owned by the landlord-operator. Buildings and streets are under single ownership and there are no previously unaffiliated parties receiving service from the microgrid. The system's wires and pipes do not cross a public way.

[403] Cornell University Utilities and Energy Management, "Cornell University Fall Creek Hydroelectric Plant." Cornell University," Available at: http://www.utilities.cornell.edu/utl_hydro electricplant.html (accessed on October 15, 2009)

[404] Cornell University, "Cornell CHP Project Description - Informational Flyer," June 20, 2008, Available at: http://www.Cornell_CHP_Project_Description_June2008.pdf (accessed on October 20, 2009)

Cornell began construction of its closed loop district cooling system in 1960 in response to concerns that its water filtration plant, which was partly used for air conditioning, would not be able to keep up with future demand. In 1994, the University began a project to expand cooling capacity to address expected load growth, comply with federal law phasing out the use of chlorofluorocarbons (CFCs) in refrigerants, and ameliorate rising energy costs. The University took advantage of its close proximity to Cayuga Lake to develop a Lake Source Cooling (LSC) system as an alternative cooling source.[405]

The LSC system works as a pair of loops, one that takes in water from 250 feet below the surface of the lake and another that distributes cooled water in a loop around the Cornell campus. Cold lake water, pumped up to the campus from the lake, passes through a heat exchanger, which absorbs some of the heat in the water used to cool Cornell and its neighboring Ithaca High School. The system relies on the natural flow of heat from hot to cold and requires little energy aside from pumping to push the water two miles to the heat exchanger. The warmer water is then returned by gravity through perforated pipes to a shallow part of the lake where the discharge of warmer water has less of an impact.

Cornell's LSC system can serve up to 20,000 tons of peak cooling capacity, providing cooling to 75 buildings, comprising about forty percent of the main campus. The campus distribution system consists of over fifteen miles of underground pipe and a storage tank, giving the system a total volume of 7.5 million gallons. The LSC operates at an efficiency of 0.1 kW/ton[406], resulting in a savings of 22,000 MWh per year compared to a conventional electric powered cooling network.[407]

Central Heat and Power Plant

After the University completed the Lake Source Cooling project in 2000, it turned its resources to expanding the capacity of its heating and electrical generation system. Cornell forecast that its existing plant would be unable to meet future campus steam needs, so it commenced a repowering project in 2006. The school's existing cogeneration plant dates from the 1980s and uses back pressure steam turbines rated at 7.4 MW to generate approximately 30,000 MWh per year of electricity and 600,000 tons per year of high-pressure steam from its six boilers.[408] The 1.2 MW run-of-river hydroelectric generators also produce approximately 5,000 MWh/year, on an as-available basis depending on annual creek flows. Together, these facilities provide approximately 15% of the campus electricity needs.[409]

In order to address future steam load growth, reduce cost and increase campus electric reliability, Cornell is finishing the expanded cogeneration facility (the Cornell Combined Heat and Power Project, or CCHPP). Once complete, the CCHPP will improve overall system efficiency, reduce electricity purchases from the grid, and be capable of serving campus loads in the following configurations:

- In parallel with or without exports to the regional grid
- Islanded from the regional grid under normal conditions
- Using blackstart operation to restore service and operate islanded from the regional grid

The expansion project includes two Solar Titan 130 combustion gas turbines and two Rentech Heat Recovery Steam Generators (HRSGs), which will allow the campus to use a combined cycle system to efficiently generate electricity and produce heat. The two Solar turbines have a combined peak electrical output of 30.7 MW and a heat rate of

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[405] Cornell University Utilities and Energy Management, "Lake Source Cooling Environmental Facts and Benefits," Available at: http://www.utilities.cornell.edu/utl_lscfacts.html (accessed on October 15, 2009)

[406] Prior to the development of the LCS, Cornell's district cooling system operated at an efficiency of 0.75 kWh/ton-hour of cooling. Efficiencies of 1 kWh/ton-hour of cooling is common for such systems.

[407] For more information on the district cooling system see: http://www.utilities.cornell.edu/utl_cooling.html (accessed on April 10, 2010)

[408] Of Cornell's six boilers, three burn natural gas, two use low-sulfur bituminous coal and one just fuel oil. Two of the natural gas boilers, which date from 1992 and are the most modern, burn either natural gas or fuel oil.

[409] Lauren Gold, "Cornell central heating plant to become cleaner, more efficient," *Cornell University Chronicle Online*, January 18, 2006, Available at: http://www.news.cornell.edu/stories/Jan06/CHP.expansion.lg.html (accessed on October 20, 2009)

10,189 Btu per kWh. Although they will primarily burn natural gas, the turbines are dual fueled, which allows them to burn ultra low sulfur No. 2 diesel fuel if the gas supply is insufficient or interrupted.[410] The University has also constructed a diesel storage facility on site with a capacity of 700,000 gallons, or approximately 18 days worth of back-up supply (based on daily average plant energy production). Other important new equipment for the CCHPP microgrid include two 1-MW emergency diesel generators, which are the new plant's black-start generators.[411] The emergency generators will also be able to continuously operate in parallel with the utility and in a peak shaving mode.[412]

To satisfy this shift to natural gas, Cornell constructed a new 3.2-mile high-pressure gas line connecting the campus directly to Dominion Transmission Inc.'s interstate gas pipeline system.[413] The University secured a firm transportation entitlement (a contract to deliver a specified amount of gas) from Dominion of 15,000 decatherms (dth) per day, or approximately equivalent to the peak anticipated use on a cold winter day. On such days, the fuel requirement for the gas turbines represents approximately half of the entitlement (304 dth/hr, combined) with the other half required by the duct burners (200 dth/hr) and package boilers (121 dth/hr) to meet campus steam loads.[414]

Steam is distributed on the Cornell campus at 350 degrees Fahrenheit and between 50 and 75 psi and is returned to the plant as condensate. This condensate is returned at approximately 85% of the steam flow rate, 150ºF and 50 psig. On an annual basis, average steam load is approximately 140,000 lbs/hr, while peak load is 380,000 lbs/hr and minimum load (summer) is 55,000 lbs/hr. This system serves approximately 250 facilities representing 14,000,000 square feet of space.[415]

The new HRSGs are each rated at 58,000 pounds of unfired steam per hour and together will be able to provide up to 150,000 pounds per hour, with supplemental duct firing. The supplemental duct firing increases the efficiency of the units from an average of 83% to 99%, which is beneficial during the winter months when there is higher demand for steam.[416] Due to their higher efficiency, Cornell will always dispatch the duct burners for steam production before the package boilers.

Prior to the expansion, Cornell was interconnected to NYSEG with two high voltage (115kV) transmission lines at the campus's main substation at Maple Avenue. As part of the plant expansion, and in response to NYSEG interconnection requirements, the two existing transformers will be replaced with smaller transformers that comply with NYSEG's specifications and a third 115 kV primary transformer will be added for transmission line protection. The addition of a third transformer provides N-1 operating capabilities, meaning any single transformer can be taken out of service without disrupting campus electric service. With a combined capacity of 80 megavolt-amperes (MVA), any two transformers can easily supply the entire campus load, which currently peaks at 37.8 MVA. This extra capacity provides both operational flexibility and a sizable cushion to accommodate forecast peak system load growth, which is expected to be as high as 71 MVA in 20 years.[417]

Historically, electricity has been distributed on Cornell's campus from the Maple Avenue Substation via two separate 13.2 kV distribution systems, each serving different portions of the campus – loads associated with Cornell's endowment and loads associated with the state-funded State University of New York (SUNY). Due to SUNY requirements these systems were operated separately, as recently as 2006. Nevertheless, over the last decade the state relationship has evolved, and the state-funded part of campus is now referred to as the "Contract College Facilities." Under the new arrangement the state no longer requires physical separation, so the substation recently completed as part of the CCHPP project, does not use this configuration. Going forward, Cornell's Project Design

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[410] Thomas Kelly, personal communication with Joyce and Peer, 2009
[411] Thomas Kelly, personal communication with Joyce and Peer, 2009
[412] Cornell, "Basis of Design," pp. 33-34
[413] Cornell University Utilities and Energy Management, "Gas Delivery Line – Outreach," Cornell University, Available at: http://www.utilities.cornell.edu/utl_cchp_outreach.html (accessed on October 20, 2009)
[414] Thomas Kelly, personal communication with Peer, 2009.
[415] Cornell University, "Notice of Self-Certification of Qualifying Status of a Cogeneration Facility to the Federal Energy Regulatory Commission," October 8, 2009
[416] Thomas Kelly, personal communication with Peer, 2009; and Robb, Drew. "Cogeneration at Cornell." *Turbomachinery Magazine*, May/June 2009, p. 39
[417] Cornell, "Basis of Design," p. 23

and Construction will manage the systems as one, which will improve the coordination of fault protection, or prevention of abnormal current fed onto NYSEG's transmission system.

The University carefully tracks energy usage in its buildings and facilities on campus with over 800 meters. The Cornell Utilities Department bills these accounts separately and provides an on-line tool that enables viewing of each building's energy consumption.[418]

Cornell's Utilities Department manages its heating and cooling systems via two Energy Management and Control System (EMCS) Operations Centers, which provide separate oversight of the operation and distribution system functions in the Chilled Water and the Central Heating Plants. To enhance its EMCS capabilities, a Load Management System (LMS) is being supplied by Solar to optimize the operation of the gas turbines, controlling imports and exports and generator synchronization with NYSEG. When installed, the LMS will also provide an automatic load-shedding scheme, to coordinate strategic load reductions at the campuses other substations in the event of a grid outage and campus loads that exceed available generating capacity. The system will run parallel to the grid and in the event of an emergency, it will be able to operate as an island or export power onto the 115 kV grid.[419] Cornell's Utilities Department presently does not prioritize electrical loads on campus. Each facility makes its own decision regarding criticality of loads and implement uninterruptible power supply[420] or emergency diesel generators as required at the facility level. Cornell's current arrangement will only allow for load shedding at the secondary buss of the main substation, which will cause a quarter of all connected loads to go offline including a mix of critical and non-critical loads.[421]

Cornell's development of separate cooling and heating systems affected the design and operation of the CCHPP. The University could have designed its system to meet all of its electric energy requirements. Still, since the cooling system is physically decoupled from the steam system, there is little use for steam produced in the summer. Whereas the University could use steam-driven chillers to run building cooling, keeping its steam load relatively flat throughout the year and allowing it to generate more electricity, Cornell's lake-based cooling system effectively removes this option. The LSC system reduces the campus energy use for cooling by over 80%, or as much as 22,000 MWh/year assuming the use of electric chillers. Thus, as uses for steam decline during the summer months, only one combustion turbine will be used.

The school anticipates the new CCHPP plant will produce 10,000 MWhrs/month in the summer, 20,000 MWhrs/month in the winter, and 15,000 MWhrs/month in the fall and winter months. During the summer, spring, and fall, only one HRSG will operate full time, while the second will come on line as needed to satisfy building heating requirements.[422]

Project Development Process

Cornell's microgrid has been a long-term work in progress with components built at different times over much of the last century. The current CCHPP project was started in 2006 and went on line in January 2010.

To undertake the significant expansion of its district heating and power services, Cornell retained a number of experienced contractors and consultants. Cornell hired Levitan & Associates, Inc. and GIE Niagara Engineering to conduct a comprehensive economic and technical analysis of the campus needs. Engineers employed by Cornell Utilities provided data on historical energy use and growth patterns, which were used to model load growth over the 25-year study horizon.

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[418] Select and view individual building energy data on Cornell campus at: http://www.fs.cornell.edu/fs/fs_facilFind.cfm (accessed on March 7, 2010)

[419] Thomas Kelly, personal communication with W.S. Joyce and Tim Peer, Cornel University, 2009

[420] A UPS is an electrical system that provides emergency power to a load (i.e., data centers or servers) when the input power source fails. A UPS differs from an emergency power system or standby generator in that it will provide instantaneous or near-instantaneous protection from input power interruptions by means of one or more attached batteries and associated electronic circuitry for low power users, and or by means of diesel generators and flywheels for high power users.

[421] Thomas Kelly, personal communication with Peer, 2010

[422] Thomas Kelly, personal communication with Joyce and Peer, 2009

The major project milestones and approximate/planned completion dates for the CCHPP expansion are as follows:

- Compilation of baseline energy data……………………Summer/Fall 2006
- Development of monitoring plan…………………………………Fall 2006
- Preliminary design and review………………………………Winter 2006/7
- Interconnection study………………………………………..Summer 2007
- Final design and review……………………………………...Winter 2007/8
- Site preparation…………………………………………………....Fall 2008
- Permit acquisition………………………………………………Fall 2007
- Construction of gas delivery line………………………………..Fall 2008[423]
- Equipment procurement……………………………………..Summer 2008
- Equipment installation………………………………………Summer 2009
- Commissioning……………………………………………Winter 2009/10
- Web-based communications………………………………Winter 2009/10
- Technology transfer………………………………………..Winter 2009/10

Permissions and Regulatory Matters

Since the CCHPP expands facilities that have existed on Cornell's campus for some time, it has not encountered as many obstacles as a new and similar project might face, particularly one that might involve the installation of similar distribution infrastructure. Cornell's self-supply of electricity dates back to the late 1800s, when the electric industry was still in its infancy, and before utility service had been established in the Ithaca region. It also pre-dated the formation of the New York Public Service Commission, which occurred in 1907. Thus, Cornell did not need to obtain any permission to distribute power over an incumbent utility's lines. Furthermore, Cornell owns all of the property and buildings to which it serves power and does not cross a public way, so there is no threat of raising a conflict with NYSEG over franchise issues.[424] Nevertheless, during the recent expansion project, Cornell did consider serving power to a shopping plaza, which it owns, one half mile away from the plant. The University opted against attempting to connect it to the microgrid because it would cross a public road and it did not want to deal with the associated utility franchise issues for a relatively small load. Cornell also went through an extensive permitting process for development of the lake source cooling system in the early 2000s. Although we don't address this project below, Cornell has provided detailed information on the system and the necessary permissions on its Campus Utilities Management website.[425]

In order to move forward with its CCHPP microgrid expansion, Cornell had to obtain the following permissions from federal, state and local authorities.

Self-Certification as a Qualifying Facility Before the Federal Energy Regulatory Commission (FERC)
Cornell submitted its notice of self-certification of its cogeneration facility as a "qualifying facility" (QF) under the federal Public Utilities Regulatory Act (PURPA) on October 6, 2009 (Docket No. QF10-13-000).[426] Cornell sought QF certification for its cogeneration system so that it can sell excess power, when available, to NYSEG.

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[423] To see the specific schedule for construction of the gas line see Cornell's website at: http://www.utilities.cornell.edu/utl_cchp_gasline_schedule.html (accessed on October 14, 2009)

[424] All entities that require the use of public ways – i.e. for transmission or distribution facilities – must be granted permission by the presiding municipal authority in the form of a franchise or some lesser consent, depending on the scope of the usage. The cities, towns, and villages of New York have specific statutory authority to grant franchises: as provided by N.Y. Gen. City Law § 20(10), every city is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city. Franchise rights are franchise-specific. In New York, franchises are typically nonexclusive, at least in principle, and the territory in which facility installation is permitted under a given franchise is the territory where the public service is provided.

[425] See Cornell University Facilities Services Utilities and Energy Management, "Lake Source Cooling: Local, State and Federal Agency Approvals," Available at: http://www.utilities.cornell.edu/utl_lscapproval.html (accessed on April 10, 2010)

[426] Cornell University, Notice of Self-Certification of Qualifying Facility Status of a Cogeneration Facility, filed with FERC on October 8, 2009

Nevertheless, on December 18, 2009, NYSEG applied to FERC to terminate its obligation to enter into new power purchase obligations for energy and capacity from QF facilities with net capacity greater than 20 MW.[427] This request follows changes made to PURPA by the Energy Policy Act of 2005, which provides for the termination of such utility purchase requirements if FERC finds that the QF has non-discriminatory access to wholesale electricity markets. In Order 688, FERC found that the markets administered by the New York Independent System Operator (NYISO) satisfied the criteria of the relevant PURPA section (210(m)(1)(A)). Accordingly, FERC's regulations established a "rebuttable presumption" that large QFs interconnected to the NYISO system have "non-discriminatory access" to wholesale markets where they can sell excess power, obviating the need for the utility purchase requirement.

On January 15, 2010, Cornell submitted a protest of NYSEG's application and requested that FERC exclude its facilities from any termination of the purchase obligation it might grant.[428] Cornell's request was based on two facts that it claimed allow it to rebut the resumption of non-discriminatory access. First, because the amount of electricity produced is tied directly to steam production, which is driven by weather conditions, Cornell's facilities have operational characteristics that are highly variable and unpredictable. Second, NYISO rules, namely penalties for facilities that under-generate compared to what they bid into the market, discriminate against intermittent resources such as Cornell's. On March 18, 2010, FERC issued its order granting NYSEG's application for a service area wide termination of its PURPA QF purchase obligation with the exception of Cornell. FERC found that Cornell persuasively explained the connection between its electric output and variable steam production and how that limited its ability to economically participate in the NYISO energy markets. FERC observed that since NYISO exemptions to penalties for under-generation provided to solar and wind resources are not extended to cogeneration units such as Cornell's, it was "effectively denied non-discriminatory access to NYISO markets." The effect of this decision will be that NYSEG will have to purchase Cornell's excess electricity in accordance with the terms and conditions set forth it its QF buy-back tariff (see NYSEG's Tariff, PSC No. 120, Leaf No.'s 275-281)

Treatment of State University of New York/"Contract College" Loads

Currently, Cornell is the legally responsible customer who pays the metered cost at the 115 kV connection to NYSEG. Assignment of cost is accomplished via budget transfers for all connected loads inside the microgrid. Prior to the transition from the SUNY to the Contract College Facilities (CCF) classification, SUNY paid its portion of the bill directly to the NYSEG. This was possible because the SUNY facilities were served through the 115 kV connection to NYSEG by a circuit separate from the endowed facilities. The microgrid still has two meters at the point of common coupling with NYSEG, but now CCF/Endowed loads are dispersed amongst the three secondary busses that serve the system. As a result, CCF can no longer be a separate, legally responsible customer. Going forward, the two meters will be aggregated and billed as a single connection.[429]

Environmental and Air Permits

New York Department of Environmental Conservation (DEC) – *State Environmental Quality Review (SEQR)* – In New York State, all discretionary approvals (permits) from a NYS agency or unit of local government require an environmental impact assessment. Cornell submitted a Long Environmental Assessment Form (LEAF) to the DEC on July 11, 2007, identifying the project's potential environmental impacts and planned mitigation strategies. The LEAF specifically addressed project impacts to land and neighbors from construction, water resources, air resources, agriculture, aesthetics, historical sites, recreational areas, transportation, energy and natural resources, noise, public health and environmental justice. On November 7, 2007, the DEC issued a Negative Declaration and Notice of Determination of Non-Significance, which determined that the project would not have a significant impact on the environment, effectively authorizing Cornell to proceed with its CCHPP project without conducting a full environmental impact report (EIR).[430]

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[427] NYSEG and Rochester Gas and Electric Corporation, Application of NYSEG and RG&E Requesting Termination of Their Obligation to Purchase from Qualifying Facilities with Net Capacity Greater than 20 MW, filed with FERC on December 18, 2009

[428] Cornell University, Answer and Protest of Cornell University to the Application of NYSEG and RG&E Requesting Termination of their Obligation to Purchase from Qualifying Facilities with Net Capacity Greater than 20 MW, filed with FERC on January 15, 2010

[429] Thomas Kelly, personal communication with Peer, 2010

[430] A copy of Cornell's Long Environmental Assessment Form and the DEC's Negative Declaration may be found on Cornell's Utilities website at: http://www.utilities.cornell.edu/doc/DEC_CCHPP_Neg_Dec%2011_6_07.pdf (accessed on October 14, 2009)

DEC – *State Facility Air Permit (Title V)* – New York's air permitting program, required by the New York State Clean Air Act [6 NYCRR Part 201] and administered by DEC's Division of Air Resources (DAR), identifies and controls sources of air pollution. State facility permits are issued to facilities that are *not considered* to be "major" (as defined in the department's regulations), but that meet the certain criteria [Subpart 201-5].[431] Cornell submitted an Air Permit Application on November 2, 2007. On June 3, 2008, the DEC issued the air permit, which will be effective for five years and must be renewed by June 3, 2013 for continued operation of the CCHPP facilities.

U.S. EPA - *Prevention of Significant Deterioration (PSD) Permit*: Because Cornell's CCHPP project modifies an existing source of air pollution (the existing central heating facility) it was required to obtain a PSD permit. The PSD applies to new "major sources"[432] or major modifications at existing sources of pollutants where the area the source is located is either "in attainment" or "unclassifiable" with the National Ambient Air Quality Standards (NAAQS).[433] On July 12, 2007, Cornell submitted its application to the EPA for a PSD air permit, addressing emissions of fine particulate matter and sulfuric acid mist. Public notification was provided on April 16, 2008 and the EPA issued the permit on June 3, 2008.

NYS Public Service Commission (PSC) - Certificate of Environmental Compatibility and Public Need
In order to construct the necessary pipeline to supply gas to the combustion turbines, Cornell was required to apply to the PSC for a Certificate of Environmental Compatibility and Public Need. This authorization gives the University rights to acquire easements to construct the pipeline as well as override specific local zoning and building requirements that might otherwise prevent the line from being built. On February 28, 2008, Cornell applied to the PSC for authority to construct the pipeline through the Towns of Dryden and Ithaca. Over the course of a four-month period, the University hosted four public forums to discuss the project with concerned citizens and neighbors. On June 30, 2008, the Commission issued its order in Case No. 08-T-0213, determining: (1) the pipeline was needed and of sufficient capacity to supply Cornell's CCHPP project with the stated volume of gas; (2) the nature of the probable environmental impacts are largely due to construction, are temporary in nature, and will be mitigated; (3) its location will not pose an undue hazard to persons or property along the area traversed; and (4) the facility will serve the public interest, convenience and necessity. Based on these findings, the Commission granted the University the CECPN to construct its pipeline subject to specific conditions regarding the management and implementation of the construction project.[434] Cornell did not need to file for a Certificate of Public Convenience and Need for electric distribution because it was not adding new distribution facilities.[435]

Permissions from the Towns of Ithaca and Dryden and Tomkins County
Cornell had to obtain a number of local permits for the construction of its new plant and the new gas line. These permissions included site plan approvals, zoning variances, building permits, permits for ammonia storage, and road crossing permits. A full list of the various local permissions required for the microgrid plant expansion are provided in Table A3 in the Appendix.

Interconnection
Cornell also had to apply for approval to interconnect its new generating capacity to NYSEG and the state high-voltage transmission system managed by the NYISO. The NYISO's requirements for generators larger than 20-MW are detailed in its "Standard Large Facility Interconnection Procedures," contained in Attachment X of the NYISO

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[431] For more information on New York State's air permitting requirements and process see the DEC's website at: http://www.dec.ny.gov/chemical/8569.html (Accessed October 15, 2009)
[432] The U.S. EPA uses the term "major source" to determine the applicability of a PSD and new source regulations. In areas that are classified as "nonattainment" a major source is any stationary air polluting source with the potential to emit more than 100 tons per year.
[433] The Clean Air Act requires the EPA to set NAAQS for widespread pollutants from numerous and diverse sources considered harmful to public health and the environment. There are two types of national air quality standards: primary standards (which set limits to protect public health) and secondary standards (which set limits to protect public welfare). The EPA has set NAAQS for six pollutants, called "criteria" pollutants, including: carbon monoxide, lead, nitrogen oxide, ozone, particulate matter, and sulfur dioxide. See the EPA for more information at: http://www.epa.gov/nsr/psd.html (accessed on October 16, 2009)
[434] For documents relating to Cornell's application see the Public Service Commission's website at: http://documents.dps.state.ny.us/public/MatterManagement/CaseMaster.aspx?MatterSeq=29827 (accessed October 16, 2009)
[435] Other permits Cornell had to obtain from the NYS DEC were two Storm Water Discharge Permits and a Permit to Take or Harass Nuisance or Destructive Wildlife.

Open Access Transmission Tariff.[436] Additionally, NYSEG provides all independent power producers with guidelines and procedures for interconnecting new facilities to its system in its Bulletin 86-01. At a minimum the application includes providing design and operating information for the proposed facility. If the facility being interconnected to the grid is of a particular size (usually greater than 2-MW), an engineering analysis must be performed in order to ascertain the potential impacts on existing infrastructure and determine what electrical devices are required to protect utility and transmission system assets. After receiving the developer's application and associated materials, the utility conducts a review and determines acceptance in accordance with the applicable process. The project developer is responsible for all utility costs incurred during the interconnection process.

Cornell submitted its electrical interconnection application to the NYISO on October 20, 2006 and to NYSEG on December 8, 2006. Based on the NYISO's initial review, it was determined that Cornell's project was not a new interconnection and would not adversely impact the grid and thus could be handled at the local level by NYSEG. Because the expanded system will be over 20-MW of capacity, NYSEG conducted an electrical interconnection impact study to verify any modifications that would be required to the transmission or switching systems to ensure safety of the local and regional grid. NYSEG's review did not identify any major required improvements.

New York State Rebates
In 2006, Cornell applied to NYSERDA for funding under its Program Opportunity Notice 1043: Distributed Generation as Combined Heat and Power, as a demonstration project. In its application, Cornell submitted a detailed description of the project including the existing and proposed equipment for the facility, system performance estimates, detailed project cost estimates, budget and milestones, analysis of the social and environmental benefits it portends to provide, and examples of similar projects implemented elsewhere. NYSERDA approved Cornell's request and contributed $1 million in SBC cost-sharing funds to support the CCHPP project.

Cost/Benefit Information

Cornell spends approximately $30 million per year on energy, including close to $20 million on grid electricity purchases and $10 million on fuels for its boilers and existing CHP facility. The total cost of its CCHPP is expected to be between $55-60 million, which the University will finance through loans. When on line, the new system will provide 50% of the campus steam from "waste heat" and expand the campus electricity production to about 80% of its needs, with the rest purchased from NYSEG.

Prior to making a commitment to construct the CCHPP, Cornell undertook the development of a comprehensive energy master planning effort. The Plan featured a risk-based economic analysis of several different technology options for meeting the campus power and heating demand. The financial analysis of central heating and electricity alternatives focused on their Present Value (PV) over a 25-year planning horizon, relative to a base case strategy of installing package boiler additions to meet the University's thermal supply requirements. Ultimately, the University selected the CCHPP microgrid project, which had a slightly lower PV than the base case, but provided the following additional benefits.[437]

Economic benefits: Include lower delivered energy cost to campus (direct) and reduced overhead costs (indirect). Sensitivity analysis showed that the CCHPP would provide a net present value of $15 to $20 million over 25-years. The project also satisfied the University's minimum financial return requirements, which is consistent with the long-term rate of return of the endowment and in the range of 8-10 percent.

Greater reliability: Cornell's microgrid will have the capability of operating in an islanded mode in the event of a regional or local electric grid power loss. The diesel generators will provide black-start support to the system, which may then be able to provide black-start support to the regional grid. Islanded operation will allow the University's essential facilities and sensitive research labs to remain operating during an outage. It will also allow the University to become a community safe haven in the case of an extended regional emergency.

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[436] See the NY ISO's website for more information on its OATT and generator interconnection requirements: http://www.nyiso.com/public/documents/tariffs/oatt.jsp (accessed on October 20, 2009)
[437] Cornell University, NYSERDA Program Opportunity Notice 1043 Proposal, August 2006

Fuel flexibility and security: The CCHPP's dual-fuel capabilities provide Cornell with the ability to operate on natural gas or distillate fuel oil, providing the campus with an alternative in case its supply of natural gas is disrupted. The University is also interested in potentially running the system on either renewable liquid or gas fuels (i.e., biomass, biogas or alternative liquid fuels) as they become economically available.

Regional electrical support: Cornell is located in an area of documented transmission constraints, particularly when the nearby AES Cayuga Power Station has an unplanned outage.[438] The University's microgrid is connected to NYSEG's 115 kV system and it anticipates participating in the NYISO's Installed Capacity (ICAP) program, although as of the time of writing, it has yet to apply.

Environmental benefits: By switching its fuel inputs to natural gas, the University expects the CCHPP to help it reduce its consumption of coal by close to 30,000 tons per year. Since natural gas is much less polluting than coal, this fuel switching will reduce Cornell's emissions of SO_x by 65%, NO_x by 70% and CO_2 by 40%.

Technology and information transfer: Cornell intends to collect and share information about its system, particularly emissions and economic data to help others understand the benefits of CHP and microgrids.

See Table A4 in the Appendix for additional detail on this project's costs and benefits to different participants.

Project Contact

Organization: Cornell University
Name Title: Tim Peer, Project Manager, P.E.
Address: Cornell University Utilities and Energy Management
131 Humphreys Service Building
Ithaca, NY 14853
Phone: (607) 255-9968
Email: tsp@cornell.edu

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[438] AES Cayuga is a 50-year old coal fired plant with 350 MW located approximately 13 miles north of Cornell's campus.

Figures and Tables

Table A1 – CHP Boilers

Boiler #	Fuel	Capacity (klb/h)	Boiler Type	Year Installed	Outlet Pressure/Temp (psig/˚F)	Notes
1	Coal	90	Spreader Stoker	1981	400/600	
2	#6 Fuel Oil	70	Sterling Vibrigate	1959	200/550	To be dismantled
5	Nat.Gas	100	D Type Package	1965	200/550	
6	Nat. Gas or #6 Fuel Oil	107.5 / 109.5	D Type Package	1992	400/600	
7	Nat. Gas or #6 Fuel Oil	107.5 / 109.5	D Type Package	1992	400/600	
8	Coal	175	Overfeed Stoker	1949	400/600	

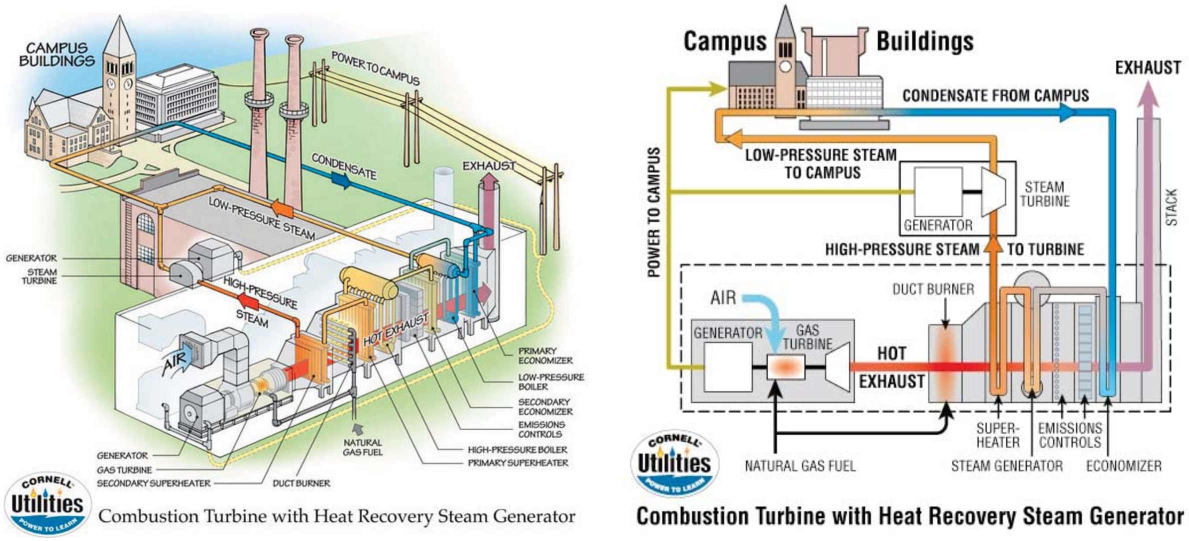
Source: Cornel University

Table A2 – Existing Cornell Campus Electric Generators

Steam Turbo-Generators			
Unit #	Nominal Capacity (kW)	Inlet Pressure (psig)	Year Installed & Manufacturer
1	1700	400	1986 Turbodyne
2	5800	400	1986 Turbodyne
Diesel Engine Generator			
Unit #	Nominal Capacity (kW)	Fuel	Year Installed & Manufacturer
1	750	Diesel	1986 Caterpillar
Hydroelectric Generators			
Unit #	Nominal Capacity (kW)	Intake Flowrate (gpm)	Year Installed & Manufacturer
1	800	39,630	1981 Ossberger
2	1072	54,600	1981 Ossberger

Source: Cornell University

Figures A1 & A2 – CCHPP System Illustrations

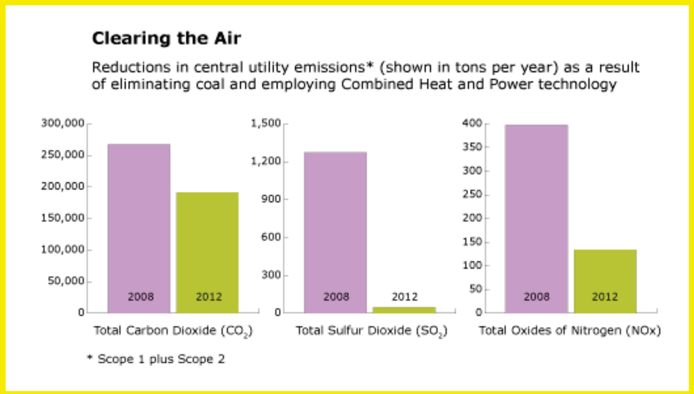


Source: Cornell University

Table A3 – Local Permits Required for CCHPP Facility

Locality	Permit
City of Ithaca	- City of Ithaca Preliminary and Final Site Plan Approval for the CCHPP - City of Ithaca Operating Permit for Aqueous Ammonia Storage
Town of Ithaca	- Preliminary and Final Site Plan Approval for the Cornell Service Yard Project (CSYI) and Maple Ave Substation Renewal (MASR) - Preliminary and Final Site Plan Approval for the Cornell Combined Heat & Power Project (CCHPP) - Preliminary and Final Site Plan Approval for Court Side Equipment Staging - Zoning Variance #1 – CCHPP Height - Zoning Variance #2 – MASR Height - Zoning Variance #3 – CCHPP Sprinkler - Building Permit for CSYI - Building Permit for MASR - Building Permit #1 for CCHPP – Site Excavation - Building Permit #2 for CCHPP – Foundation - Building Permit #3 for CCHPP – Balance of Work - Building Permit #4 for CCHPP – SCB Foundation - Building Permit #4 for CCHPP – SCB Balance
Town of Dresden	- Town of Dryden Culvert Permit
Tomkins County	- (3) Road Crossing Permits

Figure A3: Comparison of Air Emissions Before and After CCHPP



Source: Cornell University Sustainable Campus (2010)[439]

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[439] Cornell University Sustainable Campus, Available at: http://www.sustainablecampus.cornell.edu/energy/energy.cfm (accessed on April 10, 2010)

Table A4 – Summary Microgrid Cost/Benefit Components

Type	Description	Point of View	Calculation	Value/Potential Value
BENEFITS				
Reduced grid electricity purchases from CCHPP	Baseline purchases = 221,819 MWh/yr Expected purchases = 61,409 MWh/yr Reductions = 160,410 MWh/yr	Cornell	160,410 MWh/year @ avg. bundled rate of $0.08914/kWh[440]	$14,299,000/year
Reduced grid electricity purchases from Lake Source Cooling[441]	Approximately 22,000 MWh/yr	Cornell	22,000 MWh/year @ avg. bundled rate of $0.08914/kWh	$1,961,080/year
Reduced purchases of coal	Baseline purchases = 65,000 tons/yr Expected purchases = 35,000 tons/yr Reductions = 30,000 tons/yr	Cornell	30,000 tons/year @ avg. US coal price in 2009 of $44.72/short ton[442]	$1,341,600/year
Improved reliability	New CCHPP system will be able to island campus during regional blackouts	Cornell		N/A
Fuel flexibility	CCHPP has capability of using fuel oil stored on site instead of natural gas in cases of supply interruption	Cornell		N/A
Participation in NYISO ancillary services and/or capacity market (i.e., demand response)	Cornell can participate in the ISO's demand response program and receive capacity and energy payment for participation	Cornell	Remuneration for participation in the following NYISO programs: Special Case Resources ICAP Emergency demand response Black-Start (ancillary services)	TBD
Sales of electricity to grid	At certain times of the year, Cornell may be able to generate electricity and sell it to the grid	Cornell	See NYSEG's Leaf 275 (p. 367 of its Schedule for Electric Service)[443]	TBD
Avoided line losses and generation and distribution capacity	The reduction of Cornell's demand on the grid in the amount of **15 MW** peak demand avoids grid line losses and may reduce the need for	Society	15 MW @ $85.39/kW-year for 2010 (includes line losses, and avoided generation and	$1,280,850 (2010)

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[440] Average energy rate from Cornell's Baseline Facility Electricity and Fuel Consumption estimates provided in its PON No. 1043 proposal.

[441] This is equivalent to avoiding burning of 19 million pounds of coal annually, CO_2 reduction of 56 million pounds, 645 thousand pounds of SO_2, and 55 thousand pounds of NO_x.

[442] This is the average delivered price of coal to the commercial and institutional sector increased in 2009 as reported by the US Energy Information Administration. [Data on commercial and institutional coal prices have only been available since 2008.] Available at: http://www.eia.doe.gov/cneaf/coal/page/special/coal_prices.html (accessed on April 15, 2010)

[443] See NYSEG's electric service schedule at: http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/NYSEG/SuppliersPartners/PDFs%20and%20Docs/120v86.pdf (accessed on October 20, 2009)

	additional grid-connected generating capacity as well as distribution system investment		distribution capacity)[444]	
Regional electric system support	CCHPP has capability to curtail grid purchases or export electricity during periods of regional shortage. System may be able to provide black-start support to regional grid as well.	Society	Comparable to what Cornell is paid for participation in NYISO demand response programs	TBD
Reduced emissions of SO_2	800 tons/year (est.)	Society	800 tons @ $84.00/ton[445]	$67,200
Reduced emissions of NO_x	250 tons/year (est.)	Society	250 tons @ $325/ton	$81,250
Reduced emissions of CO_2	50,000 tons/year (est.)	Society	50,000 tons @ $3.08/ton[446]	$154,000

System installation cost	Cost of new equipment, materials and labor for the construction and installation of CCHPP	Cornell	Only includes CCHPP improvement, none of previously installed infrastructure	$57,500,000
Lake Source Cooling System	Cost of piping, pumping station, and heat exchanger	Cornell		$55,000,000
Natural gas pipeline	Cost of material and labor for construction of 3.2 mile pipeline	Cornell	Part of CCHPP project, not included in total above	$2,500,000
Increased natural gas purchases	Secured an entitlement to 15,000 Dth	Cornell	Estimate provided by Cornell	$17,000,000-$20,000,000
Interconnection Costs	Cost of interconnection applications, engineering analysis, and equipment	Cornell	Estimate provided by Cornell	$2,800,000
NYSERDA Incentive	Cornell received more than $1 million in Systems Benefits Charge funds for this project	Society		$1,000,000

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[444] Value for avoided costs comes from the NYPSC Energy Efficiency Proceeding (Case 08-E-1003) Decision from January 15, 2009, See Appendix 2. Note: the NYPSC forecast this value out to 2030 and over the horizon the value of avoided line losses and deferred generation and distribution capacity upstate is project to increase to as high as $144.21/kW-year beginning in 2021.

[445] Based on snapshot of SO2 and NOx market offer prices (cost to purchase allowances) as reported by Evolution Markets, Inc., on October 20, 2009. See: http://new.evomarkets.com/index.php (accessed on October 20, 2009)

[446] Based on average Regional Greenhouse Gas Initiative auction results for 2009 allowances. See: http://www.rggi.org/co2-auctions/results (accessed on October 20, 2009)

A.3 NEW YORK UNIVERSITY’S WASHINGTON SQUARE PARK COGENERATION MICROGRID

Project Name:	New York University (NYU) Washington Square Campus Cogeneration Microgrid
Location:	New York City, NY
Owner/Developer:	NYU
Ownership Model:	Landlord/Campus Type 2
Status:	Operating (expansion under way)

Microgrid Typology

Project originator	[✓ Private sector]	Government	
Microgrid system owner	Single		Multiple
	Utility or ESCO	[✓ Property owner]	
Energy users	[✓ Self]	Self + others	Others
Cross public street?	[✓ Yes]	No	
Form of energy distributed	Power only	[✓ Power + thermal]	Thermal only
Limits on microgrid size?	[✓ None]	# of customers	Volume of sales
Interconnected at voltage?	LV	[✓ MV]	HV
Operate independently of grid?	[✓ Yes]	No	
Multiple resources	[✓ Yes]	No	
Certified QF?	Yes	[✓ No]	

Microgrid Summary Statistics

- **Number of distinct customers**: one (NYU campus buildings)
- **Types of end uses served**: Administrative offices, classrooms, residential dormitories, research laboratories, and food services operations
- **Production technologies employed**:
  - Existing facilities
    - 7 Caterpillar D399 Engines with waste heat boilers rated at 895-kW each
    - 1 steam turbine rated at 2.4-MW
    - 3 dual fuel high temperature hot water boilers rated at 65-MMBtu/hr each
    - 1 high-pressure steam boiler rated 114-MMBtu/hr (decommissioned 2009)
    - 3 Electric centrifugal chiller (1500 tons each)
    - 3 Absorption chillers (2500 tons each)
  - New facilities
    - 2 dual fuel Solar Taurus 60S series turbines with a nominal rating of 5.5-MWp each
    - 2 duct fired burners rated at 70-MMBtu/hr each
    - 1 Absorption chiller (2500 tons)
- **Peak electric capacity**: 13.4-MW
- **Peak electric demand**: 17.5-MW
- **Annual electric usage**: 180,000-MWh 130,000 MWh (purchased from Con Edison)
- **Peak thermal demand**: 120,000 lbs/hr
- **Peak cooling capacity**: 14,000 tons (10,000 tons steam-driven and 4,000 tons electric-driven)
- **Peak cooling demand**: 10,000 tons
- **Annual thermal**: 750,000-MMBtu or approximately 220,000 MWh (thermal)
- **Estimated annual CO_2 reductions**: 44,000 tons (versus existing plant) – 70,000 tons (versus separate heat and power); NYU frequently uses: 57,500 tons (38% reduction)
- **Estimated annual NOx, SO_2 and CO reductions**: 1,160 tons (83% reduction)
- **Estimated annual PM reductions**: 402 tons (98% reduction)

Ownership Model

New York University's (NYU or University) trigeneration system is an example of a Landlord/Campus Type 2 microgrid.[447] NYU owns and operates the system, which is intended for self-service to the various buildings owned by the University on its Washington Square Park campus. The NYU microgrid crosses public streets to deliver both electric and thermal energy to interconnected buildings, but it does not provide service to any unaffiliated customers. With the exception of the underground vault where the new cogeneration plant will be located, which the University leases from the New York City Department of Transportation, NYU owns all of the property, on both sides of the street, to which energy from the microgrid is delivered.

Background/Project Objectives

New York University is a private, non-profit institution of higher learning located in New York City. The University includes fourteen schools, colleges, and divisions at six major centers in Manhattan including the Washington Square Center in Greenwich Village, which is the school's main hub. With a faculty of approximately 6,000 and a student body of more than 29,000 full-time and 22,000 part-time students, NYU is one of the country's largest private universities. It is also one of the largest employers in New York City with over 16,000 employees. NYU maintains over five million square feet of interior space and provides housing to 11,000 of its full-time students.

Like any university of its size, NYU consumes a significant amount of energy. In 2005, the University spent approximately $50 million to supply energy to its facilities. With annual purchases of close to 140,000-MWh, the University is consistently one of the top twenty annual purchasers of electricity in Consolidated Edison's (Con Edison) service territory.[448] The University also consumes 850,000 dekatherms of natural gas and 13.3 million gallons of fuel oil annually (See Table A1: Total Electricity and Fuel Consumption in the Appendix), which it purchases from a number of different suppliers. In total, NYU uses approximately 2,000,000 MMBtus per year to supply electricity and space conditioning to its residence halls, academic buildings and other facilities.

NYU has produced energy on its campus since the 1960s when it installed its first steam plant beneath Tisch Hall at West 4th Street and University Place. The original plant only provided energy to loads on that block. In 1980, NYU installed a new cogeneration facility to provide electricity and expanded thermal energy service to several of its core administrative and educational buildings around the Washington Square campus.

Around 1999, NYU began investigating its options for addressing the replacement of its existing cogeneration facility, which was approaching the end of its useful life. The plant, which ran mainly on diesel fuel, had to be retired or repowered in order to meet new federal air emissions rules. After considering several options (see below), NYU decided to make the more significant investment in a modern cogeneration facility, which would allow it to further expand the microgrid. This decision was influenced by a number of considerations. Perhaps most importantly, the existing plant had served the university well, providing reliable and low cost energy for over twenty years. NYU saw an upgrade as an opportunity to expand service to more buildings at its Washington Square campus, removing those buildings from over-burdened local utility lines and improving overall reliability to critical loads including additional research facilities, student dormitories, and administrative buildings.[449]

Although an expanded microgrid would still be reliant on natural gas delivered by Con Edison, the University felt that it nevertheless would provide a greater degree of energy independence and ability to control the cost of energy. A modern cogeneration system would provide long-term financial benefits by allowing the University to improve its overall energy efficiency and further reduce total campus energy costs, which had rapidly increased over the past

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[447] The Landlord/Campus Type 2 microgrid model has a single non-utility owner that installs and operates the system to supply electricity and/or thermal energy to multiple buildings also owned by the landlord-operator. Buildings and streets are under single ownership and there are no previously unaffiliated parties receiving service from the microgrid. In contrast to the Landlord/Campus Type 1 model, the Type2 system's wires and pipes cross a public way to deliver energy.

[448] Consolidated Edison, FERC Form 566 Report: List of Purchasers Who in Any of 2006, 2007 and 2008 Purchased One of the Twenty Largest Amounts of Electricity, Filed January 28, 2009.

[449] Michael Hyams, personal communication with Alicia Hurley, September 2009 and Lincoln Anderson, "NYU finding little cooperation on co-generation," *The Villager*, March 7-13, 2007

few years.[450] Finally, NYU viewed the project as the best option from an environmental perspective, for both the University and the community. Modernizing the cogen facility is expected to produce significant reductions in emissions of local air pollutants, including nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOC) and particulate matter (PM and PM_{10}). Also, in 2007, NYU committed to meeting New York City Mayor Michael Bloomberg's accelerated greenhouse gas emissions reduction target of 30% below FY2006 levels by 2017.[451] The cogeneration microgrid is a cornerstone of the University's plan to meet this important environmental objective.

Detailed Microgrid Description

NYU's cogeneration microgrid dates back to 1980, when it expanded its original steam plant to provide electricity to seven buildings and hot and chilled water to approximately thirty buildings. Today the facility produces approximately 30,000-MWh per year and approximately 750,000-MMBtu of usable thermal energy. The prime movers for this plant are seven Caterpillar D399 diesel engines with waste heat boilers, rated at 895-kW each. The engines' waste heat boilers feed hot water into the campus high-pressure distribution system (at 365 degrees Fahrenheit and 250 psi), which is also supplied by four fuel oil-fired boilers, three rated at 65-MMBtu and one at 114-MMBtu (the latter boiler was retired at the beginning of 2009). For cooling, the system uses both centralized and in-building chiller equipment powered by electricity (centrifugal chillers) and waste heat (absorption chillers) from the diesel engines and distributed as chilled water.

The power and thermal energy is distributed via an underground network that crosses public streets in as many as five locations around Washington Square.[452] Power is served to critical loads in Kimmel Hall across La Guardia Place and as far away as Rufus Smith Hall on the northern side of Waverly Place. The Brown and Main buildings on the southern side of Waverly Place receive cogen power when it is available, typically on a seasonal basis when thermal loads are highest.[453]

In 1999, NYU began taking steps to address the aging cogeneration facility, which was approaching the end of its useful life and running up against new air emissions requirements. NYU considered two options, namely (1) dismantling the existing cogen system, rebuilding the steam system's boilers, reconnecting buildings to Con Edison's system and installing local generators and fuel tanks to meet safety and critical load requirements at a cost of approximately $30 million; (2) repowering the existing facility by upgrading the technology and emissions controls, but leaving the size of the system essentially the same at a cost of approximately $60 million; or (3) modernizing and expanding the cogeneration system to remove additional buildings from the macro-grid, at an initial capital cost of approximately $126 million.[454] For the reasons stated above, NYU opted to modernize and expand the existing system.

Due to its status as a non-profit educational institution, the University is able to finance the expansion using and tax-exempt bonds issued by the Dormitory Authority of the State of New York (Authority). In 2007, the Authority issued approximately $126 million of Series 2007A revenue bonds on behalf of NYU to pay or reimburse the University for costs incurred in connection with the upgrade and expansion of the co-generation facility.[455] The availability of Authority revenue bonds backed by NYU tuition and fees provides the University with a low cost source of financing.

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[450] Gallatin Students NYU, "Greening the Urban Campus: A Sustainability Assessment of New York University," December 2006, Available at: http://www.nyu.edu/sustainability/pdf/gallatinassessment.pdf (accessed on March 23, 2010)

[451] New York University, *Climate Action Plan*, Winter 2009, Available at: http://www.nyu.edu/sustainability/climateaction (accessed on March 11, 2010)

[452] Based on co-gen system drawings in: "NYU Green" a presentation before the New York Association of Energy Engineers on November 20, 2007

[453] NYU Green (2007)

[454] NYU Green (2007)

[455] Dormitory Authority of the State of New York, Official Statement for New York University Insured Revenue Bonds, Series 2007A, June 14, 2007, Available at: http://www.dasny.org/dasny/OS_fiscal_0708/New%20York%20University%20Series%202007A%20Final%20OS.pdf (accessed on March 22, 2010)

The microgrid's new generating plant will be located under the sidewalk and plaza along Mercer Street between 3rd and 4th Streets, adjacent to the existing CHP Boiler Plant under Tisch and Warren Weaver Halls. This location allows the thermal output of the generators to be fed into the existing high temperature hot water system. Building the plant in a different location also allows the existing plant to continue to provide power and thermal services to the University during construction, minimizing service disruptions and associated costs. Over the 2008-2009 period, the existing plaza was excavated and a concrete vault for the new plant installed underground. Once the construction of the new plant is complete, NYU will re-landscape the plaza with a new park.[456]

To support the development of an expansion plan, NYU retained SourceOne, a utility services consulting firm, which examined approximately eight different scenarios to determine plant capacity and identify the best Washington Square loads to tie into the microgrid.[457] The project team estimated that given the footprint of the Mercer Street vault, the project could be sized up to 20 MWe. To identify the best loads, NYU focused on adding approximately 15 buildings that were easy to get to from the main plant and had attractive business cases for interconnecting. Key criteria for the loads included peak electric demands of at least 250 kW, high load factors and significant thermal demands. The project team also identified electric loads with a high value for reliability; these included research labs, data centers, dormitories, and administrative buildings. Finally, due to the challenge of managing sub-metered buildings, only master metered buildings were selected. After analysis, the team settled on adding 25 buildings to the system (see Figure A1 in the Appendix for a map of the microgrid distribution system).

The expanded microgrid will feature two new dual fuel Solar Taurus 60S series turbines with a nominal rating of 5.5 MWe each (60.5 MMBtu/hr each), coupled with two heat recovery steam generators that deliver a nominal steam output of 20,000 lb/hr unfired and 60,000 lb/hr fired (each). In combination with the existing steam turbine, the microgrid will have a peak electric generating capacity of 13.4 MW. The two duct burners, rated at 70 MMBtu/hr each, will only combust natural gas to produce steam. Waste heat from the combustion turbines will provide approximately 20 MMBtu/hr of the required heat input (each), reducing the overall amount of natural gas burned. In addition, the project will include the refurbishment of two dual-fuel boilers, the addition of a single 2,400-ton steam driven chiller, new gas compressors and balance of plant equipment.[458]

Building from the existing distribution network, the expansion project will include approximately 1,400 linear feet of additional and refurbished utility conduits to carry the required electric cables and steam pipes. Power will continue to be distributed on the microgrid at 5-kilovolts (kV) and stepped down by transformers for distribution inside buildings. To serve the new electric loads on the system, the utility conduits will cross public streets in approximately sixteen different points.

NYU's microgrid is currently coupled with Con Edison's area network at 13.2 kV via the substation located under Warren Weaver Hall. Historically, the system has operated isolated from the grid with utility backup. The microgrid was originally interconnected to Con Edison's network in what is called "open transition," meaning that if a fault occurs on the microgrid (e.g., one of the generators goes down), a transfer switch disconnects load from internal generators before connecting it to Con Edison's system.

The expanded system, however, will be interconnected in parallel with Con Edison and will therefore be capable of both importing and exporting power to the network while simultaneously generating to meet local loads. NYU decided to design the system to operate in parallel and use Con Edison as backup mainly for economic reasons; operating the microgrid in isolation would require additional generating capacity (i.e., N+1 contingency design) to be on hand and available during both planned and unexpected outages. The ability to import power will allow the microgrid to meet the coincident peak demand of interconnected loads, which is between 15-16 MW several days a year. When demand exceeds generating capacity (13.4 MW) on these days, NYU will purchase energy from Con Edison using its standby tariff SC-14 (high tension service). Parallel operation will also allow NYU to balance its thermal demand and production and maintain higher system efficiency because the system will be able to export

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[456] NYU, "Cogeneration Project Frequently Asked Questions." Available at: http://www.nyu.edu/fcm/chpfaq.htm (accessed on February 3, 2010)

[457] NYU Green (2007)

[458] NYSDEC, Permit Review Report: ID: 2-6205-00246/00005, January 29, 2010, Available at: http://www.dec.ny.gov/dardata/boss/afs/permits/prr_262050024600005_r1.pdf (accessed on March 22, 2010)

excess power to Con Edison when microgrid thermal/electric demand is not aligned with thermal/electric production.

NYU's pre-existing seven 850 kW diesel generators will be used only as backup to the microgrid and to provide macrogrid support services in the form of demand response. When the new plant is commissioned in June 2010, NYU intends to use its existing diesel generators to participate in the New York Independent System Operator's (NYISO) Special Case Resources (SCR) demand response program. Under the program, the NYISO calls on registered facilities to provide load reductions when operating grid reserves are forecast to be short or deficient. In effect, NYU's engines will serve to eliminate any supplemental grid purchases they may require during peak periods, freeing up grid capacity to support reliability in lower Manhattan. Participation in the program will also provide NYU with an additional revenue stream to pay for the current system expansion in the form of SCR capacity and energy payments. Capacity payments are made monthly, based on either auction or a bilateral contract price, and participants are paid for making the capacity available whether they are called or not. Energy payments are determined based on the location-based marginal price (LBMP) associated with the amount and duration of load reduced during an event. Still, there are risks. If NYU is not able to meet its contracted demand reduction during an event will be assessed a deficiency penalty. Due to air emissions issues, the engines will collectively be limited to no more than 2,000 hours of run time (285 hours each). It is likely that their operation will be limited to fewer hours as SCRs are only called upon several times a year when peak demand is highest and system capacity most limited. According to the NYISO, the New York City region has averaged only 15 hours of SCR-eligible events per year over the 2001-2008 period.[459] During this same period, the average energy payment for SCR events was $461/MWh, which is provided on top of the monthly capacity payments.

Through its contractor Thermo Systems, NYU will also install new microgrid monitoring, automation, and control systems. Under a turnkey contract, Thermo will provide a complete detailed design package, which will include the following components:

- Programmable Logic Controllers (PLC)[460] and Supervisory Control and Data Acquisition (SCADA)[461] hardware and software as well as instrumentation and control valves.
- Process automation design incorporating redundant Allen Bradley ControLogix PLCs and Rockwell FactoryTalk software, software applications that allow accommodating the real time exchange of information between microgrid system components and system managers.[462]

Project Development Process

NYU's cogeneration microgrid has evolved over nearly half a century. The original steam plant, built under Warren Weaver Hall in the 1960s, served only loads on that block, a "superblock" purchased by NYU for educational purposes as part of the Greenwich Village redevelopment of the 1950s.[463] The cogeneration plant, built in the early 1980s, expanded the steam plant and took advantage of the simultaneous production of electricity and heat to increase the number of buildings served by the system. Although NYU began investigating options to repower the plant in the late 1990s, efforts to build an expanded facility did not start in earnest until about 2005.

To undertake the significant expansion of its district heating and power services, NYU retained a number of experienced contractors and consultants, including New York City-based SourceOne (technical review, financial evaluation, contract development, and utility liaison), Vanderweil Engineers (engineering consultants), Levitan

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[459] Donna Pratt, "NYISO's Demand Response Programs," September 2009, Available at: https://www.nyiso.com/public/webdocs/services/market_training/workshops_courses/nymoc/8_demand_response_01_2009.pdf (accessed on March 22, 2010)

[460] PLCs are essentially digital computers used for automation of electromechanical processes in various industries or machines. The main difference between PLCs and other computers is that PLCs are designed to withstand severe conditions (such as dust, moisture, heat, cold) and have the capability to execute extensive "input/output" processing arrangements.

[461] SCADA usually refers to a computer system that provides monitoring and coordination services for a given industrial or other electromechanical process. It can be used to monitor heating, ventilation, and air conditioning systems or various energy uses in a building.

[462] Thermo Systems Industrial Automation, "News Q2 2009: Thermo Systems Begins Campus Cogeneration Automation Project for NYU," Available at: http://www.thermosystems.com/news_Q2_09.asp (accessed on March 23, 2010)

[463] New York City Landmarks Preservation Commission, "University Village, Designation List 407," November 18, 2009, p. 4

Associates (energy management consulting), the Air Resources Group (handling of air permitting issues), Sebesta Blomberg (independent engineering service provider), Skanska (construction management) and Thermo Systems (design and development of the cogen plant automation package). These consultants worked closely with NYU's internal staff, which provided engineering, finance, legal, operations and public affairs support.

Prior to making a decision on the final location and design of its expanded plant, NYU undertook several months of discussion with members of the local community, which occurred mainly through the forum created by the Manhattan Community Board-2 (see "Permissions and Regulatory Matters" for more information). Originally, the University had three different options for locating the new plant – under Gould Plaza, under Mercer Plaza, or a hybrid of the two. After determining that it would preserve scarce classroom space and result in the least disruption to the local community, NYU opted for the Mercer Plaza site, for which it had been able to obtain a permit from the City. Still, residents of 250 Mercer Street opposed the location due to concerns about a lengthy excavation and Plaza tree removal. NYU and the 250 Mercer co-op board eventually agreed to a monetary settlement, which removed the last remaining community opposition to the project.[464] In late March 2007, Community Board-2 voted unanimously to approve the Mercer Plaza site.[465]

Construction began during the summer of 2007 and is expected to last 24-27 months, with project commissioning in early-to-mid 2010. The major project development milestones and approximate completion dates for the NYU microgrid expansion are as follows:

- Building energy data analysis and evaluation…………………………Fall 2006
- Preliminary design and initial permitting…………………………Winter 2007
- Community presentations and site approval..……………………...Spring 2007
- Site preparation……………………………………………………....Fall 2007
- Utility relocations……………………………………..Spring-Summer 2008
- Vault excavation and underpinning…………….…………Summer-Winter 2008
- Electric distribution installation…...…….…………Spring 2007-Summer 2009
- Vault construction……………………………………….……..........Fall 2009
- Equipment rigging…………………………….….….……..Summer 2009
- Title V air permit renewal…………………………….……..Winter 2010
- Plaza reconstruction and landscaping……………………………....Winter 2010
- Start up and electric switch over…………………………Spring-Summer 2010

Permissions and Regulatory Matters

NYU's microgrid is unique in that it is located in a dense urban area and interconnects multiple loads, separated by pubic streets, within the service territory of a franchised investor owned utility. In order to proceed with the development of its microgrid, NYU had to obtain a number of permissions from local and state authorities addressing issues such as emissions from the system's engines and boilers to crossing public streets in lower Manhattan with conduits carrying electric and thermal distribution lines. There were also a number of related regulatory and technical issues such as sub-metering for existing campus housing units and interconnection with Con Ed's network.

As mentioned above, NYU's microgrid grew from its original steam plant. The cogen expansion in the 1980s represented the first time NYU sought to deliver energy to one of its buildings across a street. At the time Con Edison did not object to the project, presumably for two reasons: (1) the utility's steam system, which serves mainly mid- and downtown Manhattan, does not reach into the Washington Square area and it would likely have been very expensive to connect to it; and (2) NYU owned the property on both sides of the streets it was crossing, as well as all the buildings that were receiving energy service from the plant, so it wasn't proposing to compete with the utility to serve other customers. Although the project was likely eligible to be a "qualifying facility" (QF) under the Public

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[464] Lincoln Anderson, "Green (cash) sways co-op in NYU's green plan," *The Villager*, Volume 76, Number 44, March 28 - April 3, 2007, Available at: http://www.thevillager.com/villager_204/greenswayscoop.html (accessed on March 31, 2010)

[465] The New York Observer, "NYU: We Will Build Plant Under Mercer Street," March 28, 2007

Utilities Regulatory Policy Act (PURPA), NYU never pursued QF certification for the first cogen plant. NYU officials were not able to provide specific information on why QF status was not obtained, but it is likely because the plant was built to operate in isolation from the regional grid. By designing the system for non-parallel operation, the system would not be able to export to the grid, making the benefits associated with QF status, particularly the requirement that utilities purchase excess electric output at "avoided costs," irrelevant.

Siting of Generating Plant and the Local Community Board

Revisions to the New York City Charter in 1975 allocated greater responsibility to local representative bodies called Community Boards. The 59 Community Boards in New York City, each one consisting of 50 unsalaried members appointed by the President of the associated Borough, have a broad advisory role with respect to any matter affecting the district. While they generally do not have final decision-making authority, their positions typically reflect district views and can have significant influence on Mayoral or City Council decision-making. While Community Boards can examine and hold hearings on virtually any topic impacting their districts, their main areas of focus include municipal service delivery, the New York City budget, and land use. With respect to the latter, Community Boards exercise the initial review of applications and proposals of public agencies and private entities for the use, development, or improvement of land located in the community district. On a given land use proposal, boards typically conduct a public hearing and prepare and submit a written recommendation to the city planning commission.[466]

In the case of NYU's new cogeneration facility, receiving approval from Manhattan Community Board-2 represented an important, although not necessarily required, step. NYU sought approval from the Board on two specific issues, namely the new cogen plant's Mercer Plaza location and the re-landscaping plan for the new park on top of the site. As mentioned above, after settling with the 250 Mercer St. co-op board, the Board endorsed the plant location in March 2007. The Board approved a resolution endorsing NYU's post-construction landscaping plan for the Plaza in July 2009.[467]

Crossing public streets – revocable consent

New York City administers a formal, organized system by which applicants may obtain a revocable consent allowing them to install and use infrastructure within public space. The New York City Department of Transportation (DOT) administers the revocable consent program and obtaining a permit requires petitioning the Division of Franchises, Concessions and Consents.[468] The petition must include detailed plans regarding the proposed installation including maps that accurately identify the available capacity in the street for the proposed installation. The DOT distributes the petition to appropriate New York City agencies, which vary depending on the nature of the revocable consent structure proposed.[469] Other private parties that already occupy space in the street are allowed to challenge a given petitioner. Where no issues arise, the DOT executes a revocable consent agreement with the applicant subject to approval by the mayor. All petitioners must pay a filing fee ranging from $100 to $750, depending on the installation, as well as an annual fee based on the number of linear feet of public space occupied.

NYU originally obtained a revocable consent to occupy public streets with its microgrid distribution lines in several locations around the Washington Square area in 1980. The revocable consent was for a term of ten years and has been renewed after each term since. For the expansion project, several additional street crossings were required. Instead of petitioning DOT for a new consent, NYU sought to amend its existing permit, which it was able to obtain without challenge.

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[466] NYC Charter Section 197-c gives a detailed description of the Community Board's role in the Uniform Land Use Review Procedure. The following website provides information on the origins and role of the Community Boards: http://www.nyc.gov/html/cau/html/cb/main.shtml (accessed on April 6, 2010)

[467] Manhattan Community Board No.2, "Resolution supporting the proposal for public open space to be built above the NYU Co-generation Plant of Mercer Street," July 30, 2009, Available at: http://www.nyu.edu/construction/pdf/cogen_CB2ParksResolution_0709.pdf (accessed on April 17, 2010) and NYU Office of Government and Community Affairs," Mercer Street Landscaping Project," July 6, 2009, Available at: http://www.nyu.edu/construction/pdf/mercerLandscaping.pdf (accessed on April 17, 2010)

[468] New York Department of Transportation – Revocable Consents: Information for Applicants, Available at: http://www.nyc.gov/html/dot/html/permits/revconif.shtml (accessed on March 10, 2010)

[469] Id., these may include the Department of Buildings, Department of City Planning, and various other agencies responsible for administering rules for safety, zoning, and preservation of landmarks.

Sales to unaffiliated customers
Since the vault at Mercer Street has the footprint available to size the expanded cogeneration system even larger than the currently planned 13 MW, NYU considered connecting to private customers located close to its system. Two issues, however, steered the University away from this. First, NYU was concerned that it would endanger the tax-exempt status of the project's financing, which is subject to strict rules regarding the use of such funds for "private" versus "public" benefit. Second, although additional loads could help the University size the system larger and operate it more efficiently, adding unaffiliated private customers might imply an obligation to serve and create new liabilities under the Home Energy Fair Practices Act, particularly if there were residential customers involved. For these reasons, NYU decided to connect only its own buildings to the microgrid.[470]

Sub-metering
When it conducted its feasibility assessment for the current plant expansion, NYU found that its student residence halls provided particularly favorable energy demand characteristics, including a good relationship between peak and baseload (load factor) and a large thermal energy demand (thermal sink). While many of the residence halls in the Washington Square area will now be connected to the microgrid, NYU opted against interconnecting one building because every apartment was sub-metered. Interconnection to the building, an old hotel with old electric wiring and metering would have been complicated and costly. Ideally, NYU would remove the old sub-metering equipment and master meter the building. Still, to do so would require approval from the New York Public Service Commission (PSC), which promotes apartment building sub-metering as a means of encouraging energy efficiency?

In 2008 the PSC denied an unrelated request from NYU to remove Con Edison meters from another of its residence buildings on East 26th Street. In its petition, NYU had requested a waiver of Con Edison's tariff P.S.C. No. 9 – Electricity, Third Revised leaf No. 278 (b)(2) prohibiting the redistribution of master metered electricity taken under the S.C. 9 rate tariff to a dormitory "where the tenants or occupants reside in individual apartments equipped with separate kitchen and bathroom facilities." NYU argued that students occupying the building are not billed for their electric consumption and that master metering would result in lower rates, reducing the overall electricity costs for the building. In its denial of NYU's request, the PSC stated that the action would be "contrary to our policy and the public interest." By metering each separate apartment, "students could be responsible for their electric consumption and become active participants in the effort to conserve electricity and protect the environment."[471]

Air permits
NYU's previous cogeneration facility operated under a New York State Department of Environmental Conservation (NYSDEC) Article 19 Title V Facility Permit (Permit No. 2-6205-00246/00005). On June 30, 2004 NYU submitted to NYSDEC Region 2 an Engine NO_x Reasonably Available Control Technology (RACT) Compliance and Operating Plan[472] to maintain the then current 9.0 gm/gram per brake horsepower-hour (bhp-hr) NO_x emissions as RACT for the seven diesel engine generators that were nearing the end of their useful lives. The plan concluded that no NO_x control technologies were economically feasible for the generators to achieve the recently instituted standard of 2.3 gm/bhp-hr (effective April 1, 2005). NYU requested an economic variance from the new regulation and proposed a major repowering and equipment replacement project to bring the campus system in compliance.

On January 29, 2010, the NYSDEC renewed the permit for the expanded plant, finding that there are "no criteria or regulated pollutant emission increases, only emission decreases, and Prevention of Significant Deterioration (PSD) and New Source Review (NSR) regulations are not applicable to this repowering project." The Permit Review Report concluded that the project would provide a "significant permanent environmental benefit… tremendously favorable reductions for New York State in its non-attainment area."[473]

Interconnection and Sales of Electricity to the Grid
When NYU built its cogeneration system in the 1980s, it installed a substation with switchgear under Warren Weaver Hall. As mentioned above, this system was designed to operate in isolation from the grid (i.e., not in

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[470] Michael Hyams, personal communication with Alicia Hurly, September 2009
[471] Case No. 07-E-0820, Petition of New York University to Remove the Individual Apartment Meters and Consolidate the Meters Pursuant to Service Classification SC-9 Located at 334 East 26th Street Dormitory in the Territory of Consolidated Edison Company of New York, Inc., Order Denying Petition for Waivers. (Issued February 21, 2008).
[472] Pursuant to 6 NYCRR 227
[473] NYSDEC, Permit Review Report (2010)

parallel and no exports to the grid), obviating the need for complicated or lengthy interconnected procedures. The current expansion project, however, will be interconnected to Con Edison's system in parallel to allow NYU to import grid power simultaneously with its own generation as well as to export to the grid to facilitate thermal balancing (i.e., when microgrid thermal demand requires electricity production in excess of the connected electric demand). As of the time of writing, NYU and ConEd were negotiating the terms and conditions of interconnection (this is a non-standard interconnection on ConEd's Manhattan network) and excess purchases. NYU will likely receive payments for any electricity exported to ConEd equivalent to the NYISO's location-based marginal price for the Manhattan Zone at the time of export plus a factor for transmission and distribution losses.[474]

New York State Rebates

Although the buildings connected to the Washington Square Park microgrid have not received electric service from ConEd since the expanded plant was installed in 1980, NYU's other buildings continue to receive retail electric and gas service and contribute to the state System Benefits Charge (SBC). The SBC is a tax added to retail sales of electricity to support various social and environmental initiatives managed by the New York State Energy Research and Development Agency (NYSERDA). NYU's contribution to the SBC makes it eligible for NYSERDA rebate programs. In 2002, the University applied to NYSERDA for funding under its Technical Assistance project, to undertake a feasibility study for system repowering. NYSERDA approved NYU's request and contributed $1 million in SBC cost-sharing funds to support the study.

Cost/Benefit Discussion

Although as of the time of writing it's not yet complete, the projected total installed cost of the expanded NYU microgrid is expected be approximately $126 million. This figure includes the capital cost and installation of the new equipment including the Solar Taurus combustion turbines and heat recovery steam generators, construction of the plant, a new 2,500-ton steam absorption chiller, underground cabling and piping, new switchgear, and administrative costs including consulting and legal fees. A $1 million grant from NYSERDA defrayed some of the University's cost to analyze the feasibility of the project. Also, NYU's use of long-term tax-exempt public financing should lower its cost of capital as compared to a similar privately financed project. As an institution with long-term interests in the development of its campus and its relationship with the local community, New York University is able to endure much longer payback periods on its investment than for-profit entities.[475]

The NYU microgrid is expected to provide significant social and private (NYU) benefits. The benefits to NYU include reduced costs for energy from avoided electric commodity, transmission and distribution charges and improved overall energy efficiency. We estimate the value of NYU's reduced purchases of bundled electricity from ConEd to be approximately $9 million to $11.6 million per year. The switch to natural gas as the predominate fuel for the cogeneration plant will also reduce NYU's purchases of #6 fuel oil by 1.7 million gallons per year and will eliminate its purchases of #2 diesel fuel, saving approximately $7.5 million annually. Moreover, the capability of the system to operate as an island using the combustion turbines with backup from the reciprocating engines on peak days, or to draw power from the grid when the system needs maintenance, should improve the overall reliability of service to the interconnected buildings in the Washington Square campus. Unfortunately, the project team does not have estimates from NYU on the approximate economic value of this improved reliability, but they did confirm that the new system should prevent costly interruptions to research labs on campus. Finally, NYU's participation in state demand response programs will allow it to receive compensation for reducing its peak demand when called upon by the NYISO. As noted above, NYU will be paid a monthly capacity payment ($/kW-month) for being available to the program and an energy payment ($/MWh) for every hour it reduces its demand during events. Historically, energy prices have averaged $461/MWh, but have been as high as $650/MWh while monthly capacity prices for the New York City zone have averaged $9.32/kW-month during summer months and $4.30/kW-month during winter months.

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[474] For discussion regarding ConEd's buy-back program see: http://www.coned.com/dg/service_categories/buyBack.asp# and ConEd's SC-11 "buy back tariff," Available at: http://www.coned.com/documents/elec/295-309.pdf (accessed April 17, 2010)

[475] Michael Hyams, personal communication with Alicia Hurley, Vice President for Government Affairs and Community Engagement, September 2009.

The social benefits of NYU's microgrid include reduced local emissions of criteria air pollutants, reduced emissions of greenhouse gases, and reduced demand on the local electric grid, potentially deferring investment in the distribution system or peak electric generating capacity. With respect to the latter, NYU's expanded microgrid will reduce demand on the macrogrid, on average, by an additional 8-MW; however, its total reduction in peak demand will be nearly 17.5-MW when the existing reciprocating engines are brought on line, when the grid most needs it. Based on figures developed by the NYPSC for energy efficiency investments associated with the Energy Efficiency Portfolio Standard, the 8-MW reduction in demand would be valued in 2010 at approximately $1.9 million (avoided line losses and avoided generation and distribution capacity). The microgrid expansion will also reduce NYU's overall electricity usage by as much as 60,000 MWh per year, or an amount equivalent to approximately 13,000 average New York residences.[476] As a whole, however, the microgrid reduces macrogrid electricity consumption by approximately 85,000 MWh (or about 18,500 NYC residences).

NYU's new facility will also significantly reduce local emissions through both the application of state of the art technologies and fuel switching. The older cogeneration facility burned primarily #6 (residual) oil and #2 (diesel fuel) oil. The new facility will reduce use of #6 oil by close to 80% and virtually eliminate the use of #2 oil entirely by approximately doubling the combustion of natural gas.[477] In its Title V permit review report, the NYSDEC found that the expanded microgrid system's future potential to emit (PTE) was significantly less than the existing cogeneration plant. As Table A2 in the Appendix shows, based on the future maximum potential to pollute (i.e., running on 100% fuel oil) the new facility was found to be lower than the previous plant for all of the major criteria pollutants. Analysis by SourceOne, also found that the system would reduce regulated air pollutants by more than 80% compared to NYU using grid power and building boilers.[478]

Finally, NYU's microgrid will greatly reduce the University's emissions of greenhouse gases. When put into service, the new cogeneration facility will account for the single largest reduction measure in NYU's Climate Action Plan, avoiding 44,000 short tons of carbon dioxide equivalents (CO_2e) each year, a 23% decrease from the University's FY2006 emissions total.[479] This will take NYU substantially closer to the 30% by 2017 commitment it made to the City of New York. Moreover, the US EPA estimated that compared to using grid-based electricity and #6 fuel oil-fired boilers for building heat, the repowered and expanded microgrid will reduce emissions of CO_2 by approximately 70,000 tons per year.[480]

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[476] New York City has estimated that the average New York residence consumes approximately 4,600 kWh per year. See: New York City Mayor's Office of Sustainability, "New York City's Climate Change Challenges through 2030," Available at: http://www.nyc.gov/html/planyc2030/downloads/pdf/greenyc_climate-change.pdf (accessed on April 17, 2010)
[477] NYU, Climate Action Plan, March 2010, Available at: http://www.nyu.edu/sustainability/climateaction (accessed on March 23, 2010)
[478] NYU Green (2007)
[479] NYU Climate Action Plan (2010)
[480] US EPA Climate Protection Partnership, "Letter of Support for the NYU Cogeneration Project," October 10, 2007, Available at: http://www.nyu.edu/fcm/EPA%20letter%20on%20CHP%20emissions%2010%2010%2007.pdf (accessed on April 6, 2010)

Figures and Tables

Figure A1: Map of NYU's Washington Square Campus Microgrid

Source: New York University (2007)

Table A1: List of NYU buildings receiving electric service from microgrid

Old Plant	Expanded Plant
Bobst Library	Silver Towers
Shimkin Hall	Coles Sports Center
Tish Hall	Mercer Street Law Dorm
Warren Weaver	D'Agostino Hall Dorm
Brown Building	Vanderbilt hall
Waverly Building	Hayden Hall Dorm
	Furman Hall
	Kimball Hall
	Kaufman Management Center
	Education Building
	Goddard Hall Dorm
	715-719 Broadway
	Meyer Complex
	Weinstein Dorm
	Rufus Smith Hall
	12-16 Waverly (new science center)

Source: New York University (2010)

Table A2: NYU's Total Electricity and Fuel Consumption (FY2007)

Energy Type	Amount	Unit
Electricity purchased from Con Ed	139,723,112	kWh
Electricity produced by Cogen Plant	27,595,664	kWh
Oil #2, #4, and #6 to buildings	1,069,281	Gallons
Oil #2, #4, and #6 to Cogen Plant	4,037,767	Gallons
Natural gas to buildings	1,793,949	Therms
Natural gas to Cogen Plant	5,455,571	Therms
Steam to buildings	79,505,000	Pounds

Source: New York University, Environmental Assessment Report FY2007, February 2009

Table A3: Comparison of Historical Average and Future Cogeneration Facility Emissions (tpy)

Pollutant	Expanded Microgrid PTE*	Previous Microgrid PTE	% Reduction
NO_x	139	465	70.11%
SO_2	20	115	82.61%
CO	119	148	19.59%
PM_{10}	5	24	79.19%
CO_2**	64,900	109,450	40.70%

*Expanded microgrid PTE correspond to 100% fuel oil firing case (worst case).
** CO_2 emissions are based on expected operating conditions using natural gas.
Source: Title V permit modification application and report

Source: NYSDEC Title V Permit Report (2010)

Table A4 – Summary Microgrid Cost/Benefit Components

Type	Description	Point of View	Calculation	Value/Potential Value	Period
BENEFITS					
Reduced electricity purchases	60,000 MWh/year	NYU	$0.17-0.20/kWh at avg. ConEd bundled rates	$9,000,000 - $11,600,000	Per year
Reduced fuel purchases	The new cogeneration equipment will reduce NYU's use of certain fuels	NYU		See below	
#6 fuel oil	1,700,000 gallons	NYU	$1.40/gallon (EIA 13-month average at NY Harbor Jan-09 to March-10)	$2,380,000	Per year
#2 diesel fuel	1,700,000 gallons	NYU	$3.02/gallon (NYSERDA two-year historical average for NYC)	$5,134,000	Per year
Sales of power to grid	N/A	NYU	TBD, likely to be hourly LBMP + distribution adder	N/A	
Participation in ISO Special Case Resource (SCR) demand response program	By participating in the NYISO's SCR program, it will be able to reduce load on the microgrid during peak periods by taking power from the existing diesel generators. NYU will receive a monthly capacity payment and energy payments for every MWh shed during NYISO events.	NYU	Monthly auctioned capacity payment plus energy payment for volume and hours of demand reduction	N/A	
Capacity	NYU will have approximately 4 MW of peak load reduction available to participate in the SCR program and will receive a $/MW-month capacity payment.	NYU	4 MW @ $6.81/kW=month (4-year avg monthly auction price)	$27,240	Per month
Energy	$/MWh (market rate)	NYU	4 MW @ 15 hours @ $461/MWh (historical avg)	$27,660	Per year
Fuel flexibility	New generators can run on either natural gas or diesel fuel	NYU		N/A	
Improved reliability	Expanded capacity of cogen facility, back-up diesel generators, islanding capability and grid backup will improve campus electric reliability	NYU		N/A	
Avoided line losses and generation and distribution capacity	The addition of 8-MW of capacity in Manhattan may reduce the need for additional grid-connected generating capacity to serve those loads	Society	8 MW*$237.30/kW-year (includes line losses, and avoided generation and distribution capacity)	$1,898,400	Per year

Reduced emissions of CO2	70,000 tons/year (total reduced compared to without microgrid system)	Society	$3.08/ton	$215,600	Per year
Reduced emissions of SO2	95 tons/year (based on PTE calculations)	Society	$84/ton	$7,980	Per year
Reduced emissions of NOx	326 tons/year (based on PTE calculations)	Society	$325/ton	$105,950	Per year
NYSERDA Incentive	Technical assistance for feasibility analysis funded through ratepayer funds	NYU	N/A	$1,000,000	One time
COSTS					
System capital costs	Cost of new infrastructure, installation, support services	NYU	Only includes microgrid extension improvements, none of previously installed infrastructure	$126,000,000	One time
Interconnection	Included in above	NYU		N/A	One time
Operating costs	N/A	NYU		N/A	N/A
Increased fuel purchases (natural gas))	5,000,000 therms		$1.01/therm	$5,050,000	Per year
Standby Charges	NYU will purchase standby power services from Con Ed under its SC-14 tariff (high-tension service)	NYU	TBD	TBD	Per year
NYSERDA incentive	Technical assistance for feasibility analysis funded through ratepayer funds	Society		$1,000,000	One time

A.4 BURRSTONE ENERGY CENTER

Project Name: Burrstone Energy Center at Utica College & St. Luke's Hospital & Nursing Home
Location: Utica, New York
Owner/Developer: Burrstone Energy Center LLC
Ownership Model: Landlord/Campus Type 3
Status: Operating

Microgrid Typology

Project originator	[✓ Private sector]	Government	
Microgrid system owner	Single		Multiple
	[✓ Utility or ESCO]	Property owner	
Energy users	Self	Self + others	[✓ Others]
Cross public street?	[✓ Yes]	No	
Form of energy distributed	Power only	[✓ Power + thermal]	Thermal only
Limits on microgrid size?	[✓ Area footprint]	# of customers	Volume of sales
Interconnected at voltage?	[✓ LV]	HV	
Operate independently of grid?	[✓ Yes]	No	
Multiple resources	[✓ Yes]	No	
Certified QF?	[✓ Yes]	No	

Microgrid Summary Statistics

- **Number of distinct customers**: Three
- **Types of customers/end uses**: College campus, hospital and nursing home
- **Technologies employed**:
  - Four natural gas-fueled, lean-burn Cummins reciprocating engines
    - Hospital: two engines, 1.1-MWe each (Model #: QSV 81G – 100 psig steam and hot water)
    - College: one engine, 1.1-MWe (Model #: QSV 81G – 100 psig steam and hot water)
    - Nursing home: one engine, 334-kWe (Model #: QSK19 – steam and hot water)
  - One hot water absorption chillers (100-ton single effect)
  - One steam absorption chiller (300-ton double effect)
- **Peak electric capacity**: 3.6-MW
- **Peak electric demand**: 4.9-MW (Hospital 2.5-MW, College 1.8-MW, Nursing Home 0.6-MW)
- **Total annual electric usage**: 29,800-MWh
- **Annual electric produced by microgrid**: 24,850-MWh
- **Peak thermal capacity**: Approximately 7,000 lbs/hr (100 psig steam) and 700 gpm (200ºF) hot water (all to Hospital)
- **Annual thermal**: 32,200-MWh (109,870 MMBtu) (Hospital)
- **Annual CO2 reductions**: 4,000 tons per year (developer could not provide % reduction)
- **Annual SO2 reductions**: 28 tons of SO$_2$ per year (developer could not provide % reduction)
- **Annual NOx reductions**: Negligible reductions of NO$_x$

Ownership & Service Model Explanation

The Burrstone Energy Project (Project) is a microgrid that reflects the Landlord/Campus Type-3 ownership and service model.[481] While Burrstone Energy Center LLC[482] (Burrstone) independently owns and manages the microgrid production and distribution facilities, it does so from the Faxton-St. Luke's Hospital campus. Burrstone sells the electric and thermal output of its plant to three distinct customers: Faxton-St. Lukes Hospital, Utica College, and St. Lukes' Nursing Home ("Hospital," "College," and "Home," respectively and collectively "customers"). Champlin Avenue, a public road, separates the college from the hospital and home and energy distribution facilities link the separate properties. Burrstone entered into a 15-year power purchase agreement (PPA) with the customers for the energy produced by the system; all three will receive electric service from the microgrid while only the hospital will receive the thermal service.[483]

Background/Project Objectives

The Burrstone project is located in Utica, a city of approximately 60,000 in central New York. The college is situated on 128 acres in a predominantly residential area directly across from the St. Luke's campus of Faxton-St. Luke's Hospital and Nursing Home. Champlin Avenue, a public road, separates the properties.[484] The college maintains 15 buildings on campus including several residence halls, administrative buildings, an athletic center, and classrooms, which serve approximately 3,000 students with over 450 instructional and administrative staff. The hospital employs approximately 3,500 full and part-time employees who provide in-patient care for up to 26 patients at the Faxton Campus and up to 588 patients at the St. Luke's long-term and acute care facilities. The home provides service to 242 full time patients.

Prior to the development of the Burrstone Project, all three participating customers received full electric service from the local electric distribution utility Niagara Mohawk Power Corporation d/b/a National Grid (National Grid). For thermal loads, the hospital used two thirty year-old 38,000 lb/hr boilers, which typically operated at 60% efficiency, and two 500-ton electric chillers. The home also has natural gas-fired boilers, centrally located, to produce hot water that is distributed throughout its facilities with heat pumps. Cooling loads at the home are supplied using electric chillers. At the college, all thermal loads were supplied locally in each individual building with natural gas-fired domestic hot water tanks and electric space cooling.[485]

The Burrstone Energy Center Project was conceived several years ago with two main goals in mind for the participating customers: (1) improving on-site reliability and (2) reducing energy costs.

The college, hospital and home have critical (i.e., uninterruptible) end use loads, which require a reliable, and in some cases continuous, energy supply. High electric loads in National Grid's service territory during the summer have occasionally led to local power disruptions, at high cost to operations. By law, the hospital is required to have back-up generation to supply power to life support and other life-critical equipment. It maintains four diesel-fueled back-up generators capable of supplying 50% of its peak demand, which automatically switch on if a service interruption is detected. Similarly, the home has a 400-kW back-up generator capable of meeting approximately 66% of its peak power requirements. Prior to the development of the Burrstone Project, Utica College had only 50kkW of portable back-up diesel generators available in the event of a blackout. The school purchased the generators in response to the 1998 northeast ice storm, which caused power outages all over the region. Nevertheless, the diesel generators only provide enough power to supply a few buildings on campus (the capacity

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[481] We have defined the Independent Provider model as a microgrid that is owned and operated by an independent, non-utility firm, which sells electricity and/or thermal energy to multiple, unaffiliated customers. This business model is strictly commercial, that is, the independent owner/operator does not produce primarily for its own consumption.

[482] Burrstone Energy LLC was incorporated by Bette & Cring LLC, which is headquartered in Latham, NY. Bette & Cring LLC provides construction, real estate and property management services for several business sectors across the country (see: http://www.bettecring.com/).

[483] Cogen Power Technologies Inc, which is a Bette & Cring company, is responsible for operating and maintaining the Burrstone microgrid under the 15-year PPA.

[484] Utica College, "The UC Campus," Available at: http://www.utica.edu/instadvance/marketingcomm/campus/ (accessed March 30, 2010)

[485] Tom Kelly, personal communication with John Moynihan, 2009.

represents only 2% of campus peak demand) and college administrators wanted a more robust system that would be able to maintain comfortable conditions for students and staff in the event of an emergency.

Energy cost savings were another major reason the customers were interested in pursuing the microgrid. Officials at the college indicated that they are forecasting lower future enrollment, so minimizing operating costs is a priority.[486] By using the diverse electric load profiles of the participants' buildings and the hospital's significant demand for thermal energy, a collaborative combined heat and power (CHP) microgrid could provide sizable savings over the existing configuration. Still, the capital costs for the cogeneration facility were too onerous for the project participants to make the investment themselves. Contracting with Burrstone to finance, build and operate the system allowed the microgrid system to be developed without the participating customers providing capital upfront. In exchange, the participating customers signed long-term PPAs with Burrstone with performance provisions that allowed the company to share in any energy cost savings it could deliver.

Detailed Microgrid Description

It is estimated that on an annual basis, the Burrstone Project will generate approximately 29,000 MWh of electricity and 32,000 MWh of thermal energy in the form of steam, hot water and chilled water to the participating customers. With a combined peak electric demand close to 5-MW, the Burrstone microgrid participants consume approximately 230,000 MMBtus of natural gas.

The Burrstone microgrid is powered by four natural gas-fired reciprocating engines configured to cogenerate electricity and thermal energy and designed to operate as baseload. The generating units are housed in a 5,400 square foot building owned by Burrstone on the Faxton-St. Lukes campus. Two of the reciprocating engines provide electric service to the hospital (2.2-MWe total capacity), another provides service to the college (1.1-MWe) and a smaller engine (334-kWe) serves the home. The generators were configured to provide dedicated electric service to each end user at the request of National Grid. The utility continues to meter and provide separate electric service to each of the participating customers as well as the Burrstone facility itself, which has a separate service agreement with the utility to provide power to its CHP building.[487] This was done to prevent any potential "sales for resale" that might occur if the Burrstone plant was simply connected to the hospital.[488]

The hospital uses all of the waste heat produced by the engines for hot water and space heating and cooling (at 7,000 lbs/hr and 100 psig). This thermal energy is piped in the form of 200-degree hot water at a rate of 700 gpm to hospital loads, approximately 2,000 feet from the CHP facility. Ideally, Burrstone would have used a single prime mover, such as a combustion turbine and piped steam directly into the hospital's existing steam distribution system at a much lower cost. Still, because National Grid was opposed to a single prime mover, Burrstone had to use more modular reciprocating engines with different thermal production characteristics (see "Permissions and Regulatory Matters" below for more discussion on this). These engines produce hot water that had to be piped across the St. Luke's campus into the hospital boiler room. The plant's waste heat alone is insufficient to meet the hospital's full thermal demand, so it continues to run one of its pre-existing gas-fired boilers. To take advantage of the thermal output during the summer, Burrstone installed two new absorption chillers – a 100-ton single effect hot water chiller and a 300-ton double-effect steam chiller – at the hospital to provide air conditioning using hot water instead of electricity. Both the college and home continue to use their pre-existing boilers for all hot water production and electric driven chillers for air conditioning.[489]

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[486] Thomas Kelly, personal communication with Harter White, 2009.

[487] National Grid bills the Hospital as a Large General Time of Use (TOU) customer (SC3A) because its monthly demand has been greater than 2-MW in any six consecutive months over the last 12 months. Both the home and the college are billed as a Large General customer (SC3) because their peak monthly demands exceed 100 kW and are less than 2-MW.

[488] Under National Grid's electric service tariff approved by the New York Public Service Commission (PSC No. 220 Schedule for Electric Service), it states: "electric service will not be supplied under any service classification of this rate schedule for **resale**, submetering, redistribution or other redisposition provided, however, that any customer may furnish electricity for the use of his tenants or for the use of other occupants of his premises provided that the customer shall not **resell**, make a specific charge for, or submeter or measure any of the electricity so redistributed or furnished" (emphasis added). See: https://www.nationalgridus.com/niagaramohawk/non_html/rates_psc220.pdf (accessed April 15, 2010)

[489] The home's existing heating system is not conducive to using the project's waste heat while the college is too far away from the plant for cost-effective use.

The engines generate electricity at 480 volts, which is stepped up by three transformers to 13.2-kV for distribution to the customers. In order to distribute power to each of the microgrid users, Burrstone installed approximately two miles of cables as well as new electric switchgear on the college campus near its gas line service entrance, approximately one mile from the cogeneration plant. Utica College installed a tracking system to monitor the electric power quality delivered to the campus by the Project.

The Burrstone microgrid operates in parallel with the macro-grid and is capable of black-start and islanded operation during grid outages. While the microgrid will provide approximately 80% of the annual electrical usage, due to the high incremental cost of additional capacity, the system was not designed to meet the peak load requirements of the interconnected customers. For the hospital, the engines are capable of meeting electricity demand during 97% of the hours of the year. Burrstone implemented a load-shedding scheme to ensure that the hospital could prioritize the loads it wanted energized if the reciprocating engines and the existing back-up generators could not meet all of their requirements. Burrstone does not control the hospital's back-up generators, so during an outage, the generators are started automatically and may be ramped down after detecting the Burrstone engines. Similarly, the engine serving the college can supply approximately 60% of its respective peak demand. Since power is distributed on the college campus via just two circuits (with peak demands of approximately 800-kW each), one must be opened for the engine to operate if the campus demand is above 1,100 kW. During an extended outage, the college can manually cut power to individual buildings in order to close both circuits and "fine-tune" the loads it wants supplied by Burrstone. The Burrstone engine serving the home is capable of meeting between 50-60% of its peak demand. Burrstone tied the generator into the home's existing Automatic Transfer Switch so that when utility power is lost, the back-up diesel engine will supply power to critical loads while the Burrstone engine will power the remaining lower priority loads.

Each microgrid customer will remain connected to National Grid's system, from which additional power will be purchased as needed. For the approximately 20% not provided by Burrstone, the customers will buy energy from National Grid under its standby tariff, SC-7. Under the standby tariff customers pay demand charges that are approximately one-third what they would otherwise pay under standard Large General Service (SC-3 or SC-3A). The demand charges are calculated based on the peak from the twelve months of service prior to installation of the new generation.

Since there will be times when the microgrid has failed to use (or underused) generating capacity, it will be capable of exporting power to the grid. To do so, Burrstone signed a PPA with National Grid. Under the contract, Burrstone is paid the location-based marginal price (LBMP), or the wholesale energy price that is equivalent to what other generators delivering power in Burrstone's location receive, from the New York Independent System Operator's (NYISO) hourly day-ahead market. Currently, Burrstone's export price is tied to the real time price of imports from West Canada Hydro, which is published by the NYISO.[490]

To operationalize the microgrid's interaction with the wholesale power market, Burrstone developed an algorithm that governs the microgrid control system.[491] Using market prices fed into the algorithm, the microgrid control system will provide signals to the units indicating when to run and when not to run. It will check the NYISO's day-ahead prices and compare against hourly data and a forecast load profile to determine the strategy the units will operate under. Burrstone's algorithm makes hourly operational decisions, which are automatically implemented by the Energy Management System.

Burrstone financed and installed the new electric generation and distribution facilities and built the cost of the new infrastructure into the Project power purchase agreement. Under the terms of the PPA, Burrstone will recover its costs in the rates it charges the customers and will share the value of any savings the Project generates as compared to what the customers would otherwise pay National Grid. The horizon of the PPA is 15-years, and Burrstone has

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[490] Burrstone believes it is the first cogeneration project to structure this type of "buy-back" contract with a utility, where it is receiving hourly prices as opposed to average LBMPs.

[491] An algorithm is a mathematical method for solving a problem using a process that performs a sequence of operations following a series of instructions.

two 5-year options to extend its title to the generating units. Once Burrstone releases title to the Project, the participating customers must pay "fair market value" for the system.[492]

Project Development Process

The "Hospital, College and Home" began to consider developing a microgrid project approximately six years ago. Originally, the customers entered into an agreement with ENTrust Energy to develop a shared cogeneration system, but for various reasons the project never materialized. After contracting with Burrstone in 2007, development of the project took 2 ½ years from inception to completion. The most significant delay was associated with the negotiation with the Public Service Commission (PSC) and National Grid to allow Burrstone to cross Champlin Avenue to provide power from the plant to Utica College (see below for more discussion). The official ribbon cutting ceremony marking the completion of the project took place July 10, 2009.

The major project milestones and approximate completion dates are as follows:

- Compilation of baseline energy data…………………….………Early 2006
- Preliminary design and review…………………………………Mid 2006
- Final design and review……………………………………......Late 2006
- Site preparation………………………………………………......Fall 2008
- Local permit acquisition……………………………………..Fall 2007
- State regulatory approval…………………………………...…..Fall 2007
- Financing secured…………………………………………….…..Feb 2008
- Equipment procurement……………………………………......Jan 2009
- Equipment installation………………………………………Spring 2009
- Commissioning……………………………………………Summer 2009

Permissions & Regulatory Matters

Burrstone is a precedent-setting project in New York State because it serves different customers with energy from its facilities and crosses a public way to do so. Significantly, as discussed below, the Public Service Commission (PSC) ruled that the microgrid and its related distribution facilities is a single "qualifying facility" under state law, making it exempt from regulation as an electric corporation. This effectively allowed the project to go forward without the risk of onerous – and likely costly – regulatory requirements and oversight from the PSC, which can include rate regulation and various administrative, financial and reporting requirements. Nevertheless, in order to secure the support of National Grid, Burrstone undertook measures including the installation of three dedicated sets of prime movers to separately serve each end use customer with electricity (as opposed to a single prime mover that served all three), which also required three separate interconnections to the utility's system. Although there is no law or rule on the books that specifies this, National Grid's request could stem from an interpretation that dedicated prime movers for each customer is akin to self-generation, whereas a single prime mover serving multiple customers would reflect more of a utility-type service configuration. Burrstone only provides thermal services to the hospital and since Utica does not receive district steam service from a franchised steam corporation, there were no regulatory permissions required for this aspect of the system.

Self-Certification as a Qualifying Facility before the Federal Energy Regulatory Commission
On June 26, 2009 Burrstone submitted FERC Form 556 to self-certify the microgrid for Qualifying Facility (QF) status as a cogeneration system pursuant to the Public Utilities Regulatory Policies Act (PURPA) or Title 18 of the Code of Federal Regulations (CFR) Section (§) 131.80. As a certified federal QF under PURPA, Burrstone is not subject to state regulation. Moreover, as the local regulated electric utility, National Grid is obligated to purchase any excess electricity produced by the facility. In its filing, Burrstone noted that it estimates approximately 13% of

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[492] Under the terms of the PPA, the institutions cannot voluntarily leave the PPA early. Still, if the parties wanted to purchase the system earlier than the 15-year period, Burrstone has stated it would accommodate them.

the electric energy produced by the facility annually would be sold to National Grid.[493] This arrangement would allow Burrstone to export power when the electrical demand of the hospital and college are below the capacity of the plant. During these periods, Burrstone will export to: a) meet more of the thermal demand of the hospital; and b) take advantage of favorable market rates for exported power.

New York State Clarification of Burrstone's Regulatory Status

Before proceeding with this project, Burrstone petitioned the PSC for a Declaratory Ruling that its proposed project was a "qualifying facility"[494] under state law and therefore would not be subject to PSC jurisdiction as a "corporation," "electric corporation," "steam corporation," or "person."[495] The primary issue before the PSC was whether the Burrstone Project's distribution lines, in reaching multiple users, were still "related facilities" within the state statutory definition of "cogeneration facility." Clarification of this point was important for determining how the PSC would treat the entire Burrstone microgrid project for regulatory purposes.

The PSC agreed that the Project qualified as a "cogeneration facility" under PSL §2 (2-a).[496] The PSC further found that the Project's distribution lines qualified as "related facilities" under PSL §2 (2-d), which states "[t]he term "related facilities" shall . . . include also such transmission or distribution facilities as may be necessary to conduct electricity, gas or useful thermal energy to users located **at or near** a project site" (emphasis added). The PSC relied on two prior rulings (described herein as Nissequogue and Nassau District)[497] in finding that distribution facilities crossing a public way did not influence a determination of whether those facilities are "related facilities."[498] In Nissequogue and Nassau District, the lines crossing a public street were between 1.5 and 1.9 miles long, a distance far greater than the 3,800 feet Burrstone was proposing. The main distinction found between the cited cases and Burrstone was that instead of serving the same user on either side of the public street, the Burrstone Project would serve multiple users, one of which owned property separated from the other two by a public street. Nevertheless, the PSC found that this difference was immaterial because PSL §2 (2-d), in using the plural term "users," contemplated distribution to multiple entities.

Thus, because the Project's distribution lines were "related facilities" under PSL §2 (2-d), the Project as a whole (generating facility and distribution lines) was a "cogeneration facility,"[499] and therefore qualified for the exemptions discussed in PSL §§ 2(3), 2(4), 2(13), and 2(22). As a result, Burrstone was found not to be a "corporation," "electric corporation," "steam corporation," or "person" and therefore, with the exception of PSL Article VII, exempt from the Public Service Law.

Showing its support for Burrstone, in a separate petition, National Grid requested that the PSC waive two standby tariff requirements,[500] which it thought might endanger the Project. Specifically, National Grid considered the Burrstone Project to occur on three distinct sites and thus run afoul of the tariff's site-specific requirements. As discussed above, at National Grid's request Burrstone had designed the microgrid system so that each participating customer would be served with electricity from dedicated engines. In its discussions with Burrstone, the utility had been clear that it felt that multiple unaffiliated customers served by a single prime mover should be treated as an electric corporation. Installing dedicated generators was National Grid's requirement for its support of the project. The PSC concluded, however, that such waivers were unnecessary because National Grid had incorrectly interpreted

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[493] Burrstone Energy Center, LLC, FERC Form No. 556: Certification of Qualifying Facility Status for an Existing or Proposed Small Power Production or Cogeneration Facility, June 29, 2007

[494] It is important to note that a federal Qualifying Facility under PURPA is a different designation than a qualifying facility under New York State law. New York has its own, albeit similar, definitions of qualifying facilities, which are exempted from treatment as an electrical corporation under state law. Federally designated PURPA QF's, on the other hand, are exempted from state regulation entirely.

[495] *See* PSL §§2(3), 2(4), 2(13), and 2(22).

[496] Case 07-E-0802, Burrstone Energy Center LLC, Declaratory Ruling (issued August 28, 2007).
PSL §2 (2-a) states: "The term "co-generation facility", when used in this chapter, includes any facility with an electric generating capacity of up to eighty megawatts, . . . together with any related facilities located at the same project site, which is fueled by coal, gas, wood, alcohol, solid waste refuse-derived fuel, water or oil, . . . which simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy that is used solely for industrial and/or commercial purposes."

[497] Case 93-M-0564, Nissequogue Cogen Partners, L.P., Declaratory Ruling (issued November 19, 1993); Case 89-E-148, Nassau District Energy Corporation, Declaratory Ruling (issued September 27, 1989).

[498] Case 07-E-0802, pp. 5-6.

[499] Defined by PSL §2 (2-a)

[500] Specifically, Leaf No. 102 and Special Provision L, at Leaf No. 106-q

the single-site provisions in a way that conflicted with the Public Service Law.[501] The PSC indicated that based upon its status as a cogeneration qualifying facility, the Project as a whole occupied one site, not three. This was because "cogeneration facility" is defined to include the distribution systems crossing property lines to reach customers "at or near" the project site, and thus incorporates those customers into the system itself. Because the PSC found that Burrstone and all three of its customers were located on one site, it considered the tariff's single-site provisions to be satisfied.

Permit to Cross Champlin Avenue with Electric Line

In addition to the Declaratory Ruling from the PSC described above, Burrstone had to apply to the Department of Transportation (DOT) for a permit to install cables under Champlin Avenue, a public road. To obtain this permission, Burrstone followed the DOT's formal procedure for utilities to cross public roads or highways with transmission or distribution lines.[502] This permission was obtained without difficulty or challenge from any party.[503]

Air and Environmental Permits

The NYS Department of Environmental Conservation (DEC) required Burrstone to file for an Air State Facility permit to operate the four reciprocating engines. The permit was granted on November 28, 2007. By installing equipment to track and restrict the facility's carbon monoxide levels under 100 tons per year, Burrstone was not required to file for a Title V permit.[504]

Consistent with the State Environmental Quality Review Act (SEQRA), Burrstone also submitted an Environmental Assessment Form. In response, the DEC issued a Negative Declaration affirming that the Project would not have a significant or adverse impact on the environment, effectively authorizing Burrstone to proceed with its project without conducting a full environmental impact report.[505]

Interconnection

In its Bulletin 756, National Grid provides all independent power producers with guidelines and procedures for interconnecting new facilities to its system. At a minimum, the application includes providing design and operating information for the proposed facility. If the facility being interconnected to the grid is of a particular size (usually greater than 2-MW), an engineering analysis must be performed in order to ascertain the potential impacts on existing infrastructure and determine what electrical devices are required to protect utility and transmission system assets. After receiving the developer's application and associated materials, the utility conducts a review and determines acceptance in accordance with the applicable process. The project developer is responsible for all utility costs incurred during the interconnection application and review process.

As mentioned above, at National Grid's request, each customer served by the Burrstone microgrid receives separate dedicated electric service from engines operating in parallel with the grid. As a result, instead of a single application for a larger 5-MW prime mover, Burrstone had to undertake four separate interconnections of smaller generators. National Grid performed interconnection studies for each of the applications. Burrstone estimates that the additional applications, processing time and equipment increased the cost of interconnecting the project by close to a factor of three.

In total, the microgrid has the capacity to export 1.7 MW to the grid (600 kW from the College and 1.1 MW from the Hospital). National Grid requires that if the interconnected generation becomes "out of tolerance" with the utility system, such as if the line voltage drops more than 10% for longer than 10 cycles, the utility breaker must be opened. The utility breaker cannot be closed until utility power is within tolerance for five minutes. Once it is, Burrstone can resynchronize the plant to the utility by closing the utility breaker. While the breaker is open, the plant can operate in island mode within two minutes.

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[501] Case 07-E-1033, Niagara Mohawk Power Corporation d/b/a National Grid – Petition for a Waiver of Certain Requirements of the Company's Tariff With Respect to the Customers of a Proposed Cogeneration Facility Owned and Operated By Burrstone Energy Center LLC, Order Interpreting and Directing Compliance with Tariff Provisions (Issued December 17, 2007).

[502] See DOT procedures for highway crossing permits at: https://www.nysdot.gov/divisions/operating/oom/transportation-systems/traffic-operations-section/highway-permits (accessed on February 28, 2010)

[503] Thomas Kelly and Michael Hyams, personal communication with John Moynihan, 2009.

[504] Department of Environmental Conservation. "ENB Region 6 Completed Applications 11/28/2007" http://www.dec.ny.gov/enb/20071128_reg6.html

[505] Ibid.

National Grid originally requested Burrstone to install a direct trip transfer scheme, at the additional cost of $300,000, to prevent any inadvertent exports of power from the engines to the grid. The utility was concerned that during outages the site could export enough power upstream from the plant to energize power lines, potentially putting its line workers in danger. Still, after extensive discussions, Burrstone convinced the utility that the microprocessor protective relays that it installed at each point of common coupling with the grid (provided from National Grid's approved list of equipment), would effectively prevent any unintended back-feed. The microprocessors recognize when utility power is lost, and automatically open the circuit breaker. Burrstone also argued that the small amount of power that would be exported under such conditions would only be a small fraction of the upstream demand and would immediately cause Burrstone's generators to trip offline.

New York State Rebates

Through their electric service from National Grid, the "Hospital, Home and College" pay the System Benefits Charge (SBC), a tax added to retail sales of electricity to support various social and environmental initiatives managed by the New York State Energy Research and Development Agency (NYSERDA). In 2006, on behalf of the three participating customers, Burrstone applied to NYSERDA for funding under its Program Opportunity Notice 1043, Distributed Generation as Combined Heat and Power, as a demonstration project. In its application, Burrstone submitted a detailed description of the project including the existing and proposed equipment for the facility, system performance estimates, detailed project cost estimates, budget and milestones, analysis of the social and environmental benefits it portends to provide, and examples of similar projects implemented elsewhere. NYSERDA approved Burrstone's request and contributed $1 million in SBC cost-sharing funds to support the CHP project.

Benefit/Cost Discussion

The total installed cost of the Burrstone microgrid was $15 million, which includes the engines, construction of the CHP plant, two absorption chillers at the hospital, underground cables, piping and new switchgear. These costs were offset by the $1 million NYSERDA demonstration grant and property tax abatement provided by Oneida County worth approximately $150,000.

The microgrid operating and maintenance (O&M) costs include both fixed and variable components. The fixed O&M costs total approximately $100,000 per year and include taxes and insurance. Natural gas usage at the plant is expected to be approximately 250,000 dekatherms per year. Burrstone and the microgrid participants also pay National Grid for standby service under the utility's SC-7 tariff.

The benefits to participating customers include improved service reliability and reduced energy costs. Burrstone successfully demonstrated its ability to improve reliability of service to the college campus in March 2010 when National Grid was replacing an electric meter. The Utility cut power to the campus for six hours while a meter was replaced. During this time the Burrstone plant powered the college. The campus facility director took non-critical loads off the system to maintain a campus-wide load less than 1 MW, roughly equivalent to the maximum capacity of the engine serving the college. Although not yet demonstrated, the Burrstone system will be able to provide similar support to the hospital and home. As mentioned above, in cases of utility outage, both customers will in first instance start their emergency backup generators to serve essential demands (i.e., life support systems). During extended outages, the hospital's loads will be transferred to the Burrstone system, allowing the emergency generators to shut down within approximately thirty minutes (reducing the running time of these more polluting sources of power). Meanwhile, the home will use both its backup and Burrstone power to meet its full demand during emergencies.

Under their service agreement with Burrstone, the hospital and home will save approximately $500,000 per year on energy costs, while the college is estimated to save approximately $300,000 per year. Together these savings represent approximately 15-20% of the customers' annual utility expenses. Additionally, because Burrstone financed the project using a combination of its own equity and debt, the capital outlay was kept off the customers' balance sheets, freeing up capital potentially for other capital improvements. Burrstone will recoup the capital and O&M costs through the 15-year PPA. After the initial PPA term expires, the participating customers have the option to purchase the system at a fair market value or exercise the option to extend Burrstone's contract for an additional five years.

From a societal perspective, the Burrstone project will provide both environmental benefits and support to the regional macrogrid in the form of reduced demand (and/or additional capacity). Based on values calculated by the PSC for its Energy Efficiency Portfolio Standard, this additional capacity in upstate New York will provide approximately $85.39/kW-year in 2010, escalating to $140.36/kW-year in 2020, in terms of avoided line losses, and generation and distribution capacity costs. On an annual basis, this amounts to approximately $307,000 in 2010 for the 3.6 MW of capacity. Moreover, Burrstone estimates that the microgrid will reduce emissions of CO_2 by approximately 4,000 short tons per year due to the use of waste heat from the reciprocating engines. These savings are driven by the replacement of 70% of the hospital's thermal energy supply with waste heat, representing approximately 7,000 short tons of reductions in CO_2 by avoiding use of older and less efficient gas boilers. These savings are offset by a slight increase in emissions per MWh of electricity produced by the reciprocating engines as compared to National Grid's system average emissions factor, which is relatively low due to the significant contribution of hydroelectric generation in the regional power mix. Finally, the decrease in boiler usage at the hospital also amounts to 28 tons per year of reduced local emissions of SO_2, an important, but relatively insignificant reduction of this acid rain-causing pollutant.

Project Contact

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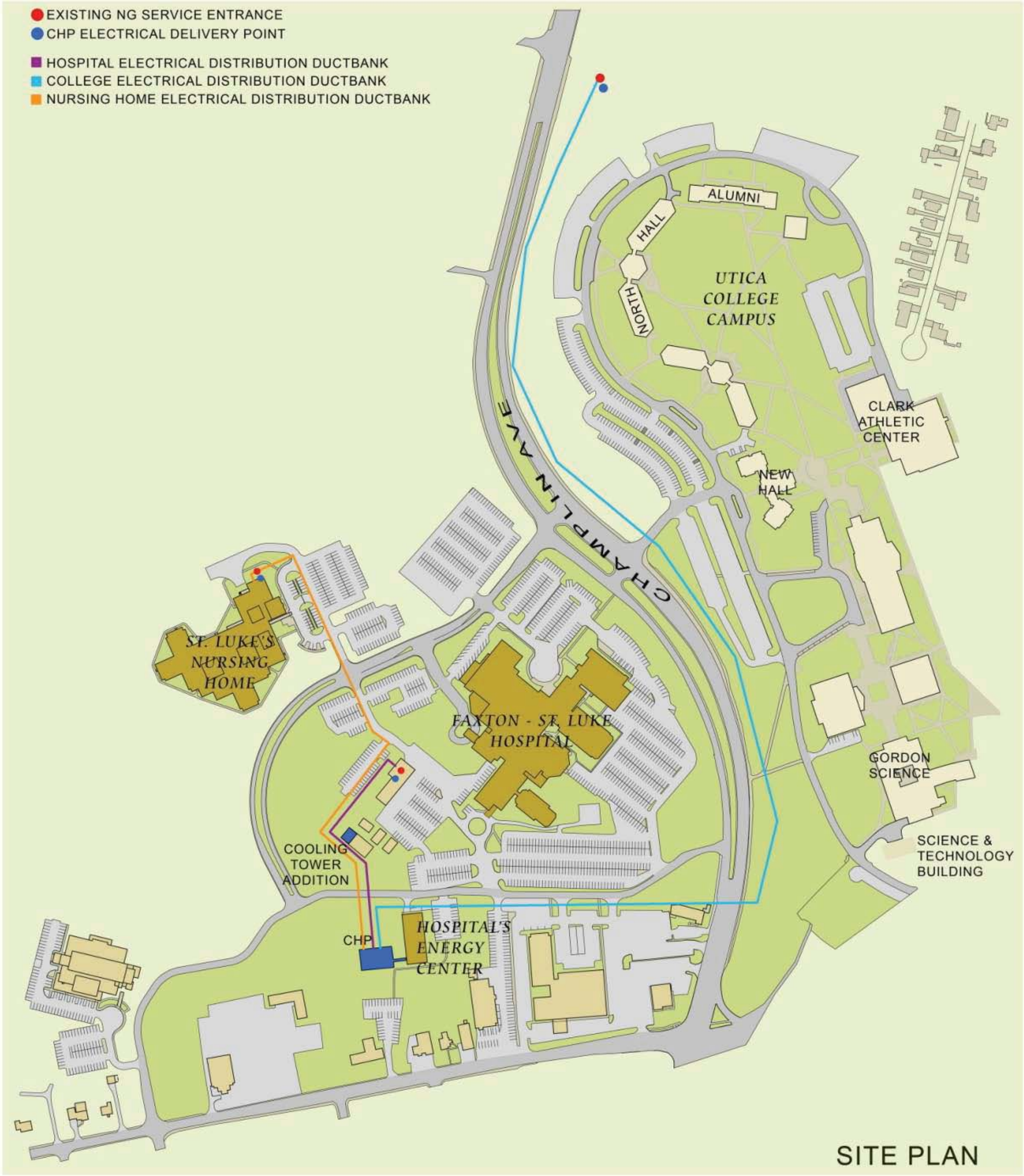
Figures and Tables

Figure A1: Map of Burrstone Microgrid Area



Source: Burrstone Energy Center

Table A1: Summary Microgrid Cost/Benefit Components

Type	Description	Point of View	Calculation	Value/Potential Value
BENEFITS				
Reduced electricity purchases	College = 7,150 MWh/year Hospital = 15,550 MWh/year Nursing Home = 2,800 MWh/year	Participants	7,150 MWh/year*8.9 c/kWh 15,550 MWh/year*8.9 c/kWh 2,800 MWh/year*8.9 c/kWh	$2,269,500
Reduced demand charges	SC-3 tariff demand charges; SC-3A tariff demand charges	Participants	TBD	TBD
Reduced fuel purchases for hospital thermal	32,200 MWh/year (thermal) or 110,000 MMBtu/year natural gas fired boiler at 60% efficiency	Participants (hospital)	183,333 MMBtu*1.01/MMBtu gas	$185,166
Sales of power to grid	Pursuant to National Grid's buy-back tariff, SC-7, and LBMP energy prices	Participants	See below	See two rows below
Capacity	TBD	Participants	TBD	TBD
Energy	TBD	Participants	TBD	TBD
Improved reliability		Participants		N/A
NYSERDA Incentive	Ratepayer funded financial support for distributed generation deployment	Participants	Lump sum	$1,000,000
Avoided line losses and generation and distribution capacity	The addition of 3.6 MW of capacity in Utica avoids grid line losses and may reduce the need for additional grid-connected generating capacity as well as distribution system investment	Society	3.6 MW*$85.39/kW-year (2010) (line losses, avoided generation and distribution capacity)	$307,404
Reduced emissions of CO2	4,000 tons per year	Society	$3.08/ton	$12,320
Reduced emissions of SO2	28 tons per year	Society	$84/ton	$2,352
Reduced emissions of NOx	Negligible	Society	$325/ton	$0
COSTS				
System capital costs	Includes full cost of equipment, installation, labor for microgrid generating plant and energy distribution facilities including absorption chiller	Participants		$15,000,000

Interconnection	Includes cost to interconnect three separate prime movers to three participating customers (i.e., administrative and equipment costs)	Participants		N/A
Operating costs	See below	Participants		See two rows below
Fixed costs	Taxes and insurance	Participants	$100,000/year	$100,000
Variable costs	Administrative and operating costs	Participants	N/A	N/A
Fuel purchases (natural gas)	250,000 dekatherms (total; incremental unknown)	Participants	$1.01/therm	$252,500
Standby Service Costs	Demand charges plus energy costs	Participants		TBD
NYSERDA incentive	Ratepayer funded financial support for distributed generation deployment	Society	Lump sum	$1,000,000

A.5 STAMFORD ENERGY IMPROVEMENT DISTRICT

Project Name:	Stamford Energy Improvement District (EID)
Location:	Stamford, Connecticut
Owner/Developer:	Pareto Energy
Ownership Model:	Independent Provider
Status:	Planning

Microgrid Typology

Project originator	Private sector	[✓ Government]	
Microgrid system owner	Single		Multiple
	[✓ Proj. Developer]	Property owner	
Energy users	Self	Self + others	[✓ Others]
Cross public street?	Yes	[✓ No]	
Form of energy distributed	Power only	[✓ Power + thermal]	Thermal only
Limits on microgrid size?	None	[✓ Declared district area]	
Interconnected at voltage?	[✓ LV]	HV	
Operate independently of grid?	[✓ Yes]	No	
Multiple resources	[✓ Yes]	No	
Certified QF?	Yes	[✓ No]	

Microgrid Summary Statistics

- **Number of distinct customers**: presently one, but planning underway for expansion
- **Types of customers/end uses:** government office building
- **Technologies employed**:
    - One United Technologies PureCell 400 – 400-kW phosphoric acid fuel cell with 0.785 MMBtu/hr heat recovery (fueled by natural gas)
    - One General Electric Jenbacher JMS 316 – 672-kW reciprocating engine with 2.5-MMBtu/hr thermal output and Heat Recovery Steam Generation (natural gas)
    - One existing 325 kWp reciprocating engine (diesel)
    - One Hot water absorption chiller with 150 tons capacity – Broad Model BYDH 50 or an equivalent options from Trane, Carrier, or other manufacturers
    - Pareto Energy GridLink™ inverter
- **Peak electric capacity**: 1.072 MW steady-state
- **Annual electric consumption**: 4,700-MWh
- **Annual electric production**: 4,460-MWh
- **Peak thermal capacity**: 2.8-MMBtu/hr high-grade only; 5.1-MMBtu/hr including low-grade
- **Annual thermal production**: 7,600-MMBtu
- **Peak cooling capacity**: 150 tons
- **Annual cooling**: 200,000 ton-hrs
- **Annual CO_2 reductions**: 850 tons/year (25% reduction)
- **Annual SO_2 reductions**: 2,028 lbs/yr (99% reduction)
- **Annual NO_x reductions**: 4,088 lbs/yr (90% reduction)

Ownership & Service Model Explanation

On October 6, 2009, the City of Stamford's Board of Representatives unanimously approved an energy services agreement (ESA) with Pareto Energy, a private energy consulting and services firm, to develop a clean energy project for the city's Government Center. Located in downtown Stamford, the Government Center will be the first project in what Pareto and the City anticipate will become a larger microgrid system made possible by Connecticut's Energy Improvement District (EID) legislation, which passed the state legislature in 2007. Although the EID legislation contemplates the development of microgrid cooperatives, the project currently being undertaken by Pareto is consistent with an Independent Provider ownership and service model.[506] Under the 20-year ESA, Pareto will own and operate the system and sell electricity, heating and cooling to the Government Center, and potentially, other public and private customers that wish to join at a later date.

Background/Project Objectives

The City of Stamford is located in southwestern Connecticut, covers an area of 37 square miles and has approximately 120,000 residents.[507] Consistent with Connecticut state law, the City of Stamford adopted an ordinance establishing an Energy Improvement District (EID) on November 11, 2007.[508] EIDs are municipal authorities that may work with local property owners to purchase or lease distributed energy systems to supply energy locally (the state law is described in detail below under "Permissions and Regulatory Matters"). In Stamford's local authorizing law, the district is defined as an area – principally the downtown central business district, the South End neighborhood and an industrial area along Magee Avenue – whereby property owners may voluntarily join together to purchase and operate energy systems to provide electricity, heating and cooling (see Figure A1 in the Appendix for a map of the Stamford EID area). The EID is governed by a board of directors, appointed by the mayor, consisting of government officials and participating individuals and businesses.

The intent of the Stamford EID is to facilitate the development of new clean energy systems including those using renewable energy technologies and distributed generation in combined heat and power (CHP) configurations. The EID allows property owners to develop these projects in partnership with other adjacent properties in an effort to increase in-city electricity capacity, improve reliability, reduce greenhouse gas emissions, and to better manage overall energy costs.[509]

Stamford decided to pursue the development of EID microgrids for two main reasons, both of which are centered on the issue of local economic development. First, the State of Connecticut has among the highest average retail electric rates of any state in the continental United States, hindering the city's ability to attract private enterprise.[510] Second, Stamford experiences frequent local grid disruptions, particularly brownouts, which are equally damaging to local commerce. In 2006, downtown Stamford was afflicted by several blackouts that were the result of transformer failure and other distribution system related causes.[511] The brownout condition on the other hand, stems largely from the city's location in the southwestern part of the state; an area that suffers from local transmission constraints and is adjacent to the mid-Atlantic national transmission corridor, one of the two major national

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[506] We have defined the Independent Provider model as a microgrid that is owned and operated by an independent, non-utility firm, which sells electricity and/or thermal energy to multiple, unaffiliated customers. This business model is strictly commercial, that is, the independent owner/operator does not produce primarily for its own consumption.

[507] City of Stamford, "About Stamford," Available at: http://www.cityofstamford.org/content/36/106/default.aspx (accessed on February 10, 2010)

[508] City of Stamford "Ordinance Number 1076 concerning Establishment of an Energy Improvement," Available at: http://www.cityofstamford.org/filestorage/25/50/258/92789/EIDOrdinance.pdf (accessed on February 10, 2010)

[509] Letter from Mayor Malloy, July 27, 2009, Available at: www.cityofstamford.org/content/25/50/258/92789/93725.aspx (accessed on February 10, 2010)

[510] According to the US Energy Information Agency, in October 2009 Connecticut had the second highest average retail electricity rates in the United States (behind Hawaii) and the highest among the continental states. For more information see: http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=CT (accessed on February 10, 2010)

[511] Local outages are poorly tracked and distribution system performance not publicly reported in Connecticut. Pareto noted that they relied on the newspapers to find out about local blackout events.

reliability problem areas.[512] A regional deficiency of 700 MW of installed capacity is exacerbated by a combination of continued load growth (from 1999 to 2004 peak demand grew by 27%), and difficulty in siting new generation and transmission projects.[513] The city's reliance on imported power makes it particularly vulnerable to high prices resulting from congestion and low reserve margins.[514] As a result of these hardships, Stamford has sought ways to reduce its dependence on Connecticut Light & Power (CL&P).[515]

Ensuring the availability of both reliable and low cost power is a major issue for attracting and maintaining business activity in Stamford, which has become a financial services hub.[516] Stamford officials hope that through the deployment of locally sited distributed production systems, the EID will offer participating local businesses improved reliability, and stable and predictable energy costs. EID projects such as the one Pareto is undertaking at the Government Center can help alleviate regional transmission congestion by sourcing more capacity from within the business district load pocket.[517] The goal is that Pareto's anchor project at Stamford's Government Center will demonstrate this potential for savings and improved reliability and encourage individuals and businesses to participate in, and expand, the EID.

Stamford's location in the New York-northern New Jersey-Long Island ozone non-attainment area also makes the installation of clean distributed generation within the city load center valuable environmentally, both locally and regionally. Due to the transmission congestion problems in the region, the New England Independent System Operator has had to keep older (and more polluting) plants, which should be retired, on-line and available to support the grid.[518] Although at this stage the EID is relatively small, Stamford's hope is that if private customers participate and the scope of the project expands, the EID has a potential to displace emissions from more polluting electric generation serving the city. It is not clear at this time if the EID can encourage enough new capacity to have such an impact on the regional grid.

Detailed Microgrid Description

Stamford's Government Center EID project will utilize several clean power technologies to provide electricity, heating and cooling in a tri-generation configuration. These technologies include a 400 kW fuel cell, capable of 1.7 MMBtu/hr thermal output and a 672 kW gas-fired reciprocating engine, capable of 2.5 MMBtu/hr of thermal output.[519] In serving the Government Center's electricity loads, Pareto will dispatch the fuel cell first, and expects it to run at a capacity factor of approximately 92%; the reciprocating engine will provide the balance of power to the building (approximately 1,260 MWh/year). The existing 325 kW diesel back-up generator will supplement Pareto's units only when required to meet peak building loads during a blackout. An absorption chiller will be installed to accommodate the use of thermal production during the summer for building cooling. The plant will be located in a building above ground and adjacent to the Government Center parking garage.

The Government Center is a 250,000 square foot commercial office building owned by the City of Stamford. A typical office building, the Center houses several municipal agencies, including public safety and the City Council

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[512] Department of Energy (2006), *National Electric Transmission Congestion Study,* August 2006, Available at: http://nietc.anl.gov/documents/docs/Congestion_Study_2006-9MB.pdf (accessed on February 10, 2010.

[513] Michael Freimuth and Guy Warner, "Progress Report on CHP Development in Stamford," Available at: http://www.epa.gov/chp/documents/wbnr111909_stamford_presentation.pdf (accessed on February 10, 2010) and Willie D. Jones, "Electric Power Plant Explosion Reveals History's Biggest Lesson," IEEE Spectrum Available at: http://spectrum.ieee.org/tech-talk/energy/policy/electric-power-plant-explosion-reveals-historys-biggest-lesson (accessed on April 10, 2010)

[514] Id.

[515] Donna Porstner, "District gathers businesses for energy savings," November 12, 2007, Available at: http://www.paretoenergy.com/about/press/District_gathers_businesses.pdf (accessed on February 10, 2010)

[516] Id.

[517] Pareto Energy, "District gathers businesses for energy savings," Available at: http://www.paretoenergy.com/about/press/District_gathers_businesses.pdf (accessed on February 10, 2010)

[518] Kevin McCarthy, "Kleen Energy Project and Related State Legislation," OLR Research Report 2010-R-0092, February 16, 2010

[519] The fuel cell is capable of producing 0.785MMBtu/hour of high-grade and 0.923MMBtu/hr of low-grade thermal output and the reciprocating engine can produce 2.6 MMBtu/hr of high-grade (exhaust + jacket water) and 0.7 MMBtu of low-grade thermal. Dr. Shalom Flank, Pareto Energy Chief Technology Officer. Interviewed by Thomas Kelly. December 16, 2009

chambers as well as a cafeteria. Once Pareto's system is online (expected in May 2011), the building will be able to purchase 80% of its average electrical and thermal energy consumption from the facility. The system is being intentionally undersized in relation to the building's peak demand, eliminating the need for capacity that would only be used a few times per year. The existing standby generator will make up the difference in the event of a grid outage, so that full load can still be met under all conditions. Maintaining a connection to CL&P allows the Government Center to use grid power during these periods as well as when its power equipment is being serviced. It also allows the facility to engage in energy arbitrage, or to be operated to take advantage of grid electricity when prices are low and self-generate when prices are high.

Pareto will distribute electricity to the government center from a 480-volt bus on the low-voltage side of Connecticut Light & Power's (CL&P) 13 kilovolt (kV) transformers. The system will also deliver hot and chilled water to the building for space conditioning and domestic hot water supply, displacing a set of dual fuel boilers (fueled exclusively by natural gas) and some cooling provided by two direct expansion chillers per floor (powered by electricity). By design, Pareto's system will not be able to fully satisfy the peak summer load of the Government Center. The new absorption chiller will serve most of the building's cooling demand, which will be topped off by electricity purchased from CL&P to drive the direct expansion chillers when necessary.

The Government Center will be interconnected to CL&P using Pareto's proprietary "non-synchronous" interconnection controller called "GridLink." GridLink is capable of interconnecting multiple power sources and converting power flows from AC to DC and back to AC. GridLink can control the amount of power supplied to loads, from zero to full capacity, within milliseconds. The controller uses a small amount of built-in power storage to smooth out load following and power fluctuations. GridLink also prevents back feed, so from the vantage point of the grid, interconnected generators look like reduced load rather than an embedded power source. As a result, Pareto contends that GridLink avoids the need for lengthy interconnection procedures and expensive grid protection requirements. As the first commercial demonstration of GridLink, the Government Center project will provide an opportunity to test such claims.

According to Pareto, other advantages of the GridLink controller include:

- Parallel operation[520] with the utility macrogrid, which allows end-users like the Government Center to receive the benefit of multiple independent sources of power;
- Ability to combine multiple power sources, including utility power, without need for synchronization, or that the alternating current produced by power sources is "in-sync" in terms of amplitude and voltage, both among microgrid sources and between the microgrid and the macrogrid;
- Elimination of fault current contributions, or abnormal current fed into a circuit, so utilities can add unlimited amounts of distributed generation without having to upgrade their substations; and
- Power converters produce a "perfect power" signal, meaning surges and power fluctuations from utility feeds and internal sources are eliminated.

In the event of a blackout or other Independent System Operator (ISO) declared emergency, the Government Center will be largely unaffected. The non-synchronous configuration of its interconnection to CL&P means that no "islanding" is required from an electrical engineering standpoint. Moreover, because the Government Center already participates in an ISO New England demand response program with the firm EnerNOC, the building boasts an advanced energy management system programmed to shed load in the event of a grid emergency. During a blackout, this load shedding will provide time to start the building's back-up diesel generator, which in conjunction with Pareto's system will provide enough capacity to operate all building systems independently from the grid. This operational flexibility will further enhance the Government Center's ability to serve as a cooling center and provide refuge to local residents when there are electric service disruptions on hot summer days.

Under the EID, installation and interconnection of distributed generators at multiple sites is encouraged, providing a modular structure to microgrid development. Instead of growing a larger central plant, as more users join the EID, new distribution infrastructure will be installed connecting distributed resources and loads. Pareto is currently negotiating with a multi-family residence operated by Charter Oak Communities, the City of Stamford Housing

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[520] Parallel operation with the grid allows a generator and the utility to power a location simultaneously.

Authority, to join as an additional customer of the EID. Ultimately, Pareto estimates that the Stamford EID could grow by an additional 25 MW of load by 2014.[521]

EID Development Process

The major events/milestones in the development of the Stamford EID are:

- Series of blackouts in downtown Stamford…………………………..Summer 2006
- Connecticut State EID Legislation adopted…………………………..Summer 2007
- Stamford adopts ordinance establishing local EID………………………..Fall 2007
- Stamford signs energy consulting contract with Pareto Energy……………Fall 2007
- First meeting of the Stamford EID Board……………………………Summer 2008
- Pareto submitted interconnection application to CL&P…………………...Fall 2008
- Draft interconnection agreement with CL&P prepared………………...Winter 2009
- Stamford applies for EPA Showcase Communities Grant……………Summer 2009
- Stamford signs energy service agreement with Pareto……………………..Fall 2009
- Project development and finance plan complete…………………………Fall 2009

Pareto estimates it will take about a year and a half from the time its contract was signed with the City of Stamford to bring the Government Center project online. The major activities over the next twelve months will be:

- Begin design-build planning process…………………………………...Spring 2010
- Project development and finance plan complete………………………Spring 2010
- Apply for necessary permits…………………………………………Summer 2010
- Begin site construction……………………………………………...Winter 2011
- Install fuel cell………………………………………………………Winter 2011
- Plant commissioning………………………………………………...Spring 2011

Pareto anticipates that Stamford's Government Center will serve as a "proof of concept" for the EID idea and lead to subsequent projects that may be interconnected as single or multiple microgrids. By demonstrating that the EID can be successful, the Government Center project will be critical to attracting additional private and public sector participants and EID growth. Pareto is currently working with the City of Stamford to identify potential future projects where microgrids may be deployed.

Permissions & Regulatory Matters

On June 1, 2007, the State of Connecticut passed House Bill (HB) 7432, "An Act Concerning Electricity and Energy Efficiency" (signed into law as Public Act (PA) 07-242), allowing municipalities to declare and form energy improvement districts to encourage the development of local distributed energy resources.[522]

PA 07-242 empowers any municipality to form an EID that will be administered by an "Energy Improvement District Board," comprised of uncompensated individuals appointed by the municipality's chief elected official. Once formed, the EID may own, lease or finance new distributed resources including customer- and grid-side resources (power plants with a capacity of 65 MW or less), combined heat and power, and energy efficiency projects.

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[521] Ibid.

[522] State of Connecticut, "House Bill No. 7432. Public Act No. 07-242 AN ACT CONCERNING ELECTRICITY AND ENERGY EFFICIENCY," Available at: http://www.cga.ct.gov/2007/ACT/Pa/pdf/2007PA-00242-R00HB-07432-PA.pdf (accessed on February 10, 2010)

Other powers that may be exercised by the EID board include: determining the location, type, size and construction of distributed resources in the district, subject to the approval of municipal, state and federal agencies as required by law; making plans for developing and operating these resources and for coordinating the facilities; fixing and collecting fees for use of the resources; and operating and maintaining the resources the board owns or leases. The Act also allows the board to hire staff and issue revenue bonds to pay for the costs of acquiring, purchasing, constructing or improving any distributed resources. The bonds may be secured by a pledge of any grant or contribution from the participating municipality, state or federal agency or private party.[523]

The EID law requires the chief elected official to notify each property owner within the declared district of the opportunity to join. Property owners may record on the local land records their decision to participate; a new owner of a property located within the district may rescind or change a previous owner's decision.

While the EID law states that the board shall be allowed to "confer with anybody or official having to do with electric power distribution facilities," including electric distribution companies in regard to the "development of electric distribution facilities in such district and the coordination of the same," the law does not *explicitly* authorize EIDs to install, own and operate distribution infrastructure. In fact, PA 07-242 specifies that it shall not be construed as authorizing a district to be an electric distribution company, or to "provide electric distribution or electric transmission services… or own or operate assets to provide such services."[524] Defined in the Connecticut general statutes under section 16-1,[525] electric distribution companies are persons "providing electric transmission or distribution services within the state," or electric companies "owning, leasing, maintaining, operating, managing or controlling poles, wires, conduits or other fixtures along public highways or streets, for the transmission or distribution of electric current for sale…"

Ultimately, the capability of adding new customers and distributed energy resources within the designated EID zone, without regard to building ownership or separation by public streets, would enable distributed generation projects to be optimally scaled and to take advantage of customer electric and thermal load diversity. Because the law does not explicitly forbid EIDs from providing distribution services, it may be permissible for EIDs to distribute energy through their own distribution facilities, provided that the energy sales occur within the defined EID area. Still, the ability of the EID to expand to directly serve multiple interconnected users located at different sites is unclear at this time. Ultimately, it may be necessary for the state legislature to adopt additional legislation that clarifies the ability of EIDs to make these investments, lest EIDs become entangled in litigation with local distribution utilities.

Interconnection

The State of Connecticut has established three general categories for the interconnection of electric generation equipment, which vary depending on the capacity and characteristics of the project, including: inverter-based systems 10 kW or less; systems between 10 kW and 20 MW; and systems over 20 MW.[526] Inverter-based and certified projects with generating capacities between 10 kWp and 2 MW, may qualify for "fast track" interconnection to local electric distribution systems. Generally speaking, however, to qualify for interconnection project developers must undergo a review and demonstrate that the project adheres to the utility's conditions and standards. Typically, the local utility has the right to reject a given application, based on system stability, voltage and frequency control concerns, the presence of an area or secondary distribution network, fault current capacity at a given substation, and a host of other potential issues.

On November 10, 2008, Pareto submitted its application to CL&P for interconnection of the EID project at the Stamford Government Center. On February 17, 2009, the two parties had a draft interconnection agreement. Pareto has found that, like many other distribution utilities, some of CL&P's interconnection requirements limit the

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[523] The United States Conference of Mayors. "Connecticut Legislature Passes Energy Improvement Legislation. http://www.mayors.org/usmayornewspaper/documents/06_18_07/page17_Connecticut.asp

[524] CT General Statutes, Section 23(b)

[525] See Section 16-1(a)(8) and (29)

[526] The Connecticut Light And Power Company, "Guidelines for Generator Interconnection," Available at: http://nuwnotes1.nu.com/apps/clp/clpwebcontent.nsf/AR/GuidelinesGeneratorInterFastTrack/$File/Guidelines_Generator_Inter_Fast_Track.pdf (accessed November 23, 2009)

capabilities and overall effectiveness of the microgrid. For example, CL&P only allows for "top-down" power flow, meaning that interconnected microgrids – or any distributed generation for that matter – cannot export power onto the distribution system or contribute to grid voltage or frequency control.[527] While intended primarily as a safety measure, this requirement reflects the currently limited utility awareness and control over real time power conditions at specific locations on the distribution system, and greatly diminishes the potential value a microgrid could provide. Consequently, CL&P is requesting, as a condition of interconnection, that Pareto install a relay to prevent any back-feed from the microgrid's power sources. According to Pareto, this requirement only adds cost to the project, since GridLink is already capable of preventing any back feed or stray voltage onto the system.[528] Pareto projects total interconnection costs will be approximately $670,000, or nearly 10% of the total project installed costs. Though the interconnection costs are quite significant for this initial project, they are expected to diminish significantly for future projects.[529]

Benefit/Cost Discussion

The total installed cost of Stamford's Government Center EID project is estimated to be approximately $7 million. Nevertheless, the Stamford Government Center has applied for $3.4 million in state and federal rebates, grants and tax incentives, representing approximately 45% of the project's total cost. Pareto expects the project to receive at least $2.9 million of these incentives, making the net project cost approximately $3.6 to $4.1 million, depending on whether the US Environmental Protection Agency awards the project a competitive grant. Table A1 in the Appendix a detailed enumeration of the installed costs and expected incentives for this project and Table A2 for a summary of the anticipated cost/benefit components.

Under the "shared savings" terms of its service agreement with Pareto, the Government Center is guaranteed never to pay more for energy than it would have without the microgrid project. Meanwhile, the benefits from any financial savings accrued as a result of the system operating below the costs of utility electric and gas service are shared between Pareto and the City. Pursuant to the contract, Pareto will bill the Government Center what it would have otherwise paid CL&P in electricity costs under its existing tariff, Large Time-Of-Day Electric Service Non-Manufacturers Rate 58, or possibly a future tariff, if applicable.[530] Similarly, Pareto will charge the Government Center for avoided gas purchases based on Yankee Gas' R-30 Large General Firm tariff when Pareto supplies heating or hot water, which reduces the City's gas bill for heat.[531] The contract assumes the Government Center's existing boilers have a conversion efficiency of 80% from gas input to useful thermal output. The City of Stamford will separately meter and continue to pay its own gas bill for whatever supplementary thermal load that continues to

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[527] As a general matter, the stability of the electric grid (i.e., macrogrid) is maintained using voltage and frequency control to keep the production of *real* and *reactive* power in balance demand at all times. Simply defined, real power is that portion of electric current that is capable of doing work. Reactive power complements real power. Reactive power is consumed by motors and other magnetic equipment during distribution of electricity and must be replaced on the grid, typically by generators or capacitors located at the local level, in order to avoid causing current and voltage to be out of phase resulting in system losses and potentially damaging end-user equipment. Because electricity cannot at this time be economically stored in significant volumes, the amount of *real* power produced on the grid must be equal to the amount consumed at all times. If it is not in equilibrium, the 60 Hz frequency of the grid may be disrupted; this frequency is correlated with the rotating speed of synchronous generators interconnected to and producing power on the grid. At the local level, microgrids can provide voltage (reactive power) and frequency (real power) support to the macrogrid first by reducing the need for locally sited capacitors and second, by exporting these services to the local grid using its local control systems. Still, a major challenge faced by microgrids in providing these services would be the absence of sensing and communication systems in place on distribution systems that would allow real time coordination and control between the microgrid and utility. See S. Chowdhury, S.P. Chowdhury and P. Crossley, *Microgrids and Active Distribution Networks*, The Institution of Engineering and Technology: London, United Kingdom, 2009

[528] Michal Freimuth and Guy Warner, "Progress Report on CHP Development in Stamford," November 19, 2009, Available at: http://www.epa.gov/chp/documents/wbnr111909_stamford_presentation.pdf (accessed on February 10, 2010)

[529] Because this is the first project to deploy GridLink, the costs are higher than is expected for future projects. Pareto points out, however, that in many locations the interconnection process would be lengthy and expensive – or often impossible – when trying to use the more traditional parallel/synchronous approach. Thomas Kelly, Pace University, personal communication with Dr. Shalom Flank, Pareto Energy's Chief Technology Officer, April 23, 2010.

[530] The Connecticut Light And Power, "Large Time-Of-Day Electric Service Rate 58," Available at: http://nuwnotes1.nu.com/apps/clp/clpwebcontent.nsf/AR/rate58/$File/rate58.pdf (accessed on February 10, 2010)

[531] Yankee Gas, "Large General Firm Service-Rate 30," Available at: http://www.yankeegas.com/BusinessCustomer/rate30.asp (accessed on February 10, 2010)

be met using the existing boilers. Pareto will also separately meter and incur the cost of the gas it has to buy to run the fuel cell and engine.

Ideally, these costs will be recovered in the electricity rates and avoided gas purchases for energy it supplies to the Government Center; however, Pareto does assume some market risk with respect to its purchases of natural gas as compared to Yankee Gas tariff prices. The service agreement between Stamford and Pareto provides that if the total costs paid by the city for heating, cooling and electric service from all sources (i.e., generated on-site, provided under regulated tariffs, or procured through third parties) supplied to the Government Center, for any calendar year or period prior to the termination of the agreement, exceed what it would have paid otherwise, Pareto will cover 70% of the additional cost.[532] It is projected that peak gas consumption for the two prime movers will be 10.8 MMBtu/hr with annual gas purchases of approximately 44,000 MMBtu (projected). Finally, since the new system will increase the building's water usage, Pareto will provide the city a credit, on a quarterly basis, equal to its cost for the usage in that period.[533]

Annual Operating and Maintenance (O&M) costs for the entire system serving the Government Center are expected to be approximately $260,000. This figure includes the following components.[534]

- O&M for the engine and fuel cell (including the annual UTC maintenance contract)
- O&M for heat exchange equipment, chiller, and thermal distribution to the building loops
- O&M for the electrical equipment (including GridLink components)
- O&M for the emissions controls (SCR system materials and labor)
- CL&P demand charges and supplemental electricity purchases
- Administrative costs (billing, management fees, insurance, etc.)

Pareto's business model anticipates earning project development fees from the successful completion of the EID scheme and associated projects. Its developer fee is approximately 6% of total project costs, or about $400,000. Once the Government Center EID project is built, and final installed costs and fees have been calculated, Pareto estimates that payback on the investment will be approximately five to eight years, depending on fuel costs.

As discussed in detail above, improving the reliability of electricity service in Stamford is a major objective of the EID initiative. Generally speaking, the value of improved reliability for microgrid participants could be quantified as the reduction in lost productivity (or revenues) associated with electric service interruptions. The project at the Government Center is designed to enhance on-site electric reliability through the ability of the new system to operate independently from the macrogrid (see "Detailed Microgrid Description" above for more information). While no estimates of the cost of service interruptions to activities at the Government Center were available, it is clear that reduced interruptions of government services will produce material benefits to the community in the form of service availability and unproductive staff time. Additionally, although also very difficult to quantify, as the main public hub in Stamford the Government Center will now be able to serve the community as an emergency-cooling center during crisis events, such as during heat waves and regional blackouts.

Local officials also believe that the EID has the potential to help Connecticut achieve its renewable portfolio standard (RPS) objectives.[535] The RPS program requires electric companies and Energy Service Companies (ESCOs) to make renewable energy 27% of their supply mix by 2020.[536] Companies subject to the RPS program may do this by purchasing renewable energy credits (RECs) from different qualified technology "classes." In 2006, the Connecticut Public Utilities Commission added a third class to its RPS program, requiring that utilities purchase at least 4% of their supply from CHP by 2010. Utilities and ESCOs will be able to fulfill their RPS obligations by

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[532] Energy Service Agreement between the City of Stamford and Pareto Energy Ltd., Section 8.4 "Shared Savings," October 2008

[533] The efficiency factor that Pareto used to convert electricity to chilled water is 0.85kWh/ton. The efficiency factor used to convert natural gas to steam or hot water is 80%.

[534] This annual O&M figure does not include what might be called "major maintenance events" such as fuel cell stack replacement and engine overhaul, which are not expected to occur until after the plant has operated for some time.

[535] City of Stamford, "Stamford Cool & Green 2020," Available at: http://www.cityofstamford.org/content/25/52/138/164/172/521/4843/97310.aspx (accessed on February 10, 2010)

[536] Database of State Incentives for Renewables and Efficiency, "Connecticut Renewable Portfolio Standard," Available at: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT04R&re=1&ee=1 (accessed on February 19, 2010)

purchasing RECs from these on-site DG projects.[537] The Government Center project, which will be eligible to sell Class I and III RECs, will be able to make significant additional revenues, on the order of $0.02-0.04/kWh produced, or approximately $90,000-$180,000/year, from participation in the RPS.[538]

Although difficult to quantify, the Government Center and other projects developed pursuant to the EID legislation may provide indirect financial benefits by supporting congestion relief, at both the distribution and transmissions levels. Currently, Fairfield County residents and business pay $300 million per year in federally mandated congestion charges, which include both the cost of congestion and measures to respond to it.[539] While congestion costs have decreased in recent years, with the construction of the Bethel-Norwalk and Norwalk-Middletown transmission lines, the federally mandated congestion charge still account for approximately 0.85 cents per kWh for Stamford customers who buy their electricity from CL&P.[540] The City of Stamford hopes that, in conjunction with other measures such as energy efficiency and demand response, the growth of the EID will, in the medium to long-term, become an effective solution to the region's congestion problem (as opposed to building new central station generation and transmission capacity), and ultimately reduce costs while improving local reliability.

Finally, the project at the Government Center is expected to provide environmental benefits in the form of reduced emissions of carbon dioxide (CO_2), sulfur dioxide (SO_2) and nitrogen oxides (NOx). Pareto estimates that annual emissions reductions will amount to approximately 850 tons of CO_2, 2,028 pounds of SO_2 and 4,088 pounds of NOx. For the portion of the Government Center's energy loads served by Pareto's system, these reductions represent the near elimination of SO_2 (99.2% reduction), a 90% reduction in NOx and a 25% reduction of CO_2 emissions. The CO_2 savings will be achieved largely through the shift to natural gas and the improved efficiency of energy use associated with tri-generation. The NOx reductions are attributable to the lower emissions profiles of the technologies and the use of selective catalytic reduction (SCR) systems on the engine. The reduced use of grid power from the New England Independent System Operator area combined with the shift to natural gas virtually eliminates SO_2 from that portion of energy use now supplied by Pareto. By using the waste heat produced by the fuel cell and engine, the project will reduce the building's reliance on separately generated electricity (i.e., from the grid) and thermal energy (i.e., produced using on-site boilers fed by natural gas). Additionally, because the new system is designed to meet most of the building's on-site energy demand, it is expected to also reduce the need to run the existing back-up diesel generator during regional blackouts, avoiding combustion of diesel fuels (this is not included in the emissions reductions estimates noted above). Due to the unpredictable nature of blackouts, it is difficult to determine how often and to what extent this may occur – only experience will bear out this potential benefit.

Project Contacts

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[537] City of Stamford, "Energy Improvement District: OLR Research Report," http://www.cityofstamford.org/content/25/50/258/92789/93749.aspx

[538] Michael Hyams, personal communication with Shalom Flank, 2010. Note: As of January 2010, Class 1 CT RECs were trading in the $20-24/MWh range. The alternate compliance payment for RPS obligated entities that do not acquire RECs is fixed at $55/MWh for Class 1 & 2 resources and $31/MW for Class 3 resources. See: Evolution Markets' REC Market Updates, January 2010 and February 2010

[539] Freimuth and Warner, 2009

[540] Kevin E. McCarthy, "Connecticut's High Electric Rates and the Legislative Response," OLR Research Report 2010-R-0015, January 20, 2010

Figures and Tables

Figure A1: Map of Stamford's Energy Improvement District

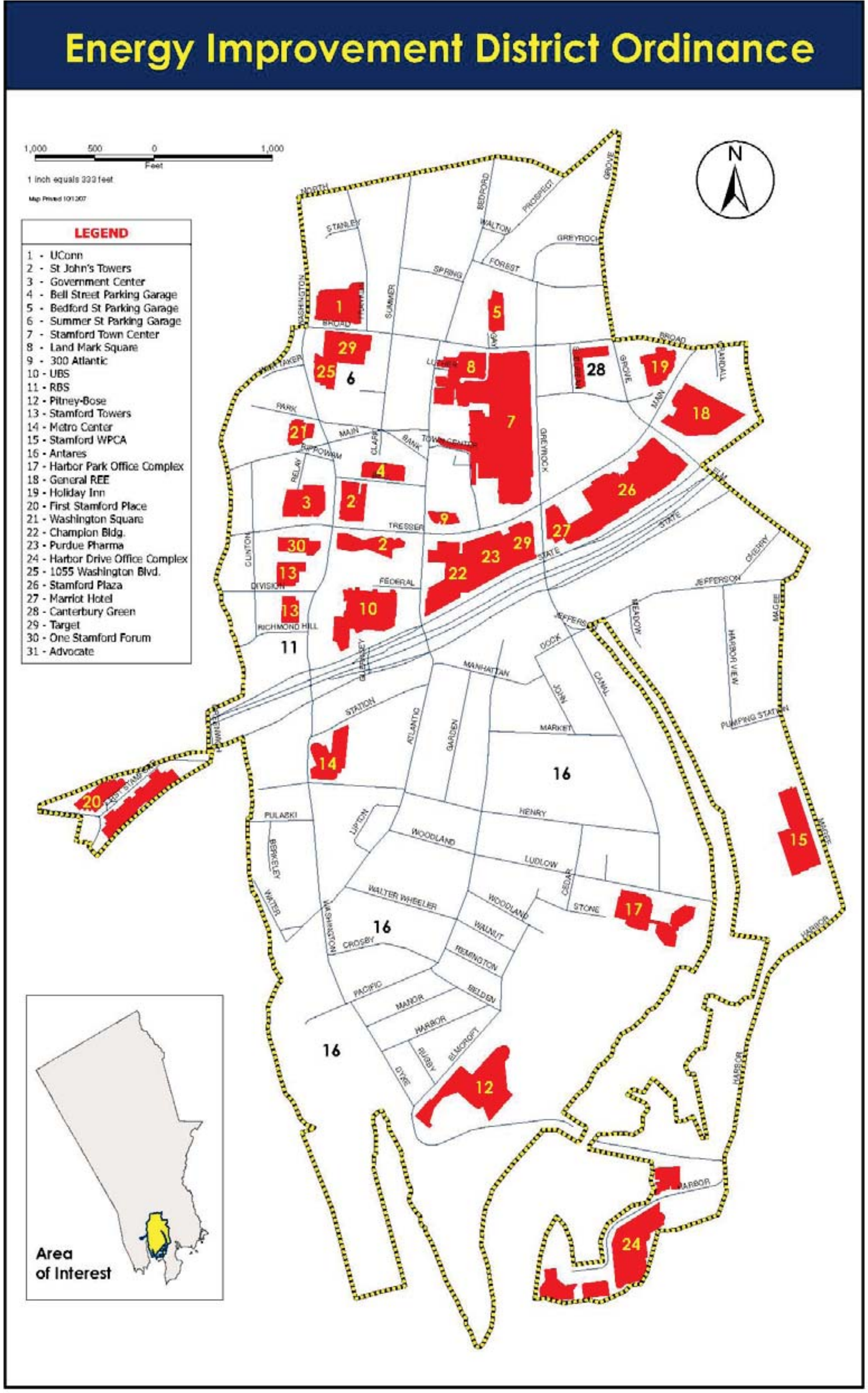

Table A1: Government Center Project Costs and Rebates (thousands $)

Costs		**Incentives**	
Site Work Construction Materials/Finish	$69	CT Clean Energy Fund Feasibility Grant	-$50
Mech/Elec/Plumbing	$1,223	CT Clean Energy Fund On-Site Renewables	-$1,000
Interconnection/Switchgear	$670	Federal Bldg Energy Efficiency Tax Deduction	-$166
Sound Proofing	$60	Federal Efficiency & Conservation Block Grants	-$223
Fuel Cell	$1,903	Federal Investment Tax Credit	-$1,449
Engine and Emissions Controls	$661	EPA Climate Showcase Communities Grant (Pending)	-$500
Heat Recovery	$95		
Absorption Chiller	$130		
Project Support/General Requirements	$68		
Construction Documents/As Built	$338		
Permitting	$85		
Design-Bid Award/General Conditions	$209		
Insurance	$80		
Design-Build Fee	$248		
Project Development Fee	$381		
Financing and Construction Loan Fee	$535		
Contingency	$345		
Total Upfront Cost	$7,000	Total Incentives	-$3,388
Net Project Cost	**$3,612**		

Source: Pareto Energy

Table A2: Summary of Anticipated Cost/Benefit Components for Government Center EID Project

Type	Description	Point of View	Calculation	Value/Potential Value
Benefits				
Reduced purchases of electricity from CL&P	Will reduce electricity purchases at Gov't Center by over 90%. Avg. Annual consumption is 4,668 MWh. Microgrid will produce 4,466 MWh	City of Stamford	4,466,000 kWh @ $0.1724/kWh (per year)[541]	$769,938.40
State Incentives	CT Clean Energy Fund Feasibility Grant and On-Site Renewables Incentives (fuel cell)	City of Stamford	One-time lump sum payments	$1,050,000
Federal Incentives	Federal Efficiency and Conservation Block Grant, Building Energy Efficiency Tax Deduction, Investment Tax Credit, and EPA Climate Showcase Community Grant	City of Stamford	One-time incentives / tax credits taken in year of investment. Tax incentives / credits are taken by developer. Value of building tax deduction = $0.30 -$1.80 per square foot, depending on technology & amount of efficiency[542]	$2,338,000
Class I (fuel cell) and Class III (CHP) REC sales	Purchased by RPS-compliant load serving entity	City of Stamford	4,466,000 kWh @ $0.02-0.04 per kWh produced (per year)	$89,320-$178,640
Reduced Federal Congestion Charges	$300 million assessed in Southwestern Connecticut	City of Stamford, Society	Value attributed to project not quantified	N/A
Reduced emissions of SO_2	2,015 lbs/year (est.)	Society	2,015 lbs @ $84.00/ton (per year)[543]	$84
Reduced emissions of NO_x	4,072 lbs/year (est.)	Society	4,072 lbs @ $325/ton (per year)	$662
Reduced emissions of CO_2	825 tons/year (est.)	Society	825 tons @ $3.10/ton (per year)[544]	$2,558
Improved reliability and service capability	System will enhance Gov't Center's ability to serve as a cooling center during local grid emergencies	Society	Estimates not available at this time	N/A

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[541] Based on EIA figures for average bundled commercial rates in CT in 2009. See: http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html (accessed on April 29, 2010)

[542] See the federal programs page of the Database of State and Incentives for Renewables & Efficiency (DSIRE) or more information on the federal energy efficiency and distributed generation incentives and tax credits. Available at: http://www.dsireusa.org/incentives/index.cfm?state=us (accessed on April 29, 2010)

[543] Based on snapshot of SO2 and NOx market offer prices (cost to purchase allowances) as reported by Evolution Markets, Inc., on October 20, 2009. See: http://new.evomarkets.com/index.php (accessed on October 20, 2009)

[544] Based on average Regional Greenhouse Gas Initiative auction results for 2009 allowances. See: http://www.rggi.org/co2-auctions/results (accessed on January 26, 2010)

Avoided line losses and generation and distribution capacity	The addition of 1-MW of capacity in downtown Stamford may reduce the need for additional grid-side resources to serve those loads	Society	Difficult to quantify - CT has not estimated a specific figure for the value of such investments	N/A
Costs				
System installation cost	Cost of new equipment, materials and labor for the construction and installation	City of Stamford	Total one-time cost for equipment and installation. See breakdown of costs in Table A1	$3,612,000
Operating costs	Administration, operating and maintenance, and insurance costs	City of Stamford	Includes administration costs, CL&P standby service costs, and O&M for: engine and fuel cell; heat exchange equipment; chiller and thermal distribution; electrical equipment; and emissions controls. (per year)	$260,000
Interconnection Costs	Cost of interconnection applications, engineering analysis, and equipment	City of Stamford	One-time cost	$670,000
Increased natural gas purchases	Annual net increase in gas costs due to increased consumption from on-site generation (i.e., fuel switching from grid electricity to natural gas used to self-generate)	City of Stamford	44,000 MMBtu purchases (after) less 10,000 MMBtu purchases (before) = 34,000 MMBtu (difference) * $9.62/kcf[545]	$300,000
State Incentives	See above	Society	One-time lump sum payments	$1,050,000
Federal Incentives	See above	Society	See "Federal Incentives" above	$2,338,000

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[545] Delivered natural gas cost is an estimate based on published Yankee Gas tariff R-30 delivery and demand charges, historical (10-year) natural gas commodity prices at Citygate in Connecticut, as published by the Energy Information Administration and using Pareto's estimate of net gas usage at the Government Center once the project is commissioned. For EIA gas prices see "Series History" at: http://tonto.eia.doe.gov/dnav/ng/NG_PRI_SUM_DCU_SCT_M.htm (accessed on April 28, 2010)

A.6 WOKING TOWN CENTRE ENERGY STATION

Project Name: Woking Town Center Energy Station
Location: Woking Borough, Surrey, England
Owner/Developer: Thameswey Energy Limited
Ownership Model: Independent Provider
Status: Operating

Microgrid Typology

<table>
<tr><td>Project originator</td><td colspan="3">[✓ Private sector]</td><td colspan="2">Government</td></tr>
<tr><td rowspan="2">Microgrid system owner</td><td colspan="4">Single</td><td rowspan="2">Multiple</td></tr>
<tr><td colspan="2">[✓ ESCO]</td><td colspan="2">Property owner</td></tr>
<tr><td>Energy users</td><td colspan="2">Self</td><td colspan="2">Self + others</td><td>[✓ Others]</td></tr>
<tr><td>Cross public street?</td><td colspan="3">[✓ Yes]</td><td colspan="2">No</td></tr>
<tr><td>Form of energy distributed</td><td colspan="2">Power only</td><td colspan="2">[✓ Power + thermal]</td><td>Thermal only</td></tr>
<tr><td>Limits on microgrid size?</td><td>None</td><td colspan="2"># of customers</td><td colspan="2">[✓ Peak Load Served]</td></tr>
<tr><td>Interconnected at voltage?</td><td colspan="3">[✓ LV]</td><td colspan="2">HV</td></tr>
<tr><td>Operate independently of grid?</td><td colspan="3">[✓ Yes]</td><td colspan="2">No</td></tr>
<tr><td>Multiple resources</td><td colspan="3">[✓ Yes]</td><td colspan="2">No</td></tr>
<tr><td>Certified QF?</td><td colspan="3">Yes</td><td colspan="2">[✓ Not Applicable]</td></tr>
</table>

Microgrid Summary Statistics

- **Number of distinct customers:** 12
- **Types of end uses served**: Government offices, hotels, retail and other commercial buildings
- **Technologies employed:**
    - One Deutz 620 1.35-MWe gas fired reciprocating engine
    - One pre-existing 110-kW diesel engine (decommissioned in 2005)
    - Two 800-kWth absorption chillers
    - Two gas boilers (2 x 1.25-MWth capacity)
    - One 160 m^3 thermal storage (heat accumulating tank)
- **Peak electric capacity:** 1.35-MWe
- **Peak thermal demand:** 1.6-MWth
- **Peak electric demand:** 1.05-MWe
- **Peak cooling demand:** 1.2-MW
- **Annual electricity produced:** 7,031-MWh
- **Annual thermal output:** 6,152-MWh
- **Total fuel input:** 19,962-MWh
- **Electric efficiency:** 35.2%
- **Thermal efficiency:** 30.82%
- **Annual CO_2 reductions:** 2,200 short tons per year (54% relative to grid power and boilers)
- **Annual SO_2 reductions**: N/A
- **Annual NOx reductions**: N/A

Ownership Model Explanation

Woking's Town Center Energy Station (Energy Station or microgrid) is an example of an Independent Provider microgrid.[546] Electricity and thermal energy is produced and sold to different users in close proximity to each other. The owner of the system, Thamesway Energy Limited (TEL), is an unregulated public/private energy services company (ESCO) primarily engaged in merchant energy services and sales. The Borough of Woking is a co-owner of the company and several of its governmental buildings receive service from the Energy Station. Through the use of the UK's "private wires" rule, customers are physically linked together by non-utility owned distribution facilities, which cross public streets.[547] The Town Centre Energy Station also exports surplus power onto the utility distribution system, for which it receives credits that apply to other government facilities, making this microgrid a hybrid physical/virtual system. Woking and a Danish energy services company, International A/S[548] created TEL to build, finance and operate projects that benefit Woking's citizens.[549]

Background/Project Objectives

The Borough of Woking is a bedroom community of 100,000 people located southwest of London. Woking Borough Council (WBC) was one of the first municipalities in the United Kingdom (UK) to comprehensively examine measures for reducing climate change-related emissions, when it issued a plan in 1990 to reduce CO_2 by 20% in five years. WBC began examining options to produce its own energy in the mid-to-late 1990s because local leaders wanted to have more autonomy over the Borough's energy purchasing decisions and to provide low-cost and clean alternatives to residents and local businesses. Further motivation to identify low-cost solutions was provided in 2000, when the UK established a Climate Change Levy on all non-residential energy users.[550] The Levy applies to sales of energy for light, heat and power to commercial, industrial and governmental customers, but "good quality"[551] combined heat and power (CHP) projects are exempt.[552] While WBC was interested in pursuing CHP and other clean energy projects, national privatization laws designed to limit publicly-owned enterprises constrained WBC's ability to raise capital for local energy projects. As a result, Borough leaders investigated innovative ways to reduce local energy costs with an eye toward self-sufficiency and environmental sustainability.

To overcome its capital constraints and advance its local energy and environmental goals, WBC established Thameswey Limited (Thameswey), an energy and environmental services company (EESCO), in 1999.[553] Thameswey's stated objectives include: 1) promoting energy efficiency, energy conservation and environmental objectives by providing energy and/or environmental services; 2) developing and implementing technologies for the

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[546] We have defined the Independent Provider model as a microgrid that is owned and operated by an independent, non-utility firm, which sells electricity and/or thermal energy to multiple, unaffiliated customers. This business model is strictly commercial, that is, the independent owner/operator does not produce primarily for its own consumption.

[547] As of 2007, approximately five percent of Woking received electricity and thermal energy services by private wires and pipes.

[548] ESCO A/S International owned by Miljo-Sam Holding APS. Miljo-Sam Holding APS is owned by Pen-Sam (a Danish pension fund) and Hedeselskab who also own Hedeselskabet Miljo og Energi A/S. See: http://www.fuelcellmarkets.com/3,1,847,1,980.html (accessed march 19, 2010)

[549] The Town and Country Planning Association, "sustainable energy by design: a guide for sustainable communities," Available at: http://www.bwea.com/pdf/tcpa-sust-energy.pdf (accessed on March 19, 2010)

[550] HM Revenue and Customers, "Climate Change Levy – in depth," Available at: http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageExcise_InfoGuides&propertyType=document&id=HMCE_PROD_009791#P50_4524 (accessed on March 19, 2010)

[551] Good Quality CHP refers to generation that achieves high levels of efficiency as defined by UK authorities. For discussion regarding the granting of an exemption to the Climate Change Levy for such systems see: European Commission, "State Aid N 539/2002 – United Kingdom Climate Change Levy Exemption for Electricity Exports of Good Quality CHP," May 3, 2003

[552] Currently the Climate Change Levy is £0.00441 per kilowatt-hour sold and is adjusted annually for inflation. See: http://www.hmrc.gov.uk/budget2006/bn51.htm (accessed on April 10, 2010)

[553] Thameswey Energy Ltd., is a public/private joint venture Energy Services Company or ESCO between Thameswey Ltd., and ESCO International A/S owned by Miljo-Sam Holding APS. Miljo-Sam Holding APS is owned by Pen-Sam (a Danish pension fund) and Hedeselskab who also own Hedeselskabet Miljo og Energi A/S, a Danish green energy company. Projects are financed with shareholding capital and private finance with project development carried out jointly between the Council and Hedeselskabet Miljo og Energi A/S who also own DDH Contractors UK Ltd., who act as the turnkey contractor on large scale district energy schemes. Hedeselskab is a foundation committed to environmental projects whose patron is Her Majesty Queen Margarethe II of Denmark. For more information see: http://www.thameswaygroup.co.uk/ (accessed January 17, 2010)

production and supply of energy; 3) producing and supplying energy in all its forms; 4) acquiring and holding capital interests in companies engaged in the energy and/or environmental services business; 5) providing financial, managerial and administrative advice, services and assistance; and 6) providing facilities and services for its customers and the customers of companies to which it holds interest.

Wholly owned by the Borough of Woking, Thameswey is the parent company of a number of subsidiaries including Thamesway Energy Limited (TEL), a joint venture public/private energy services company (ESCO). Formed in May of 2000, TEL develops low carbon energy projects, which allow it to sell electricity and thermal energy within Woking and in other locations in Britain. By establishing TEL, Woking is now able to use both public and private funding for its projects. In fact, the primary purpose of forming TEL was to attract investment from external, private sources and be free to spend those funds with more flexibility than could Thameswey. TEL's objectives mirror Thameswey's with the exception that its primary function is to "own and operate plants for the production and supply of electricity, heat and chilled water to customers and activities ancillary thereto"[554] (see Figure A4 in Appendix for a diagram of TEL's ownership structure).

It was through TEL, that Woking developed the UK's first combined cooling, heat and power microgrid – the Woking Energy Station – that has served both public and private institutions located in the Town Centre since 2001. In addition to reducing energy costs and providing environmental benefits to the community, microgrid participants were attracted to the project for its potential to improve electric reliability. This interest stemmed in part from several prolonged power outages that remained engrained in the public consciousness – namely those that occurred as a result of two major storms that occurred in 1987 and the winter of 2000/2001.[555]

Detailed Microgrid Description

The Woking Energy Station uses a 1.35 MWe gas fired reciprocating engine in a tri-generation configuration (electricity, heating and cooling), to supply electric and thermal energy to a cluster of both government and privately owned buildings in downtown Woking. These buildings include the Woking Borough Council's Civic Offices, Big Apple leisure complex, Metro Hotel, HG Wells Conference and Events Center, Woking YMCA, Lightbox Museum, Quake Nightclub, a 161-room Holiday Inn Hotel (built without a boiler or chiller plant on site) and the Victoria Way Car Park, where the Energy Station plant itself is located (see Figure A1 in the Appendix for a map of the project area). In order to make use of the waste heat from the engine across seasons and at different times of the day and improve the system's load factor and economics, the Energy Station features 163,000 liters of thermal storage and hot water absorption chillers (1.6 MWth total capacity) for air conditioning. This system allows the nightclub to be cooled in the evening from chilled water produced by the absorption chillers fed with thermal energy produced by the plant during the day and stored in the heat tanks.[556] The Energy Station also features two 1.25 MWth boilers, which provide standby and peaking thermal energy supply.

The Woking Town Centre microgrid has the ability to supply 100% of the interconnected electric loads. A 35% reserve margin also allows it to export excess electricity over public wires to other Woking government buildings and some residential customers that are not part of the "private wires" system. This is accomplished under an enabling agreement pursuant to the rules governing licensing exemptions for electricity suppliers in the British power market. TEL compensates Electricite de France(EDF) for "wheeling" the power on its lines by paying distribution use of system or "DUoS" charges. To be competitive with grid prices, TEL charges private customers designated to receive service from the Energy Station over the public wire system retail commercial rates; for WBC facilities, it sells power at cost (see "Permissions & Regulatory Matters" for more discussion regarding the licensing exemption regime).[557]

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[554] Allan Jones (2004), "Woking: Local Sustainable Energy," Available at: www.bcse.org.uk/docs/events2004/Woking%20local%20energy.doc (accessed on March 1, 2010)

[555] "The Woking Story" (2005), Available at: www.ideascentre.co.uk/download/file?ref=68&download=true (accessed December 10, 2009)

[556] London Climate Change Agency (2007), "DTI/OFGEM REVIEW," Available at: http://www.hm-treasury.gov.uk/d/London_Climate_Change_Agency_Call_for_Evidence_DTI_OFGEM_REVIEW.pdf (accessed Nov. 15, 2009

[557] Allan Jones (2004)

The Town Centre microgrid's internal loads are connected via an 11kV/400v "private wires" electric network and hot and chilled water distribution systems.[558] All the buildings are electrically interconnected at both at medium and low voltage throughout the microgrid with a single point of common coupling to EDF's local grid at the Energy Station plant.[559] A permanent connection to the external distribution grid is maintained in order to synchronize the Energy Station's engines, which is required for export of power. In the event of an outage, the Woking Energy Station can operate in island mode. When the grid supply fails, the G59[560] circuit breaker disconnects the system within 0.5 milliseconds from the grid and shuts the engines off to prevent reverse power flows. At the same time, the reciprocating engine is capable of black start operation and will energize the private wires circuits within approximately 10 seconds – bringing load on in a stepped sequence to avoid 'stalling' the engines – allowing islanded operation. Once the outage has ended, the system re-synchronizes with the grid in about four seconds without dropping load or voltage.[561]

TEL's business model is to analyze each potential customer's energy consumption and develop a long-term agreement that provides cost savings as compared to the status quo. The contract's price is tied to gas markets and can be adjusted up or down in response to spot prices. Prices are less than what they would pay the local utility. From the perspective of the Borough, the initial capital structure adopted for TEL limited WBC's contributions to the Energy Station to 3.8% of the company's equity stake in the investment, the rest being funded by a combination of private equity and debt. This structure has changed since WBC became the majority shareholder of TEL after the Local Government Act of 2003 was adopted (see "Permissions and Regulatory Matters" below). Consistent with a practice it established in the early 1990s to fund municipal energy efficiency projects, WBC requires that its share of revenues earned or savings achieved from TEL projects be recycled back into the company's capital base to support future projects.[562]

Project Development Process & Important Milestones

TEL was responsible for all stages of development for the Energy Station, from the design and financing stages through to construction and commissioning.[563] In planning the microgrid, TEL and WBC adopted a collaborative and cooperative approach with local agencies and residents. WBC worked to gain the support of the local planning board and special effort was given to assuage residents' concerns regarding the project effects on health, safety, noise and emission issues. To gain the community's acceptance for the project, Thameswey and local leaders carefully chose the system design and technology used and held numerous meetings to discuss impacts. The loudest concerns from community members had little to do with the environmental impact of the project and instead revolved around financial issues and why the Borough was taking on the carbon challenge.[564]

TEL began work on the Energy Station in June 2000, shortly after being incorporated, and the system was commissioned on March 21, 2001. TEL continues to manage the operation and maintenance of the microgrid through its partner, Xergi Services Ltd.

Important milestones in the development of the Woking Energy Station include:

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[558] Thameswey Energy Ltd., "Woking Town Centre CHP- Phase 1," Available at: http://www.fuelcellmarkets.com/thameswey_energy/news_and_information/3,1,847,1,979.html (accessed on March 18, 2010)

[559] ICLEI (2005), "Woking a model for energy decentralization," Available at: http://www.iclei.org/index.php?id=1505&no_cache=1&tx_ttnews[tt_news]=1001&tx_ttnews[backPid]=6836&cHash=f6b2d73ef6 (accessed on Dec. 10, 2009)

[560] In the UK, loss of grid protection is loosely referred to as 'G59' protection after the Electricity Association document G59/1 which details the requirements.

[561] The Woking Story (2005), Available at: www.ideascentre.co.uk/download/file?ref=68&download=true (accessed Dec. 10, 2009)

[562] This model is based on the energy efficiency "recycling fund" Woking established in the early 1990s with much success. Under the program, money earmarked for energy projects would be put in a separate account and any money saved from projects completed would be recycled for use in subsequent investments. Between 1990 and 2000, the recycling scheme allowed the Borough to invest £2.5 million in efficiency projects resulting in annual savings of over 725,000 pounds per year.

[563] Thameswey LTD, "Submission in response to Ofgem's Call for Evidence Regarding Heat Distribution," March 2008

[564] Thomas Kelly, personal communication with John Thorpe, March 2010

- WBC issues report examining local climate change mitigation strategies………1990
- WBC receives legal research grant from Energy Savings Trust………………...1998
- WBC began seeking partners to explore the formation of an ESCO…………..1998
- Thameswey Ltd and TEL are incorporated……………………………….Fall 1999
- TEL negotiates energy service agreements with customers………………..Fall 1999
- TEL is capitalized…………………………………………………………...2000
- DDH Contractors UK begins construction……………………………Spring 2000
- Energy Station is operational………………………………………....Spring 2001
- Energy Station service extended to new Lightbox Museum and YMCA……….2006

Permissions & Regulatory Matters

Woking's Energy Station set a number of firsts in the UK for small-scale urban microgrid deployment. Prior to the development of the Energy Station, the ability of municipal authorities to become involved in providing energy services was shrouded in uncertainty; now, partly as a result of WBC's leadership, municipal authorities can involve themselves in the capital-intensive sector as long as they demonstrate their finances are in order (see below). The Energy Station was also the first "private wires" microgrid to be deployed in the UK. The project greatly benefited from the development of a clear regulatory pathway – the electricity supplier licensing exemption – that authorizes ESCOs to provide direct power services to customers without being subject to onerous government licensing requirements. Still, statutory limits to the amount of load that can be served using private wires (see below) acts as a policy hedge against the potential erosion of the customer base of existing distribution network operators as well as the creation of new vertically integrated monopolies. No such policy or regulation exists in the UK for the distribution of thermal energy, so TEL was able to lay down pipes to distribute hot and chilled water to the Energy Station's customers without limitation.

Public-Private Partnership in the UK Energy Services Sector

Local government finance in the UK is tightly controlled by the central government. Local councils do not have much flexibility in determining their capital and revenue budgets.[565] As they considered options for developing an ESCO, Woking officials were concerned that existing laws and regulations governing how public money is invested would severely limit their range of options for structuring and financing energy projects.

In 1998, WBC received a grant from the Energy Savings Trust to examine the legal issues surrounding the formation of public/private partnerships in energy services. The purpose of the research was to determine whether it was legally feasible for Woking authorities to form a company to deliver energy to local residents and businesses. The research found that under existing law,[566] local authority ownership of any energy venture must be less than 20%, or central government capital controls would apply. Based on advice from this work, WBC established Thameswey, through which the Council would form other public/private joint ventures to support its energy and environmental objectives. TEL was formed in partnership with the Danish ESCO International A/S, to be Thameswey's unregulated arm for undertaking community energy projects like the Woking Energy Station.[567] Initially, TEL financed its projects with shareholder equity and private funds, a structure that allowed Thamesway Ltd. to escape the capital controls that would otherwise be imposed on a purely local government venture.[568]

The ownership constraint on local authorities was lifted in 2003 with the adoption of the Local Government Act, which allowed the Secretary of State to authorize local governments to "trade" in relation to any of its normal business functions.[569] Authorization depends on whether the local government has a good credit rating or

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[565] The Woking Story (2005)

[566] The Authorities Goods and Service Act of 1970. See: The Woking Story (2005)

[567] Through Thameswey Ltd., the WBC owns 19% of TEL's equity capital (approximately 3.8% of total equity) and International A/S, owns 81%.

[568] EST Energy Services Programme, "Woking Borough Council's Thameswey Joint Venture Project," Available at: http://www.projects.bre.co.uk/CHP/ES%20Case%20Study%2006.Woking.pdf (accessed on February 10, 2010)

[569] The Energy Savings Trust, "The Well-Being Power: Using the Power to Deliver Sustainable Energy Objectives," Briefing Note: August 2006, Available at:

Comprehensive Performance Assessment of fair, good or excellent. As a result, WBC has increased its equity stake in TEL and is now majority owner of the company with 90% of the company's shares.

"Private Wire's" and the Electricity Order 2001

In 1990, Britain became one of the first countries to "privatize" or restructure its electricity industry; its approach became a model for many subsequent restructuring efforts that took place including many of those in the United States. Britain unbundled the vertically-integrated national electric utility facilitating, over the next decade or so, the development of a number of new players including generators, suppliers, network companies, and a system operator, all overseen by a regulator under the Secretary of State, the Office of Gas and Electricity Markets' (Ofgem) (see Table A1 in the Appendix for a description of the different players in the British market).

Among other significant sector reforms, the Utilities Act of 2000 established a licensing structure administered by Ofgem, which permits entities to provide generation, transmission, distribution or supply services in the power market. The law explicitly forbids the same entity from holding both a distribution and a supply license. Nevertheless, the law also provides exemptions from the licensing requirements. Expounded in Electricity Order 2001 (Class Exemptions from the Requirement for a License), these exemptions allow suppliers to produce and distribute electricity directly to end use customers using both the public wire system (existing utility network) or through the limited development and use of "private wires."[570]

Private wires systems link small scale or distributed generators with end use customers, alongside or within the existing distribution system. In addition to avoiding the administrative burden of obtaining a supplier or generator's license, exempt energy providers operating on private wires networks avoid other charges including fees associated with the use of transmission and distribution systems, and several additional costs including the Climate Change Levy and compliance with the Renewables Obligation and Energy Efficiency Commitment (see Figure 1 below).[571, 572, 573] The exemptions from these "public purpose" taxes is partly conditioned on the basis that the supplier uses eligible renewable or "clean CHP" technologies. Developers must adhere to a number of other conditions that limit the size and scope of service of private wires service. These include:

- An exempt generator can produce up to 50-MW of electricity per site, without obtaining approval from the Secretary of State, and up to 100-MW of electricity per site with approval.
- An exempt generator can also distribute power from each generating site directly to customers over "private wires" up to the above-specified thresholds (50-MW without approval and 100-MW with approval).
- Exempt suppliers may only serve up to 1-MW of load that is classified as "domestic," or residential, using private wire configurations. This means that an exempt supplier with a maximum load of 50 MW can distribute power over private wires to 49-MW of non-residential load and 1-MW of residential load.

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http://www.energysavingtrust.org.uk/content/download/179209/422541/version/4/file/wellbeing_england_wales_bn.pdf/perma/1 (accessed on April 10, 2010)

[570] Electricity Order 2001, Available at: http://www.statutelaw.gov.uk/SearchResults.aspx?TYPE=QS&Title=The+Electricity+(Class+Exemptions+from+the+Requirement+for+a+Licence)+Order+2001&Year=&Number=&LegType=All+Legislation (accessed on March 19, 2010)

[571] The Renewables Obligation (RO) is the main support scheme for renewable electricity projects in the UK. It places an obligation on licensed suppliers of electricity to source an increasing percentage of their electricity from renewable sources. The RO Order came into effect in April 2002 and for the 2009-2010 period, suppliers must source 9.7 percent of their sales with qualifying renewable resources. For a general description see: OFGEM, "Renewables Obligation," http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx (accessed November 28, 2009) and Ofgem, "Renewables Obligation: Guidance for licensed electricity suppliers," March 27, 2009

[572] London Climate Change Agency, "Electricity Exempt Licensing Regime," Available at: http://www.lcca.co.uk/upload/pdf/EXISTING_EXEMPT_LICENCING_REGIME_3.pdf (accessed on November 28, 2009)

[573] The Energy Efficiency Commitment (EEC), which was instituted over the 2002-2008 period required licensed suppliers serving at least 50,000 domestic customers either individually or as part of a group of companies (i.e. including the number of customers supplied by the licensee's holding company and any wholly-owned subsidiaries of that holding company) to meet an energy efficiency target established by Ofgem. The EEC was recently abandoned in favor of a Carbon Emissions Reduction Target program. Mirroring the EEC, the CERT requires licensed gas and electricity suppliers to meet a carbon reduction obligation. Since private wires schemes are capped at 1-MW of residential service, they were excluded from the EEC and will continue to be excluded from the CERT. For information on the EEC and CERT see: Ofgem, "Energy Efficiency," Available at: http://www.ofgem.gov.uk/Sustainability/Environment/EnergyEff/Pages/EnergyEff.aspx (accessed on April 14, 2010)

- Projects can also distribute power over “public wires,” or the incumbent utility’s distribution system. These projects must pay DUoS fees, but are allowed to bypass transmission rates and other public purpose charges if they use clean technologies. Still, for public wires distribution, there is an aggregate per company cap of 5 MW, of which only 2.5 MW can be residential.[574]

A summary of the conditions exempting electric generators and suppliers from the licensing requirements is provided in Figure A3 in the Appendix.

As a small generator/supplier, TEL is exempt from the supplier licensing requirement. This allows TEL to sell the electricity and thermal output from the Energy Station directly to customers on its network as opposed to through a licensed supplier, acting as a broker, at much lower wholesale prices. The exemption for small-scale producers and suppliers allows TEL to receive retail prices for energy, while simultaneously providing competitive prices to end use customers that are not required to pay transmission or distribution charges and avoid the cost of building heating (i.e., boilers and fuel).[575, 576]

Private Wires, Competitive Markets and Consumer Protection

Expanding the exemption limits on private wires to help support more investment in clean distributed generation has been an ongoing policy debate among lawmakers and regulators in the UK. A major concern among regulators is the conflict between encouraging open and competitive energy markets and adopting policies like “private wires” that effectively replicate natural monopolies. In May 2008, the European Court of Justice addressed this issue in a ruling on the Citiworks versus Leipzig Airport anti-trust case. The source of the case was an exemption under German law allowing the electricity infrastructure at Leipzig Airport to be operated as a monopoly with no third party access to the local distribution network. The European Court of Justice found that the exemption, which is geographically determined, prevents connected customers from changing their supplier, which runs counter to the European Union Directive on competitive electricity markets.

The implications of the Citiworks ruling is that distribution network operators, including those that are currently exempt from having a license, will generally have to allow third party access to customers within their system. The Department for Energy and Climate Change (DECC), which is responsible for administering the license exemption regime in the UK, intends to consult on what that means in practice and on the potential amendments to the Class Exemption regime that may be necessary to take account of the EU Court’s judgment. Analysts believe that the DECC will likely change the exemption rules only to state that unlicensed parties must offer third party access without being proscriptive on how this could be implemented.[577]

The DECC has directed operators of private electricity networks to comply, in the same way as licensed operators, with the Electricity Safety, Quality and Continuity Regulations 2002. These regulations set out specific requirements relating to the safety of the public and general requirements relating to quality and continuity of electricity supply. One provision of note under these rules is that, in contrast to New York’s Home Energy Fair Practices Act (HEPFA), ESCOs providing generation services to end use customers are allowed to shut off service to residential customers for failure to pay their service bills. Nevertheless, customers have the right to appeal to Ofgem and are allowed to purchase their energy supply from the local utility or other ESCOs.[578] As far as we know, this has yet to occur on any of TEL’s or any other private wire system and procedures for determining how it would be implemented on such systems are not yet developed. While third party access to private wires systems would make them less secure and more difficult to finance, these systems would still avoid compliance costs associated with the Renewables Obligation and Climate Change Levy and, presumably would be allowed to charge their own DUoS fees.[579] That said, the issue of whether and how participating customers can choose a supplier other than the primary private wires supplier has raised questions regarding the compatibility of private wires type systems with principles of electric competition.

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[574] The 5-MW limit was imposed in order to cap the data exchange and transaction costs for distribution network operators.

[575] Thameswey Energy Ltd, “Future Energy Strategy for the UK,” Available at: http://www.fuelcellmarkets.com/news_and_information/3,1,847,1,964.html (accessed on: November 28, 2009)

[576] National Grid, “GB Seven Year Statement 2008,” Available at: http://www.nationalgrid.com/uk/sys_08/print.asp?chap=4 (accessed on November 28, 2009)

[577] Isabelle McKenzie, “How to Allow Third Party Access for Private Wires,” Fontenergy, August 10, 2009

[578] Thomas Kelly, personal communication with John Thorpe, Thameswey Ltd., 2009.

[579] Casey Cole, “Zero Carbon Must Not Depend on Private Wires,” *Carbon Limited*, January 19, 2009

Distributing Heat
Much like the US, the market for direct heat services via district energy, CHP or other methods is an underdeveloped market. Rather than buying heat from a supplier, heat is generally produced on-site by homes and businesses from fossil fuel, mainly gas, or electricity, which have mature and competitive markets. Gas and electricity markets in the UK operate under a sophisticated economic and operational regulatory framework to ensure that charges imposed by network monopoly providers are fairly priced and that appropriate technical standards are established to enable multiple parties to buy and sell competitively in the market. In contrast to the Electricity Order 2001, which identifies a clear pathway for laying down private wires, there is no clear policy or regulatory framework in the UK that instructs developers on thermal distribution.

As the UK's Department of Business Enterprise and Regulatory Reform (BERR) recently observed, heat markets suffer as a result of this lack of a regulatory framework, increasing the transaction cost of reaching commercial terms and negotiating contracts between suppliers and customers. While processes and requirements for anyone wishing to install gas or electric distribution facilities are laid out in legal and regulatory frameworks (UK's Electricity and Gas Acts), a company wishing to distribute thermal energy does not have a pre-existing supply network nor clear regulatory guidance for obtaining right-of-ways or permits.[580]

The absence of well-developed thermal networks and regulatory vacuum for heat distribution is in many ways an opportunity for ESCOs like TEL. Currently, TEL is free to negotiate terms with customers for thermal distribution and supply with few limitations. As demonstrated by the Woking Energy Station and the other CHP-based private wires arrangements deployed by TEL, it has successfully negotiated service agreements with its end use customers and is allowed, without restriction, to distribute thermal energy on a "private pipes system" to those customers. Nevertheless, not all ESCOs are successful in finding and capitalizing on opportunities to provide heat services to end use customers. As a result, BERR is currently in the process of investigating how to promote energy efficient delivery of thermal energy use in the UK and is closely examining options for developing clear policies and frameworks to provide certainty to what it views as an emerging market.[581]

Benefit/Cost Discussion

The Woking Energy Station project cost approximately £2.5 million installed ($4.0 million, constant 2000 $). Of this amount, the capital share invested by the WBC through Thameswey was approximately £100,000 ($160,000). The rest of the project capital consisted of a combination of private equity and debt. For all of its energy projects, TEL has established a minimum 8% return on investment.

Unfortunately, TEL could not share detailed cost data or proprietary tariff and transaction information for participating customers with the project team. While Woking and Thameswey have accounted for and published the energy and environmental benefits of their various efficiency and supply projects in aggregate, the numbers for specific projects have not been made public (that is, beyond what is documented here). Still, based on other accounts of private wires systems, we have a general understanding of the cost components of private wires electric service and how that might compare to standard grid service.

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[580] United Kingdom Department of Business, Enterprise and Regulatory Reform, "Heat Call for Evidence," January 2008
[581] Ibid.

Figure 1: The average price to beat for one kilowatt-hour of electricity (in US cents/kWh)

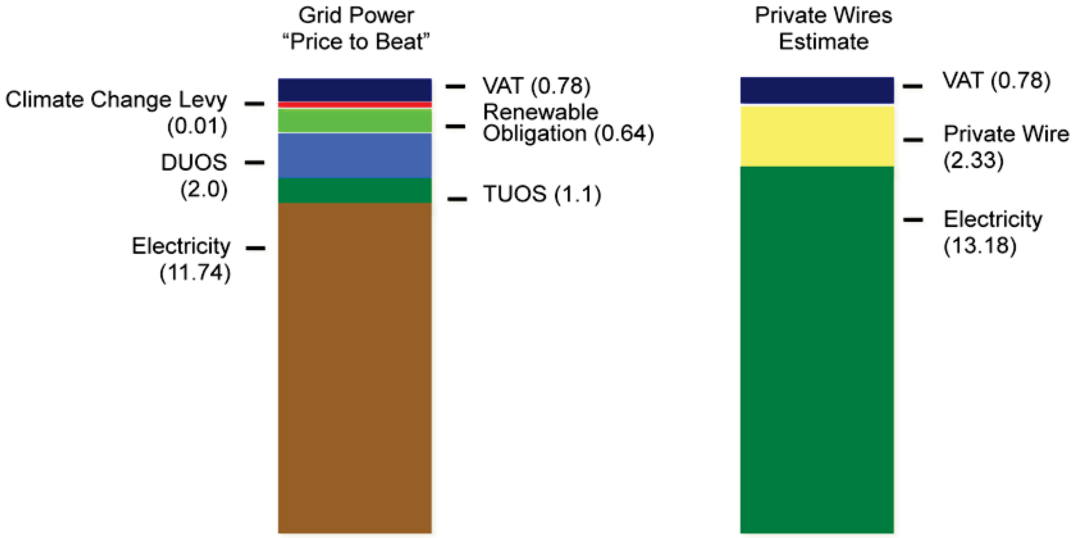

Figure 1, which is a variation on a chart the London Climate Agency uses to explain the economic benefits of private wires, indicates that there may be advantages to employing private wires schemes for participants. Customers that receive service from such arrangements are only responsible for paying the cost of the electricity, private wire distribution infrastructure and the value added tax. In Figure 1 we estimate the average retail cost of electricity for a typical small commercial customer in 2009 – the private wires "price to beat" – to be US 16.2 cents/kWh (10.5 pence/kWh).[582] As seen in the figure, grid customers have a number of additional surcharges and must pay both the TUoS and DUoS; the approximate contribution of these components to the average retail price is estimated in Figure 1.[583] Additionally, due to the proximity of supply and demand, private wire arrangements benefit significantly from more efficient distribution and use of energy; systems like the Woking Energy Station have far fewer losses in transmitting power from generation to loads than the macrogrid does (approx. 5-6%); on average, transmission and distribution losses in the UK macrogrid account for approximately 9% of electricity produced while private wires systems, which transmit power much shorter distances and do not require as much transformation, may lose 3-4%.[584] TEL also takes advantage of waste heat produced during combustion in its reciprocating engine to provide various thermal energy services like space conditioning, further reducing the final cost of energy to participating end users. In the centralized electricity grid this energy is lost as waste heat, which accounted for 62% of the primary energy inputs for the electricity sector in 2007.[585]

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[582] Department of Energy and Climate Change, "Industrial electricity prices in the EU for small, medium, large and extra large consumers," Energy Statistics: Prices: International Comparisons, Available at: http://www.decc.gov.uk/en/content/cms/statistics/source/prices/prices.aspx (accessed on April 15, 2010)

[583] HM Revenue and Customers, "Rates of VAT on different goods and services," Available at: http://www.hmrc.gov.uk/vat/forms-rates/rates/goods-services.htm#4 and Claverton Energy Research Group, "Typical Power Distribution and Transmission Costs," October 2009, Available at: http://www.claverton-energy.com/energy-experts-library/downloads/gridoperations (accessed on April 14, 2010)

[584] Transmission typically accounts for about 2% of losses while distribution accounts for 7%. See: National Grid, "Investigation into Transmission Losses on UK Electricity Transmission System," June 2008, Available at: http://www.nationalgrid.com/NR/rdonlyres/4D65944B-DE42-4FF4-88DF-BC6A81EFA09B/26920/ElectricityTransmissionLossesReport1.pdf and Ofgem, "Electricity distribution losses: a consultation report," February 2003, Available at: http://www.ofgem.gov.uk/NETWORKS/ELECDIST/POLICY/DISTCHRGS/Documents1/1362-03distlosses.pdf (accessed April 17, 2010)

[585] In 2007 the electricity system in the UK consumed 86.1 million tonnes of oil equivalent (mtoe) in the course of producing electricity; of these inputs, conversion losses totaled 53.2 mtoe, or 61.7 %. See: Department of Business, Enterprise and Regulatory Reform, "UK Energy Flow Chart 2007," Available at: http://www.decc.gov.uk/en/content/cms/statistics/publications/flow/flow.aspx (accessed April 17, 2010)

The improved efficiency of systems like the Woking Energy Station generates societal benefits in the form of reduced emissions of greenhouse gases. According to the Department for Environment, Food and Rural Affairs (Defra), the 10-year (2000-2010) average emissions factor for the UK's electricity sector is approximately 0.535 kg CO2/kWh (1.177 pounds CO2/kWh). TEL calculates its CO_2 savings by looking at the units of productive energy produced by its systems, namely kWh of electricity and heat combined. For gas-fired systems like the Energy Station, TEL has calculated savings of approximately 0.286 kg of CO_2 per kWh (0.63 lbs CO_2 per kWh or 630 lbs per MWh) compared to using average grid power and heat from standard building gas boilers. This means that on average, the Energy Station emits approximately 1,900 short tons of CO2/year, representing a savings of approximately 2,200 tons compared to using grid electricity and natural gas-fired building boilers.[586]

The Woking Energy Station microgrid and similar projects undertaken by Thameswey are also helping WBC meet its policy objective of supplying the Borough's electricity and thermal energy needs with local renewable and clean sources. In 2000, WEB set an ambitious near-term goal of supplying 20% with renewable or clean sources by 2010. Since then, through the work of TEL, the town has now built up a network of over 60 local generators, including cogeneration and trigeneration units, photovoltaic arrays and Britain's first hydrogen fuel cell station. In so doing, the Council has reduced its own carbon dioxide emissions by around 80% since 1990 and those of the borough as a whole by approximately 20%. Over the same period, it has also reduced local authority energy usage by over 50%.[587]

While WBC has not quite met its target of 20% renewable or clean supplies by 2010, its accomplishments put it in a field of its own and continue to exceed the national targets communicated in Planning Policy Statement 22. While all of the measures Woking has taken to date have been voluntary, it is anticipated that under a new national Carbon Reduction Commitment penalties may be assessed if communities do not meet the established emissions targets.[588] With its already very strong start, it is likely that Woking will be in a good position to continue to lead British municipalities in these efforts.[589]

Although the Woking Energy Station microgrid has produced benefits for its participants and WBC, there is concern regarding the debt burden the Borough is shouldering as a result of its various enterprises, including local real estate ventures. Just over the past five years, WBC has borrowed $145 million for energy and non-energy related capital projects. WBC is responsible for repaying this debt beginning in 2015 through an anticipated end date in 2077.[590] The size of its debt burden may deter future spending on projects.

As mentioned above, there are disadvantages to the use of private wire networks. Customers are not protected in the same way as those supplied by licensed energy companies, and cannot easily switch energy suppliers. These networks are also still dependent on the external public networks for backup power, when necessary. Nevertheless, there is increasing support for the use of private wire networks and until the terms of use for distributed generation on the public wires improves, private wires will continue to be an important means of facilitating investment in renewable and high efficiency energy production.

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[586] Thomas Kelly, personal communication with John Thorpe, 2010

[587] Parliament, Available at: http://www.parliament.the-stationery-office.com/pa/cm200607/cmselect/cmtrdind/257/25707.htm (accessed on March 19, 2010)

[588] Carbon Trust. "Carbon Reduction Commitment". http://www.carbontrust.co.uk/climatechange/policy/CRC.htm Accessed Nov. 28, 2009

[589] Thameswey Energy Ltd. "A Case Study From Woking, December 5, 2008" http://www.inspire-east.org.uk/FileAccess.aspx?id=1800

[590] Get Surrey. "Woking Borough Council debt highest in the county" http://www.getsurrey.co.uk/news/s/2053718_woking_borough_council_debts_highest_in_the_county

Figures and Tables

Figure A1 – Map of Woking Town Center Energy Station Area

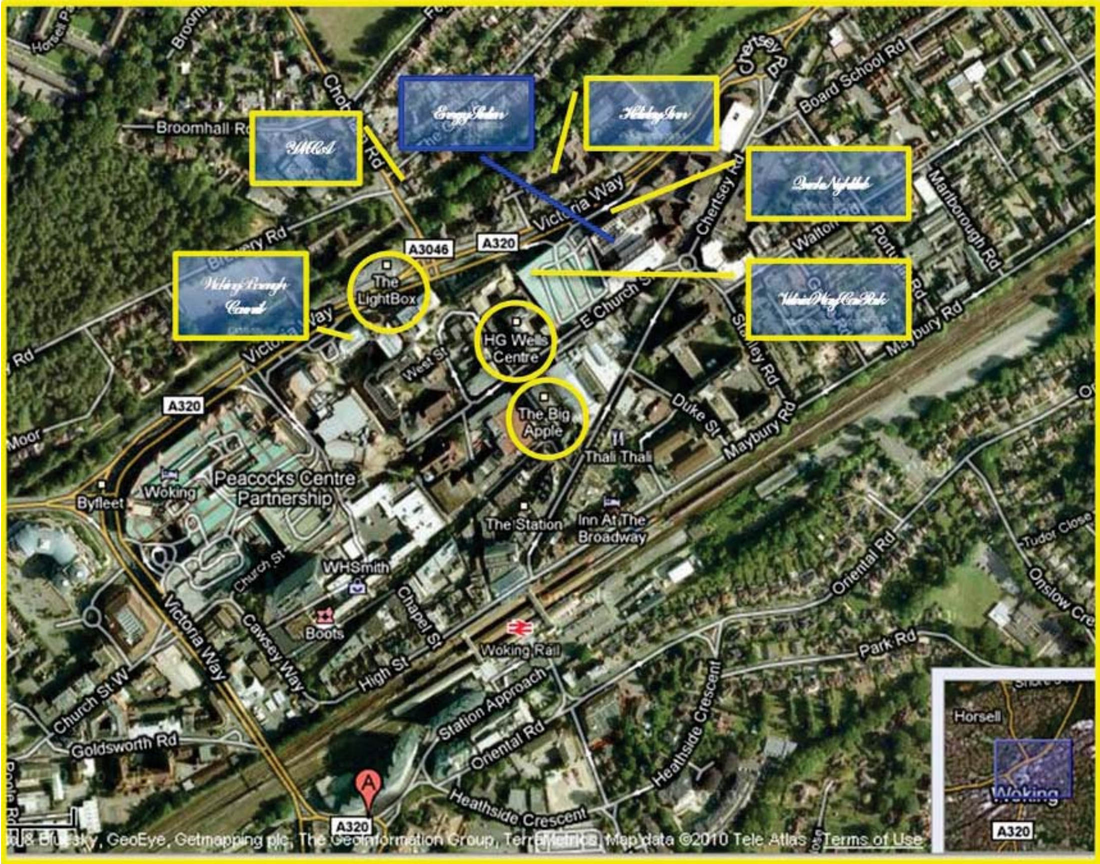
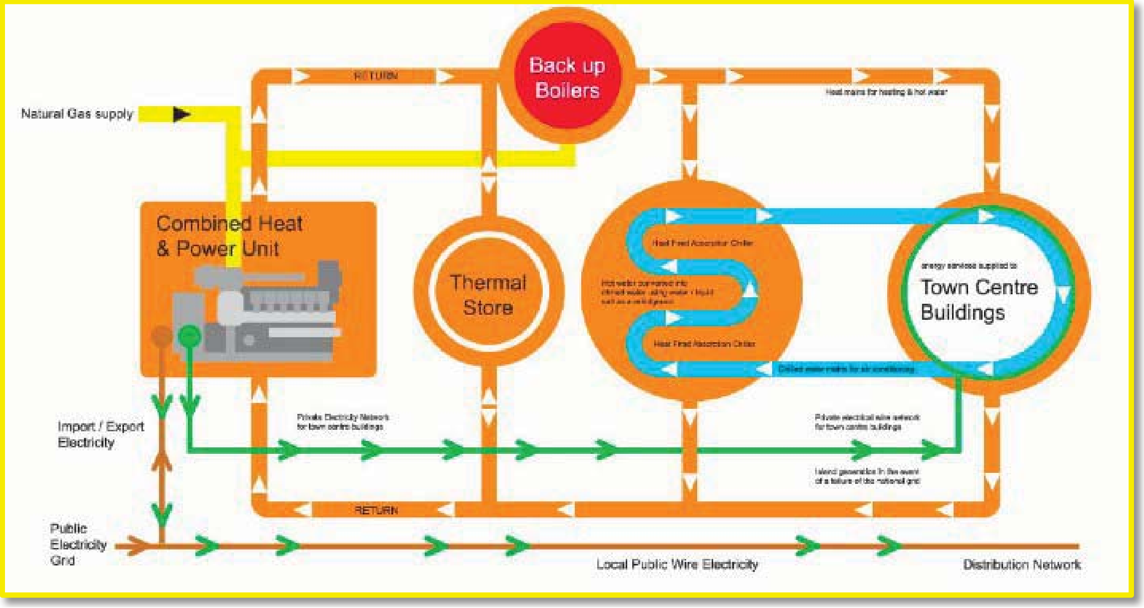


Figure A2 – Schematic of Woking Town Center Energy Station Trigeneration Microgrid



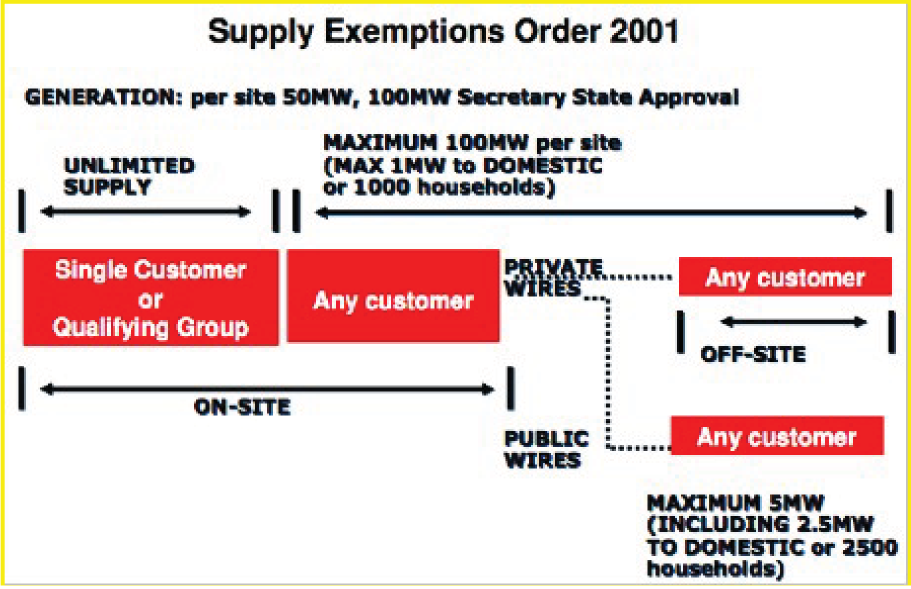
Source: London Climate Agency (2007)

Table A1 – Description of Main Stakeholders in the British Electricity Industry

Stakeholder	Description
Ofgem	Under the Secretary of State, regulates both gas and electricity markets
Generators	Own and operate large power stations that feed into bulk electricity market
Suppliers	Purchase electricity from generators in wholesale markets or through bilateral transactions and sell retail to business or domestic customers; suppliers may purchase from anywhere in Britain
Network Companies	Maintain, operate and reinforce the electricity networks at the bulk (transmission) or local (distribution) levels
Transmission Network Owners (TNOs)	National Grid is the TNO in England and Whales; Scottish Power (SP) and Scottish and Southern (SS) or the TNOs in Scotland.
Distribution Network Owners (DNOs)	Seven companies operate the fourteen distribution network regions in Britain (EDF Energy; Central Networks; CE Electric; Western Power Distribution; SP; and SS).
System Operator	National Grid, which is responsible for balancing electricity and supply with demand

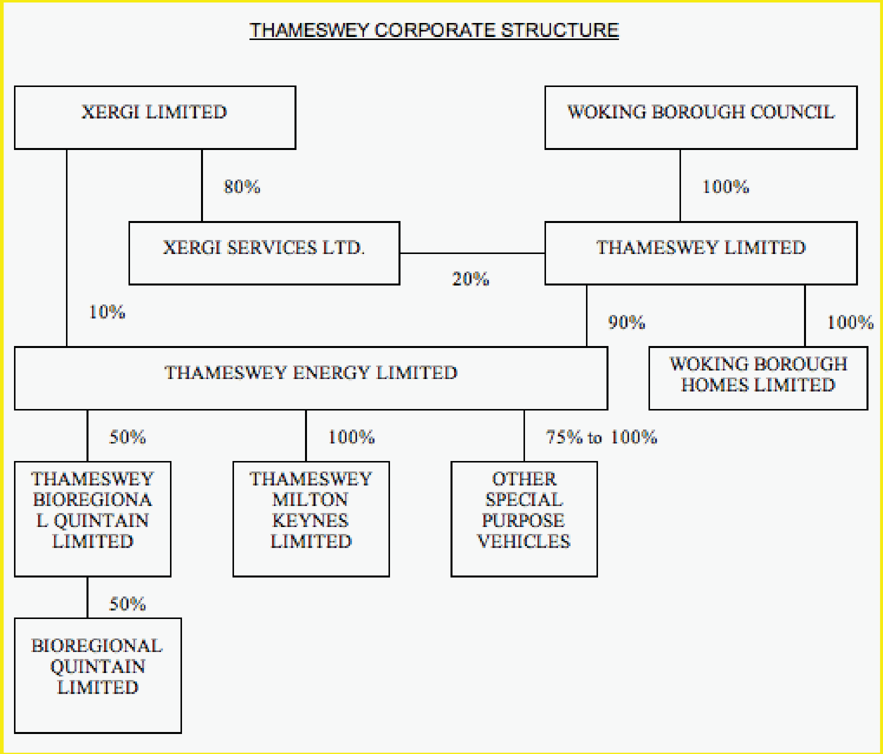
Source: Parliamentary Office of Science and Technology, "Electricity in the UK," Postnote, February 2007

Figure A3 – Conditions on Exempt Suppliers for Private and Public Wires



Source: London Climate Change Agency (2007)

Figure A4: Current Ownership Structure of Thameswey



Source: Thameswey (2010)

APPENDIX B STATE OFFICIALS AND OTHER STATE ENERGY EXPERTS INTERVIEWED

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