Multi-User Microgrids & District Energy

USDN Final Report

Beginning in January 2015, the Urban Sustainability Directors Network (USDN) funded a peer-learning process to explore emerging best practices related to developing multi-user microgrids and district energy projects in U.S. cities. The process, spearheaded by the City of Boston and the Boston Redevelopment Authority, brought together four cities in Massachusetts, along with New York City and Washington D.C. (as well as three Tier 2 cities), key regulators and utilities from the three jurisdictions, and key district energy/microgrid developers.

Tier 1 Cities	Boston, New York City, Washington D.C., Cambridge, Somerville, and Northampton
Tier 2 Cities	Chicago, Ann Arbor, and Boulder

The project consisted of the following activities:

- a city-only web-assisted conference call where cities shared briefings with each other on their respective microgrid/district energy activities;
- a day-long in-person workshop with all stakeholders at the 2015 International District Energy Association Conference;
- the development of a scoping white paper entitled *Microgrids & District Energy: Pathways to Sustainable Urban Development*; and
- the development of additional analyses focusing on ownership models, value streams, and legal barriers for potential multi-owner microgrids in MA, NY, and D.C. as well as a microgrid development straw proposal

Project partners that contributed to implementing these activities include Raab Associates, Ltd. (Project Manager and Workshop Facilitator), the City of Boston, the Boston Redevelopment Authority, the Pace Energy and Climate Center, the International District Energy Association, Harvard Law School, and the US Green Building Council.

This report compiles the products from the above activities.

Final report organization:

Microgrids & District Energy: Pathways to Sustainable Urban Development

Pace Energy and Climate Center
PACE LAW SCHOOL

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

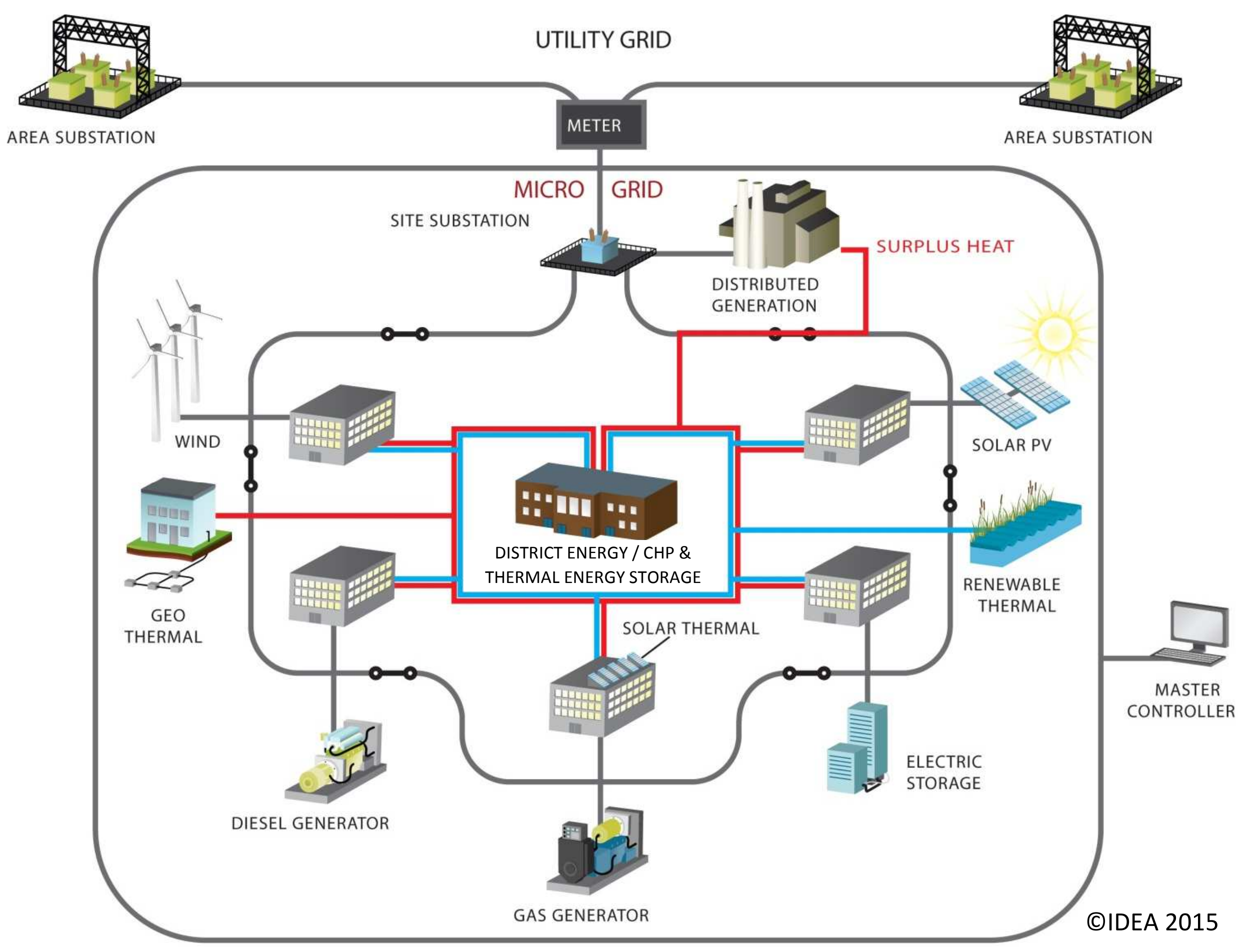
CONTENTS

1 Introduction

A microgrid is an energy system specifically designed to meet some of the energy needs of a group of buildings, a campus, or an entire community. It can include local facilities that generate electricity, heating, and/or cooling; store energy; distribute the energy generated; and manage energy consumption intelligently and in real time. Microgrids enable economies of scale that facilitate local production of energy in ways that can advance cost reduction, sustainability, economic development, and resilience goals. As they often involve multiple stakeholders, and may encompass numerous distinct property boundaries, municipal involvement is often a key factor for successful implementation.

This report provides an introduction to microgrid concepts, identifies the benefits and most common road blocks to implementation, and discusses proactive steps municipalities can take to advance economically viable and environmentally superior microgrids. It also offers advocacy suggestions for municipal leaders and officials to pursue at the state and regional level. The contents are targeted to municipal government staff but anyone looking for introductory material on microgrids should find it useful.

Many microgrids are built within the property boundary of a single owner such as a hospital or university campus. However this document focuses on microgrids that serve more than one entity. It outlines the various goals that microgrids help advance, describes their technical composition, and enumerates guidelines for identifying promising candidate sites. Given recent and ongoing technological advances in sensors, controls, and distributed generation the hurdles to microgrid development are less due to technical and engineering constraints and more often thwarted by legal, regulatory and financial challenges. The below graphic illustrates a microgrid with a variety of energy resources. Most microgrids will only use a subset of the methods shown.



2 The Case for Microgrids

The initial stimulus for microgrids has largely come from state and local governments and policymakers desiring a more effective public sector response to the social, economic, and environmental disruptions caused by widespread and long-term power outages. College, university, and hospital campuses are analyzing microgrids as tools to reduce energy costs, achieve environmental and sustainability goals, and ensure that the power is on when it is most needed. Utilities and their regulators are exploring opportunities for strategically sited, designed, and operated microgrids to substitute for costly electric distribution system capital expenditures, lowering costs for all ratepayers.

"As the microgrid market evolves from the single owner campus and critical public infrastructure models, more complex multi-party constructs built around economic development, area redevelopment, and resiliency as an enhanced private sector service are beginning to emerge. The promise of microgrids to provide this multi-faceted set of benefits drives the current enthusiasm for these systems as cities and communities strive to remain economically competitive, environmentally responsible, and energy resilient.

Campuses are commonly treated as a single electric meter, so it's easy to account for resiliency and efficiency benefits when you bundle in renewables or CHP. However, Business Improvement Districts can be 500 individual electric meters, which makes qualifying for, accruing, and distributing monetary benefits very complicated. Regulatory, statutory, and financing innovations are required to achieve the technology transfer of campus scale energy systems into districts of privately owned buildings, forming Multi-User Microgrids (MUMs). Whereas 20th century regulation enabled the grid to scale up into regional networks, 21st century regulation will help ratepayers to benefit from clean and resilient, locally-deployed generation and storage technology.

Compared to single-owner campuses, Multi-User Microgrids (MUMs) face many challenges including:

- There is no industry standard business model that accounts for retail level electricity sales
- Incumbent utilities are likely to perceive accelerated renewables integration as eroding their rate base
- There is often no regulatory or statutory support to realize revenue streams or formally recognize microgrids
- Real estate developers and property managers are generally unaware of the opportunities and risk averse to joining new district systems
- The energy planning process typically does not include municipal government or district scale stakeholder engagement

In 2007, the Connecticut legislature passed an act that attempted to ameliorate these challenges. Under the legislation, municipalities are empowered with expanded financing options, tax exemptions and franchise authority through the formation of Energy Improvement Districts (EIDs). Although the EID concept has been implemented, market activity to date has been minimal.[1]"

2.1 Energy Savings, Efficiency, Economic Competitiveness and Grid Support

Appropriately designed, operated, and sited microgrids can create economic benefits for both users and non-users of the microgrid. Microgrids may incorporate a suite of distributed energy resources ("DER") including energy efficiency investments, electric generation technologies utilizing combined heat and power ("CHP"), solar photovoltaic (PV), energy storage, optimizations algorithms, and intelligent energy management. This integrated local energy portfolio can directly create benefits by significantly reducing the overall energy costs for the microgrid users compared to purchasing energy from the main grid, deliver power and heat resiliency to the site and indirectly reduce costs for all grid users by lowering peak load on the entire electric system.

The direct economic benefits of microgrids emanate primarily from improving overall energy efficiency—whether by reducing energy consumption or using energy more intelligently. Whole-building energy efficiency measures can reduce overall energy consumption and costs as well as reducing the necessary size of the microgrid's generation sources. CHP can provide continuous base load power at a lower cost than the main grid by utilizing the waste heat from electricity generation for purposes such as space and water heating and absorption cooling. Intelligent energy management software, communication and controls can shape load profiles, optimize onsite energy production and consumption, and shift energy demand in response to price signals.

These technologies can create economic savings as measures within single buildings, but combining them into a larger system with multiple technologies and loads via a microgrid can create synergistic effects that further improve economic, reliability, and grid system benefits. For example, a CHP system that jointly serves multiple users with complementary usage (see section 3.5.4 Complementary Energy Users) may enable significantly larger energy cost savings than separate systems that serve each building individually. Consider one user with a large and consistent demand for thermal energy, but little demand for electricity, paired with a nearby user with the opposite usage pattern. By combining such complementary loads, a single CHP system will have a marked improvement in efficiency and utilization rate, thereby creating a far more economically viable, and environmentally superior system than operating each individually. While it's rare to find such perfectly complementary partners, the different load profiles of each can still offer a great deal of load "smoothing" to the overall system.

When sections of the electric grid become congested due to demand growth, utilities need to make significant investments to upgrade the system by replacing old or installing additional infrastructure. Microgrids are able to provide grid support as they decrease the overall load on the main grid by reducing onsite energy consumption and self-generating a large portion of the demand. When microgrids reduce this strain, the utility can defer or avoid these costly investments, as well as avoid additional investment in other generation sources, thus further reducing the entire grid's energy costs. For distribution only utilities, this results in lower costs for procuring energy and capacity.

2.2 Sustainability

Microgrids have proven to be a cost-effective approach to achieving sustainability and environmental goals, by reducing harmful air pollutants such as greenhouse gases. Incorporating energy efficiency and renewable generation sources such as solar PV or wind will provide emission-free energy. Microgrids enable greater economies of scale for renewable energy while allowing multiple users to share the environmental benefits produced by these measures. Intelligent energy management and storage can also be utilized to operate the microgrid in the cleanest way possible—shifting energy demand to when the cleanest sources are available, for example.

Microgrids incorporating CHP systems that run on natural gas can also have significant sustainability benefits. For the same reason that they reduce energy costs, they also reduce air pollution by significantly improving fuel efficiency as compared to the main grid. Because CHP systems are designed and sized to operate continuously as opposed to intermittently, they can produce much greater net emissions reductions than other forms of generation like solar PV and wind. For perspective, the CO_2 emissions from a 5 MW natural gas-fired CHP system are approximately half the CO_2 emissions compared to separate heat and power with the same energy output.[2]

2.2.1 Emissions Comparison Table[3]

"The below table compares the annual energy and CO_2 savings of a 10 MW natural gas-fired CHP system over separate heat and power with the energy and CO_2 savings from utility-scale renewable technologies and natural gas combined cycle (NGCC) systems producing power only. This shows that CHP can provide overall energy and CO_2 savings on par with comparably sized solar photovoltaics (PV), wind, NGCC, and at a capital cost that is lower than solar and wind and on par with NGCC."

Category	10 MW CHP	10 MW PV	10 MW Wind	10 MW NGCC
Annual Capacity Factor	85%	22%	34%	70%
Annual Electricity (MWh)	74,446	19,272	29,784	61,320
Annual Useful Heat Provided (MWh_t)	103,417	None	None	None
Footprint Required (sqft)	6,000	1,740,000	76,000	N/A
Capital Cost ($M)	$20	$60.5	$24.4	$10
Annual Energy Savings (MMBtu)	308,100	196,462	303,623	154,649
Annual CO_2 Savings (Tons)	42,751	17,887	27,644	28,172
Annual NO_x Savings	59.9	16.2	24.9	39.3

The values in the above table are based the baseline value of CHP, PV, Wind, and NGCC electricity displacing National All Fossil Average Generation resources (eGRID2012) – 9,572 Btu/kWh, 1,743 lbs. CO_2/MWh, 1.5708 lbs. NO_x/MWh, 6.5% T&D losses, CHP thermal output displaces 80% efficient on-site natural gas boiler with 0.1 lbs./MMbtu NOx emissions

2.3 Reliability, Resiliency, and Business Continuity

Recent widespread power outages of long duration have galvanized interest in new approaches for improving society's capacity to respond to and recover from natural or man-made calamities. Hurricanes, snowstorms, flooding, and icing have exposed the inadequacies of current approaches to mitigating the impacts of power outages that are so often a consequence of these events.

A key impetus for microgrid development is enhanced energy reliability, resiliency, and business continuity. Microgrids provide this service through the ability to disconnect and operate independently from the grid—otherwise known as islanding. This functionality allows microgrids to continue to provide energy services even when the main grid is down. Maintaining some level of energy services during main grid outages is important for businesses and organizations that place a premium on high-quality and reliable power.

A Department of Energy report estimates that for every hour of power disruption credit card and brokerage operators can lose up to $2.5 million and $6.5 million respectively.[4] The below table shows estimated interruption costs per event, average kW, and unserved kWh, in 2013 USD by duration and customer class.[5]

Interruption Cost	Interruption Duration					
(2013 USD)	Momentary	30 Min	1 Hour	4 Hours	8 Hours	16 Hours
Medium and Large Commercial & Industrial (Over 50,000 Annual kWh)						
Cost per Event	12,952	15,241	17,804	39,458	84,083	165,482
Cost per Average kW	15.9	18.7	21.8	48.4	103.2	203.0
Cost per Unserved kWh	190.7	37.4	21.8	12.1	12.9	12.7
Small Commercial & Industrial (Under 50,000 Annual kWh)						
Cost per Event	412	520	647	1880	4690	9055
Cost per Average kW	187.9	237.0	295	857.1	2,138.1	4,128.3
Cost per Unserved kWh	2,254.6	474.1	295	214.3	267.3	258.0
Residential						

Cost per Event	3.9	4.5	5.1	9.5	17.2	32.4
Cost per Average kW	2.6	2.9	3.3	6.2	11.3	21.2
Cost per Unserved kWh	30.9	5.9	3.3	1.6	1.4	1.3

The promise of reliable power can also attract additional economic development. If microgrids can offer reliable power at a competitive price, firms that value this service may be more likely to locate at sites that are either part of a microgrid or microgrid-ready.

Operating through extended grid outages is *extremely* important for critical infrastructure. Natural disasters such as hurricanes, earthquakes, and tornados may render the main grid inoperable by knocking down distribution and transmission lines or disabling other parts of the grid. As the name suggests, it is at precisely these times that critical infrastructure facilities are most needed. Microgrids are self-sufficient systems possessing local power generation sources, with less exposed infrastructure and so are less prone to disruptions and damage during such events. Therefore, critical infrastructure within a microgrid will be much more likely to maintain power and continue operating during emergency events that affect the surrounding macrogrid. Ensuring continuity of power supply at nursing homes and assisted living facilities keeps vulnerable populations safe in place. Supplying power, heating, and cooling to multifamily apartments, condos, and co-ops during outages reduces the number of people that may otherwise require assistance. Providing centers of refuge that offer temporary safe shelter for those who can't stay at their residences is an essential tool for disaster recovery.

2.3.1 What is Critical Infrastructure

The Department of Homeland Security defines critical infrastructure as "those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, national economic security, or national public health and safety."[6] In the context of microgrids, states have defined critical infrastructure in the process of developing incentive programs for microgrids serving such facilities. In New York, the NY Prize—a competitive solicitation to fund microgrids—will only consider microgrids that incorporate at least one of the following users:

Wastewater Treatment
Hospitals
Facilities of Refuge / Shelters
Police Departments
Fire Stations
Emergency Medical Services

2.3.2 Emergency Generators: Why CHP is a Better Choice

Traditionally, the ability to operate throughout grid outages has been provided by the use of onsite emergency and backup generators sized to meet the critical loads of a single building. Experience has demonstrated that backup generators are inferior to continuously operating power sources on both economic and operational grounds. For example, emergency/backup generators:

- Are only run when the grid is down or for infrequent maintenance and testing
- Are dead assets sitting unutilized most of the time; tying up scarce financial resources locked into the generator
- Are not providing value while idle
- Are more prone to failure in their time of need due to lack of familiarity under operating conditions and less rigorous maintenance as an idle asset
- Do not provide the cost offsets of avoided thermal energy consumption that's available from CHP systems

Systems with CHP can operate on a continuous basis, particularly when paired with the load aggregation capability of district energy systems. The benefit is in the form of consistent and reliable energy cost savings and reduced emissions. Emergency generators typically operate on locally stored liquid fuels. During outage events of longer duration it may be infeasible to transport fuel in to replenish depleted storage tanks. Additionally, while diesel generators were once exempted from certain pollution controls, this is no longer the case.[7]

2.3.3 Cost Premium for Resiliency

The ability to operate islanded from the main grid requires additional infrastructure to allow the microgrid to disconnect safely from the main grid and afterwards maintain service to critical loads throughout the duration of the disconnection. These requirements can vary greatly from site to site but ultimately will add an additional cost layer to microgrids when compared to systems not built for resiliency.[8] Depending on the characteristics of the microgrid, these additional costs will have an impact on the overall savings obtained from increased energy efficiency. For sites that require a degree of energy reliability that exceeds that of traditional distribution system service, it's essential to consider the value that energy resiliency and business continuity provides—especially in comparison to other means of providing this service.

3 Design Criteria

This document assumes that the reader already has a general familiarity with the technologies of distributed generation (solar, wind, etc.) so these will not be discussed in detail. A key design aspect one should bear in mind: in order for microgrids to provide resiliency, especially thermal resiliency, combined heat and power (CHP) must be a central component. This technology will be discussed in detail along with several other key technical considerations.

3.1 Energy Efficiency

The cheapest and cleanest energy choice of all is that of unused energy. Such reductions in energy consumption have been nicknamed "*nega*watt" hours. A recent report by the ACEEE found that the average cost of saving a kilowatt hour (KWh) is 2.8 cents via energy efficiency programs as compared to typical charges on the electricity U.S. grid which average roughly 10 cents per KWh (plus distribution charges). [9]

Energy efficiency measures, whether retrofits or new building standards, should be implemented in conjunction with the microgrid (if not before). With this in mind, it often makes sense to explore opportunities for microgrids and district energy systems in tandem. Steps can be taken to ensure future development or retrofits are compatible with existing or planned community district energy assets, such as district energy-ready (DE-R) design. See section 6.9 Planning for District Energy-Ready Buildings for more detailed information.

While reducing energy costs and emissions by reducing overall energy consumption, energy efficiency also ensures that the microgrid design is appropriately sized from the outset. Designing a microgrid without first pursuing energy efficiency can significantly increase overall capital and operating costs by requiring the purchase of larger capacity generation systems which consume more fuel than would otherwise be needed.

3.2 Combined Heat and Power

CHP is the simultaneous production of useful thermal energy and electricity. Waste heat from the production of electricity is captured in the form of hot water or steam that can be used for space and hot water heating, cooling in combination with thermally activated chillers, or other types of process heat applications. CHP is far more efficient than the traditional energy system configuration that draws electricity from the main grid and heating from an onsite boiler or furnace. CHP systems can achieve efficiency ratings of more than 80%, while generating heat and electricity separately is typically no more than 45% efficient. Note that CHP can also be used in warmer climates where space heating is rarely, if ever, needed. The "waste heat" from electrical generation can also be converted for cooling applications through use of a well-established technology: absorption chillers.

It's also worth noting that a CHP plant will need a "storm resistant" fuel source. On site storage is one path, though a connection to a natural gas pipeline may also be sufficient. For example, during Super Storm Sandy in New York City, short of localized damage to the gas pipeline by things like uprooted trees, virtually all gas customer's service continued to work. But fuel considerations should be a part of the risk profile being evaluated.

There are several reasons for CHP's crucial role in the microgrids currently being designed:

- Without heat recovery, the cost of on-site electric generation will almost always be more costly than purchasing electricity from the grid
- CHP provides reliable power day and night and throughout emergency events. Natural gas supplies are rarely disrupted while other energy sources such as PV or wind can only provide intermittent energy
- Machines such as elevators and water pumps need a significant surge of power when their motors first start up. This surge power can be provided by CHP systems while presenting challenges for other energy sources like batteries

GHG savings per kW of capacity is far greater for a CHP system than for an equivalently sized PV or wind installation due to the higher capacity factor of the CHP system (see section 0

- ➢ Emissions Comparison Table)
- ➢ Without CHP the microgrid cannot provide any heat resiliency without significant additional investment. Your buildings may be lit, but they will be unheated

3.3 Renewables: Solar and Wind

With current technologies, CHP will likely continue to be a central part of microgrid projects if heating and critical electrical loads are to remain online during a grid outage. Solar and wind generation can and do play an increasing role in on-site electrical generation for many microgrids. As things currently stand, the general mix of microgrid energy supplied tends to be roughly 80% CHP and 20% renewables in mixed generation deployments. As the cost of renewables declines they will likely take a progressively larger share of the electrical generation mix. They have the obvious advantage of not needing fuel delivery but their generation is also intermittent. Also, they are not able to provide resiliency on their own without a large amount of on-site electrical storage.

3.4 Storage

A microgrid where all electrical needs are met through renewables generation, with storage, is technically attainable. So too are those where all energy needs, thermal energy included, can be accomplished with renewables only. Storage prices have been dropping over the last several years and all indications are that they will continue to do so. However, they have not yet reached the point of cost viability to support all the loads required by a typical microgrid and will likely not do so for at least the next several years. The current role of storage is primarily to smooth the intermittency of renewables generation and, in a few areas, to smooth a customer's load profile during the day to help reduce demand charges from grid purchased power. Storage can also be used to participate in ancillary services and other wholesale markets.

It's not clear exactly when the inflection point of cheaper battery storage will enable more widespread and substantial deployment. But it's a definite possibility. One thing that local governments can do to help prepare for this it to keep abreast of technological developments, such as new battery chemistries and other storage technologies, and help ensure that local building codes, fire codes, and other ordinances allow for their implementation.

3.5 Site Selection[10]

An ideal microgrid site would combine all of the following attributes:

- ➢ High demand users with consistent and non-coincident peaks in electric, heating, and cooling needs
- ➢ Critical infrastructure and/or end user that places a high value on power quality & reliability
- ➢ Access to plenty of solar insolation, wind exposure, or onsite biofuels
- ➢ A site that is already engaged in another major construction process that has its own financing
- ➢ A current or imminent need to replace, upgrade or install heating, cooling and power equipment onsite
- ➢ Existing high energy prices
- ➢ An existing steam or thermal loop on the site, or planned excavation that offers the opportunity to lay electric and thermal distribution networks

In reality, few sites meet all of these criteria. Several important tools and processes, however, can help municipalities identify those sites with the best mix of these attributes to achieve their goals.

3.5.1 Energy Planning Process[11]

While community-wide energy planning is not necessary to find the optimal project sites for microgrids, undertaking an energy planning process can help secure the attention of high-level officials, coordinate activity across different municipal agencies, and integrate microgrid efforts into the community's broader development goals. In an energy plan, communities can better answer the following questions:

- ➢ Where and how is energy currently used today in the community, and how is that expected to change?

- Where does the community expect development to occur in the future? Would microgrid infrastructure installation at these sites be most economical as part of the larger development?
- What type(s) of economic activity does the community want to attract and can a microgrid be an economic development driver?
- What critical infrastructure is vulnerable to regional power outages?
- How does the community want to address its carbon footprint?

A successful energy planning exercise will answer these questions and then follow-up with coordinated studies that engage business leaders, local government agencies, and key affected parties to identify the right project sites.

3.5.2 Integration Into Capital Planning

Incorporating microgrid development into capital planning can help identify good candidate sites. Sites with planned or needed infrastructure upgrades can be good candidates for microgrid development for several reasons. First, planning and executing other infrastructure upgrades with a microgrid development can save time, materials, and overhead. Additionally, installing CHP to replace traditional boiler plants and other HVAC equipment at or near the end of their useful lives allows for the associated capital expenses to be viewed as a marginal cost increase from a traditional "replacement in kind" rather than as a simple stand-alone expenditure. Finally, if potential sites implement significant infrastructure upgrades prior to microgrid consideration, viable designs may be "locked-out" of consideration for years due to sunk investments.

3.5.3 Anchor Energy Users

Successful microgrid projects typically require an anchor energy user, a site with significant energy demand that will likely remain at the same location for many years in the future. Such a site, at the heart of a microgrid, can help insure its long-term viability. Microgrids are capital assets with very long service lives. Therefore perceived project risks are diminished when centered on a core user who will be there for the microgrid's useful life.

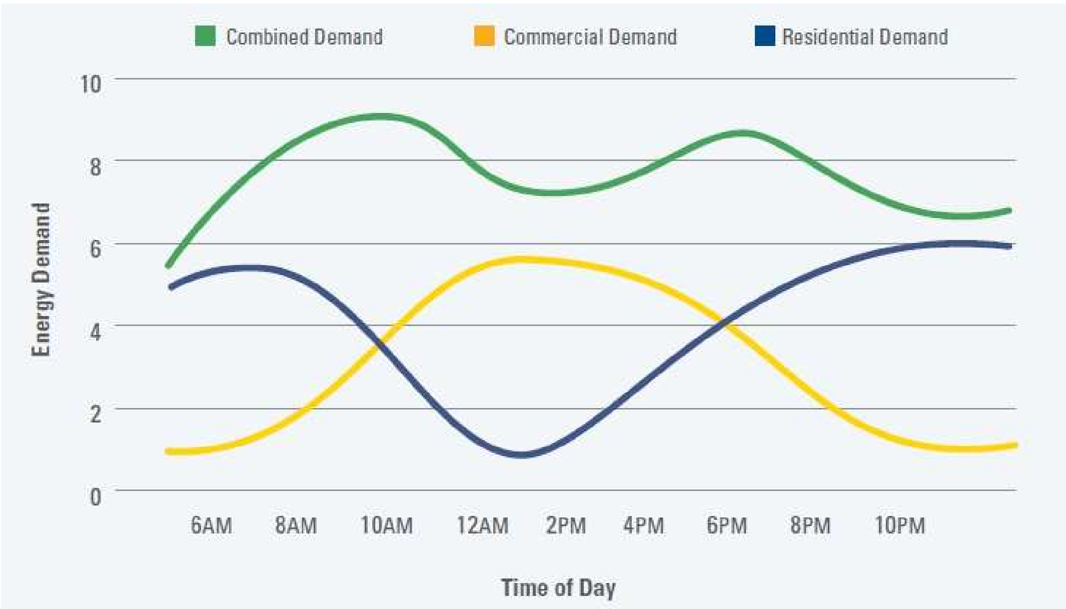
These users are likely to have larger and more stable energy demand, and significant concurrent requirements for the waste heat from electricity production that is an important component of an economically viable microgrid. There are typically scale economies up to a certain size. Larger generators tend to be more efficient than smaller ones as the fixed costs (engineering, design, permitting, financing, etc.,) do not increase proportionally with energy generation capacity. Provided that they have the right energy demand characteristic, the incremental economic value of attaching proximate sites may be significantly higher than the incremental costs associated with a small increase in the network distributing that energy. A microgrid where the energy generation and distribution assets are used at a high capacity factor and asset utilization rate for a large proportion of the hours of the year is characteristic of a preferable value proposition.

The anchor user can also foster microgrid development by taking the lead in negotiating financing for the system. This is particularly the case when a primary end user can use its credit capacity, access to tax-exempt or other forms of low cost capital, or its own financial strength to secure a more advantageous project cost of capital that is extended to other parties in the development. Examples of such tenants include municipalities, hospitals, universities, convention centers, industrial parks, commercial centers, and prisons.

3.5.4 Complementary Energy Users

Instead of, or preferably, in addition to incorporating a single anchor user with a stable energy demand, microgrids can become more economical when they target complementary energy users that when joined together present a *sizeable*, *constan*t and *concurrent* energy demand. Just like an anchor user, when multiple users combine to provide a relatively constant energy demand on a daily, weekly and seasonal basis, microgrid assets are more fully and economically utilized. This circumstance makes microgrids advantageous by allowing multiple users to jointly and economically produce and consume, whereas they may not have been able to self-generate energy in a cost effective manner on their own.

"Consider the example of a commercial center next to a large residential area. As illustrated in the below figure, the commercial building is used intensively between the hours of 8 AM and 5 PM, with demand increasing and decreasing quickly during the morning and evening, respectively. The adjacent residential area complements this load profile because it demands more electricity during early mornings and late evenings. The pair of users provides a combined daily demand profile that is far steadier. This complementary demand profile can be paired with a generator such as a CHP unit and ensure that the generator's capacity will be utilized consistently."[12]



3.5.5 Recognizing Underdeveloped Locations

In addition to the right sets of users with the right energy demand, communities could also look for physical locations with untapped potential, such as:

- Existing sites with generation that can be cost-effectively reconfigured or expanded to serve a microgrid
- Sites already slated for significant development, like brownfield redevelopment areas, new mixed use development, or multi-building commercial/industrial/residential redevelopment where microgrid infrastructure can be cost-effectively installed simultaneously with planned development
- Sites that already generate substantial waste heat that can be recovered to serve a microgrid

To take one example: On the site of a former brownfield in Atlanta, GA, Atlantic Station represents a good example of how to save money by building community energy in the midst of a larger capital project. Atlantic Station used Brownfield Tax Allocation District dollars to fund a 7,500 ton chilled water plant with two-mile network of distribution pipes, providing cooling to an already-planned 140 acre mixed-use development where a steel mill once operated. When excavation is occurring for some other reason (e.g. roads, sewer, gas lines, etc.,) it's prudent to investigate the future value of installing district energy infrastructure, as it may be added at such a time for a much smaller marginal cost.

3.5.6 Offsetting Utility Capital Investments

The initiation and planning of large-scale private and public-private development projects is a fortuitous time for assessing microgrids. In certain circumstances, the new load growth associated with development may present an opportunity to reduce utility costs and benefit all ratepayers. Costly utility investment in new substations, transformers and other distribution assets can be avoided or deferred by onsite distributed energy resources. If this is the case, the utility should be engaged in a partnership to best determine how the microgrid could be designed, configured and operated in a manner that works to the advantage of all parties.

3.5.7 Rights of Way

If a microgrid needs to cross a right of way (e.g., public street, railroad), additional technical constraints and/or planning or legal procedures may need to be addressed. While the need to cross a right of way should not exclude a potential site from consideration, a site with similar promise and absent the complexities of right of way issues should be considered a preferable choice. See section 7.3 Rights of Way and Franchise for more details.

3.6 Wiring for Resiliency

Microgrids are typically designed to provide only a portion of the electricity requirements for their participants, since local generating capacity for the entire electrical load typically is cost prohibitive and unnecessary for meeting the objectives of most projects. Consequently some electricity will need to be drawn from the grid. How much, and at what periods of the day this occurs, is a matter of the microgrid's specific design characteristics. For example, solar panels may produce an excess of power during the day but obviously they cannot function at night.

Microgrids by definition are capable of operating separated from the grid in the event of a grid outage. Resiliency is often a primary impetus for the project. Resiliency can be secured by powering (and heating) loads that have been identified as critical. The control system must have the ability to shed non-critical loads with a rapid enough response time to insure that the power supply and power demand are kept in balance on an instantaneous basis.

Load shedding generally takes one of two forms. Either an entire building is electrically cut off from the microgrid (thermal connections could be unaffected) or buildings are wired in such a way so that a subsection of electrical power is provided to critical systems only. For example, if a large multifamily building were wired for critical loads, the system might allow for the operation of a single elevator, minimal common area lighting, water pumps, the boiler plant, and perhaps several outlets in the lobby for charging mobile phones. This would leave the building "livable" but residents would be without power in their apartments. Though not ideal from a quality-of-life standpoint, it would keep the building habitable and allow for heat and running water.

Retrofitting buildings to separate critical from non-critical load does incur some cost, but with the smarter metering and controls that have been introduced over the last few years, especially those using power-line communications, this retrofit can now be accomplished without having to rewire the building's entire electrical system.

4 Financing the Microgrid

The development plan for a technically feasible and economically viable microgrid often falters at the point of financing. Except for the lifetime cost of energy, the cost of financing is often the largest single component of total project cost. Successfully moving from project concept and design to completion and operation hinges, in large part, on securing financing at a price that enables an economic return that will support the investment.

In the first section of this chapter we summarize the revenue sources that are the foundation for project success. We encourage communities to include in their analysis revenues that might be available from sales of energy, capacity and/or ancillary services in wholesale energy markets.

The following section addresses a variety of different financial mechanisms that might be utilized. These instruments are not all relevant to the circumstances of every project. The purpose is to highlight a range of alternatives, alerting the reader to instruments and combinations thereof that might otherwise be overlooked.

For completeness we add brief sections covering ongoing maintenance, ownership structure, and financial phasing. Each of these three topics is an important consideration in the overall design and assessment of the project financial plan.

Microgrids are in the earliest stages of market development. As projects proliferate and the financial community gains a much deeper base of information for analysis, we can expect an evolution in financial products, services, and terms. This section concludes with observations on key areas where progress might be made.

4.1 Microgrid Profitability Considerations

What enables microgrids to succeed as a profitable investment is the extent to which the revenues over the project's lifetime exceed the costs. With a larger difference (lifetime revenues less lifetime costs, or net revenue), the impetus for investment will be greater, and the potential pool of interested financiers will also be greater. When the net revenue over time is small, investment may be attractive to a smaller set of project sites with a long-term investment time horizon and financing sources willing to accept lower returns and/or longer periods of capital recovery (e.g. 15 or 20 years).

While seemingly an obvious statement, it's critical to focus on the sources of project returns, the expected value or riskiness of each source of return, and how the value of these expected benefits are analyzed by different financiers.

4.1.1 Economies of Scale

Perhaps the largest benefit of microgrids is that they enable load aggregation, economies of scale, and, with CHP, the productive utilization of waste heat in a manner that may be significantly more efficient at the multi-building level than within individual buildings. This results in several areas of cost reduction:

- Larger equipment deployments (boiler plants, CHP) are generally more efficient than smaller deployments. This means a higher output of useful energy per unit of fuel and lower fuel costs
- Aggregation of *concurrent* electrical and thermal loads:
    - Smooth demand resulting in an increased base load for on-site CHP (this means greater efficiency) as well as lower demand (KW) charges from the utility
    - Enables a larger portion of the electricity from intermittent renewable sources (wind, solar) to be used onsite, thus boosting their payback period. This effect is even higher in areas with less generous, or non-existent, net metering policies
- Concentration of boiler plants and generators into a central location:
    - Allows maintenance staff to conduct more of their normal maintenance in one location that reduces productive time lost in travel between buildings
    - Reduces the costs of storm hardening critical equipment

- Standardization of equipment:
  - Reduces costs for training and spare parts
  - Homogenizes operational and maintenance procedures
  - Allows for cheaper implementation of equipment redundancy (N+1) thus providing lower probability of downtime or other reductions in service
- On site electrical generation can enable buildings to remain powered on in the event of a grid outage. This enables critical infrastructure (police, fire, hospitals, emergency services) to continue functioning, and helps avert safety issues. It also has obvious benefits to quality-of-life in residential deployments and helps avert loss of income to commercial facilities (data and critical transaction losses, forfeited sales, food spoilage, manufacturing, and commercial downtime costs)

Where cogeneration/tri-generation can be utilized, it is possible to increase the energy efficiency of the block, campus, or neighborhood by more than 50%. This reduces money spent purchasing electricity from the grid. Of critical importance is productive use of waste heat that saves the cost of purchased fuels (natural gas, or oil) that would otherwise be necessary for space heating, hot water heating, and other uses of heat and/or steam at the site. In the summer, the waste heat can provide heat-driven cooling that reduces the need to purchase and run chillers for cooling. This further lowers the site's electric energy and demand charges. It also provides for "resilient thermal energy" for the site, ensuring that during extended interruptions in grid power supply some or all heating needs are met during cold winters, that more cooling is available during hot summers, and that hot water service is retained during an emergency.

4.1.2 Measurement and Verification

Microgrids will most likely require an on-going measurement and verification (M&V) protocol. Usage must be measured and/or metered, the cost of service calculated, and customers billed appropriately. When multiple separate entities are connected, transparent cost determination and equitable apportionment will be essential. An outside (i.e., impartial) contractor will likely be needed in such situations.

There will also need to be M&V even for "single customer" microgrids such as those of a university or hospital; departmental budgets will have to track energy costs. Rigorous monitoring of usage at the most granular level feasible has proven to be the cornerstone of maintaining performance and cost savings over the long run. In such cases the facilities management group may be the one to provide M&V, but there should be an additional staffing and training component if done internally rather than by an outside contractor.

4.2 Cost Offsets and Ancillary Income

The economic viability of a microgrid project is significantly enhanced if the project includes a well-designed, high efficiency combined heat and power or district heat and power system. As noted previously cost savings from onsite power generation and productive use of waste heat for heating and/or cooling provides the foundation for an attractive investment.

There are other value streams that should be considered in assessing microgrid development opportunities. The contribution they're likely to make to the "value stack" may be markedly less than total energy (and capacity) cost savings from CHP and efficiency investments, but when available and appropriate, these sources of income should not be ignored.

Demand Response:[13] FERC defines demand response as "changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."[14] Microgrids can enable participation in these programs.

Renewable Energy Credits (REC) / Carbon Reduction: Local generation can reduce a site's carbon footprint through use of renewable energy, energy efficiency, and/or lack of macro grid transmission loss. Such carbon reductions can be sold on secondary markets. Third party M&V will likely be required for this.

Ancillary Electricity Grid Services: There are a number of inherent issues with any large-scale electrical grid such as voltage control, reactive power, and frequency regulation. There are existing and emerging business models in place in parts of the US that allow DER's to be compensated in wholesale power markets for helping to alleviate these issues[15]. At the distribution system level, the REV proceeding is examining new products, services and transaction mechanisms to compensate DERs for providing services to the grid. Microgrids, if appropriately designed, configured and operated could be well suited to providing ancillary services in wholesale power markets, and in the future, at the distribution level, once these markets are established.

Utility Distribution System Cost Reductions: Local generation reduces the load on the utility's electricity grid. Such reductions could also mean deferred or avoided capital expenditure for the utility. New York is experimenting with a series of pilot projects designed to test the viability of strategically sited and operated DER's, as a substitute for distribution capital expenditures[16]. These experiments and new market designs that may emerge from the pilots could offer a new source of income for Microgrids that are situated in the right geographic areas and operated in a manner that predictably and reliably reduces requirements in that location.

Insurance: If the microgrid offers power or heat resiliency, such backup capacity could result in lower insurance premiums.

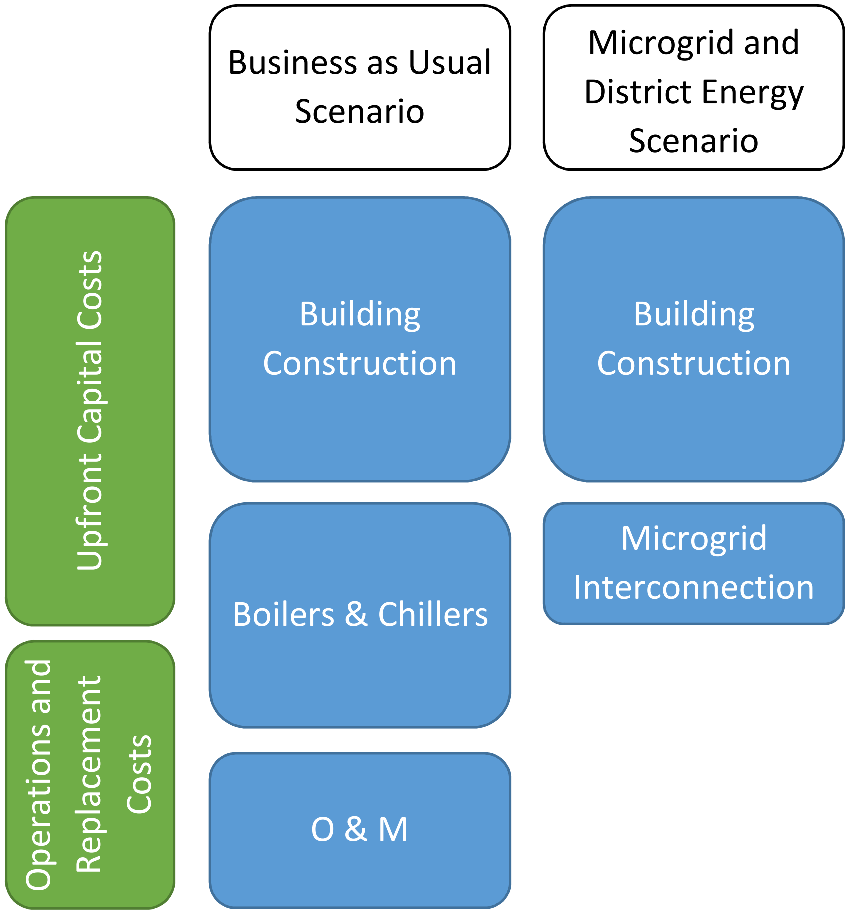
By their very nature microgrids are likely to have more than one stakeholder. It's not uncommon for different stakeholders to approach their investment and participation with differing strategies. Microgrid models are readily adaptable to hybrid financing. Individual stakeholders might also choose to make use of several different financing mechanisms just for themselves.

Potential customers should take a holistic view of total cost of ownership when structuring any deals. Include financial incentives *and penalties* wherever possible that align the interests of all stakeholders, especially for long-term contracts. Of key consideration should be the long term risk factors. Engagement of a third party subject matter expert (SME) by customers is *strongly* recommended to represent their interests during design and contract negotiations.

Microgrids may create significant and tangible benefits for non-users of the microgrid as well. Societal and electric grid system benefits of microgrids can include enhanced resiliency of critical infrastructure and reduced capital and operating costs in the generation and delivery of electricity. Furthermore, to the extent that microgrids incorporate low or no emitting distributed energy resources, such as high efficiency CHP, renewable energy, storage, and energy efficiency, they can deliver deep reductions in emissions of greenhouse gases and criteria air pollutants.

Presently, these benefits are not captured by the owners and users of the microgrid, and thus go uncompensated. When those who assess an investment in microgrids are unable to monetize, in part or in whole, the value streams from public and grid benefits that they create, they may be deterred from going forward with the project. In those instances where the sum of private and public benefits are significantly greater than total costs, society and utility ratepayers will be worse off by the failure of markets and policies to account for total benefits.

Building owners benefit from interconnecting to district thermal systems associated with multi user microgrids. This interconnection obviates the need for boilers and chillers inside the building, freeing up space for more leasable floor area and rooftop space. Interconnected buildings also eliminate operations, maintenance and replacement costs associated with boilers and chillers.



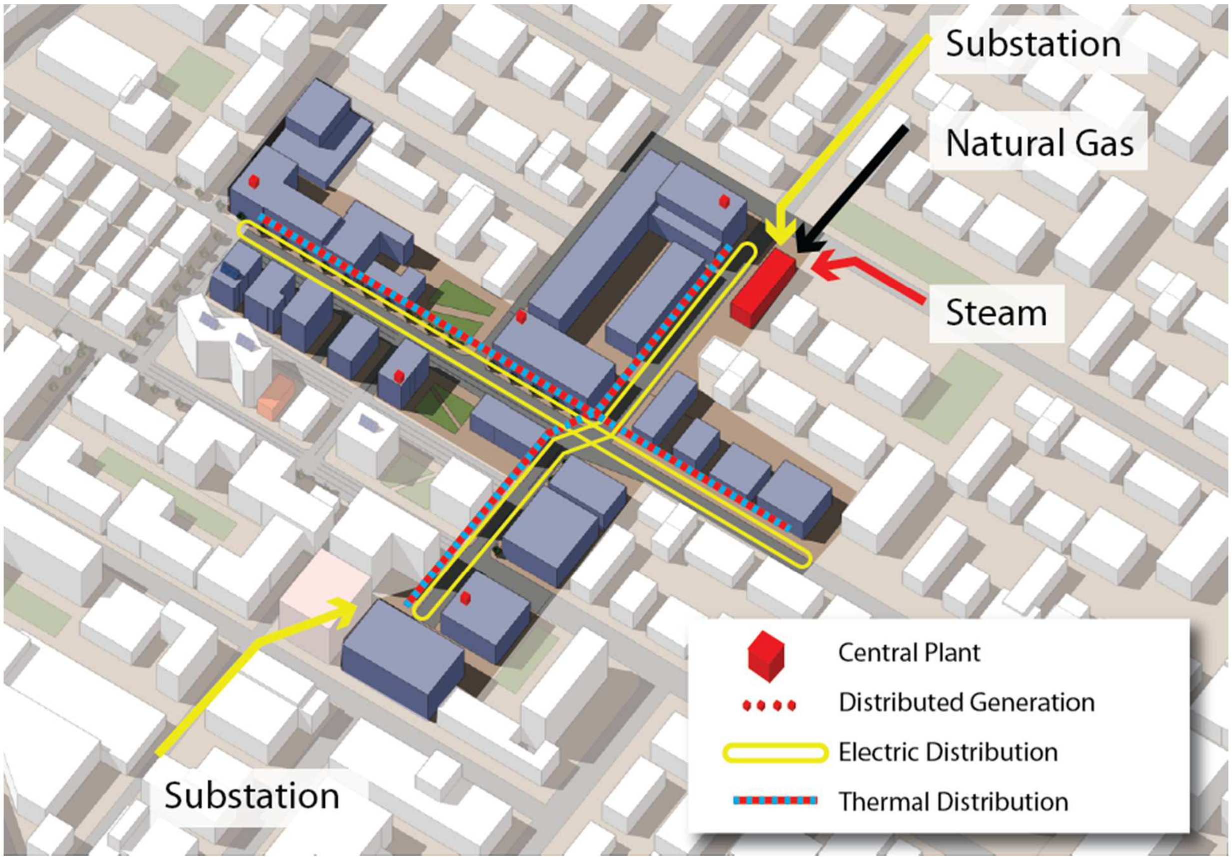
4.3 Scalability and Financial Phasing

One of the benefits of a microgrid is that it can be constructed in phases and scaled out over time. The cost implications, both immediate and longer term, need to be part of the planning process.

Consider the example of a microgrid created by a municipality for district thermal and electrical services. It will connect several dozen buildings in their downtown mixed-use district that will include municipal buildings, privately held commercial stores, and some multifamily housing. For simplicity, we'll assume that generation will be solely from CHP and rooftop solar and that the CHP equipment will be housed in a new structure that will be specially built for that purpose. There are two general choices in the initial design: design and build for the existing loads (buildings set to be connected immediately plus some margin for error) or design and build for future expansion.

If the latter option is chosen, it might be best to include several additional elements in the initial build out such as:

- A larger footprint for the CHP equipment building (central plant) to allow for additional units to be added in the future
- Larger pipes for thermal distribution and larger capacity electrical transmission wiring and controls
- More linear feet of pipe and electrical conduit laid into the ground near future customers or areas slated for development, or additional underground excavation/tunneling with placeholder conduit



While these additional measures can save a great deal of future costs, they still need to be funded in the short term. The plan for this funding can take several forms:

- The entire cost can be "baked in" to the project's price tag and funded as part of the original scope. This means that initial users are essentially subsidizing expansion to future customers
- The municipality can have the design engineers determine the marginal cost difference between a standard build out (for current scope) and the additional scalability enabling measures. This portion of the cost could then be financed separately (perhaps at the municipality's expense) while the remainder is then incorporated into the cost of service, PPA, etc.
- Vendors (those involved in construction and/or maintenance), energy services companies, or other investors may wish to fund this capability if they are granted a share of future revenues
- Landowners on the periphery of the microgrid may be willing to provide funding so as to facilitate their future participation when their own buildings become ready

The project planners should be certain to carefully address the costs, benefits and implications of phasing and funding issues, when formulating the long term vision for the microgrid.

4.4 Construction Financing and Own, Operate, Maintain Options

When examining financing options and conducting benefit-cost analyses it's important to examine *marginal* cost considerations and not just the *gross* cost. For example, consider a conventional boiler plant that is past its useful life where a like-for-like replacement would cost $4M. If the cost of installing a comparable combined heat and power (CHP) system and connecting it to the microgrid is $6M then the *marginal* cost for the additional benefits (lower electricity costs, redundancy, etc.) is $2M. In order for this measure to recover its costs, it only needs to generate an additional $2M in benefits, not the $6M of the entire upgrade's price tag. This is a much lower threshold to meet and the benefits to costs ratio (BCR) should be calculated with this in mind.

An additional option is the bundling of energy efficiency projects with one or more microgrid components. Energy efficiency upgrades (e.g., lighting, insulation, high efficiency motors and drives, smarter controls) often have very attractive payback periods. When combined with other projects that have longer payback periods the overall financial performance of this portfolio may allow for better financing terms.

4.4.1 No Financing

Energy improvements are often eligible for financing well below typical market rates. One should not exclude the possibility of financing without a holistic examination of one's cost of capital. Also, some financing mechanisms such as an energy performance contract may require a *partial* cash commitment.

If a participating entity has sufficient funds (positive fund balance, retained earnings) or access to attractive capital re-imbursement formulas, then the project may be financed, in whole or in part, by internal sources. The use of internal funds raises the ownership stake of the entity, thereby increasing its claim on the share of the microgrid's ongoing financial benefits. Internal funding bypasses some of the costs and constraints of taking on outside equity or debt investors. However, internal funding is not costless and when analyzed this approach should set a price on the use of internal capital that represents the "opportunity cost", or the return on the next best investment that could be made with these funds.

4.4.2 Equity Financing

In an equity financing arrangement, investors contribute to the project and acquire an ownership stake that entitles them to a share of the returns arising from the profits and increase in economic value generated over time by the project. Note that investors need not be participants in the microgrid. The equity investor takes on more risk than does the debt investor. Equity financing in most instances will be more expensive, sometimes markedly more expensive, then debt financing.

4.4.3 Power Purchase Agreements (PPA)

PPAs are used by energy services companies (ESCOs) for financing the build-out of power generation assets (e.g., photovoltaics, CHP, fuel cells). Typically they are structured to involve little to no upfront capital cost for the customer(s). The cost of installation is recouped through the sale of energy back to the customer at a pre-set rate. Note that "pre-set" does not necessarily mean fixed. Some, or all, of the rate may be tied to variables such as natural gas prices or the cost of electricity from the local utility.

PPAs often include long-term maintenance agreements and agreements for the operation of the system. O&M agreements are typically priced on a cents per kWh basis, and added to the PPA's other cost components (e.g. return of capital, return on capital, etc.). One source of risk for customers is that PPAs might have built in escalation charges and these should be evaluated. To help mitigate such a risk, linking the price of energy from the assets to an objective measure (say a published price of electricity in the local market or the price of natural gas) can help ensure a favorable cost for customer even when energy prices fluctuate.

Contracts also typically include nonperformance clauses for both sides. For the customers, it may mean that they are required to purchase some or all of the energy produced, with potential minimum thresholds. PPAs can be an instrument providing a good risk/reward tradeoff for customers. For those with capital constraints PPAs are designed so that the user incurs no upfront costs. Institutions may wish to preserve limited debt capacity for investments that are central to their mission. In such instances a PPA can be structured to be off the balance sheet of the host site. It's essential that the seller's economic interest is aligned with the buyer. Contracts should be structured so that the seller is incentivized to keep their assets running at peak efficiency: the more energy they produce, the higher their profit, and when the system is down (and the buyer is incurring a loss) the seller should shoulder a significant share in the risk of losses from outages and poor capacity factors.

For example, consider a PPA for rooftop solar panels with no cost to the customers that offers electricity at 2 cents per KWh below grid rate each month. If the solar panel's output is below the customers' needs then they'll be buying all of the electricity produced. The more that's produced, the more the customers save and the higher the income for the ESCO. The ESCO is incentivized to keep the panels running well, conduct proactive maintenance, and repair any damage quickly.

If the assets can be connected to a microgrid then this could allow for an even larger set of distributed energy assets to be acquired. The same model outlined above would apply but the customer base has now been extended to the entire microgrid site.

4.4.4 Tax Exempt (Municipal or Authority) Bonds

This type of financing may be available to help lower total financing costs of the project when municipalities, hospitals, universities or other non-profit entities are participating in the project. Bear in mind that a municipality's participation could take several different forms such as an energy customer, energy provider, managing agent, and/or as an infrastructure provider (by constructing or operating the electrical and thermal connection assets for example). Examples include municipal bonds, industrial development authorities, state health and educational facilities finance authorities.[17]

4.4.5 Energy Performance Contracts (EPC)

These contracts are somewhat similar to PPAs (see above). Whereas PPAs are typically tied to generation assets EPCs can encompass other measures and services such as building retrofits or boiler plant operation. Some or all of the upfront costs for energy improvements are borne by the ESCO and the building owner is able to pay back the loan through energy savings. EPCs typically involve a third party for M&V that provides reporting for on-going costs and energy savings.

EPCs are sometimes structured with the ESCO sharing a stake in both the risks and rewards of the project. For example, the ESCO may receive a fixed amount of the savings but any amount beyond that may be shared between the ESCO and the property owner. This helps align incentives between the two.

4.4.6 Property Assessed Clean Energy (PACE)

PACE programs, where available, can be extremely advantageous as they allow a private landowner to receive a loan from the state or local municipality for energy improvements to their property. This is essentially an energy performance contract from a government source. Projects are scoped so that the energy savings from the resulting projects are greater than the amount needed to service the new debt. Payments are levied by the local municipality by adding a line item on the property tax bill. This debt is senior to any mortgage.

The distinguishing feature of PACE loans is that they're connected to *property* and not the *owner*; so contract obligations are transferred upon sale. This mitigates the risk in situations where property owners are reluctant to pay for energy projects if they envision a possible sale before reaching that project's payback period.

One drawback of PACE loans is that they are sometimes unavailable to two sectors: municipal and small residential. Municipalities don't typically pay property taxes and so such an arrangement wouldn't apply; much as municipal bonds don't typically apply to the private sector. As of July 2015, there remains an outstanding issue for small residential: in July 2010, the FHFA released a Statement on Certain Energy Retrofit Loan Programs, which dampened residential PACE programs by advising Fannie Mae and Freddie Mac to avoid buying mortgages with PACE assessments.[18] The issue remains unresolved. Note that this restriction does not apply to medium and large multifamily structures (whether rental or owner occupied) as mortgages for these properties are not under FHFA's umbrella.

4.4.7 Qualified Energy Conservation Bond (QECB)

A QECB is a bond that enables qualified state, tribal, and local government issuers to borrow money at attractive rates to fund energy conservation projects. A QECB is among the lowest cost public financing tools because the U.S. Department of the Treasury subsidizes the issuer's borrowing costs. These are taxable bonds—meaning that investors must pay federal taxes on QECB interest they receive. Issuers may choose between structuring QECBs as tax credit bonds (bond investors receive federal tax credits in lieu of interest payments) or as direct subsidy bonds (bond issuers receive cash rebates from the U.S. Department of the Treasury to subsidize their net interest payments).[19]

4.4.8 On-Bill Financing

Some utilities have programs in place for on-bill financing (OBF) of energy improvements. OBF allows utility customers to invest in energy efficiency improvements and repay the funds through additional charges on their utility bills. It is most commonly structured as a loan or tariff, but could also be structured as an energy service agreement or lease. Utilities tend to look for projects that are “bill-neutral,” meaning that energy savings are sufficient to cover the monthly payments for the financing so that the total monthly charge on the utility bills is less than or equal to the pre-investment amount.[20]

Because OBF tends to favor bill-neutral arrangements, they’re usually paired with energy efficiency projects. The high capital costs of some microgrid components means that few, if any, projects can be exclusively financed this way. However, this type of funding may still have a role to play in the financing mix since energy efficiency measures and retrofits can and should be one of the first phases of any microgrid project.

4.4.9 Design, Build, (Own), Operate, Maintain (DBOOM)

A DBOM/DBOOM contract (ownership is optional) is typically a combination of several of the above financial mechanisms and essentially turns the entire project into an outsourced solution. It means that the builder will need to approach the project from a complete lifecycle perspective rather than a “one-off” construction contract. The two largest advantages are a significant reduction in customers’ management efforts for both construction and operations as well as a very good alignment of incentives. External management of facilities allows customers to focus on their core services. If the same firm designs, builds, and operates the facility, the firm is better incentivized to make choices in design that reduce the total cost of ownership. Its time horizon is now measured in decades rather than just a couple of years.

Third party ownership also offers advantages to private sector customers: the possibility of qualifying the project for tax-exempt purchasing and financing, and the ability to hold their stake in the assets off their books.

Of course, just because a project is outsourced and competitively bid does not mean there aren’t risk factors. As with any such contract, customers should hire subject matter experts to represent their interests.

4.4.10 State Green Banks

Some state governments have established agencies to issue and oversee debt for clean energy projects. These are intended to be niche players that typically only fund proposals that cannot be funded normally. Green Banks are not usually intended to compete with commercial lenders. Their mandate may include projects that have technologies that are too new for banks to feel comfortable with, where transaction costs are too high under current conditions, or where traditional lenders are looking for a loss prevention alternative.

4.5 Ongoing Maintenance

Any building that connects to an electrical or gas utility will have some line of demarcation for maintenance of the physical connections. This may occur at the property line, on the customer side of the meter, or some other point.

Ensure that maintenance for all sections of the microgrid has been planned for. Any microgrid infrastructure that is “behind the meter” will typically not be maintained by the utility company. This could mean the entire microgrid depending on the specific implementation. Any distributed energy resources, interconnection equipment, cabling, conduit, or other behind the meter sections not covered by either a PPA or DBOOM contract (see previous section) will have a maintenance component to them. Ensure that an inspection and maintenance plan is in place for every aspect of the microgrid, and that an appropriate cost-sharing plan is in place for the common components.

There are often third party contractors available to cover such work. Conduct a complete benefit-cost analysis for in-house vs. contracted maintenance. Ensure that labor management costs are part of that equation. Also consider the lifecycles of the various components. Generation assets may have a lifecycle of 10-20 years but well maintained underground piping lifecycles are typically much longer than that.

4.6 Ownership Structure

It may be desirable to have some or all of the microgrid under the umbrella of an ownership structure different from one or more of its customers. It could take the form of a publically-owned municipal entity, corporation, non-profit, or public-private partnership (PPP). Each locality will a have a different set of financing, tax, and incentive considerations. All of these should be taken into account when deciding what ownership model(s) to use.

For example, municipalities cannot make use of PACE Financing, section 179 tax credits, or accelerated depreciation, while private companies cannot issue tax-exempt bonds. Municipalities may also be constrained by certain staffing models that don't mesh well with the management of a microgrid.

5 Coalition Building

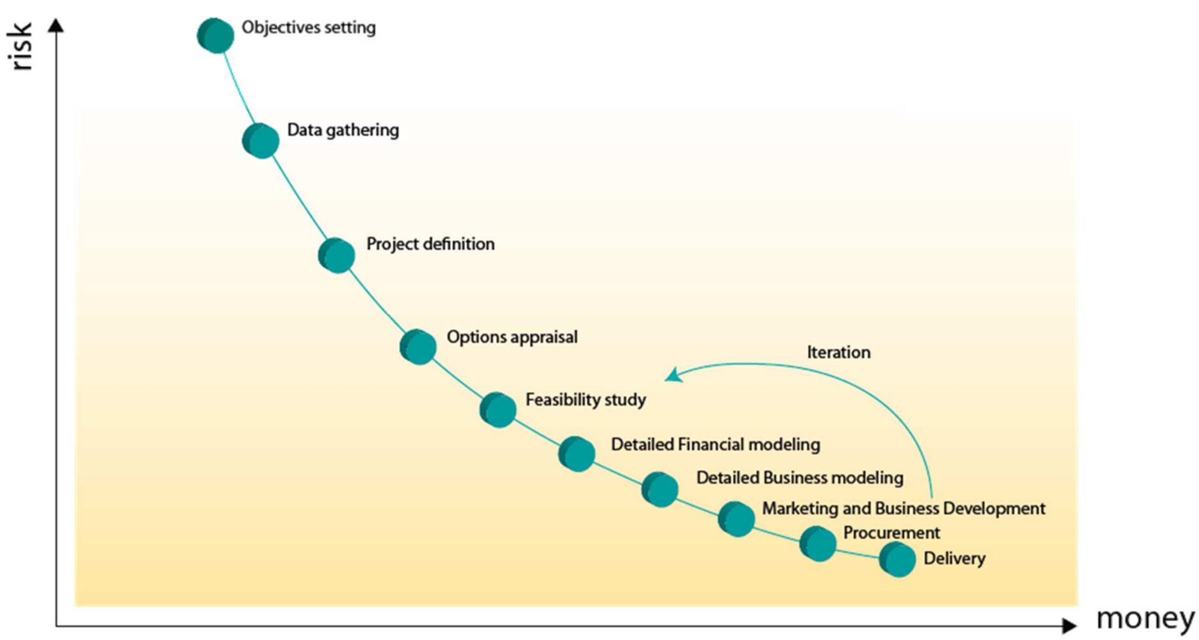
Community microgrids and district energy systems provide stakeholders, service providers, and end-users the means to achieve specific objectives such as:

- Energy efficiency and cost savings
- Economic competiveness derived from sustainable residential, commercial, and institutional assets
- Carbon footprint reduction and energy security
- Use of local resources and sustainable community development
- Reliable and resilient local energy infrastructure that enables business continuity

A dedicated "champion" is key to the success of a microgrid/district energy project and its journey from concept to completion. The champion has the longer-term vision and the determination to leverage resources and stay the course. Ideally, this is a paid staff position whose job description is clearly allocated to this effort. Volunteer or other unpaid staff can often find it difficult to stay engaged over the long gestation period that's typical of these large-scale developments.

While a champion often works tirelessly to address and overcome the hurdles involved, coalitions create the means of achieving a coordinated approach to pool expertise and resources. They can develop effective ways to help achieve the outcomes and objectives of the project and also create opportunities for collaboration and public/private partnerships.

Coalitions provide the project and the champion with the right partners needed at various phases of decision-making during the projects flight path (see the below figure[21]). Risk decreases over time as it becomes possible to collect more detailed information and firm up project costs as the project progresses through its development stages.



In order to reap the benefits of the coalition, it is important to recruit the right people and devise a set of objectives and activities that provide the motivation for members of the coalition to participate effectively. While the specific partners in a coalition may vary by project, the following list provides potential candidates for the coalition:

- Community/City Planning, Energy, Economic Development and Sustainability Staff
- Elected Officials – Mayors, City/County Managers, Governors
- Urban Planners, Architects & Engineers
- Building Facility Managers
- Local District Energy Providers
- Local Utilities
- Potential Developers including:
  - Local governments
  - Campuses and institutions (university, hospital, industrial parks)
  - Other public sector developers such as housing authorities
  - Property developers, landowners and building managers
  - Private sector developers

Each member of the coalition can provide expertise and information such as strategic plans, business models, technical know-how, climate action plans, sustainability guidelines, planning documents, and energy use data. It is important that the governance structure be transparent and clear and that the coalition moves the project forward on its intended path.

6 Municipalities and Urban Policy

Municipalities can serve as the catalyst for launching and sustaining environmentally superior and economically viable microgrids. They can be active partners in the microgrids (direct stakeholders) or play an indispensable role as a facilitator of multiple interests, a conduit to resources and economic incentives and as a source of advocacy.

This section will discuss specific measures that a municipality has available to spur microgrid project development and includes examples of district energy/microgrid zones already created. Zoning is one powerful tool at the municipality's disposal. Municipalities can offer additional development rights (higher densities, more floors) in exchange for the development of low energy buildings and neighborhoods.

6.1 Strong, Resilient Cities

Municipal and business leaders are focusing attention on improving the energy resiliency of their towns and cities. Communities are facing growing economic, social, and sustainability challenges and elected officials are increasingly interested in local energy production as a means of addressing them. The resilience of energy infrastructure in the face of extreme weather events is of particular concern. As community leaders are delegated ever more responsibility for addressing these matters they are looking to local energy projects; such as microgrids and district energy systems with CHP, as an effective response.

6.2 Energy and City Planning

Energy production, delivery, and use is a significant driver for the health and welfare of residents, the growth and development of business, as well as energy stability for cities and communities of all sizes. Until recently, for a majority of property owners, businesses, and local governments, energy has been viewed as little more than a bill to pay. Similarly, land-use planners and property developers not necessarily focused on the energy requirements of tenants, residents, and building owners. But a growing recognition of the ability of alternatives to manage energy costs, concern about national and local energy security, and threat of climate change are increasingly focusing attention on local energy opportunities.

In a number of states and local jurisdictions, access to low-cost, long-term capital, and other energy and environmental policies have opened up unprecedented opportunities to make money, restore budget cuts to core missions and activities, and put assets to more productive use, while meeting wider social and environmental objectives. To take advantage of these benefits, many municipalities and other public sector organizations, as well as businesses and landowners, are actively considering becoming energy producers as well as consumers by developing energy projects themselves, or by forming partnerships with the private sector to develop more sustainable properties and communities.

The potential to reduce emissions and energy costs can play an important role in city building, guided by growth and development decisions, as well as broader community objectives associated with sustainability and economic development. In these settings, communities can describe areas where there are opportunities to locate thermal energy facilities close to potential users and link them. Linking sources and users through a community energy network can improve capital efficiency, conserve space, improve operating efficiency through better load management, and create opportunities for community-scale resource conservation and energy efficiency. By doing this the subscribers to the community energy services can experience both health and financial benefits compared to traditional generation and delivery of energy. For example, manufacturing facilities may generate excess heat that can be supplied for the benefit of others in a district energy network. Similarly, large occasional-use facilities such as convention centers, stadiums, and arenas may allow the redirection of under-utilized energy capacity to surrounding buildings.

Many communities already have Climate Action Plans, and revisiting those to integrate microgrids and thermal energy considerations can open up a range of new opportunities. In cities that have a comprehensive plan, or a plan for new development, or redevelopment of a specific area, municipal leaders may be able to consider that plan in the context of local energy generation potential. Many cities are planning new development areas and revitalizing aged industrial areas by undertaking urban renewal or brownfield projects that would benefit greatly from a community based energy system.

Assessing the potential value and impacts of local energy in order to become a project champion, sponsor, or developer requires a general understanding of the opportunities. A perceived lack of skills, money, or understanding of the project development process can seem like daunting obstacles. Crucially, public project managers will need to adopt the commercial approach of a private developer. Land-use planning has a role to play in supporting project proponents in the early stages by mapping energy opportunities, sourcing, and providing data.

6.3 Energy Mapping

An energy map is a tool that can be used to organize/present data as the basis for defining energy character areas as part of an energy planning process. Energy maps are commonly used in planning departments across Europe as part of a broader community energy planning (CEP) initiative, and have recently begun to gain traction in North America. While energy maps are not a prerequisite to project development, they can help:

- Identify opportunities for new energy projects
- Determine suitable technologies and approaches to energy generation, distribution, and supply
- Highlight opportunities to link to other projects or share energy centers
- Aid decisions about prioritizing projects

Energy maps provide evidence for moving forward with a community based energy project and the basis for rational decisions to support planning policies. They also provide information for local infrastructure plans. Project proponents can choose to use one as a starting point for energy strategies for new developments and/or revitalization projects, and to highlight possible or priority projects.

Energy maps can also be used to define energy character areas, where the particular characteristics of an area are used to define the appropriate energy solution or planning policy. For example, mature residential suburbs are usually lower-density areas with little mix of use and many owners. These areas may be most suitable for micro-generation technologies (small, often building-integrated technologies, such as solar power). In contrast, city center locations have a higher density of buildings with a mix of uses including offices, shopping centers, hotels, and public buildings. While there still may be many different building owners, they usually have standardized decision-making processes for procuring energy services. Areas such as these can develop large-scale heating and cooling networks served by CHP plants, with islanding capability.

In this way, energy maps can illustrate energy character areas and help project proponents make good investment decisions and plans, whether at the single-building, neighborhood, or city scale. Energy maps can be an overlay to zoning and use-planning so that appropriate uses are targeted and concentrated.

Most energy maps are based in a Geographic Information System (GIS) platform, and are often prepared at the local or municipality scale. An energy map might be used in a variety of ways:

- Energy strategy: a map could form the starting point for the energy strategy for a development by identifying energy options
- Identifying energy solutions: a map can identify likely energy solutions, such as implementation of a district energy network, as part of an urban renewal project
- Priority projects: the map might point to possible investment opportunities for a project proponent
- Inform growth options: maps provide information that can aid decisions on the allocation of development sites
- Exclude inappropriate areas: for example, where nature conservation or landscape character are concerns

There is no single defined process for preparing an energy map. The project proponent will determine the level of detail necessary. For a given area, a map might include:

- An assessment of existing building energy demands and energy installations as a baseline
- Projected locations of new development at different stages in the planning pipeline, and an assessment of how this will affect energy demands over time
- The availability of potential local and renewable fuels
- A heat map, showing the location of large public buildings and other anchor loads

See “Power Play: an Energy Map of New York City” for one interactive example.[22]

6.4 Planning Policy for Microgrids and Community Based Energy Systems

The planning process has a significant influence over a community’s ability to develop successful community based energy systems. Accounting for the conservation of energy in land use is imperative for achieving local, regional, and provincial goals associated with infrastructure, the environment, and energy resource management. Planners have a suite of tools at their disposal to shape and guide nodes of development, urban form, density, and land use as a means to support the development and expansion of district energy systems.

6.5 Factors Influencing the Built Form of Cities

Historically, the built form of many North American cities has been influenced by abundant, low-cost energy. Low-cost energy supply has prompted many middle-class North Americans to move away from the urban core, accepting longer commute times in exchange for lower housing prices. This has left a mark on the built form of many communities, developing regions of scattered single-detached, single-use development. Dispersed, low-density development makes providing frequent transit service difficult and increases the use of private automobiles. Another factor influencing the shape of North American cities has been the prevalence of large-scale, centralized energy production.

Energy planning in the 20th century was typically the responsibility of government agencies, particularly at the state level. Large-scale generation facilities were viewed favorably, on the assumption they would achieve economies of scale through centralization and large capital investments. The result has been a monopolistic procurement model, where decision-making around energy planning is removed from energy end-users and centralized in the hands of a few large-scale producers and government agencies. This energy model has allowed consumers to locate at almost any distance from a generator, with regulation keeping electricity prices low and removing the need to consider proximity from homeowners and businesses. More recently, energy price volatility, as well as vulnerability associated with weather related events, has alerted producers, consumers, and decision-makers to the implications of energy scarcity in meeting local demand.

6.6 Shaping the Urban Environment for Community Based Energy Systems

In contrast, urban environments with their higher density, compact, urban form, and mixed land use represent the greatest potential for the development and expansion of community-based energy systems. Major urban centers are now encouraging concentrated development and increased density within existing urban boundaries to protect productive agricultural and environmental lands outside city limits, while maximizing infrastructure investment.

Planners influence the location, form, density, and uses of future development, and can therefore shape the city building process to maximize the potential for microgrids and district energy systems. In particular, they should take a proactive position in the early identification of nodes of activity which could support community-based energy systems. Municipalities should try to incorporate the development of community-based energy assets in their official plan documents. More detailed direction can be provided within neighborhood-specific or secondary plans. Local officials, developers, and industry should collectively identify opportunities to concentrate urban form and leverage sources of waste heat. Infill and intensification efforts can be used for community based energy system development by requiring new development applications to undertake a study to determine the feasibility of energy asset connection, such as district energy, within a serviced area. In some cases, identifying a single, large thermal user can act as a catalyst for microgrid and district energy development. Encouraging compact development will improve the efficiency of community based energy systems while reducing capital costs.

6.7 Planning Tools for Community Based Energy Systems

Municipalities have a number of tools and resources available to encourage the development of community-based energy systems. Official plans provide the authority for municipalities to implement specific policies through the review and processing of development applications. Zoning bylaws capture potential land uses within a municipality. Planners can zone for, dedicate, and/or assemble lands for energy facilities. Community improvement plans, zoning activities, and powers of subdivision offer the opportunity to review community energy proposals. Achieving energy planning considerations in the development review process often requires the official plan to provide an energy vision based on objectives outlined in supporting legislation, accompanied by a zoning bylaw that specifies targets for development approval.

6.8 Bylaws and Regulations to Encourage Community Based Energy Systems

Several communities across North America have developed "district energy zones" – areas or neighborhoods with an existing or planned district energy service that require new developments to connect. For example, the City of North Vancouver requires all new development applications in excess of 1000 m^2 to connect to the Lonsdale District Energy Corporation system.[23] In exchange for connection and increased efficiency, developers receive a density bonus to increase saleable floor area. In some cases, mandating connection may not be possible. In these instances, district energy pre-feasibility studies can be required as part of the site-plan approval process. Municipalities can also designate local improvement areas, with a specific levy added to property tax to offset part of the district energy system capital costs.

Any sort of bonus permissions or incentives should be acknowledged upfront in the official plan and/or zoning bylaws. The permissions must be in place and vetted through a public process for acceptance, to avoid creating an unfair development advantage. Engaging stakeholders early on in the development process regarding the opportunity for a district energy or other community based energy system is critical. In order to capitalize on potential opportunities for connection, timing must be considered with respect to the development of the new energy asset, age of existing equipment, and connections to new services.

Depending on the jurisdiction and project objectives, some or all of the following planning policies and tools may be applicable:

- Establish dedicated district energy zones or service areas and consider mandating connection to the system within these zones. At a minimum, require a district energy connection feasibility study as part of the site-plan approval process for all new developments larger than 1000 m^2. Interconnection to district energy and CHP systems should be predictable, consistent and transparent
- Ensure zoning bylaws, site development/application process, subdivision and new development approval processes support the development of district energy systems. For example:
  - Use energy mapping, zoning bylaws, and site-plan approvals requirements to locate heat sources near identified heat sinks, and concentrate density in dedicated district energy service areas
  - Reduce permit fees and expedite approval for projects that meet community energy priorities
- Incorporate consideration for GHGs and energy demand into the land-use planning and development processes. Provide tools to assist municipal governments with the measurement and evaluation of GHG emissions
- Targets for energy efficiency or GHG reductions might be measured by achieving an energy density expressed as J/m^2 or MWh/hectare

- Require total cost assessment of new developments and adjust development charges to account for all new infrastructure expansions (typically intended to recover costs for maintenance of roads, water services etc.)
- In some jurisdictions, additional capital costs for infrastructure can be recovered through supplementary charges on property taxes
- Provide cohesive integration of land use, energy, and transportation into all planning documents, identifying nodes of planned development with density and floor space thresholds that could support district energy
- Remove policies that compromise the ability to advance district energy systems, such as restrictions on mixed-use developments in urban environments

See the sample zoning language from Vancouver[24] for an example.

6.9 Planning for District Energy-Ready Buildings

In many cases, it makes sense to explore opportunities for microgrids and district energy systems in tandem. Various steps can be taken to ensure future development is compatible with existing or planned community-based energy assets.

Currently housing developers are largely focused on provisions in building design, whereas district energy is more about energy demand and servicing. Heating systems based upon natural gas (forced air) or electricity (baseboard heaters) are well established, and installing them in new buildings have become the default options for developers. If district energy infrastructure is not already in place, it requires a greater degree of upfront evaluation.

6.10 Encouraging District Energy-Ready Buildings through Planning

Planners have a number of tools to encourage district energy ready (DE-R) buildings by ensuring proposed building design and systems are compatible with district energy:

- Green building or neighborhood standards. New buildings in a specific district energy zone could be required to demonstrate at least 25% energy efficiency improvement over the building code. A standard that sets an electricity conservation target will discourage the use of electric heaters. A renewable energy target will discourage the use of natural gas forced air, although such a target alone will not be effective if the source of electricity is hydro (renewable) or if the district energy system is gas fired
- Where the development of a district energy system is planned or anticipated, all new buildings or retrofits to buildings larger than 1000 m^2 or approximately 10,800 ft^2 (this may vary according to local conditions) should incorporate the following DE-R elements:
  - Hydronic HVAC system
  - Centrally located domestic hot water system in lieu of point-of-use heaters
  - Space allocated for an Energy Transfer Station (ETS)

DE-R building design can be negotiated and established through:

- Development agreements (e.g. Dockside Green, Victoria, British Columbia)
- Standard land-use covenants
- Prescriptive requirements for the site, such as energy conservation performance targets
- Development permit area guidelines with process requirements, such as DE feasibility studies or development permit checklists requiring site-level DE infrastructure

DE-R building design can be encouraged or incentivized through:

- Reductions in development cost charges or community amenity contributions
- Tax revitalization exemptions

- Streamlined approval processes
- Development permit area guidelines encouraging or incentivizing hydronic heating or cooling infrastructure within buildings

Once a system is operational, a service area bylaw can require buildings to connect. It is recommended that the municipality own a majority portion of the community-based energy system or heat source when establishing a service area bylaw. Some municipalities have offered financial assistance to developers to help cover the "premium" associated with installation. This may be reduced substantially if a building also requires cooling.

7 Legal & Regulatory

Microgrids will be required to comply with a variety of existing municipal, state, and federal requirements. In many jurisdictions, the exact regulatory requirements are uncertain and this uncertainty creates a hurdle for microgrid development. However, as the value proposition of these and other distributed energy resources becomes known around the country, more and more regulators are looking at new frameworks that minimize regulatory uncertainty regarding microgrids. This section will survey existing legal and regulatory frameworks surrounding microgrids, while also noting some areas where a more favorable regime can be pursued.

7.1 Interconnection

In order to interconnect with the wider electric grid, a microgrid will require an interconnection agreement with the incumbent utility. An interconnection agreement will typically state the technical requirements for the microgrid to operate in parallel with the utility's system, and often assess costs to the interconnecting customer-generator to pay for any upgrades that are necessary to the utility's system in order to safely accommodate the customer's system.

Various states have set out different interconnection rules and procedures. A typical interconnection standard prescribes:

- What a customer must put into the application for interconnection
- How long the utility has to review that application
- What kinds of studies can be required upon various showings of necessity
- How to assess the costs of those studies
- How to assess the costs of any utility system upgrades those studies justify

Another common feature of interconnection standards is incorporating the technical standards established by a third party agency, such as the 1547 series of standards adopted by the Institute of Electrical and Electronics Engineers (IEEE), so as to avoid legislatively prescribing technical requirements that may change or be sensitive to precise interpretations. Across the United States, forty-five States have different interconnection standards or guidelines. Some jurisdictions have adopted streamlined interconnection procedures for distributed generation projects below a certain capacity threshold. For example, New York has adopted Standardized Interconnection Requirements (SIR) for distributed generation projects with a capacity below 2 MW.

Interconnection standards and processes may change in the future as understanding of microgrids advances. New York, for example, is in the process of reviewing interconnection standards through the Reforming the Energy Vision (REV) proceeding and intends to raise the SIR threshold to 5 MW. The IEEE standards are also being reviewed to develop more closely tailored rules for microgrids.[25]

7.1.1 Advocacy: Interconnection

Microgrid developers would benefit from standardization, clarity, and cost control in the interconnection process.

Standardization

Standardization benefits developers in at least two ways. First, by knowing the technical requirements for interconnection before designing the microgrid, developers face less risk that a utility will require a costly redesign in order to connect. Second, and relatedly, by meeting the technical requirements for interconnection as part of the design, the developer reduces the need for a costly and time-consuming engineering analysis of the microgrid as part of the interconnection process.

Clarity

Generally speaking, interconnection becomes more complex in the microgrid context, and existing interconnection processes may not capture the full range of that complexity. To ensure safe operation with the macrogrid, the utility may require more information on the microgrid's internal controls, or visibility into its performance, than is typically required in the case of a single customer-generator.

The anti-islanding provisions of many interconnection requirements may also benefit from greater clarity, considering their application to microgrids that intentionally island a whole section of the utility's distribution system. Local interconnection procedures should be reviewed at the level at which they are issued – i.e., State legislature, regulatory commission, or utility – and appropriate application and review procedures established. Due to the varied nature of how these standards are promulgated, it is impossible to issue a uniform recommendation on the actors or procedures that should be targeted.

Cost Control

The cost of interconnecting a microgrid will depend on what upgrades are required of the utility's system to accommodate the microgrid's DER. These costs may vary based on where the microgrid is being built. Minimizing them may be possible by building a microgrid capable of providing services to the distribution system. Two types of effort may be helpful:

- Utilities may be required to provide certain grid information to developers to allow them to identify areas where interconnection costs are likely to be smaller. This effort could be accomplished by appealing to the regulatory authority and requesting a ruling to this effect
- A utility may be able to minimize the costs of grid upgrades where a developer can guarantee maintaining certain operational parameters (e.g. implement demand response and load following to keep power import/export within a certain range, or utilizing DERs that can provide distribution-level ancillary services like voltage regulation)

Developing microgrid-specific interconnection processes that identify these opportunities may help control interconnection costs in the future.

7.2 Power Export

Once interconnected, there are various means by which excess power in the microgrid may be exported onto the wider grid, and correspondingly, different ways in which a microgrid may be compensated. For example, a microgrid could enter into a PPA with the incumbent utility. In this case, the rate for excess energy provided to the wider grid could be either the retail rate, the wholesale rate, or something in between. In the case that a microgrid qualifies as a "Qualifying Facility" under the federal Public Utility Regulatory Policies Act ("PURPA"), then in general, the incumbent utility will be required to purchase the excess energy from the microgrid unless the microgrid has nondiscriminatory access to the wholesale electricity market.[26]

Alternatively, in some jurisdictions, a microgrid can export excess electricity under a net metering regime, where excess electricity exported onto the grid will typically be credited to the customer-generator's next utility bill at a rate that reflects all or some portion of the retail cost of that electricity. Various net metering rules often distinguish between different types of generation so that, for example, solar generation may receive a more beneficial credit rate than a combined heat and power (CHP) system. Alternatively, some types of generation may be ineligible to receive net metering credits at all. These discrepancies may tend to make exporting power from a microgrid with several different types of generation sources problematic. One solution may be to independently meter the different sources of generation so that they can be accounted for separately, with output of the specific generation type "mapped" to the relevant net metering policy. How to resolve this tension so that microgrids with multiple types of generating resources straddling different regulatory statuses will not be excluded from participating in net metering is an open question in many jurisdictions. In addition, in some jurisdictions net metering is not available to some types of regulated entities. For example, in Massachusetts, net metering is not available to any entity regulated as an electric company, generating company, aggregator, supplier, energy marketer, or energy broker.[27]

Net metering policies exist in forty six States across the country. Most of these States have a uniform policy, though some States like Texas permit individual utilities to adopt policies while the State itself has no policy as a whole. Many of these policies also apply only to investor-owned utilities, and not to municipal utilities or electric cooperatives. These policies permit a variety of different generating resources to participate with a variety of types of compensation. For example, twenty States permit combined heat and power systems to net meter. In those that don't (and some that do), a feed-in tariff may also provide financial incentive for on-site CHP, such as California's CHP FiT.[28]

7.2.1 Advocacy: Power Export

Microgrid developers may benefit from net metering policies that:

- Allow microgrids to utilize all forms of distributed generation without discrimination in the form of net metering eligibility or differing credit rate
- Set the credit at retail rate
- Set the credit at a similarly beneficial value-based rate[29]

Typically, net metering policies will be either legislatively prescribed or promulgated by the State's utility regulator. Lobbying efforts for these policies should be targeted at the appropriate authority.

7.3 Rights of Way and Franchise

In some jurisdictions, utilities are granted monopoly rights in their service territories, so-called "franchise" rights. In these territories, non-utility entities are prohibited from delivering electricity. The form of this prohibition varies by jurisdiction. In some jurisdictions, a non-utility entity is prohibited from delivering electricity, in the engineering sense, across a public right-of-way. In these jurisdictions, there is little, if any, limitation on electricity service on private property. In other jurisdictions, however, non-utility entities are prohibited from transferring ownership and control of electricity, irrespective of whether such transfer occurs across a public right-of-way or on private property.

Exceptions to a utility's monopoly are also highly jurisdictional dependent. In New York, for example, a municipality can typically issue a competing franchise or other consent in a utility's service territory which would allow a microgrid to cross a public right-of-way;[30] in Massachusetts, by contrast, only the utility itself can consent to a microgrid that infringes on the utility's franchise.[31] Franchise issues may be avoided in cases where the microgrid utilizes existing utility infrastructure to wheel power between microgrid users. Note that use of a utility's existing infrastructure may impact the microgrid's ability to operate in island mode. Be sure to investigate this and weigh it accordingly in any benefit-cost analysis. In such a case, the contractual and service relationship between the utility and the microgrid users may adopt many forms: a microgrid "wheeling" charge, a net metering arrangement that shares credits among all sites, etc.

7.3.1 Advocacy: Franchises

The most effective markets for microgrids will develop where utilities do not have an effective veto over projects that implicate their franchise rights. The grantors of a franchise, a competing franchise, or a lesser consent are typically at the municipal level. These local authorities should be approached to ascertain the type of consent required to operate a microgrid that distributes powers over public rights of way, and involve the utility to the extent necessary to either negotiate for consent or modify the utility's franchise to make it nonexclusive.

7.4 Standby Tariffs and Exit Charges

Standby rates are utility rates that a customer pays to interconnect with the utility system while producing its own power. They are often set utility by utility, though several jurisdictions have State-wide policies, and are designed to compensate the utility for the cost of fixed transmission and distribution assets that the customer might not otherwise pay for but must nevertheless be maintained for the customer to use the grid as its "backup." The cost of standby delivery *strongly* affects the economic viability of the DG technology in instances when the customer does not completely disconnect from the grid, as is the case with most microgrids.

Generally, a utility customer will pay a tariff in the form of a monthly demand charge. This is an additional fee to any electrical generation charges for actual electricity used. Some utilities require a customer to contract for the measured peak electrical output of the customer's onsite electrical generator, which can inequitably affect the economics of a project that might shed load in the event it switches to grid power. Other utilities may fix the charge based on a customer's peak demand. In the microgrid context, where all of the customers served by the microgrid can interact as a single controllable entity to the grid, it is important that the coincident peak of all customers be measured, and not the aggregation of their individual peaks, which may not coincide.

Microgrid developers would be benefited by standby rates evolving towards a comprehensive valuation mechanism that bases cost and compensation on performance, taking into account the diversity and redundancy of supply built into the microgrid.[32] Reformation of these rates should take place at the level at which they are issued, which varies jurisdiction.

7.5 Emissions

Microgrids are required to comply with federal and state environmental laws, including laws and regulations related to air pollution. The Federal Clean Air Act requires pre-construction environmental permitting of new stationary facilities in order to meet the goals of the National Ambient Air Quality Standards (NAAQS) program. The "criteria pollutants" regulated under this program that are of greatest relevance to DG are nitrogen oxides (NOx) (as a precursor to ground level ozone or smog), carbon monoxide (CO), sulfur dioxide (SO2), and particulate matter (PM). NOx is the primary (and often the only) criteria pollutant that significantly affects most DG projects.

Although the permitting process is established and regulated under federal law, it is administered, in most cases, by the States. This leads to a high degree of variability in implementation, ranging from no control requirements to extremely stringent levels of control.

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. 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. Emission levels will be measured by a source's "potential to emit," or the source's maximum possible emissions if operated at full capacity for 8,760 hours per year.

- "De minimis exemption" refers to the fact that most states have a threshold below which units are either too small or emit a small enough amount that they do not have to apply for a permit of any kind. The requirements and conditions for these exemptions vary by state, but most states allow some kind of de minimis exemption. Sources that are not exempted must obtain a permit
- Sources that fall in between the de minimis and the major thresholds are generally subject to state minor source permitting. Both the minor source permit and the major source permit are likely to require some kind of emission limitations or controls. These control requirements could be anything from raising the stack height of a unit to installing the most stringent control technologies available. The permitting process also can range from a simple application to a complex cost-based technology evaluation. The requirements vary depending on the state and the type of unit proposed
- New or modified sources that exceed certain potential emissions thresholds are called "major sources" and are subject to the federal New Source Review program. This level of preconstruction permitting will require the application of either "Best Available Control Technology" or the "Lowest Achievable Emissions Rate"

In addition, greenhouse gas emissions may be regulated in the Northeast under the Northeast States' Regional Greenhouse Gas Initiative, or in California under the State's Cap-And-Trade program.[33] The applicability of these requirements depends upon the capacity of the distributed generation source and the technology it employs.

7.6 Building and Fire Codes

Code development and enforcement is a patchwork of state and local regulations. There tend to be few provisions in existing standards, codes, and building construction regulations that address either traditional or emerging distributed generation technologies. This limitation, combined with a lack of familiarity on the part of many local code enforcement officials, can create significant additional cost for a developer through cumbersome site-specific testing, evaluations and approvals.

Issues likely to affect a microgrid include:

- **Zoning and building codes:** While many permutations of zoning concerns are possible, common ones include overly restrictive rules dictating where generation can be sited, height restrictions, lot coverage limitations, and setback requirements that may not allow for the placement of solar panels or small wind installations on existing rooftops or building sites. Silence in "permitted use" sections of a zoning code that can, in effect, prohibit on-site generation or storage. Municipalities should review applicable zoning codes and local homeowners' associations' covenants and consider removing or altering those that unintentionally impede microgrid development within the municipality's jurisdiction. Municipalities can also create a variety of incentives to encourage microgrid development including conditional zoning variances (e.g., floor and area ratio bonuses for incorporating various DER), flexible building standards (e.g., granting points in a green building standard for incorporating DER), and streamlined permitting processes. These actions can help make microgrids more economical and the development process more straightforward
- **Mechanical/plumbing codes:** Many localities will not allow a gas-fired unit to be installed unless it is listed as a gas appliance by an approved agency. Subsequently, exemption must be sought through the use of a "Registered Professional Engineer who will submit a report declaring the installation meets all applicable standards and is in safe operating condition"
- **Fire codes:** Under many fire codes, an analysis of the fuels flammability and combustibility must be performed for many generation sources. The fire department will need to know where a unit is located and how to disconnect the unit in case of a fire. The installation of a fire suppression system may be required[34]

8 Appendix A – For Further Reading

8.1 Community Microgrids: Smarter, Cleaner, Greener

An introductory report on community microgrids and the many benefits they offer. It lays out a roadmap for communities considering microgrids from setting goals and identifying the vision for a project to choosing sites, completing analyses, acquiring financing, and getting approval to build. The report also considers the regulatory environment for microgrid development and offers recommendations for making the region friendlier to microgrids. This document should be read by municipal and community leaders, state and local government and regulatory officials, emergency managers, large business owners, and any other individuals interested in resilient, affordable, and clean energy.
http://energy.pace.edu/sites/default/files/publications/Community%20Microgrids%20Report%20%282%29.pdf

8.2 Community Energy: Planning, Development & Delivery

Aims to support mayors, planners, community leaders, real estate developers and economic development officials who are interested in planning more sustainable urban energy infrastructure, creating community energy master plans and implementing district energy systems in cities, communities and towns. The new guidebook provides an overview of the local energy project development process, in a form that is accessible to lay readers, to assist them in making informed decisions on the analysis, planning, development and delivery of district energy systems. IDEA engaged UK-based district energy specialist Michael King, author of the UK guidebook by the same name, to revise Community Energy: Planning, Development and Delivery for the U.S. market to reflect relevant national energy and environmental policies and incorporate current U.S. market conditions and policy drivers on a federal, state and local level.
http://www.districtenergy.org/community-energy-planning-development-and-delivery/

8.3 District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy

Argues that modern district energy is the most effective approach for many cities to transition to sustainable heating and cooling, by improving energy efficiency and enabling higher shares of renewables. Provides concrete policy, finance and technology best-practice recommendations on addressing the heating and cooling sectors in cities through energy efficiency improvements and the integration of renewables.
http://www.unep.org/energy/portals/50177/DES_District_Energy_Report_full_02_d.pdf

8.4 US Department of Energy – Technical Assistance Partnership

The DOE's TAP provides a variety of support resources for CHP projects including free first level technical assessments.
http://www.energy.gov/eere/amo/chp-technical-assistance-partnerships-chp-taps

8.5 Qualified Energy Conservation Bond Case Study

Public Building Upgrades: Reducing Energy Bills in the City of Philadelphia
http://energy.gov/sites/prod/files/2014/06/f16/public-building-qecb.pdf

8.6 Powering District Energy Projects at the Eco-Districts Summit

http://ecodistricts.org/powering-district-energy-projects-at-the-ecodistricts-summit/

8.7 BC Hydro: Sustainable Communities Program

https://www.bchydro.com/powersmart/business/programs/sustainable-communities.html

9 Appendix B – District Energy/CHP Microgrid Case Studies

Ten District Energy/ CHP case studies have been selected to illustrate the multiple dimensions of Microgrids with CHP and District Energy. These are summarized below and will be attached as a separate document.

Location	Description	Country
Princeton University Princeton, NJ	Super resilient and islandable Campus District Energy/CHP/Microgrid with 5MW of integrated Photovoltaics. Leverages New Jersey Cogeneration Law to allow for wheeling of electricity across utility-owned wires to buildings also served by thermal energy from central plant.	USA
Coop City Bronx, NY	Privately owned 40 MW microgrid supplying power and thermal energy to mixed-use community of over 60,000 residents. Maintained 100% operation during Super Storm Sandy and back fed Con Edison electric grid during extended regional outage.	USA
Markham District Energy Markham, Ontario	Municipal utility providing hot water, chilled water and power to support economic development, mission-critical healthcare and new urban real estate development.	Canada
University of Massachusetts Medical School Worcester, MA	Mission-critical healthcare campus has expanded CHP capacity to provide power, steam & chilled water for enhanced resiliency. Recent project expansion was supported by grant from local utility and features significant emission reductions under MA Green Communities Act.	USA
New York University Manhattan, NY	CHP/district energy/microgrid provides primary energy, including thermal and power, to support urban oasis in lower Manhattan. Central plant maintained operations during Super Storm Sandy to prioritized campus buildings.	USA
District Energy St. Paul St. Paul, MN	Microgrid with renewable Biomass fueled CHP and District Heating and Cooling systems were financed by long-term municipal revenue bonds secured by long-term contracts with initial customers. Recent integration of renewables includes photovoltaics and solar hot water systems.	USA
Marine Corps Air Ground Combat Center Twenty-nine Palms, CA	Utilizing third party ESCO strategy, the largest Marine Training Base in the world integrated CHP and renewables to deliver highly-reliable energy for critical mission operations.	USA
Veolia Energy North America Boston-Cambridge, MA	New owner has invested in CHP to transform independent power producer asset into base load, low heat rate CHP to provide power and district heating to Cambridge/Boston thermal grid.	USA
Hamilton Community Energy Hamilton, Ontario	This geo-exchange based district energy system sits on a former brownfield site in Hamilton. It was designed, built and is operated by Hamilton Community Energy, a District Energy subsidiary of the City owned Hamilton Utilities Corporation	Canada
Helen Ltd. (Helsingin Energia) Helsinki	A for-profit company owned by the city of Helsinki, which supplies electric energy to nearly 400 000 customers in Finland and covers over 90% of the heat demand of the capital city with district heating. The power grid connection is self-healing and provides enhanced reliability and uptime through active feeds from two substations.	Finland

10 About the Authors

Dan Leonhardt, Senior Energy Policy Associate, Pace Energy and Climate Center. Dan's work focuses on increasing the deployment of clean distributed energy resources through rigorous policy analysis and direct community engagement especially on the topic of microgrids. In his former position as Assistant Director of Energy Finance and Sustainability Management at the NYC Housing Authority, he was tasked with increasing energy and water efficiency for over 600,000 low and moderate income residents of New York City. dleonhardt@law.pace.edu

Tom Bourgeois, Deputy Director, Pace Energy and Climate Center. Tom has been a leading thinker on distributed generation, energy efficiency, renewable energy, and region economic development for over two decades. An economist by training, Tom manages the Center's Community Energy program, which brings his areas of expertise together to fashion cutting edge energy solutions like microgrids. Tom also is co-director of the U.S. Department of Energy's Northeast CHP Technical Assistance Partnership. tbourgeois@law.pace.edu

Brad Bradford, Community Energy Planner, International District Energy Association (IDEA). Brad is an urbanist and energy professional, with a belief and understanding that investment in cities and critical infrastructure will be the solution to some of the 21st century's most pressing problems. An urban planner by training, Brad's portfolio includes advocacy work with provincial and state governments, capacity building with community members and municipalities, ongoing involvement with energy and infrastructure research, and other initiatives at the intersection of city building and thermal energy solutions. brad.idea@districtenergy.org

Jordan Gerow, Staff Attorney, Pace Energy and Climate Center. Jordan has written on the legal hurdles to microgrids extensively, contributing to state studies on microgrids for critical infrastructure, and advising communities across New England on the frameworks required to make microgrids a reality. He has contributed to the Center's work in the REV proceeding and multiple utility rate cases where microgrids have been proposed. jgerow2@law.pace.edu

Nick Martin, Energy Policy Associate, Pace Energy and Climate Center. Nick's work is focused on accelerating deployment of distributed generation and microgrids in the Northeast and Mid-Atlantic regions. He conducts research and analysis on economic, legal, and regulatory issues to help communities fully capture the benefits of distributed generation and microgrids. nmartin2@law.pace.edu

Laxmi Rao, Director of International Programs, IDEA. Laxmi has over 30 years of experience in the fields of CHP, district energy, metering and controls, sustainability, information systems and technology, and project management. In addition to developing the technical program for IDEA's conferences and workshops, she also manages grants and the development of tools to support district energy, microgrids, and CHP. She has also worked on renewable energy, water conservation and Green IT projects, served on MIT's Campus Energy Task Force, and has developed technical and energy planning tools for US Department of Energy's CHP Technical Assistance partnerships. laxmi.idea@districtenergy.org

This paper benefitted from the review and comments of:

Justin Fung, Pace Energy and Climate Center

Pearl Gray, Pace Energy and Climate Center

Seth Hoedl, Summer Fellow, Emmett Environmental Law Clinic, Harvard Law

Dr. Jonathan Raab, Raab Associates, Ltd.

Travis Sheehan, Boston Redevelopment Authority

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All links are valid as of June 15, 2015

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[5] Page xii, http://emp.lbl.gov/sites/all/files/value-of-service-reliability-final.pdf.pdf
[6] Patriot Act of 2001 Section 1016 (e)
[7] US News and World Report: Federal appeals court blocks EPA rule that exempted backup generators from pollution controls http://www.usnews.com/news/politics/articles/2015/05/01/appeals-court-overturns-rule-on-backup-generators. Full court opinion: http://www.cadc.uscourts.gov/internet/opinions.nsf/2E87E0199203E71B85257E3800500091/%24file/13-1093-1550129.pdf
[8] Systems designed without the ability to island safely from the main grid are required to shut down when the main grid is down to avoid back-feeding energy onto the grid and energizing infrastructure that utility maintenance may be repairing.
[9] The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs; March 25, 2014; Research Report U1402; http://www.aceee.org/research-report/u1402
[10] Pace Energy and Climate Center - Community Microgrids: Smarter, Cleaner, Greener at http://energy.pace.edu/sites/default/files/publications/Community%20Microgrids%20Report%20%282%29.pdf
[11] Id.
[12] Id.
[13] FERC Order 745, approved in 2012, calls for wholesale-market operators to pay the full market price, known as the locational marginal price, to economic demand response resources in real-time and day-ahead markets as long as dispatching DR is cost-effective and helps operators clear the market. In May 2014, the U.S. Court of Appeals in Washington, D.C. vacated the Federal Energy Regulatory Commission's Order 745 in a 2-1 decision after a challenge from the Electric Power Supply Association. Possible rule changes as well as challenges to this decision are still on-going as of March 2015. State demand response programs may still be available for microgrids.
[14] http://www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp
[15] See for example the Princeton Microgrid which receives payments for Ancillary Services in the PJM market, and MIT in the NE-ISO market. Similarly the Konterra project in Maryland is a business model that combines PV and battery storage, in a scheme that includes PJM market revenues.
[16] Con Edison's Brooklyn Queens Demand Management (BQDM) is one example of an attempt to avoid additional spending on distribution networks
[17] See for example the members of the National Association of Health and Educational Facilities Finance Authorities (NAHEFFA) at http://www.naheffa.com/index.html
[18] For background information see: http://www.pacenow.org/bring-back-residential-pace/ and page 58 of this document: http://energycenter.org/sites/default/files/docs/nav/policy/research-and-reports/PACE_in_California.pdf
[19] http://energy.gov/eere/slsc/qualified-energy-conservation-bonds
[20] On-Bill Financing for Energy Efficiency Improvements; American Council for an Energy Efficient Economy (ACEEE), Washington DC
[21] IDEA Community Energy: Planning, Development & Delivery http://www.districtenergy.org/assets/pdfs/Community-Energy-Dev-Guide-US-version/USCommunityEnergyGuidehi.pdf
[22] http://blogs.ei.columbia.edu/2012/02/13/power-play-an-energy-map-of-new-york-city/

[23] In accordance with Bylaw 7575, as amended periodically, any new building larger than 1,000 square meters is required to connect to the district heating system for heating purposes unless it is determined by the City's Director of Finance that the cost to the City for providing the service would be excessive. http://www.cnv.org/City-Services/Lonsdale-Energy/Standards-and-Requirements-for-Developers

[24] http://vancouver.ca/files/cov/neighbourhood-energy-design-guidelines.pdf

[25] See, e.g., IEEE Project P2030.7, Standard for the Specification for Microgrid Controllers, at http://standards.ieee.org/develop/project/2030.7.html

[26] 16 U.S.C. § 824a-3(a) (2), (m); 18 C.F.R. § 292.303, 309.

[27] M.G.L. c. 164, § 139(e); See also 220 CMR 18.06(1).

[28] See, e.g., California Public Utilities Commission, CHP Feed-in Tariff, California Public Utilities Commission, available at http://www.cpuc.ca.gov/PUC/energy/CHP/feed-in+tariff.htm (last modified Aug. 21, 2013).

[29] See, e.g., Nat'l Renewable Energy Lab., Value of Solar Tariff, National Renewable Energy Laboratory, available at http://www.nrel.gov/tech_deployment/state_local_governments/basics_value-of-solar_tariffs.html (Factors that affect [value of solar] rate may include: Utility variable costs (fuel and purchased power); Utility fixed costs (generation capacity, transmission, and distribution; Distribution system and transmission line losses; Ancillary services (to maintain grid reliability); Environmental impacts (carbon and criteria pollutant emissions).").

[30] See "Microgrids for Critical Facility Resiliency in New York," NYSERDA, at 37.

[31] See M.G.L. c. 164, § 1G(g).

[32] See N.Y. State Dep't Pub. Serv., Developing the REV Market in New York: DPS Straw Proposal on Track One Issues Case 14-M-0101, 1, 62 (Aug. 22, 2014), available at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BCA26764A-09C8-46BF-9CF6-F5215F63EF62%7D

[33] See California Environmental Protection Agency, Cap-and-Trade Program, State of California, http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm

[34] Id.

Microgrids & District Energy: Pathways to Sustainable Urban Development

Supplemental Material: Case Studies

Case & Location	Sector	District Cooling	Energy Storage	Renewable Energy	Page
Princeton University Princeton, NJ	University	Y	Thermal	Photovoltaics	1
Coop City Bronx, NY	Residential	Y			2
Markham District Energy Markham , ON	Downtown	Y	Thermal		3
University of Massachusetts Amherst, MA	University	Y			4
New York University New York, NY	University				6
District Energy St. Paul St. Paul, MN	Downtown	Y	Thermal	Photovoltaics, Solar Thermal	7
Marine Corps Air Ground Combat Center Twentynine Palms, CA	Military	Y		Photovoltaics	8
Veolia Energy North America Boston-Cambridge, MA	Downtown				9
Hamilton Community Energy Hamilton, ON, Canada	Downtown	Y			10
Helen Ltd. (Helsingin Energia) Helsinki, Finland	Municipal	Y	Thermal		11

Note that all case studies in this document are district heating systems; utilizing combined heat and power (CHP); can island from the electricity grid; and possess black start capability. Black start capability means that the CHP system is able to start independently from the grid by using power from a backup source.

Princeton University, Princeton, New Jersey

Market Sector: University **CHP / Photovoltaic Capacity (MW):** 14.6/5 = 19.6 Total

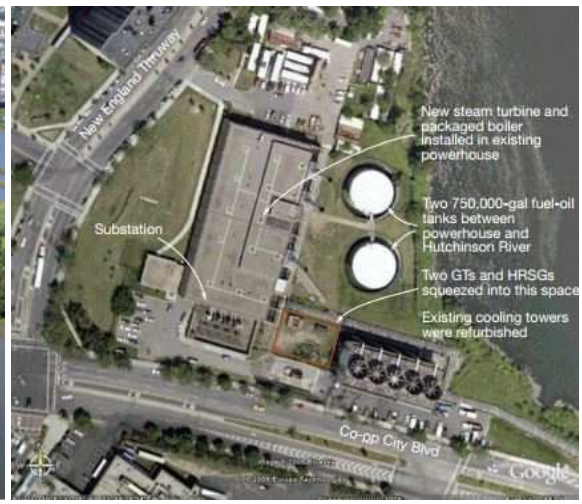
Princeton University's microgrid is noted worldwide for its resilience and sophistication. The Princeton University campus energy facility more than proved its worth when Superstorm Sandy lashed the eastern United States in October 2012. Over eight million electric customers lost their power. But the University was able to continue to power its essential buildings and operations and was able to keep the students dorms, library, all critical research centers, emergency response center, infirmary, and refrigeration powered up.

During the storm, the University was a beacon of light because of its microgrid – and the strategic vigilance of those who operate it. Seeing trouble coming as the storm bore down on New Jersey, the energy facility islanded, or disconnected, from the local utility, Public Service Gas & Electric.

The Princeton university system has four main components: steam boilers, water chillers, an electric generator, and a large Thermal Energy Storage (TES) system which stores 2.6 million gallons of chilled water that is produced during times when grid power is cheap and stored for use as needed. The Combined Heat and Power (CHP) plant and District Energy system provides a campus of 150 buildings, 9.5 million square feet and nearly 8,000 students with efficient heating, cooling and electricity. When New Jersey moved to real-time pricing in the electric market in 2003, Princeton upgraded its cooling systems and installed a cutting-edge monitoring and dispatch system in the campus energy plant. Depending on market prices, the Princeton system changes plant production strategies for electricity, steam and chilled water. During peak demand periods, Princeton reduces its electric load on the grid, which reduces stress on the grid and lowers demand costs. The campus further increases efficiency by using Thermal Energy Storage. In 2012, a 5.3-megawatt solar collector field was installed on 27 acres which Princeton owns in West Windsor Township. The system is comprised of 16,500 photovoltaic panels and reflects an extension of the Microgrid

The microgrid provides Princeton the flexibility to get out of the way and self-generate in an island mode during emergencies when the central grid is in trouble. In normal mode the university, benefits both operationally and financially. The facility can rely on the grid for back-up power should its own equipment fail. It can also hedge its power purchases based on real-time prices in the PJM Interconnection’s wholesale market. When wholesale prices are low, Princeton buys grid power; when power prices are high, it generates more power onsite. The onsite resources help ease pressure on the grid when power is in high demand. Using real-time power purchase management Princeton limits the amount of power it buys during the hours of the year when demand is highest in PJM.

Coop City, Bronx, New York



Market Sector: Large Urban Residential Co-operative **CHP Capacity (MW):** 40

Co-op City, sited next to the Hutchinson River in the Baychester section of the Bronx (New York City), is the largest single residential development in the United States. The 340-acre complex is home to about 60,000 people who occupy 15,372 residential units in 35 high-rise buildings and seven townhouse clusters as well as retail, houses of worship, day-care centers, and other amenities.

The reconstruction of its central district energy plant from 2004-2007 resulted in a robust, tri-generation facility with a combined heat and power microgrid connected to ConEdison and the facility produces annual revenues of $15-25 million from the sale of excess electricity to the utility. The investment for this microgrid was paid back after just five years, aided by the sale of surplus power back to the grid.

During Super Storm Sandy, the microgrid continued to provide electricity, heat, hot water and air conditioning for all residents, while neighboring areas sat in darkness.

Markham District Energy, Markham, Ontario, Canada

Market Sector: Downtown **CHP Capacity (MW):** 15.7

Markham District Energy (MDE) is a thermal energy utility owned by the City of Markham. It is the only district energy utility in Canada operating two thermal grid systems – Markham Center & Cornell Center within the same municipality. The systems are served from four Energy centers – Warden, Clegg, Birchmount and Bur Oak.

In the late 1990s, the deregulation of the Ontario power industry, the infamous 1998 Quebec ice storm, and IBM Canada's interest in locating a major facility in Markham Centre created a unique opportunity for Markham to develop a community energy system in step with its new downtown core known as Markham Centre, a community of over 30 million square feet of residential, commercial and institutional buildings.

Markham District Energy completed construction of the Warden Energy Centre in 2000 and commenced operations to its first customer, IBM Canada. Since 2000, nearly 6 million square feet of building space has been connected to the Markham Centre district energy system, reducing the City's carbon footprint and increasing customers' comfort compared to traditional electric resistance heating. This model of sustainability solution will serve all 41,000 residents and 39,000 employees.

During a blackout in 2003 which swept the eastern seaboard of North America, leaving nearly 10 million people in Ontario without electricity, Markham District Energy continued to function. Markham's investment in a cogeneration facility allowed the Town to continue providing heating and cooling to high-tech companies, such as IBM and Motorola.

MDE is committed to expanding its combined heat and power (CHP) fleet to match the growing thermal load in the City's district heating systems. MDE's first CHP unit (3.5 MW) was commissioned in 2001 at its Warden Energy Centre. MDE then won one of seven contracts awarded by the Province for CHP capacity resulting in the installation of the second CHP plant (5.2 MW) in 2008. In 2013 MDE's added CHP totaling 7.0 MW bringing its total capacity to 15.7MW.

CHP	Rating	Plant/System Location	Prime Mover	In-Service Date
G1	3.5 MW	Warden Energy Centre (Markham Centre)	Caterpillar G3616	2001
G2 + G3	5.2 MW	Warden Energy Centre (Markham Centre)	2 x Caterpillar G3612	2008
G4	3.0 MW	Birchmount Energy Centre (Markham Centre)	Caterpillar GC260-12	2013
G5	4.0 MW	Bur Oak Energy Centre (Cornell Centre)	Caterpillar GC260-16	2013
Total	**15.7 MW**			

Although Canadian municipalities are able to issue bonds, the actual application of municipal bonds is limited because of the challenges associated with obtaining the necessary provincial backing. Municipalities can, however, form private corporations which allow them to carry debt. For example, Markham District Energy is a private corporation whose sole shareholder is the city of Markham. Operating as a private business with municipal oversight has financial and management advantages.

As a private company, MDE can take advantage of tax advantages available to the private sector for the construction and operation of plants, such as a recently created accelerated write-off provision for certain types of equipment used to produce energy in a more efficient way. At the same time, as a wholly owned municipal entity, MDE can leverage sources of capital provided only to Canadian municipalities, such as the Green Municipal Fund.

University of Massachusetts Medical Center, Worcester, Massachusetts

Market Sector: University **CHP Capacity (MW):** 17.5

Hospitals and medical facilities are required to provide reliable, consistent care for their patients 24 hours a day, 365 days a year. This means that heating and cooling, hot and chilled water and electricity, also need to be reliable and accessible at all times. Unfortunately, storms, overloads and security breaches pose significant threats to the traditional electric grid and can result in grid failures and utility outages, putting medical facilities and their patients at high-risk. Microgrids with interconnected on-site power generation and district energy eliminate that risk.

While almost every hospital and medical facility has an emergency backup generator, CHP provides reliable energy independence from the electric grid and can seamlessly transition from on-grid to off-grid power. Using grid power and then switching to an emergency backup generator can cause patient care to stall, diagnostics to be delayed and losses in vital research due to temperature fluctuations. When off-grid power sources like CHP or district energy are used, these risks can be avoided. Backup generators often produce less electricity, less efficiently compared to CHP and district energy systems.

The University of Massachusetts Medical Center in Worcester is a 60-acre campus comprising a medical trauma center, school, and medical research center. It operates a 17.5 MW combined heat and power system. The Medical Center Microgrid utilizes a district energy loop which connects approximately 3 million square feet and provides electricity, steam, and chilled water to all buildings.

Completed in 2013, the new central plant expansion included the installation of a 7.5 megawatt, gas-fired combustion turbine and associated heat recovery system, which replaced the UMass Medical School's oil-fired steam boilers and added to the 10MW of existing CHP capacity. The new system produces 60,000 pounds of high-pressure steam per hour which is used to drive two of the plant's existing electric generators and feed the campus' steam distribution network to heat buildings and drive compressors that make chilled water for the campus' cooling systems. The expansion increased electricity, steam, and water-chilling capacity but actually reduced overall greenhouse gas emissions because the turbine is more efficient than the previous boiler system; this is despite the added energy load from the new buildings. The system operates at 80% efficiency and the thermally driven plant provides 58,000 MWh of annual electricity savings, or $6.2 million, creating a payback period of less than 3 years. National Grid granted UMass Medical School a $5.6 million incentive in support of the project.

The system was financed as part of a $450 million campus capital campaign, a result of integrating the system into the hospital's long-term master plan years prior to construction.

New York University, New York, New York

Market Sector: University **CHP Capacity (MW):** 13.4

Microgrids took a front seat during Superstorm Sandy in October 2012, proving their critical value in supporting resiliency and ensuring reliable power and heat supply.

The storm left over 8 million customers in the tristate area without power, and many communities lost power for weeks. Throughout Manhattan, over 250 large buildings were also without power for several weeks, and in many cases months, due to severe flooding that knocked out a power station in the East Village. But on the nearby campus of New York University (NYU), home to 38,000 students, the lights stayed on and buildings had heating, hot water, and cooling, thanks to a self-sufficient microgrid system designed to distribute electricity independently of Consolidated Edison's main grid network. The campus provided New York residents a safe and warm haven during the storm and emergency personnel were able to set up a command post to better assist with storm response.

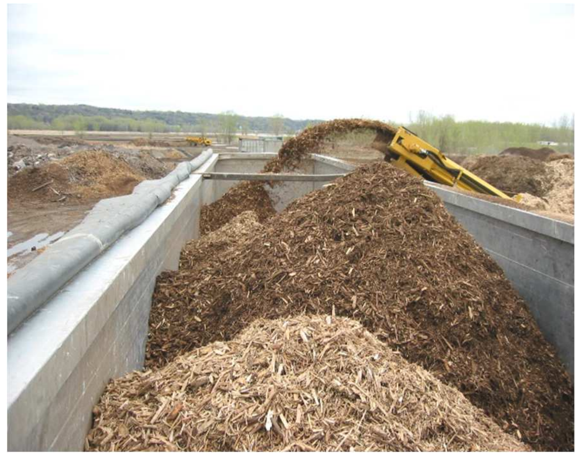
The Microgrid is anchored by a 13.4 MW CHP plant housed below Mercer Street. The system upgrade in 2011 resulted in a doubling of capacity with two 5.5 MW gas turbines and one 2.4 MW steam turbine. The steam capacity is 90,000 lbs. per hour.

The electrical and district heating and cooling systems supply electricity to 22 buildings and 100% of the heating, cooling, and water heating to 37 campus buildings. The CHP plant has an operating efficiency of 75 percent and prevents an estimated 43,400 tons per year of CO_2 emissions. By reducing demands on existing transmission and distribution infrastructure, the CHP system also helps support grid stability. NYU is also able to sell excess electricity to the utility when campus demand is low, resulting in additional revenue.

The upgrade of the plant has presented impressive results both economically and environmentally and has proven its benefits. NYU has evaluated savings on total energy costs to be $5 to $8 million per year.

The upfront capital cost of the upgrade was $125 million. However, tax-exempt bonds arranged through the Dormitory Authority of the State of New York and through NYU tuition and fees helped to provide low-cost financing sources.

District Energy St. Paul, St. Paul, Minnesota



Market Sector: Downtown **CHP Capacity (MW):** 25

District Energy St. Paul, one of several combined heat and power (CHP) plants in Minnesota, runs North America's largest hot water district heating system, in addition to distributing chilled water, and is fueled in part by wood waste. In March 2011 they added North America's largest solar thermal production to the system.

The system provides hot water service to 29 million ft^2 representing 90% of the downtown market. The District Cooling system serves over 17 million ft^2 and is supported by a thermal energy storage tank with a 6 million gallon capacity. An additional benefit of this thermal storage is the reduction of peak-electric demand by as much as 9 MW.

The CHP plant has a capacity of 25 MW (electric) and 65 MW (thermal equivalent) operates at double the efficiency of conventional power plants, and has been able to keep prices stable for customers.

Renewable clean urban wood waste is the primary fuel, but the system is fuel flexible and can also use natural gas, coal, and oil. Purchases of the municipal wood recirculate over $12 million in the local economy. The biomass wood waste displaces 275,000 tons coal per year and cuts land fill use while reducing CO_2 emissions by 280,000 tons per year. Connecting to the central plant has enabled the elimination of over 150 smokestacks at buildings and reduced sulfur dioxide and particulate emissions by more than 60 percent.

District Energy St. Paul’s for-profit consulting, operation, and management firm is Ever-Green Energy.

Marine Corps Air Ground Combat Center, Twentynine Palms, California

Market Sector: Military **CHP / Photovoltaic Capacity (MW):** 8/5 = 13 Total

Twentynine Palms, located in the Mojave Desert, is home to the Marine Corps Air Ground Combat Center, which is one of the largest military training areas in the nation. The base has a population of about 28,000 people – including military, civilian and families – and over 8 million square feet of facilities.

In late 2014, over half of all microgrids under development in the United States were on military bases. Utilizing a third party ESCO strategy, Twentynine Palms was able to integrate CHP and renewables into a software optimized microgrid in order to deliver highly reliable energy for mission critical operations.

Reliability and resiliency originally became a worry for the military base during the California energy crisis 15 years ago, which triggered many blackouts across the region. At that time, diesel generators were the only source of backup power on the base and they were unable to function and sustain operations for a prolonged period of time. Today, the CHP and microgrid system in place at Twentynine Palms allows the facility to island from the grid and sustain power independently.

On a military base, the functionality provided by a microgrid is crucial. Energy independence is seen as a national security priority, and the microgrid ensures mission readiness 24 hours a day while helping to cut costs, approximately $10 million dollars a year, from an already shrinking military budget.

Veolia Energy North America, Boston-Cambridge, Massachusetts

Market Sector: Downtown **CHP Capacity (MW):** 256

Veolia's district energy networks serve the critical energy requirements of approximately 250 commercial, healthcare, government, institutional and hospitality customers occupying 45 million square feet of building space within the central business district of Boston and the Longwood Medical Area as well as the biotechnology corridor of Cambridge. In Cambridge, Veolia operates the Kendall Station combined heat and power (CHP) plant as well as a cogeneration plant on behalf of a major biotechnology company. In the Longwood Medical Area of Boston, Veolia operates the Medical Area Total Energy Plant (MATEP) facility supplying heat, cooling, and electrical power to the hospitals in that section of the city.

Located beneath the streets and bridges of Boston and Cambridge, invisible to the cities above, is a network of district energy steam pipes delivering environmentally friendly thermal energy or "Green Steam" throughout the Boston-Cambridge system. "Green Steam" is an innovative environmental solution that recaptures and reuses thermal energy previously lost to the environment, utilizing advanced cogeneration technology. Following the completion of a 7,000-foot steam pipeline extension in 2013 and a planned reconfiguration of the recently acquired Kendall Station, up to 75% of Veolia's district energy heat supply will consist of recycled "Green Steam." This innovative $112 million investment generates significant benefits for Cambridge and Boston, including:

- Reducing greenhouse gas emissions by 475,000 tons annually - the equivalent of removing 80,000 cars from the roads
- A 6% reduction of non-transportation carbon emissions for both cities
- Minimizing thermal pollution from the Charles River ecosystem

- Improving air quality, reducing NOx and SO2 emissions by approximately 36% and 61%, respectively
- 147,500 man hours invested to support the construction of the "Green Steam" project;
- Increasing capacity, reliability and overall system efficiency
- Supporting the Greenovate Boston goal of reducing Boston's greenhouse gas emissions 25% by 2020 and 80% by 2050
- Supporting sustainable development in both Boston and Cambridge
- Increasing the region's energy reliability

Hamilton Community Energy, Hamilton, Ontario, Canada

Market Sector: Downtown **CHP Capacity (MW):** 3.5

Hamilton Community Energy's (HCE) Combined Heat and Power and District Energy System located on the grounds of a Hamilton public school, is a natural gas−fired facility that supplies electricity and hot-water heating to customers through combined heat and power. HCE produces 3,500 kilowatts of electricity through a reciprocating engine connected to a generator. The power is either sold directly to the grid or provides backup electricity to 2 million sq. ft. of commercial, institutional and multifamily properties in downtown Hamilton.

Hamilton is a port city of approximately 500,000 residents located in a densely populated region at the west end of Lake Ontario. The HCE Cogeneration Unit played a vital role in keeping City of Hamilton operations functioning during the 2003 blackout.

Hamilton Community Energy (HCE) is a division of Hamilton Hydro Services, Inc., which is a subsidiary of Hamilton Utilities Corporation, a private corporation wholly owned by the city of Hamilton.

In 2010, HCE formed a strategic partnership with McMaster Innovation Park in Hamilton, completing an on-site satellite operation to become one of the first in Ontario to combine conventional DES with renewable technology; connecting and interfacing district heating and cooling equipment with a geo exchange system of eighty-one 500 ft. geo wells.

This district energy system sits on a former brownfield site in Hamilton. Designed, built and operated by Hamilton Community Energy and opened in 2011, the district energy system provides heating and cooling services to three large buildings: the McMaster Innovation Park Atrium, the CANMET Materials Technology Laboratory, and the McMaster Automotive Resource Centre. The core of the system is an underground geo-exchange field; the stable temperature beneath the surface raises the water temperature in the pipes in winter and lowers the water temperature in summer. Used in combination with electrically powered heat pumps that further raise or lower the water temperature as needed, the geo-exchange system provides extremely high efficiency heating and cooling. Used in heating mode, the geo-exchange system is expected to deliver more than three units of output energy for each unit of input.

Helen Ltd. (Helsingin Energia), Helsinki, Finland

Market Sector: Municipal Scheme **CHP Capacity (MW):** 630

Helen Ltd, formerly Helsingen Energia, is the utility provider for the city of Helsinki and the surrounding area. It is a for-profit company owned by the city of Helsinki, which supplies electric energy to nearly 400,000 customers in Finland and covers over 90% of the heat demand of the capital city with district heating. In 2011, the connected heat load in the district heating system was 3,262 MW while the cooling load for the district cooling system was 120 MW. District cooling is provided by utilizing cold sea water, heat from sewage waste water, and the surplus heat from CHP. Eighty percent of the cooling energy leverages sources that would otherwise remain unused. Sites connecting to district cooling include data centers, shopping centers, office building and residential spaces.

Summer afternoons in Helsinki only reach an average of 70°F and for half the year daytime temperatures are less than 50°F. Heating the buildings, therefore, is close to a year-round activity. This makes the city, like the rest of the country, an ideal location for CHP.

The smart city solution combines four CHP plants, district heating and district cooling in the most energy-efficient way. The system is supported and diversified by harnessing waste heat accumulated along the energy chain. The power grid connection is self-healing and provides enhanced reliability and uptime through active feeds from two substations.

USDN MICROGRID VALUE ASSESSMENT
by John Kelly Green Business Certification Institute

Summary

The Urban Sustainability Directors Network helps cities develop long-range sustainable plans and strategies focused on lowering energy costs and emissions while providing for greater energy resiliency. USDN asked the Green Business Certification Institute to provide an overview of how district energy and microgrids could accelerate investment and innovation in urban energy sustainability while supporting the bulk grid and utilities. This article addresses this question by providing a preliminary assessment of the value and investment returns expected from policies and plans that encourage the private sector and utilities to work together to build microgrids with district energy systems. This analysis provides a preliminary assessment of the value streams produced by building the same hypothetical resilient microgrid in three different locations: New York City, Boston MA, and Washington DC (with their different wholesale markets and retail rates).

The objective is to provide a relative and comparative analysis of the projected microgrid costs, value and savings, as well as, the impact on the utility revenue. The results are intended to inform project development, financing, policy, and rates. These results are preliminary and should not be utilized for design, financing or other commercial purposes.

	NYC	Boston	DC
Operating Savings	40%	40%	60%
Utility Revenue Change	- 15%	0%	0%
Case 1: District Energy + 10 MW CHP, Simple Payback	4.6	5.9	4.9
Case 2: + 48 MW Islanding	6.1	7.6	6.3
Case 3: +Demand Charge Avoidance	4.1	5.3	4.6

This analysis reveals that a robust network of microgrids with district energy could produce value for energy users, ratepayers, cities, and utilities. Of particular interest to City leadership is operating savings, which ranged from 40 to 60%.

This analysis also reveals that district energy establishes a foundation for sustainable energy delivery and is viable without demand or distribution charge avoidance (Case 1). In Case 2 microgrid, islanding capability provides for resiliency, efficiency, price response, and local grid services. However, Case 2 savings do not appear sufficient to attract third party investment. Case 3 reveals that payments for additional grid services can accelerate third party investment and participation.

Additional findings include:

- A microgrid approach provides cities with a framework for engaging their utilities to deliver sustainable energy.
- Islanding capability enables resiliency, price response, and grid service. This includes serving as a hedge for entering the real-time price (RTP) markets with savings ranging from $20 to 30 per MWh.
- This analysis is a static assessment of full microgrid buildout, which typically takes a decade of incremental investment (e.g. phased development buildout). Instead of utility revenue declining, the microgrid is likely only to slow consumption growth in growing urban areas.
- Case 3 reveals an opportunity to design grid service payments and a dynamic demand charge to attract investment in grid services that lower utility and system operating and investment costs.
- Microgrid costs can be reduced through coordinated investment by cities, utilities, and third parties. One example is co-located energy and utility services in a common utility corridor or chase-way.
- Microgrid costs can be further reduced through the adoption of generation and demand response within the building being served. For the subject microgrid, building peak demand could be reduced by 15MW reducing overall costs by nearly $30 million.

<u>District Energy & Microgrid Benefits</u>

- lower energy costs,
- improve grid resiliency,
- ensure power to critical services during extended grid outages,
- generate billions in investment
- increase energy efficiency,
- lower overall emissions,
- moderate wholesale prices through real-time price response
- improve grid power quality
- balance local power demand in real-time to facilitate local solar, plug in vehicles, and distributed energy integration
- support the utility business model

Microgrid Background

A microgrid architecture divides the electricity system into a network of smaller nodes that serve a distinct set of customers co-located or otherwise operating as a unit (a housing development, a large production facility, a city, etc.). A utility microgrid is defined by a geographic or functional boundary inside which the utility in cooperation with local government wants to focus investments and performance improvements. A private microgrid is a campus with local power generation and thermal distribution systems. Even a resilient building, capable of generating its own power in the case of an extended grid outage, might be considered a microgrid. The important thing is that a microgrid 1) can operate *with* and *parallel* to the bulk grid, 2) has the capability to balance generation and demand in real-time within its boundaries, and 3) provides for local representation and grid service.

Now, imagine a network of microgrids defined by the cities, campuses, and major developments that they serve. Regardless of ownership or scale, the microgrid architecture framework divides vast utility service territories into a network of smaller, dynamic, customer-centric nodes. This framework establishes local representation for the capabilities, issues, and outcomes that matter to the consumers. Rather than leaving utilities behind, this transformation to a microgrid framework can be led by the utilities and the cities they serve.

Microgrid s and District Energy Benefits

For a range of reasons, including a renewed focus on environmental efficiency and safety concerns associated with extreme weather, grid operators will increasingly depend on support from microgrid services for recovery operations and to balance grid demand. Microgrids leverage distributed energy resources to lower costs and increases resiliency. Because these resources are smaller and located at or near the "point of utilization," they offer efficient and local demand/price response that can balance the grid locally to offset daily swings in power demand, solar output, and plug-in vehicle charging. When the grid is stressed or power prices are high, microgrids can offer immediate relief by increasing or decreasing their entire demand. Microgrids provide for a price responsive grid where peak power prices could be moderated through local price response.

Microgrids also leverage district energy systems that more effectively and efficiently produces thermal energy locally for delivery to a network of buildings. This reduces operating costs, increases chiller system efficiency, increases power system efficiency by providing for heat recovery, and frees up building space[1].

At the local level, the integration of load response assets within a microgrid also enables on-demand or real-time islanding (i.e. the capability to shift to reduce site demand to zero when needed). Thereby, protecting critical facilities and life safety by supporting recovery operations during grid outages. Additionally, microgrids can provide capacity, voltage support, reactive power, and frequency regulation support.

Enabling and facilitating microgrids can attract billions in investment. Investment in islanding for 1,000 one MW microgrids costing $2 million per MW would generate $2 billion in local investment and create new jobs to operate these local facilities.

> **Value of Real Estate:** Rents in downtown Boston, New York City, and Washington DC average $44, $53, and $32 per square foot respectively. Based on 1) a development using 8.8 million sq. ft., 2) a baseline mechanical space footprint of 2% or 175,000 sq-ft., and 3) a microgrid plant of 110,000; annual rental collections could increase by $3.2 million, $4.2 million, and $2 million respectively.
>
> **Value of Improved Chiller System Efficiency:** Based on 1) 40 million ton-hours of cooling to service the project, 2) a baseline chiller system efficiency of 1.1, 3) a district energy chiller system efficiency of 0.75, and 4) electricity costing $70/MWh; chiller efficiency savings equals $1 million.

In a microgrid architecture framework, the utility business model is strengthened by new services and the economic development (i.e. load growth) that results from improved bulk grid performance. Utilities serve as the optimizer and enabler for customer engagement by integrating customer assets to stabilize the grid, leveraging microgrid architecture to create partnerships at the local level.

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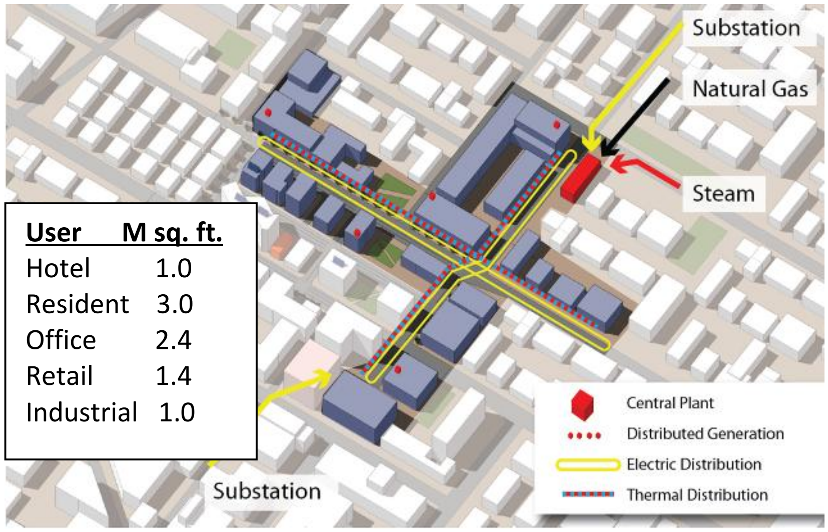
[1] Commercial real estate rents for Boston MA, New York City, and Washington DC, http://www.bizjournals.com/boston/real_estate/2015/01/boston-office-space-remains-among-countrys.html

Hypothetical Project Definition

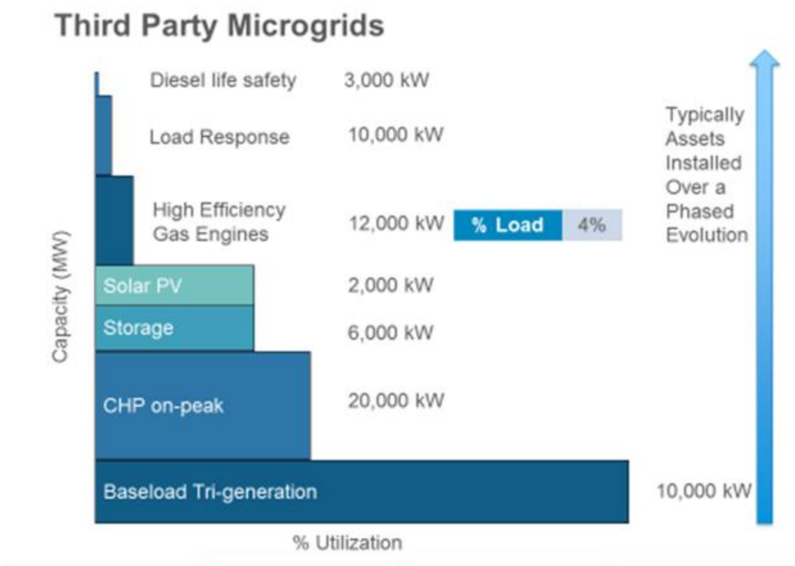
The subject project is an 8.8 million square foot microgrid with approximately 21 buildings served by a third party district energy and power system. The microgrid will be built out in phases over a 10 year period. This assessment is based on 2013 rates and energy prices for the subject locations. The final build out will have a peak demand of 58 MW, annual electric use of 250,000 MWh and annual thermal demand of 400,000 MMBtu.



User	M sq. ft.
Hotel	1.0
Resident	3.0
Office	2.4
Retail	1.4
Industrial	1.0

Figure 2 summarizes the distributed energy technology used to provide islanding capability. The microgrid operation includes the following features:

- Procure power in the real-time electricity markets
- Operate the 10 MW of baseload turbine tri-generation (turbine operating as a boiler) and 20 MW of engine based cogeneration to maximize thermal output
- Utilize storage and load response to reduce peak power costs
- Leverage all of the solar PV system output



The system includes a master controller software technology capable of monitoring building, system, and market conditions to optimize efficiency and economics in real time. This includes responding to grid operator ancillary service requests. The buildings are equipped with advanced metering and load automation to enable conservation load response to minimize energy use in real-time. As an example, in the Washington DC case, this automated load response capability reduces annual usage by 3.5% or 9,000 MWh annually, saving approximately $650,000 annually at $70/MWh.

The assessment includes three cases across the three target locations.

- Case 1: Initial district energy plant (chillers, boilers, piping, controls, and support equipment) and 10 MW turbine with a heat recovery steam generator and sufficient space and tie ins for all of the planned microgrid assets outlined in Case 2. Case 1 also includes thermal and electricity distribution.
- Case 2: Full deployment of the entire 58 MW technology suite to provide for islanding and full price, load, and demand response.
- Case 3: Assessment of economic impact of a microgrid with full demand charge avoidance and a larger thermal load (600,000 MMBtu) and a case with. The demand charge reduction case operates the site load response assetts to restrict the demand to 10 MW during on-peak periods.

This analysis is based on hourly modeling of energy demand, prices, generator electric and thermal output, and simple if statements that operate each assett based on price or maximizing thermal output.

All three cases use the following assumptions:

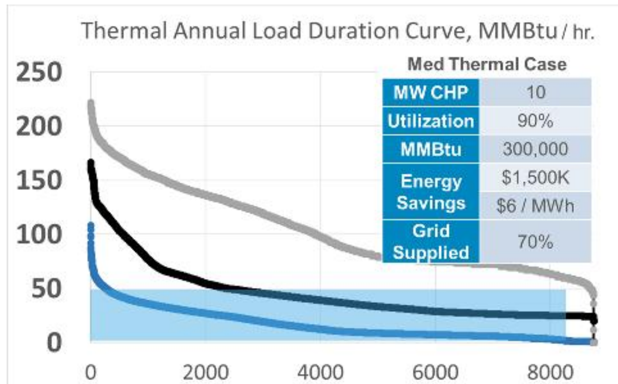
- Baseline flat supply costs shown in the adjacent Figure
- Natural gas prices shown in the adjacent Figure
- 2014 ISO real-time prices
- Commercial rates
  - o NYC – Coned
  - o Boston – Eversource
  - o DC – PEPCo

	Description	NYC	Boston	DC
Assumption	Supply Cost, $/MW	$80	$80	$70
Assumption	Natural Gas Cost, $/MMBtu	$5.5	$5.5	$5
Case 1	10 MW CHP Thermal Only	☑	☑	☑
Case 2	58 MW Islanding/RTP	☑	☑	☑
	ISO Capacity Charge Avoided	NA	NA	☑
	Distribution Charge Avoided	☑	No	No
	Demand Charge Avoided	No	No	No
	Ancillary Service/PQ	☑	☑	☑☑
	Conservation Load Response	☑	☑	☑
Case 3	Demand Charge Avoided	☑	☑	☑
	Max Thermal	☑	☑	☑

Case 1 Results: District Energy with 10 MW Turbine as a Boiler

Case 1 includes:

- 10 MW turbine with heat recovery
- Thermal distribution and metering, communications, and SCADA
- Electric distribution and metering, communications, and SCADA for the NY and DC locations



The adjacent Figure shows the thermal annual load duration curve in black for cases 1 and 2. Case 3 uses the grey maximum thermal demand curve. Also, shown is a lower thermal load for illustrative purposes. This shows the wide variation of available thermal depending upon the types of load being served. The higher thermal load represents a project with significant thermal processes. The low thermal load represents a mostly commercial building load. A 10 MW turbine was selected to maximize utilization (i.e. about 90% or 80,000 MWh of production) and thermal energy savings. This produced energy savings of about 300,000 MMBtu worth about $1,500,000 in all locations.

The overall savings is shown in the adjacent Figure for each location. This assessment assumes that the local utility is providing electric distribution for the Boston location. The DC and NYC locations assume that the third party installs electric distribution.

Description	NYC	Boston	DC
Flat Supply Rate 2014, $/MWh	$80	$80	$70
Preliminary Rough Savings Estimates ($000) – Not for project use			
Thermal Energy	1,500	1,500	1,500
Supply with Gen O&M	2,200	2,200	1,400
Electric Distribution	1,400	0	0
Recovered Rental Space	3,500	2,100	3,000
Chiller eff. Savings, kw/ton	1,000	1,000	1,500
Carbon offsets	(500)	(500)	(500)
Savings, $ million	**9,100**	**6,300**	**6,900**

The assumed project costs are shown in the adjacent Figure. This includes $5 million for thermal distribution/metering and $5 million for electric distribution/metering. District energy and power costs include turbine, heat recovery steam generators, and interconnect, electrical and supporting equipment. Chillers, boilers, and supporting equipment costs are assumed to be the same under baseline conditions compared to district energy. Construction costs in DC are about 14% lower[2].

Rough Cost Estimate ($000) ± 50%	NYC	Boston	DC
Major Equipment	$16,900	$16,900	$16,900
Combined Cycle Turbine	$8,000	$8,000	$8,000
Heat Recovery Heat Exchangers	$1,000	$1,000	$1,000
Synchronizing Switchgear.	$1,400	$1,400	$1,400
Substation and Dist. Gear	$1,500	$1,500	$1,500
Interconnect	$4,000	$4,000	$4,000
Gas Booster Compressors	$1,000	$1,000	$1,000
Labor	$11,000	$11,000	$9,350
Permitting/Fees/Other	$4,000	$4,000	$3,400
Electrical Distribution	$5,000	Utility Scope	Utility Scope
Thermal Distribution	$5,000	$5,000	$4,250
Gross Project Cost	**$41,900**	**$36,900**	**$33,900**

[2] http://laborpress.org/sectors/building-trades/127-new-york-city-construction-costs-continue-to-rise

Comparing these costs to the savings yields the simple paybacks shown in the adjacent table. A detailed conceptual design for a specific project is needed to verify these preliminary results. All three cases appear viable (i.e., simple paybacks about five years) without demand charge savings

Description	NYC	Boston	DC
Savings, $ million	9,100	6,300	6,900
Total Cost	41,900	36,900	33,900
Simple Payback, years	4.6	5.9	4.9

In terms of estimated emissions performance. The project annual savings accounts for purchasing carbon offsets at $15/ ton or ($15 * 80,000 MWh * 830 / 2000) = $500,000.

Other Performance	NYC	Boston	MD
State Average CO2e, lb./MWh	600	980	1,300
CHP CO2e, lb./MWh / offset/REC	830	830	830
State Efficiency, MMBtu/MWh	7	8	10.5
CHP Efficiency, MMBtu/MWh	6.5	6.5	6.5

Case 2 Results: Islanding, RTP, and Thermal Following

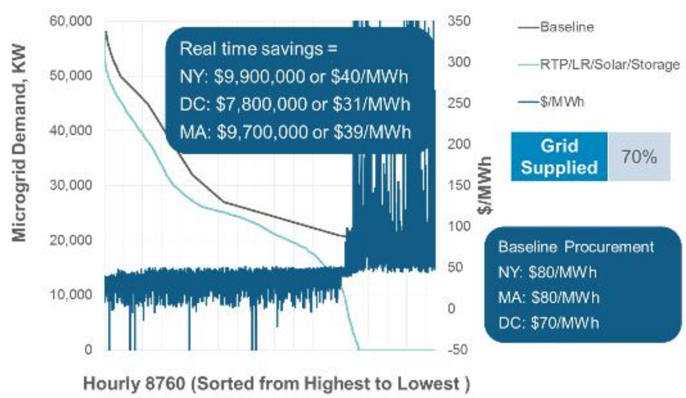
Case 2 includes adding a suite of technologies to provide for lower cost operation, resiliency, increased efficiency, and a hedge for entering the real-time price (RTP) markets. This includes:

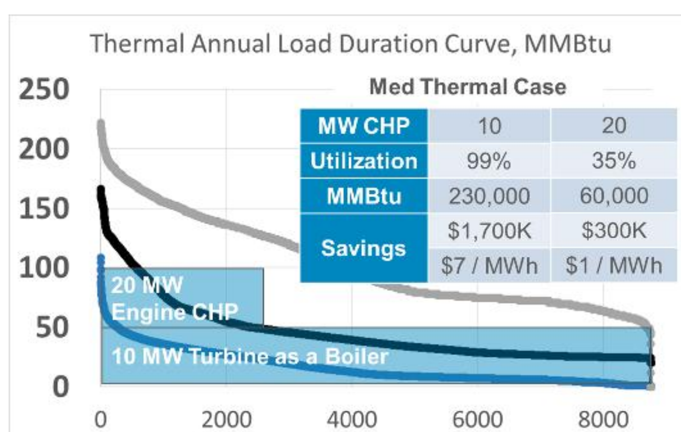
Investment Components (000)	NYC	Boston	DC
Case 1 Costs, District +10MW CHP	$42,000	$37,000	$34,000
CHP/Generation, 32 MW, 1,500/kW	48,000	48,000	44,000
Storage, $280/kWh	6,000	6,000	5,500
Solar (2 MW), $4,000/kW	8.000	8.000	7.500
Controller / Automation / LR, 10 MW	10,000	10,000	9,200
Total $, 58 MW	**~$114,000**	**~$106,000**	**~$103,100**

- Additional 20 MW of reciprocating engines with heat recovery
- Additional 12 MW of higher efficiency reciprocating engines
- Chilled water storage capable of delivering the equivalent of 6 MW of cooling for six hours a day
- 2 MW of solar PV
- 10 MW of automated load response
- Master controller software system that optimizes efficiency and economics in real time

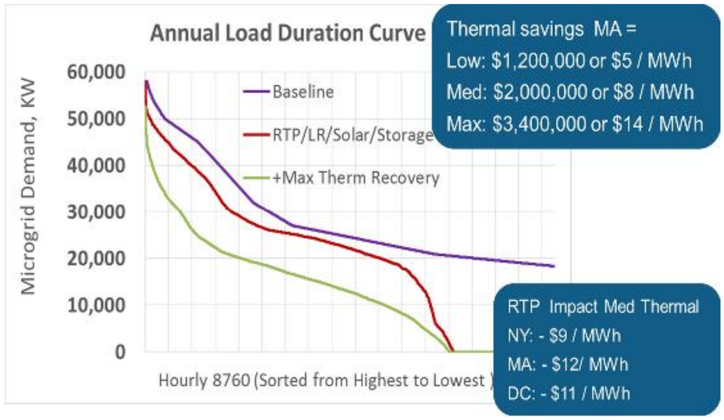
This suite of technologies enables the following key operating strategies:

- The combination of generation (42 MW), storage (6MW), and load response (10MW) provides for full islanding (58MW) capability for resiliency during extended major grid outages
- Islanding capability also serves as a hedge to enable the project to enter into the lower cost real-time price (RTP) markets offered by the respective regional Independent System Operators. The adjacent figure shows the project annual load duration curve in black and the annual load duration curve for operating in the real-time markets in blue. The blue load curve shows the projects full islanding capability being deployed for all hours where the real-time price exceeds the operating costs of the project assets. For this real-time only operating scenario, the supply cost energy savings are substantial while the utility continues to supply 70% of the entire project annual demand.





- The 20 MW of cogeneration brings the total to 30MW and increases the energy savings as shown in the adjacent Figure. This Figure depicts the thermal load duration curve for the project in black while also showing a low and high thermal case. Thermal loads very significantly depending upon the type of development. However, operating the cogeneration to maximize thermal requires operating during high real-time price periods reducing the RTP savings. This analysis reveals that the overall savings remains about the same regardless of the project annual thermal load. Increased energy savings is offset by lower RTP savings and vice versa. The adjacent Figures shows that $2 million or $8/MWh energy savings from operating the cogeneration to maximize thermal production is offset by an $8 to 14 reduction in real-time price savings in the three project locations.



- Solar and storage lower operating costs and improve efficiency
- The master controller, automation, and load response enable real time load optimization, demand response, and conservation.

Overall, the operational energy cost savings generated from deploying this technology suite and islanding capability ranges from 40 to 60%. See the adjacent figure for a summary of all of the value or savings categories.

Description, $/MWh	NYC	Boston	DC
Thermal Energy, $/MWh	7	8	7
Supply with O&M **RTP Only**	31 **40**	27 **39**	20 **31**
Demand - Standby	0	0	0
Capacity	NA	NA	13
Distribution	11	0	0
Ancillary Service/PQ	4	4	6
LR/Solar/Storage	6	7	4
Recovered Rental Space	14	8	12
Chiller Efficiency	4	4	6
Carbon Offset or REC	(3)	(3)	(3)
Total, $/MWh	74	56	66
% Reduction Cost	44%	38%	58%

- Thermal savings ranges from $7 to 8 /MWh
- The largest savings is in supply costs leveraging lower cost RTP. Note the reduction in RTP savings resulting from operating to maximize energy recovery. This means that a project with small or no thermal demand can still achieve similar overall savings.
- Only DC, which is located in PJM, can avoid ISO capacity charges, which currently average about $140/MW/day for 2014 to 2016[3].
- The NY project assumes that a third party builds and owns the site electric distribution system enabling distribution system cost savings.
- Ancillary service estimates assume a demand response payment of $17/kW/yr[4]. PJM ancillary services include $500,000 for synchronized reserve response.
- The project uses the master controller to monitor and conserve loads throughout the year producing $4 to $7/MWh of savings when combined with the solar and storage system savings.
- The chiller system efficiency is assumed to be 0.35 kW/ton improved over a baseline case with individual building chiller systems
- The project will pay $15/ton to offset all site carbon emissions from the project

[3] PJM capacity charges, http://www.pjm.com/markets-and-operations.aspx

[4] PJM demand response, and synchronized reserve, http://www.pjm.com/markets-and-operations.aspx

Case 2 Results: Utility Revenue Impact

In terms of impact on the utility revenue, this assessment evaluates three cases.

- In Boston MA, the project serves a set of existing and proposed new buildings with different owners within a small geographical boundary served by an existing utility. The project assumes that the utility builds or operates a local substation at or near the district energy building and all of the distribution and metering to the customers/buildings. A third party builds the district energy facility, power, and thermal distribution systems. The interconnect to the utility substation is at or near the district energy facility. In this location, the utility collects all of the distribution and demand charges while the district energy operator enters into contracts for thermal and electricity supply costs.
- In DC, the project assumes that the utility installs the electricity distribution and the third party installs the thermal distribution and microgrid assets for a new development.
- In NYC, the project assumes that the third party builds a complete campus microgrid including the electricity distribution. This results in avoiding the distribution charges.

For all three locations, Case 1 and 2 assume the full demand charge is paid to the utility. Case 3 estimates the potential project savings from avoiding demand charges in all three locations leveraging the full islanding capability.

In the adjacent Figure, you can see the estimated impact on utility annual revenue for all three locations for Case 2. What is not reflected in this static assessment is that the assumed projects support urban infill that occurs over a decade or more resulting in load growth not decline for the utility. In essence, the project just slows the utility revenue growth while providing cost reduction, price response, grid service, and demand reduction. The utility, project, project customers, and ratepayers can benefit from these outcomes.

	Before/After Microgrid			INVESTMENT
	NYC	**Boston**	**DC**	
Utility Revenue, $M	**22 / 19**	**16 / 16**	**7.4 / 7.4**	SCADA + Software
On-peak Demand Served, MW	58 / **53**	58 / **40**	58 / **40**	Communications
Distribution	4.4 / 1.7	5 / 5	4.2 /4.2	Feeders / Smart Switches
Demand Charges	18 / 18	11 / 11	3.2 / 3.2	
Operating Costs				Advanced Meters
Ancillary Service Benefits				System Expansion
Demand Reduction Potential	58MW	58MW	58MW	Other

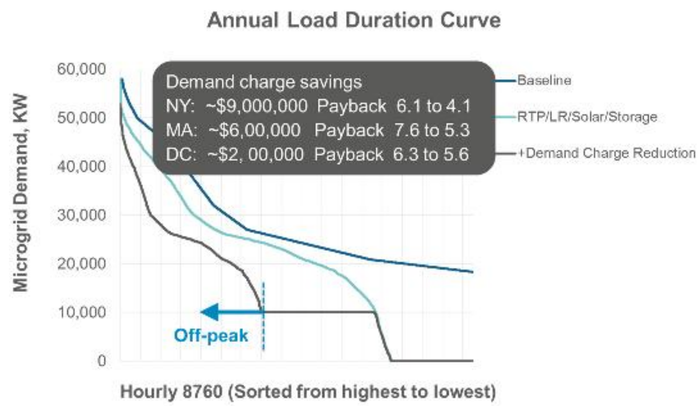
Cases 2: Third Party Return on Investment

Now we will assess the return on third party investment for each project location using a simple payback. The estimated project returns are marginal and would not likely attract private investment given uncertainties and risks. However, these projects can provide demand reduction and other grid services that if valued could tip the scale regarding investment while using pricing signals to optimize benefits to all stakeholders.

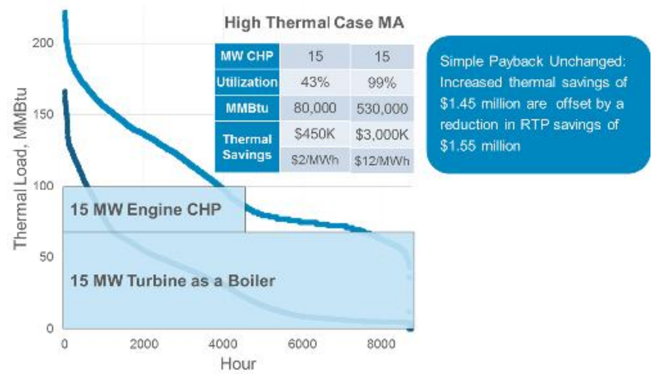
Savings ($000)	NYC	Boston	DC
Supply with O&M	7,800	6,700	5,000
Capacity Charge			3,200
Distribution Charge	2,700	Utility Distribution	Utility Distribution
Thermal Storage / Solar	450	600	450
Thermal Recovery	1,800	2,000	1,800
Ancillary Services / PQ	1,000	1,000	1,500
Load Response Conservation	1,000	1,200	650
Recovered Rental Space	3,500	2,100	3,000
Chiller System Efficiency	1.000	1,000	1,500
Carbon Offsets or REC's	(700)	(700)	(700)
Total Savings	**~$18,550**	**~$13,900**	**~$14,400**
Total Cost	**~$114,000**	**~$106,000**	**~$103,100**
Simple Payback	**6.1**	**7.6**	**6.3**

Cases 3: Third Party Return on Investment

Case 3 looks at the impact of avoiding the estimated demand charges for each project. The adjacent Figure shows that allowing for demand charge savings would improve the project returns substantially. This Figure also shows the annual load duration curve with demand charge avoidance in black. This load curve confirms that the project demand is limited to 10 MW during utility on-peak periods. This reveals an opportunity to design a demand charge that minimize utility lost revenue while providing projects with a way to secure financial value for demand reduction and other grid services.



Finally, Case 3 looks at the financial impact of serving a set of buildings with a higher thermal load. The Adjacent Figure shows that the energy efficiency savings can be almost doubled if the loads being served have a much higher thermal need (e.g. large process loads such as baking). However, reduced real-time price savings offset the $1.5 million in increased energy efficiency savings.



A Comparison of Legal Issues for Microgrids in Massachusetts, New York and D.C.[1]

S. Hoedl, Ph.D., J.D.
July10, 2015

Summary

This section provides a high-level overview of four key legal issues for microgrids in Massachusetts,[2] New York[3] and D.C. In particular, this section discusses (1) whether utilities can own generating assets and a microgrid's internal distribution infrastructure; (2) whether, and to what extent, a non-utility microgrid would infringe on a utility monopoly right, the so-called "franchise" issue; (3) whether a non-utility can cross a public right-of-way; and (4) regulatory oversight of non-utility entities, such as "electric company" regulation.

Note that in all three jurisdictions, existing laws and regulations generally do not directly address microgrids, and thus, there is some uncertainty regarding how each jurisdiction will treat these issues. Nevertheless, a few conclusions can be made. In all three jurisdictions, utilities are generally prohibited from directly owning generation assets in a microgrid, but are likely allowed to own and operate the internal distribution infrastructure. In Massachusetts, utilities have a monopoly right, i.e., a "franchise," to operate the internal distribution infrastructure in some kinds of multi-participant microgrids, but utilities in New York and D.C. likely do not have such a right. In all three jurisdictions, a non-utility entity is likely allowed to cross a public right-of-way, subject to municipal consent. In all three jurisdictions, the regulatory oversight of non-utility participation in a microgrid is highly dependent on the microgrid's engineering and ownership structure. Note that New York and D.C. have statutory exemptions from full "electric company" regulation for specific types of microgrids.

Each jurisdiction is undertaking regulatory proceedings that may clarify some of these issues. In Massachusetts, the Massachusetts Department of Public Utilities ("Mass. DPU") may consider microgrid regulation when it begins reviewing each utility's "Research, Development

[1] This report was prepared for informational purposes only. It does not, and is not intended to, constitute legal advice. Because of the rapid pace of change in this area of law and regulation, this report should not be used as a substitute for competent legal advice from a licensed professional attorney.

[2] For a more complete discussion of legal issues associated with microgrids in Massachussetts only, see *Massachusetts Microgrids: Overcoming Legal Obstacles*, (Harvard Law School Emmett Environmental Law & Policy Clinic, September 27, 2014), *available at* http://hlsenvironmentallaw.files.wordpress.com/2014/09/masschusetts-microgrids_overcoming-legal-obstacles_final12.pdf.

[3] For an earlier discussion of some legal issues associated with microgrids in New York, see *Microgrids: An Assessment of the Value, Opportunities and Barriers to Deployment in New York State* (New York State Energy Research and Development Authority, September 2010) and *Microgrids for Critical Facility Resiliency in New York State* (New York State Energy Research and Development Authority, December 2014).

and Deployment Plans" ("RD&D Plans") this August.[4] In New York, the New York Public Service Commission ("N.Y. PSC") has developed a process for clarifying microgrid regulatory issues through the REV Order.[5] In D.C., the D.C. Public Service Commission ("D.C. PSC") has recently opened a docket to explore grid modernization, including microgrids, and is seeking public comment by August 31, 2015.[6]

1. Limitations on Utility Participation

Generation Ownership

All three jurisdictions are restructured markets, i.e., generation and distribution have been separated, so that there is competition in both the wholesale and retail generation market. In Massachusetts[7] and D.C.,[8] restructuring was achieved by legislation, while in New York, restructuring was achieved by N.Y. PSC regulatory action.[9] As a consequence of restructuring, in general, all three jurisdictions prohibit utility ownership of generating assets.

Massachusetts and D.C. prohibit utility ownership of a generating asset by statute, although in both jurisdictions a utility "affiliate" is permitted to own generating assets.[10] Thus,

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[4] The recent Grid Modernization Order requires each utility to submit a "Grid Modernization Plan," which includes a "Research, Development and Deployment Plan," within nine months of the DPU's final order in the *Time Varying Rates* case or the DPU's final directive regarding the presentation of the "Grid Modernization Plan" business case for capital expenditures, whichever comes later. Investigation by the Department of Public Utilities on its own Motion into Modernization of the Electric Grid, D.P.U. 12-76-B, 5 (Mass. D.P.U. June 12, 2014) [hereinafter "Grid Modernization Order"]. Both the *Time Varying Rates* order and the *GMP Business Case* order were issued on November 5, 2014. Investigation by the Department of Public Utilities upon its own Motion into Time Varying Rates, D.P.U. 14-04-C, 2014 WL 5795311 (Mass D.P.U. November 5, 2014); Investigation by the Department of Public Utilities on its own Motion into Modernization of the Electric Grid, D.P.U. 12-76-C, 2014 WL 5795308 (Mass. D.P.U. November 5, 2014). The Grid Modernization Order specifically seeks RD&D projects that include technologies that are likely to be found in microgrids, such as energy storage. Grid Modernization Order at 28.

[5] Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. ORDER ADOPTING REGULATORY POLICY FRAMEWORK AND IMPLEMENTATION PLAN, Case 14-M-0101, 112 (N.Y. P.S.C. February 26, 2015) [hereinafter "REV Order"]. The REV Order requested stakeholder comments about microgrids by May 1, 2015. *Id.* Based on these comments, the N.Y. PSC intends to propose a framework for microgrid regulation which will also be open for public comment. *Id.*

[6] In The Matter Of The Investigation Into Modernizing The Energy Delivery System For Increased Sustainability, Order No. 17912, Case 1130 (D.C. P.S.C. June 12, 2015).

[7] Electric Restructuring Act of 1997, 1997 Mass. Legis. Serv. Ch. 164 (H.B. 5117) (West).

[8] Retail Electric Competition and Consumer Protection Act of 1999, 2000 District of Columbia Laws 13-107 (West).

[9] *See Energy Ass'n of New York State v. Public Service Com'n*, 169 Misc.2d 924 (1996) (upholding the NYPSC's authority to deregulate New York's electricity market through its existing statutory authority to set rates that are "just and reasonable"). *See* also *Electric Utility Restructuring in New York: A Status Report* (The Committee on Energy of the Association of the Bar of the City of New York, April, 1998), *available at* http://www2.nycbar.org/Publications/reports/print_report.php?rid=15.

[10] In Massachusetts, a utility is prohibited from "directly owning, operating or controlling […] generating facilities." M.G.L. c. 164 § 1A. A Massachusetts utility affiliate created as part of restructuring is allowed to own generating assets, but is not allowed to acquire new generating assets. M.G.L. c. § 1A(c). However, Massachusetts law is silent as to whether a utility could form a new affiliate which could then own new generating assets. In D.C. "the electric company," i.e., PEPCO, is prohibited from "engaging in the business of an electricity supplier" except

in Massachusetts and D.C., under current law, a utility likely could not own generating assets in a microgrid, although an affiliate might be able to own such assets, provided that the affiliate complied with jurisdictional requirements for strict operational separation between a utility and its affiliate.[11]

In New York, utility ownership of generating assets within a microgrid is uncertain at this time. Any constraints on generation ownership will be imposed by N.Y. PSC order alone and the N.Y. PSC is still pondering microgrid regulation as part of the REV Order. It is nonetheless informative to know the N.Y. PSC's present thinking regarding utility ownership of distributed energy resources ("DER") because similar limits on generation assets within a microgrid may be imposed. In the REV Order, the N.Y. PSC announced a policy of disfavoring unrestricted utility participation in DER markets.[12] As a general rule, the N.Y. PSC held that "utility ownership of DER will not be allowed unless markets have had an opportunity to provide a service and have failed to do so in a cost-effective manner."[13] Utility ownership or leasing will be allowed if "(1) procurement of DER has been solicited to meet a system need, and a utility has demonstrated that competitive alternatives proposed by nonutility parties are clearly inadequate or more costly than a traditional utility infrastructure alternative; (2) a project consists of energy storage integrated into distribution system architecture; (3) a project will enable low or moderate income residential customers to benefit from DER where markets are not likely to satisfy the need; or (4) a project is being sponsored for demonstration purposes."[14]

Microgrid Distribution Infrastructure

In both Massachusetts and D.C., there is no statutory or regulatory limitation on utility ownership and/or operation of the distribution infrastructure in a microgrid, and thus, in those jurisdictions a utility is likely free to own and operate a microgrid's internal distribution infrastructure. In New York, whether a utility will be allowed to own and operate the distribution infrastructure is uncertain at this time and is under active consideration by the N.Y. PSC as part of the REV proceedings. Some stakeholders have suggested that the N.Y. PSC should restrict utility ownership and operation of microgrid distribution infrastructure just as the N.Y. PSC has restricted utility ownership and operation of DER assets.[15] In contrast, others

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through an affiliate. D.C. CODE §34-1513(a). An "electric supplier" includes any entity that generates electricity. D.C. CODE §35-1501(17).

[11] In D.C., the utility must have "functional, operational, structural, and legal separation" from its affiliate. D.C. CODE §34-1513(c) and D.C. MUN. REGS. tit. 15 § 39.

[12] REV Order, *supra* note 5, at 67.

[13] REV Order, *supra* note 5, at 68.

[14] REV Order, *supra* note 5, at 70.

[15] For example, NRG commented that limits should be placed on utility ownership and operation of microgrids. Proceeding on the Motion of the Commission in Regard to Reforming the Energy Vision, NRG Response to Notice Soliciting Comments on Microgrids, Case 14-M-0101 (N.Y. P.S.C. May 1, 2015).

suggested that utilities would be best positioned to operate the distribution infrastructure of a microgrid, especially when a microgrid crosses a public right-of-way.[16]

2. Limitations on Non-Utility Participation: The Franchise Issue

It is commonly believed that most utilities in most jurisdictions enjoy an exclusive right to operate some component of the electricity system. For example, a utility may have the exclusive right to "distribute" electricity anywhere within its service territory or the exclusive right to distribute electricity across a public right-of-way. This right is often referred to as a "franchise," and that nomenclature is used here.[17] Although many jurisdictions do, in fact, grant utilities an exclusive franchise, other jurisdictions do not grant an exclusive franchise, either by statute or regulation.[18] Of the three jurisdictions considered here, only Massachusetts grants its utilities a franchise.

The Franchise in Massachusetts

In Massachusetts, utilities, known as "distribution companies," are granted, by statute, an exclusive monopoly right to provide distribution service within their service territories. In particular, M.G.L. c. 164, § 1B(a) provides that:

> [T]he distribution company shall have the exclusive obligation to provide distribution service to all retail customers within its service territory, and no other person shall provide distribution service within such service territory without the written consent of such distribution company which shall be filed with the department []and the clerk of the municipality so affected.

There are three key points to this statutory provision. First, the utilities enjoy an exclusive right to provide "distribution service." Second, a utility can consent to non-utility provision of

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[16] Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York State Electric & Gas Corporation, Niagara Mohawk Power Corporation d/b/a National Grid, Orange and Rockland Utilities, Inc., Rochester Gas and Electric Corporation, PSEG Long Island and the Utility Workers Union of America all support utility ownership and operation of at least the distribution infrastructure of a microgrid when a microgrid serves multiple customers, operates within the surrounding electric distribution infrastructure. REV Order, *supra* note 5, at 106-107.

[17] Note that in some jurisdictions, such as New York, a "franchise" does not refer to a monopoly right, but rather, refers to a blanket authorization to cross public rights-of-way. *See* N.Y. GEN. CITY LAW §20(10). Such an authorization need not be exclusive.

[18] For example, Connecticut grants its utilities an exclusive franchise by giving utilities the exclusive right to cross public rights-of-way. *See Texas Ohio Power v. Connecticut Light and Power*, 243 Conn. 635, 651 (Conn. 1998); Conn. Gen. Stat. § 16-1(a)(28) (2014).

distribution service. Third, the exclusive right is granted by statute; the Mass. DPU does not have authority to grant an exception.

The exact meaning of “distribution service” is not defined by statute. Case law, however, does provide some guidance and is described in detail elsewhere.[19] In brief, cases before the Mass. DPU and Supreme Judicial Court that concerned the provision of distribution service at the boundary between two utility service territories[20] suggest that the provision of a “distribution service” should be interpreted in a legal sense as the transfer of ownership and control of electricity, and not in the engineering sense as the operation of wires and lines that distribute electricity. Thus, a single legal entity is permitted to distribute electricity to itself, in the engineering sense, on its own property.[21] Similarly, a single legal entity can likely distribute electricity, in the engineering sense, to itself across a public right-of-way because by doing so it retains continuous ownership and control of its electricity. Note that there are multiple examples of microgrids in Massachusetts that do, in fact, distribute electricity across public rights-of-way.[22]

The franchise in Massachusetts does prevent a non-utility entity from operating the internal distribution infrastructure of a microgrid which serves non-affiliated entities. For example, a hospital that has its own microgrid and that is adjacent to an un-affiliated shopping mall cannot provide electricity to the shopping mall because by so providing electricity it would be transferring ownership and control of electricity from itself to the shopping mall. Ownership and operation structures that may be able to avoid this limitation on non-utility operation of a microgrid are described in detail elsewhere.[23] For example, if all entities that consume electricity from the microgrid also jointly own and operate the generation and distribution assets within the microgrid, the consumers may be able to argue that they are never transferring control and ownership of electricity because they all jointly own the electricity in the microgrid.

The Franchise in New York

In New York, it is unconstitutional for the state legislature to grant an exclusive franchise.[24] Thus, New York utilities do not enjoy a state-granted exclusive right to distribute

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[19] *See Massachusetts Microgrids: Overcoming Legal Obstacles*, *supra* note 2.

[20] *See Franklin W. Olin College of Engineering v. Department of Telecommunications and Energy*, 439 Mass. 857 (Mass. 2003) and *Massachusetts Electric Company*, D.T.E. 98-122, 2002 WL 1162710 (Mass. D.T.E. February 7, 2002).

[21] *Id*.

[22] Harvard University operates generation facilities and transfers electricity to different parts of its campus across public rights-of-way in an urban environment. *See* DNV Kema, *Microgrids—Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts* 9-5 (2014), *available at* http://images.masscec.com/uploads/attachments/2014/02/MassCEC%20Microgrid%20Study%20Final%20Report%202-18-14_0.pdf.

[23] *See Massachusetts Microgrids: Overcoming Legal Obstacle*, *supra* note 2.

[24] N.Y. Const. Art. 3 § 17.

electricity or provide any other electric service. Municipalities are prohibited by case law from granting their own exclusive franchise by contract.[25] Although, in principle, municipalities may be able to grant exclusive franchises within city limits through city-level legislative action, it does not appear to be common for municipalities to grant such an exclusive franchise because there are many existing microgrids in New York that operate within a utility's service territory. Thus, a non-utility owned and operated microgrid likely does not infringe a utility's "franchise" right in New York

The Franchise in D.C.

A single utility, PEPCO, presently operates the electric distribution system in D.C.[26] Whether PEPCO or its successor enjoys an exclusive franchise to operate any component of the electric system in the District is uncertain. Since 1913, the D.C. Code has exclusively reserved the right to grant a franchise to "own or operate" a "public utility" to the D.C. PSC.[27] Although the D.C. PSC has publically stated that PEPCO "has a monopoly over the distribution of electricity to consumers,"[28] a record that the D.C. PSC ever made a franchise grant, which must be made in writing, has not been found. Thus, PEPCO may not have any franchise rights in the electricity market in D.C. Even if PEPCO does have a franchise right, the scope of such a right is limited so that the franchise right likely does not preclude non-utility entities from operating any component of a microgrid for at least three reasons.

First, a franchise, if it exists, is likely not exclusive so that any entity would be allowed to distribute electricity. The D.C. Code has consistently contemplated that multiple entities could distribute electricity and that such entities would be regulated as "electric companies." For example, in 1898, the District Mayor was authorized by statute to issue permits that would allow "electric light companies" to extend overhead distribution wires west of Rock Creek Park.[29] In 1904, the Mayor was likewise authorized to permit the "Potomac Electric Power Company and the Washington Railway and Electric Company to build and make connections between their

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[25] *See Bartholomew v. Village of Endicott*, 59 N.Y.S.2d 84, 87-89 (1945) ("The power to establish and operate public utility services is for the public benefit and is legislative in character. Its exercise cannot be limited or curtailed by contract.") *See* also *Parfitt v. Furguson* 38 N.Y.S. 466, 470 ("It is too plain to require argument that the members of the board could not enter into a contract not to perform any of the duties which the law devolved upon them.")

[26] PEPCO is in the process of merging with Excelon. The merger is presently under consideration by the D.C. PSC. *See* In The Matter of the Merger of Exelon Corporation, Pepco Holdings, Inc., Potomac Electric Power Company, Exelon Energy Delivery Company, LLC And New Special Purpose Entity, LLC. Application and Exhibits of the Joint Applicants, Case FC1119 (D.C. P.S.C. June 18, 2014).

[27] D.C. CODE §34-1001 states "No franchise nor any right to or under any franchise to own or operate any public utility […] shall be assigned, transferred, or leased, […] unless the assignment, transfer, lease, contract, or agreement shall have been approved by the Commission in writing."

[28] "Overview of the Public Service Commission of the District of Columbia" pg. 11. Accessed June 16, 2015. Available at http://www.dcpsc.org/hottopics/overview.ppt.

[29] D.C. CODE §34-1404.

respective distribution systems.[30] The D.C. Code continues today to be open to the possibility that multiple entities could distribute electricity. For example, "electric company" is defined to include "*every* corporation, company, association, joint-stock company or association, partnership, or person … [who] physically transmit[s] or distribut[s] electricity in the District of Columbia to retail electric customers."[31] The use of the word "every" suggests that the code explicitly contemplates that there could be more than one entity physically transmitting or distributing electricity in D.C. Notably, this provision of the D.C. Code was last updated in 2013 and the use of the word "every" was unchanged, despite the fact that, at the time, PEPCO was the only "electric company" in D.C.[32] Potential regulation of an "electric company" other than PEPCO in 2013 only makes sense if PEPCO does not have an exclusive right to be the only electric company in D.C.[33] Note also that the D.C. Code appears to favor non-exclusive franchises. For example, the cable television provisions explicitly state that the D.C. PSC can only issue non-exclusive franchises.[34]

Second, the franchise is likely limited to the provision of only those services that are intrinsically not available for market competition, which likely does not include microgrids. The Retail Electric Competition and Consumer Protection Act of 1999 gave the D.C. PSC authority to issue orders and regulations to "ensure the development of a competitive market for electricity supply, billing, and any component of electric service declared to be a potentially competitive service."[35] Because the D.C. PSC has this authority, PEPCO cannot have an exclusive right to offer services that the D.C. PSC declares are potentially competitive. "Any component of electric service" is very broad, and could include, for example, the distribution of electricity, in the engineering sense, within a microgrid. To be "potentially competitive," an electric service

[30] D.C. CODE §34-1408.

[31] D.C. CODE §34-207.

[32] Energy Innovation and Savings Amendment Act of 2012, 2012 District of Columbia Laws 19-252 (West), §101(a).

[33] Note that some parts of the D.C. CODE refer to "The" electric company, suggesting that PEPCO is the only electric company in the District. For example, D.C. CODE §34-1506(a)(1) requires that "The electric company shall provide distribution services to all customers and electricity suppliers…" However, given that other parts of the D.C. CODE are not limited to a single electric company, the use of the word "The" in this provision could be a shorthand that simply acknowledges that PEPCO was the sole operator of the distribution system at the time of enactment, and not a grant of an exclusive franchise to distribute electricity.

[34] D.C. CODE § 34-1254.01.

[35] *See* 2000 District of Columbia Laws 13-107 (West) and D.C. CODE §34-1504(c)(7).

must meet a four part test.[36] Microgrids likely meet these criteria. Thus, a franchise, if it exists, likely does not extend to the internal distribution infrastructure of a microgrid.[37]

Third, a franchise granted by the D.C. PSC is limited to the ownership and operation of a "public utility," which may not cover microgrids. In D.C., a "public utility" in the electricity sector is explicitly equivalent to an "electric company,"[38] which is defined as any entity that "physically transmits or distributes electricity" in the District of Columbia to "retail electric customers."[39] Thus, any entity that does not serve "retail electric customers" is not a public utility and will not infringe on a franchise right. "Retail electric customers" is not defined in the D.C. Code or D.C. regulations. Because microgrid participants will often receive many services in addition to electricity, including heating and cooling, they are arguably not "retail electric customers." If the D.C. PSC was to adopt an interpretation of "retail electric customers" that excluded microgrid customers, a non-utility microgrid would not infringe on a franchise.

3. Limitations on Non-Utility Participation: Crossing a Public Right-of-Way

It is also commonly believed that utilities in most jurisdictions enjoy an exclusive monopoly right to cross a public right-of-way or that a utility must consent to a non-utility crossing of a public right-of-way.[40] In some jurisdictions, such as Connecticut,[41] the utilities do, in fact, have a statutorily granted exclusive right to cross a public right-of-way. However, in the three jurisdictions considered here, non-utility entities can use and cross public rights-of-way provided that the local municipality consents.

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[36] A service is competitive if "(1) Provision of the service by alternative sellers will not harm any class of customers; (2) Provision of the service will decrease the cost of providing the service to customers in the District of Columbia or increase the quality or innovation of the electric service to customers in the District of Columbia; (3) Effective competition in the market for that service is likely to develop; and (4) Provision of the service by alternative sellers will not otherwise jeopardize the safety and reliability of electric service in the District of Columbia." D.C. CODE §34-1504(e)(1).

[37] A new microgrid that lowers revenue to PEPCO, may, however, be required to pay an exit charge if the D.C. PSC holds that microgrids are a competitive service. D.C. CODE §34-1504 (e)(2).

[38] D.C. CODE §34-214.

[39] D.C. CODE §34-207.

[40] In Massachusetts, the DPU recently perpetuated the uncertainty about this issue when it declined to rule on a petition asking "whether a customer can convert a remote solar photovoltaic generation facility into a 'behind-the-meter' facility by having the Company construct a dedicated distribution line from the remote facility across a public way to the customer's existing meter." *Petition of Massachusetts Electric Company*, D.P.U. 13-08, 2013 WL 873788 (Mass D.P.U. March 4, 2013).

[41] *See Texas Ohio Power v. Connecticut Light and Power*, 243 Conn. 635, 651 (Conn. 1998); Conn. Gen. Stat. § 16-1(a)(28) (2014).

Crossing a Public Right-of-Way in Massachusetts

As discussed above, in Massachusetts, the franchise clause makes no reference to crossing a public right-of-way. Likewise, no other provision of Massachusetts law gives a utility an exclusive right to cross a public right-of-way or requires utility consent for a non-utility entity to use or cross a public right-of-way. Massachusetts law does, however, explicitly require municipal consent.[42] Thus, a non-utility microgrid can likely cross public rights-of-way, as long as it is granted municipal permission.

Crossing a Public Right-of-Way in New York

As in Massachusetts, New York statutes and regulations do not give utilities an exclusive right to cross a public right-of-way and there are multiple examples of microgrids that cross a public right-of-way in New York[43] However, to cross a public right-of-way, a microgrid needs permission from local authorities, such as a municipality, who are specifically authorized by statute to grant permission for any entity to use public rights-of-way.[44] This permission can be in the form of a so-called "franchise" or other right, such as a "revocable consent."[45] A "franchise," which does not refer to a monopoly right in New York, is typically granted to use a public-right-of-way for "public use."[46] Alternatively, a "revocable consent" allows a private party to use a public right-of-way for "private use."[47] In New York City, the Department of Transportation administers the system for granting "revocable consents" for crossing public rights-of-way.[48] The application process includes a public hearing.[49] The revocable consent is typically granted for a term of 10 years.[50]

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[42] *See* M.G.L. c. 164, § 87 ("In a town where a person is engaged in the manufacture, sale or distribution of electricity, no other person shall lay, erect, maintain or use, over or under the streets, lanes and highways of such town, any wires for the transmission of electricity except wires used by street railway companies for heat or power, without the consent of the aldermen or selectmen granted after notice to all parties interested and a public hearing.")

[43] For example, Halletts Vendee, LLC is building a 4.7 MW CHP microgrid that serves five buildings, one of which is across a public right-of-way. Note that it is not connected to the macrogrid and is not regulated as an "electric corporation." Halletts Vendee LLC - Petition for a Declaratory Ruling Regarding Commission Jurisdiction Declaratory Ruling on Qualifying Facility Exemption from Regulation, Case 14-M-0508, (N.Y. P.S.C. February 9, 2015).

[44] NY GEN. CITY LAW §20(10).

[45] *Id.*

[46] *See*, for example, NYC CHARTER, c. 14 § 362(b).

[47] NYC Charter, c. 14 § 362(d).

[48] *See* N.Y City Department of Transportation, *Revocable Consents*, http://www.nyc.gov/html/dot/html/infrastructure/revconif.shtml (last visited July 6, 2015).

[49] *Id.*

[50] *Id.*

Entities that are considered "electric corporations" under the NY Transportation Laws[51] have additional rights to cross public rights-of-way. Electric corporations are specifically granted by statute the power to use public rights-of-way, but must do so with municipal consent and subject to reasonable regulation.[52] Electric corporations are also granted the power of eminent domain to cross private property.[53]

Crossing a Public Right-of-Way in D.C.

As in Massachusetts and New York, D.C. statute and regulation do not refer to the utility with regards to crossing a public right-of way, and thus, they do not give the incumbent utility, PEPCO, an exclusive right to cross a public right-of-way nor do they require the utility's consent. Instead, D.C. statute and regulation require consent from the Director of the District Department of Transportation in order for any entity to cross a public right-of-way.[54] Thus, non-utility microgrids are likely free to cross public rights-of-way if they receive permission from the District Department of Transportation.

4. Regulatory Oversight of non-utility entities

"Electric Company" regulation

In all three jurisdictions, non-utility entities may be deemed "electric companies" and incur substantial regulatory oversight.[55] However, the exact definition of an "electric company" and the regulatory implications are highly jurisdictional dependent. Note that both New York

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[51] For the purposes of N.Y. Transportation Corporation Law, an electric corporation is defined as "a corporation organized to manufacture, to produce or otherwise acquire, and to supply for public use electricity for light, heat or power, and for lighting streets, avenues, public parks and places and public and private buildings of cities, villages and towns within this state." N.Y. TRANSP. CORP. LAW §10.

[52] N.Y. TRANSP. CORP. LAW §11(3).

[53] N.Y. TRANSP. CORP. LAW §11(3-a).

[54] D.C. CODE §34-1402 makes it unlawful to "lay conduits or erect overhead wires" without authority of law. D.C. CODE §34-1406, 1407 give the Mayor authority to grant permits for repair, enlargement and extension of existing conduits. D.C. CODE §10-1141.03(a) gives the Mayor authority to "issue permits to occupy or otherwise use public rights of way, public space, and public structures pursuant to this subchapter for any purpose, including the use of the foregoing for conduits, including conduits which occupy public space, or a public right of way on April 9, 1997." These provisions of the code are implemented by D.C. MUN. REGS. tit. 24 § 3302.1: "no person shall occupy the public right-of-way below ground with stand-alone conduit or pipe, above ground with aerial lines, or on the surface with any structure housing transmission facilities (other than public pay telephones) or be eligible to obtain public space permits authorizing or needed for the installation of such facilities, unless a Public Right-of-Way Occupancy Permit is issued by the Director [of the District Department of Transportation]." Such permits are valid for 20 years. D.C. MUN. REGS. tit. 24 § 3310.2(a).

[55] For example, in Massachusetts, the Mass. DPU has general supervisory authority to review electric company rates, charges and contracts. M.G.L. c. 164 § 76.

and D.C. have explicit statutory exemptions to "electric company" regulation. These exemptions have been used extensively in New York by non-utility entities as part of proceedings before the N.Y. P.S.C.[56] There is little, if any, precedent for the application of the D.C. exemptions before the D.C. PSC.

Note that the regulator in all three jurisdictions has some discretion to expand or contract the scope of "electric company" qualification by interpreting statutory terms that are undefined by statute. For example, in Massachusetts, an "electric company" is defined in part as an entity that "sells" electricity.[57] "Sale" is not defined by statute, and thus, in principle, the Mass. DPU could exclude some types of non-utility microgrids from "electric company" regulation by holding that such microgrids are not "selling" electricity. Both the Mass. DPU and N.Y. PSC recently used this approach with regards to electric vehicle charging stations.[58] Note, however, that the N.Y. PSC may be disinclined to take this approach with microgrids. In the REV Order, the N.Y. PSC announced a policy that microgrids in New York that serve "separate customers" are presumptively subject to "electric corporation" regulation.[59] As mentioned above, the D.C. PSC could exclude some types of microgrids from "electric company" regulation by interpreting "retail electric customer" to not include some types of microgrid customers.

In all three jurisdictions, even if a non-utility entity is deemed an "electric corporation," the regulator may have authority to craft regulatory oversight to meet the unique circumstances of that non-utility entity. This discretion is most apparent in New York, where the N.Y. PSC has adopted a "realistic appraisal" approach when applying statutory requirements on "new forms of electric service providers that differ in character from traditional electric utility monopoly

[56] *See*, for example, Petition of Eastman Kodak Company to Provide Utility Service in Kodak Park, Located in the City of Rochester and Town of Greece, Monroe County. Order Granting Certificates of Public Convenience and Necessity and Providing for Lightened and Incidental Regulation, 04-M-0388 (N.Y. P.S.C. August 2, 2004); Burrstone Energy Center LLC – Petition For a Declaratory Ruling that the Owner and Operator of a Proposed Cogeneration Facility will not be Subject to Commission Jurisdiction, Case 07-E-0802 (N.Y. P.S.C. August 28, 2007); Halletts Vendee LLC - Petition For A Declaratory Ruling Regarding Commission Jurisdiction Declaratory Ruling On Qualifying Facility Exemption From Regulation, Case 14-M-0508 (N.Y. P.S.C. February 9, 2015); Reenergy Black River LLC - Petition For Declaratory Ruling Regarding Regulation Over Proposed Electric Sales To Fort Drum. Declaratory Ruling On Qualifying Facility Status And Related Issues, Case 14-E-0184 (N.Y. P.S.C. August 18, 2014).

[57] M.G.L. c. 164 § 2(i).

[58] In a recent proceeding, the Mass. DPU held that electric vehicle charging stations are not engaged in the "sale" of electricity, but rather, provide an electric vehicle charging service, of which the provision of electricity was only one of several elements. Because the charging stations are not "selling" electricity, they are not subject to "electric company" regulation, even if they are paid by the kWh. Investigation by the Department of Public Utilities upon its own Motion into Electric Vehicles and Electric Vehicle Charging, D.P.U. 13-182-A, 2014 WL 4052812 (Mass. D.P.U. Aug. 4, 2014). A recent N.Y. P.S.C. Order had a similar holding. *See* In the Matter of Electric Vehicle Policies, Declaratory Ruling On Jurisdiction Over Publicly Available Electric Vehicle Charging Stations, Case 13-E-0199 (N.Y. P.S.C. November 14, 2013).

[59] "Where a microgrid serves electricity to separate customer accounts and is not otherwise exempt under law, it will be an electric corporation under the Public Service Law." REV Order, *supra* note 5, at 111.

providers."[60] When applying New York law to these new providers, the PSC has adopted a three-part test. First, the PSC asks if the law's requirement is applicable on its face.[61] Second, the PSC asks if the new entity can comply with the requirement.[62] Third, the PSC asks "whether imposing the requirement is necessary to protect the public interest, or would instead adversely affect the public."[63] The N.Y. PSC has previously applied this approach to microgrids.[64]

A full discussion of how different types of non-utility microgrid ownership and operation configurations might incur "electric company" regulation or qualify for statutory exemptions is beyond the scope of this report. For simplicity, the next two tables summarize, for each jurisdiction, the statutory language imposing such regulation, and the explicit statutory exemptions.

TABLE 1. Definition of "Electric Company" in each jurisdiction.

Mass.	Any entity that "manufactures and sells" or distributes and sells electricity.[65]
N.Y.	Any entity which "owns, operates or manages" any real or personal property "used for or to facilitate the generation, transmission, distribution, sale or furnishing of electricity[.]"[66]
D.C.	Any entity which "physically transmits or distributes electricity" in the District of Columbia to "retail electric customers."[67]

[60] Carr Street Generating Station, L.P. - Petition for an Original Certificate of Public Convenience and Necessity and For a Declaratory Ruling on Regulatory Regime. Order Providing for Lightened Regulation, Case 98-E-1670, 4 (N.Y. PSC April 23, 1999).

[61] *Id.* at 5.

[62] *Id.*

[63] *Id.*

[64] Petition of Eastman Kodak Company to Provide Utility Service in Kodak Park, Located in the City of Rochester and Town of Greece, Monroe County. Order Granting Certificates of Public Convenience and Necessity and Providing for Lightened and Incidental Regulation, 04-M-0388, 9, 10 (N.Y. P.S.C. August 2, 2004);

[65] M.G.L. c. 164 § 2(i).

[66] N.Y. PUB. SERV. LAW § 2(13), § 2(12).

[67] D.C. CODE §34-207.

TABLE 2. Explicit statutory exemptions from "Electric Company" designation in each jurisdiction.

Mass.	• No statutory exemption.
N.Y.	• An entity is not an "electric company" "[w]here 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."[68] • An entity is not an "electric company" if 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."[69]
D.C.	• "Electric company" "excludes any building owner, lessee, or manager who, respectively, owns, leases, or manages, the internal distribution system serving the building and who supplies electricity and other related electricity services solely to occupants of the building for use by the occupants."[70]

Licensure

Irrespective of whether a non-utility entity is subject to "electric company" regulation, it may also be subject to various kinds of licensure in each of the three jurisdictions. Besides the administrative burden of complying with the licensure requirements, some forms of licensure have additional implications. For example, in Massachusetts, any entity that is licensed as a generating company, aggregator, supplier, energy marketer, or energy broker is statutorily prohibited from net metering renewable generation.[71] Whether a particular non-utility microgrid entity will incur a licensure requirement is highly uncertain. For example, in Massachusetts, the licensure statutory language is often ambiguous. A full discussion of the licensure requirements is beyond the scope of this report. Table 3 provides a brief overview of some example licensure requirements that a non-utility microgrid may incur.

[68] N.Y. PUB. SERV. LAW § 2(13).

[69] N.Y. PUB. SERV. LAW § 2(13).

[70] D.C. CODE §34-207.

[71] M.G.L. c. 164 § 139(e). *See also* 220 CMR 18.06(1).

TABLE 3. Example licensure requirements in each jurisdiction.

Mass.	• DPU has authority to license "all generation companies, aggregators, suppliers, energy marketers, and energy brokers."[72]
N.Y.	• NY PSC exercises authority to license "Energy Services Companies."[73] • NY PSC will likely regulate distributed generation assets that sell services into the Distributed System Providers market, which will be created by the REV Order.[74]
D.C.	• "Electric Suppliers" are licensed by D.C. PSC.[75] • Construction of any "generation facility" for the "purpose of retail or wholesale sale of electricity" requires D.C. PSC pre-approval.[76]

[72] M.G.L. c. 164 § 1F(1).

[73] In The Matter Of Competitive Opportunities Regarding Electric Service. Opinion No. 97-5. Opinion And Order Establishing Regulatory Policies For The Provision Of Retail Energy Services, Case 94-E-0952, Appendix B (N.Y. P.S.C. May 19, 1997).

[74] REV Order, *supra* note 5, at 105.

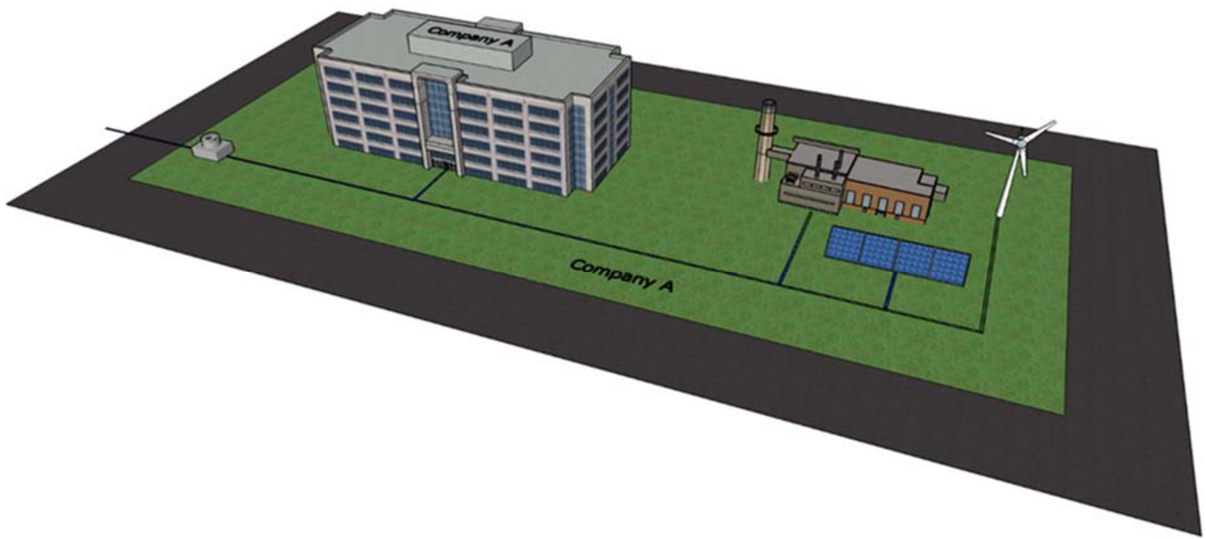
[75] D.C. CODE §34-1505.

[76] D.C. CODE §34-1516.

5. Application to Microgrid Scenarios

In this subsection, we apply the above legal discussion regarding non-utility entities to four microgrid scenarios. Each scenario assumes that the utility does not own or operate any component of the microgrid.

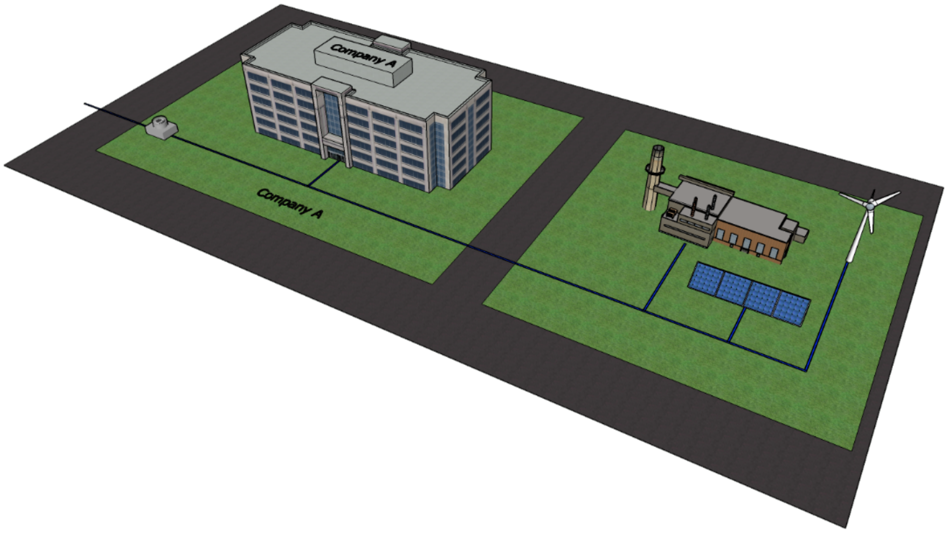
Scenario One: Single Owner / Operator with On-site DER.



In this scenario, a single legal entity owns and operates distributed generation assets and distributes electricity from such assets on a single continuous property. The microgrid is connected to the macrogrid at a single point of connection.

This scenario is likely allowed in all three jurisdictions. In Massachusetts, it would not violate the franchise because electricity that is generated by the onsite generators or procured from the macrogrid is continuously owned and controlled by the single legal entity from the point of generation to the point of consumption. In New York and D.C., because non-utility microgrids do not infringe on a franchise, this scenario is also allowed. Note that this scenario is likely excluded from “electric company” regulation in New York by an explicit property-based exemption. In D.C., it may be excluded from “electric company” regulation because it is not serving “retail customers.”

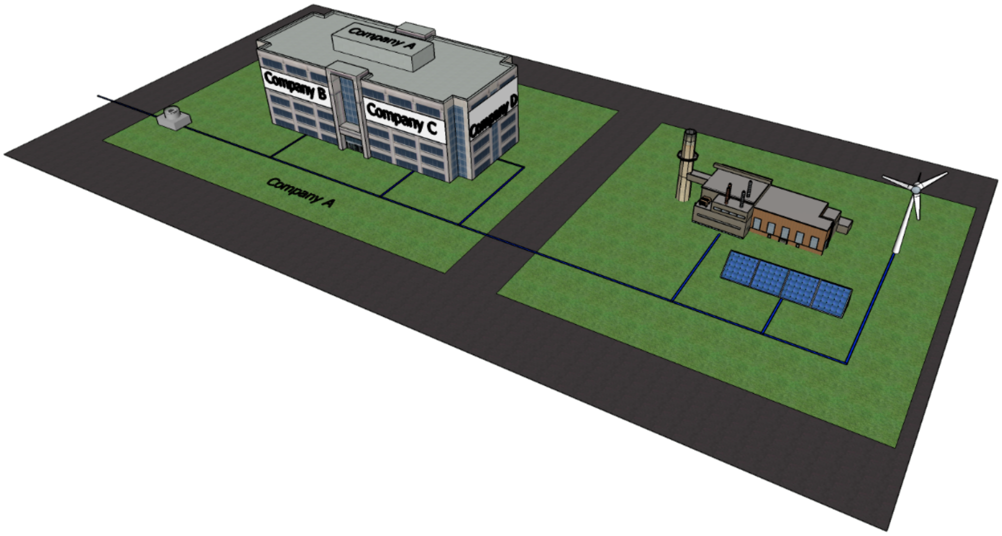
Scenario 2: Single Owner / Occupier with Off-Site Generation



This scenario is the same as scenario 1, except that a distribution line crosses a public right-of-way.

In all three jurisdictions, non-utility entities are allowed to cross public rights-of-way, provided they are granted municipal consent. Thus, this scenario is also allowed. Because the franchise clause in Massachusetts makes no reference to crossing a public right-of-way, it would not violate the franchise in Massachusetts. Likewise in New York and D.C., the fact that a distribution line crosses a public right-of-way does not change the analysis that a non-utility microgrid does not infringe a franchise. The regulatory implications, however, may be different. In New York, this scenario may qualify for either a property-based or technology-based exemption from "electric company" regulation, but whether the microgrid would be so exempt depends in great detail on the generating technology and capacity of the generators. In D.C., as in scenario 1, this scenario would likely still be exempt from "electric corporation" regulation as it still does not serve "retail customers."

Scenario 3: Multi-Tenant with Off-Site Generation

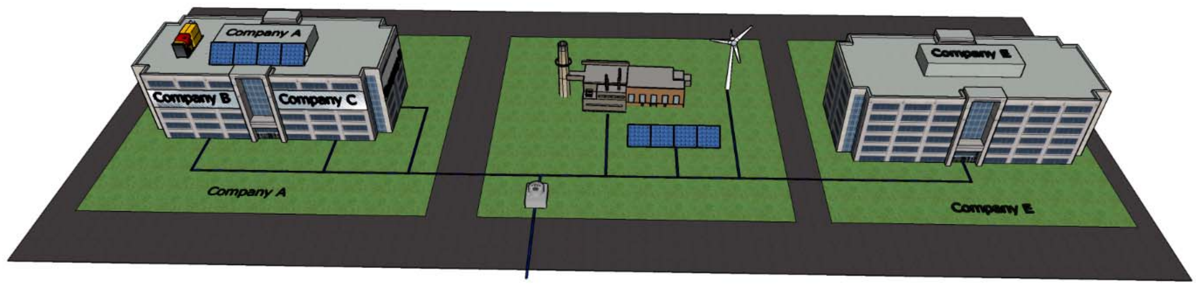


This scenario is the same as scenario 2 except that the building has tenants.

In all three jurisdictions, this scenario is also allowed, although the regulatory implications may be different than in scenario 2. In Massachusetts, although the franchise could be interpreted to prevent landlord provision of electricity to tenants, such provision has never been challenged and landlords commonly provide electricity as part of the rent in both a residential and commercial context. Thus, whether a building in a microgrid has tenants should not change a Massachusetts franchise analysis and this scenario should be no different than scenario 2. In New York and D.C., as in scenario 2, the regulatory implications depend highly on the generator technology and capacity. Note that in New York, the N.Y. P.S.C. has remarked that microgrids that serve "separate accounts" will be presumed to be regulated as "electric companies" unless otherwise provided by law.[77]

[77] REV Order, *supra* note 5, at 110.

Scenario 4: Multi-Building, Multi Tenant with both on-site and off-site generators



In this scenario, two or more property owners are served by a microgrid with DER assets that is connected to the macrogrid at one point of connection and that crosses several public rights-of-way.

This scenario would generally not be allowed in Massachusetts as it likely violates the franchise. Because this microgrid involves unaffiliated legal entities, the non-utility entity that operates the microgrid's internal distribution structure will be engaged in the transfer of ownership and control of electricity from the generator to at least one microgrid participant, and thereby will violate the utility's exclusive right to engage in such transfer. Note that the non-utility entity would not violate the franchise if the local utility consented to such an arrangement.

Creative ownership structures of this microgrid scenario may be able to avoid the franchise limitations in Massachusetts. As described above and elsewhere in more detail,[78] if all the microgrid participants jointly owned and operated all the microgrid assets, they may not infringe the franchise because they will not be engaged in the transfer of ownership and control of electricity – they will simply be sharing with each other electricity that they already jointly own.

In New York and D.C., because non-utility microgrids do not infringe a franchise, this scenario is allowed. However, as in other scenarios, the exact regulatory oversight in either jurisdiction requires very careful analysis that takes into account the generator technology and capacity.

[78] *See Massachusetts Microgrids: Overcoming Legal Obstacle*, *supra* note 2.

6. Conclusion

To briefly summarize this analysis, most microgrid ownership/operation configurations are likely permitted in N.Y. and D.C.; however, in Massachusetts, non-utility ownership/operation of the microgrid distribution infrastructure is constrained by Massachusetts' franchise statute. The regulatory implications of different microgrid ownership and operation structures depends greatly on the jurisdiction and requires careful analysis for each jurisdiction.

Multi-user Microgrid Straw Proposal

7/17/2015 Update | edited by Travis Sheehan, Boston Redevelopment Authority

1 Goal Statement

To develop a straw proposal business model which enables multiple owners of commercial real estate and/or institutional buildings to achieve greater resiliency, reduce GHG emissions, and lower total cost of energy through energy services from a "microgrid"- defined here as a local energy system producing and distributing electric and thermal energy.

2 Straw Proposal

The straw proposal outlines the desired outcomes of a microgrid, technologies that would be included in a microgrid, proposed business agreements, and a description of roles and responsibilities for each stakeholder in the microgrid.

In general, the straw proposal outlines the technology transfer of microgrid solutions from campus energy services into districts with mixed types of end users—including commercial real estate and institutional buildings—referred to here as a "multi-user microgrid".

3 Introduction

For decades, groups of buildings, typically owned by a single entity, have enjoyed the financial benefits of producing their own power—electricity, heating, and cooling. For the most part, these systems use cogeneration technology to achieve a lower total cost of energy. With the addition of islanding capability, microgrids enhance the on-site energy reliability as well as backing up the electric distribution grid—offering places of refuge for vulnerable populations in the event of a natural disaster and resultant extended utility grid outage. An islandable grid which provides competitively priced power can also be a lower-carbon source of energy compared to the electric utility grid depending on the regional mix of electric generation resources and the mix of resources used to power the microgrid. Historically, these benefits have accrued to corporate, university and medical campuses because these campuses are owned by a single entity and capital decision making yields sophisticated energy management solutions. In contrast, these benefits do not accrue to districts with multiple end users because (a) end users are not accustomed to district scale capital planning and (b) state statutory and regulatory structures do not directly address multi-user energy districts.

Multi-user microgrids face many challenges:

- End users, such as commercial real estate developers, perceive new energy management concepts as high risk
- Electric distribution utilities exercise caution when interconnecting distributed generation to the grid in order to maintain system stability and safety; new concepts such as islandability of districts within the distribution grid must also be carefully scrutinized

The series of Boston Microgrids Workshops, held between March and July of 2014, explored these opportunities and challenges of a multi-user microgrid through a multi-stakeholder process. This straw proposal is a product of those workshops, and will be further refined based on the input from the June 29, 2015 USDN multi-city multi-stakeholder workshop.

4 OUTCOMES

This straw proposal outlines an approach to attain three desired outcomes:

1. enhanced resiliency,
2. reduced GHG emissions, and
3. lower total cost of energy for end users.

There may be many ways to achieve each outcome individually, but microgrids are one way to accomplish all three goals simultaneously in the commercial and institutional real estate sector.

RESILIENCY: Microgrids should enable a city to bounce back quicker from a shock to the system than it does currently. Enhanced resiliency would achieve (a) enhanced business continuity and (b) enhanced life safety for vulnerable populations. Continuous power supply in its current incarnation is typically achieved at the building scale through redundant feeder connections and backup diesel generators. Key resiliency-related features of a microgrid include:

- ability to island;
- ability to isolate & serve critical loads;
- recovery for essential services to support a community through an extended outage; and
- enhanced reliability & power quality.

REDUCE GHG EMISSIONS: This includes integration of generation assets such as cogeneration and renewables (potentially with storage) that achieve a lower total GHG emission profile of all end uses combined within the microgrid compared to a business-as-usual case of electric and fuel inputs to a single building. Key GHG emissions reductions features include:

- renewables integration
- green buildings and up-front load reductions
- cogeneration, combined heat and power (CHP)

LOWER TOTAL COST OF ENERGY: This is the value achieved by consuming energy that is efficiently produced and locally consumed. Many campuses enjoy lower electricity and thermal costs because the efficient cogeneration of heat and power often yields a competitive lower total cost of energy compared to business-as-usual electric and gas inputs into a single building. End Users should see reductions in the combined capital and operating costs associated with conventional cooling, heating and power compared to a microgrid solution. In most cases, the economic savings comes from nearly “free” thermal energy, demand response services, and lower capacity charges and the ability to participate in ancillary services and other wholesale markets.

5 PROPOSED TECHNOLOGY MIX

Distribution Assets within the point(s) of Common Coupling: A local electric distribution network will (a) serve as a the platform for locally interconnected generation assets and loads; (b) enter into island mode to provide continuous power supply in times of macrogrid outage; (c) provide an interface with the macrogrid to optimize demand response capabilities; and (d) provide ancillary and distribution level services[1]. A local thermal distribution network will optimally utilize waste heat sources and thermal generation resources to distribute the lower cost cooling and heating energy to all end users.

Generation Assets: A portfolio of generation assets within the microgrid will (a) economically produce energy to meet peak thermal loads of end users; (b) in the case of CHP, economically produce electric energy[2] as a compliment to end-use thermal demand; (c) in the case of renewables and thermal/electric storage,[3] produce energy that can be consumed within the microgrid, reduce peak demand and, where applicable, utilize net metering and participation in ancillary services and other wholesale markets; and (d) where appropriate, produce excess thermal energy that can be exported (e.g., to a district thermal system), which may increase CHP sizing.[4]

Communications Assets: A portfolio of communications assets that include advanced metering infrastructure functionality, SCADA, load management and resource optimization capability, and appropriate interface with the macrogrid. It will also include the necessary protections for cyber-security.

6 BUSINESS AGREEMENTS & SCENARIOS

Each jurisdiction (DC, NY, and MA) will have various push and pull factors that inform the agreements required to enable multi-user microgrids. The USDN Microgrids Workshop focused on a single business agreement depicted by a the Scenario 1 diagram and table featured below. The USDN Microgrids Workshop utilized group scenario planning to work through the “deal makers” and “deal breakers” of the proposed scenario.

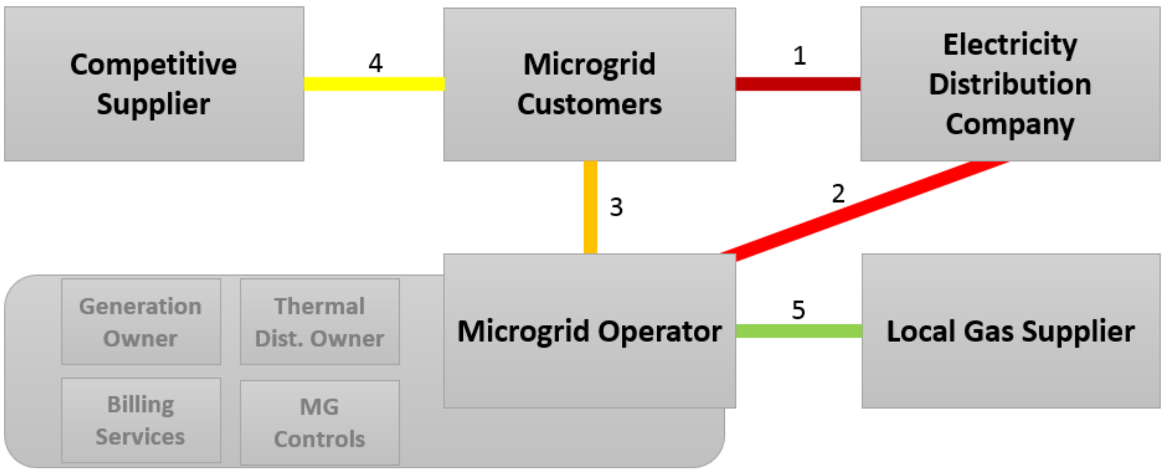
The Scenario below is one of the many business agreements possible from this microgrid straw proposal. These options are suggested because they minimize the number of enabling contracts required to accomplish the deployment of multi-user microgrids.

[1] Ancillary services may include any applicable services in Ancillary Services Markets. Distribution level services may include voltage control and feeder loading relief.
[2] When excess electric energy is generated by serving thermal loads, it may be exported to the macrogrid.
[3] A battery energy storage system (BESS) should be included in the microgrid to: (1) power essential services to support a community through an extended outage under conditions where diesel backup generators are unavailable for any reason (e.g., fuel has run out, emission constraints) and therefore intermittent PV is only source of electricity and (2) provide frequency and voltage support, including buffering PV.
[4] In addition to thermal-following CHP and other clean energy, some other gas-fired generation may be needed to meet critical loads in island mode, but the goal should be for total emissions to be lower than a base case with no microgrid and no DG.

6.1 Scenario 1:

The image below describes the structure of contracts between microgrid stakeholders where a 3rd Party Energy Development Company acts as the "Microgrid Operator" and owns the energy assets except the electric distribution wires, which are owned by the local electric utility.

6.1.1 Scenario 1 Contractual agreements diagram



6.1.2 Scenario 1 Contractual agreements table

1	**Distribution Company — Microgrid Customers**	• DISCO owned wires used in delivery of electric power • DISCO charges customers pursuant to conventional tariffs • DISCO charges 'Microgrid as a Service' Fee • When adding new load to distribution systems: any special customer charges are credited with savings of avoided distribution investments commensurate with non-imported power load (i.e. avoided substation capacity upgrades) • Transmission charges do not apply to base load power generated within the microgrid • Microgrid customers recognize change in liability for disruptions in delivery of electricity service- defining liability specific to distribution system functionality (DISCO's liability) versus load dispatch (MG Operator's liability)
2	**Distribution Company — Microgrid Operator**	• MG Operator provides T&D-related services to DC (e.g., voltage & frequency control, distribution capacity deferral) • A special contract is used to (a) define innovative services and charges (b) formalize communication & control protocols, including for islanding (c) power export to the macrogrid (d) define safety standards (e) define liabilities for disruptions in delivery of electric service (f) define

			standards for billing pursuant to customer specific services (i.e. incorporation of building specific distributed supply resources)
3	**Microgrid Operator**	**Microgrid Customers**	• MG Operator and MG Customers define protocols to optimize the market value of generation, storage & load management • MG Operator and MG Customers agree on standards for billing pursuant to optimization protocols for economic and environmental performance of microgrid • MG Operator combines applicable charges into single energy service bill for MG Customer • Microgrid and Customer-owned resources are dispatched by MG Operator • MG Customers agree to power purchase as necessary for both electric and thermal generation and distribution infrastructure investment • Agreements provide for adequate customer protections including volumetric and dispatch services obligations
4	**Competitive Supplier**	**Microgrid Customers**	• Competitive Suppler provides aggregation service for MG Customers through competitive supply contract brokered via MG Operator
5	**Local Gas Supplier**	**Microgrid Operator**	• Local Gas Supplier and Microgrid Operator enter into firm gas supply contract

7 Proposed Roles and Responsibilities of Microgrid Stakeholders

These proposed roles and responsibilities are meant to be consistent with both of the scenarios described above. They are divided into two lists—things that an entity "will" do in all of the most likely multi-user microgrid scenarios, and things that they "may" do depending on the particular multi-user microgrid scenario.

Electric Distribution Company (DISCO):

The incumbent distribution company will own electric distribution hardware. The DISCO will do the following:

- distribute power from the macrogrid into the microgrid and assist in the interconnection of the microgrid services to the macrogrid
- recover from the cost of distribution-related capital expenses and operating expenses unique to the microgrid through conventional tariffs and/or "Microgrid as a Service Fee"

The DISCO may:

- ensure that the interconnection of any local generation assets are safe and reliable
- distribute locally produced electricity within the microgrid
- serve as the Microgrid Operator
- own or manage energy storage systems as a distribution resource, if it is not used to sell energy, capacity or reserves into competitive markets outside the microgrid
- own the thermal distribution assets
- implement islanding technology to ensure isolation of a predefined area of the grid, where existing distribution lines exist
- provide demand and generation response capabilities to microgrid customers

Distributed Energy Resource Operator (including End Users with building-scale electric generation or storage technologies):

The Distributed Energy Resource Operator will:

- develop the generation assets and develop the cost recovery scheme through rate agreements for the electricity and thermal energy supplied with the Microgrid Operator, DISCO, or MG Customers
- produce and supply electric power into the microgrid distribution network
- produce and supply thermal power into the microgrid distribution network
- collect electricity supply revenues from the MG Operator, DISCO, or MG Customers
- engage in an interconnection procedure with the DISCO and MG Operator, allowing access and control of the generation assets for cost optimization, reliability, and safety

A Generation Operator may:

- supply electric power without having to enter the wholesale market with the assumption that a locally produced kilowatt hour will be cheaper than a retail kilowatt hour

Microgrid Operator:

The Microgrid Operator will:

- execute load management and optimization protocols as agreed upon by the DISCO and MG Customers

The Microgrid Operator may:

- be the DISCO or a DISCO subsidiary
- own the central energy plant and other distributed energy resources throughout the microgrid
- operate the central energy plant and other distributed energy resources throughout the microgrid
- be the single point of contact between the DISCO, generators, and loads/end users
- own generation and serve as dispatch control and entrant in the energy market
- manage building owned generation and keep records used for billing MG Customers

- manage competitive supply purchasing and contracts on behalf of the Microgrid Customers

THERMAL DISTRIBUTION COMPANY (TECO):

The TeCO will

- distribute reliable and safe thermal energy to end users

The TeCo may:

- enter into a Power Purchase Agreement with end users
- be any of the stakeholders or a sister company or subsidiary of any of the stakeholders
- develop the thermal distribution assets
- set rates to recover the cost of the distribution assets with end users

MICROGRID CUSTOMERS:

Microgrid Customers will:

- be billed by the DISCO pursuant to conventional tariffs
- enter into an agreement with the Microgrid Operator for services such as load management and optimization, competitive supply and aggregation services, thermal energy delivery and any ancillary services revenue collection from in-building energy generation

The Microgrid Customers may:

- enter into a Power Purchase Agreement with the thermal energy provider
- enter into a competitive supply contract with a Competitive Supplier
- enter into a special rate agreement or special contract such as a Microgrids as a Service Fee with the DISCO
- own generation assets and (a) gain revenues from ancillary services and local distribution support (b) net meter their electricity and thermal energy produced
- abrogate the right to retail choice for a dedicated volume of electricity coming from the microgrid (internal vs externally sourced power)
- abrogate the right to defection from thermal and electric delivery services as constituted through market-mature contracts such as Power Purchase Agreements, Energy Services Performance Contracts, and special contracts directly with the DISCO

8 Prologue to USDN Microgrids Workshop Scenario Planning Exercise

Major themes emerged from the USDN Microgrids Workshop scenario planning exercises. Many expressed that the complexity of the Straw Proposal contracts is daunting. “How would customers wrap their heads around these contracts? Would the transaction fees become prohibitive with so many contracts? Would the project be financeable based on such disparate revenue streams?” The exercise was intended to create an orderly, digestible way of looking at specific stakeholder needs in an attempt to reduce the complexity of the business model.

Many participants identified that there are no clauses regarding liability in the event of system defection or bankruptcy. This relates to both consumer protection and business assurance. Participants noted that the MG Customers would be at risk of a failed businesses entity like the MG Operator, thus ceasing their operational duties. Additionally, participants expressed concern regard the liability of each MG Customer in securing the cash-flows necessary for investments in the microgrid. It was notes that most district energy power purchase agreements have penalties for grid-defection.

There are few models for monetizing the resiliency benefits of microgrids, which participants regarded as a flaw and encouraged further exploration of existing systems benefits charges to subsidize resiliency investments that do not currently fit into the Cost/Benefit models used in rate settlements.

USDN Multi-Stakeholder Microgrid Workshop
Boston, MA | Hynes Convention Center | June 29, 2015
Workshop Summary

The Urban Sustainability Directors Network (USDN) Multi-Stakeholder Microgrid Workshop was held on June 29th, 2015 in Boston, MA at the Hynes Convention Center. The workshop was co-located with the IDEA 2015 Conference. The workshop began at 10:30am in a separate and private room allowing workshop participants to attend the IDEA conference's opening morning plenary panels—Panel 1: District Energy/CHP/Microgrids in Global Cities; Panel 2: Paradigm Shift-Utility of the Future.

Over 46 participants from Tier 1 (Boston, Cambridge, New York City, Northampton, Somerville, Washington D.C.) and Tier 2 Cities (Boulder); MA, NY and D.C. regulators; utilities; and developers attended the workshop. The names and organizations of these attendees are listed in **Appendix A**.

Opening Remarks

The workshop began with welcoming remarks from Brad Swing of the City of Boston. On behalf of Boston Mayor Marty Walsh, Swing welcomed participants to the workshop and Boston. Dr. Jonathan Raab then welcomed participants and reviewed the workshop's structure and **agenda**. Finally, the core workshop support team from the Pace Energy and Climate Center and the International District Energy Association introduced themselves to workshop participants.

Core City Updates

The delegations from the participating Tier 1 cities (Boston, Cambridge, Somerville, Northampton, New York City, and Washington D.C.) were asked to provide brief updates on any important microgrid activities or developments that have occurred since the March 26th pre-workshop City conference call as well as the driving factors for microgrid development in their respective cities.

Washington D.C. (slides)

Edward Yim provided an update for Washington D.C. Yim informed participants that Washington D.C.'s interest in microgrids stems from goals to decarbonize their electric grid and increase energy resiliency. While D.C. does not have any microgrids currently, there are several existing campus district energy systems. Yim highlighted several projects and initiatives including an initially large project at the Wharf, which has been scaled down due to business and regulatory reasons; a recently launched microgrid feasibility analysis; an investigation of sewage heat recapture; plans for microgrid development at Walter Reed Army Medical Center; and the D.C. Housing Authorities exploration of using a combination of fuel cells and solar to power 20% of their overall load.

New York City

Cathy Pasion provided an update for New York City. Pasion described the City's on-going involvement in New York's Reforming the Energy Vision (REV) proceeding including participation in various working groups. The City is striving to stay up-to-date with all on-going conversations and discussions to make sure future changes are in tune with the City's climate and affordable energy goals. Pasion informed the group that at least three sites (and likely more) in New York City were selected for microgrid feasibility studies as part of NYPrize.

Somerville
Oliver Sellers-Garcia provided an update for Somerville, MA. Sellers-Garcia shared that, while the City does not currently contain a microgrid, there is a substantial amount of planned development including 9,000 new housing units by 2030 that may be amenable to microgrid development. Much of this growth (~85%) will occur in undeveloped areas. Sellers-Garcia said that now is the time to start thinking about facilitating microgrids and district energy in planning processes.

Cambridge
Susanne Rasmussen provided an update for Cambridge, MA. Rasmussen informed the group that Cambridge currently hosts three large cogeneration facilities—Veolia's 250 customer CHP district energy system, MIT's CHP district energy system, and Harvard's CHP district energy system. Both MIT and Harvard have plans to expand their systems, and the City is exploring ways to get more customers hooked up to Veolia's district energy system. Rasmussen described two microgrids in the 'idea' and 'planning' phases within Cambridge that utilize 1MW solar arrays and will help improve energy resiliency for a water treatment plan and critical care facility. Rasmussen described the factors driving microgrid excitement in Cambridge including a cross-sector collaboration between Cambridge, Harvard, and MIT to improve the region's sustainability practices and the City's Net Zero Action Plan.

Northampton (slides)
Chris Mason provided an update for Northampton, MA. Mason described the City's interest in microgrid as being driven by the risk of long-term power outages, especially after witnessing the impact of Hurricane Sandy. Mason informed the group that the City has worked with Sandia National Laboratories to investigate the City's resiliency needs. There are currently a couple microgrids in the development stage including one at Cooley Dickenson Hospital and another at the Fire Department Headquarters (see slides).

Boston
Travis Sheehan provided an update for Boston, MA. Sheehan categorized the City's efforts into three areas—finding appropriate business models for microgrids, a citywide energy study to identify appropriate and high value areas for microgrid development, and pursuing a microgrid pilot project. The City has helped develop a series of microgrid workshops to explore business models, is working closely with Eversource to explore a pilot project in the Marine Industrial Park, and expects the citywide energy study to be released in October.

Multi-User Microgrid/DE Economic Benefit/Cost Streams in Massachusetts, New York, and Washington D.C.
John Kelly of the Green Building Council delivered a presentation to the group that explored possible benefit and cost streams for a microgrid in Massachusetts, New York, and Washington D.C. by modeling a hypothetical multi-user microgrid in each locality. Kelly's presentation slides can be accessed here. After the presentation, Kelly fielded questions from the audience, which are captured below.

- In response to a question regarding how to balance the lost revenue impact microgrids may have on utilities, Kelly suggested that microgrid development that focuses on new development would avoid the issue of reducing a utility's revenue. He also reiterated that the presentation's purpose was to explore the value of services that could be provided by a microgrid. For example, new developments can avoid otherwise costly system capacity upgrades through incorporation of a microgrid.
- A participant asked if microgrid development could create new revenue streams for utilities. Kelly responded that there are ways to create new revenue streams for utilities through various service models.
- A participant asked about potential models similar to Vancouver where new developments can apply to act as a separate and new utility in areas where the incumbent utility is not currently active. Kelly responded by saying he believes a utility-city collaboration is key for microgrids in cities.
- A participant commented that when Princeton's microgrid switched to real-time pricing, the microgrid actually began buying more energy from the local utility.
- A participant commented that discussions are being held with NE-ISO about the feasibility of microgrids being considered within the regional 6-state capacity planning system
- A participant commented that DC is investigating microgrids for potential peak shaving during certain time periods. Kelly commented that this is what the Illinois Institute of Technology (IIT) currently does and that their utility still retains most of the original distribution charges due to this mode of operation.
- A participant commented that scalability is a significant issue regarding microgrids. The participant asked if it possible to start with a building that has CHP (for example) and then expand into a microgrid and whether there is another type of model needed for investigating replicable incremental microgrid growth in an urban city. Kelly responded that Walter Reed's microgrid system is a good example. He further iterated that scalable microgrids will lose some economies of scale, but that it is entirely possible to do "microgrids within microgrids" that eventually all tie into the same system.
- A participant asked what the solar installation cost was in the presented hypothetical example. Kelly said the modeled price was $4/watt—a fairly high estimate.
- A participant asked for clarification regarding real estate benefits of the microgrid (i.e. additional rentable space). Kelly clarified that the model looks at differences in square space needed for these systems versus conventional buildings and incorporates average rental space value in each city. Kelly mentioned that roughly 2% of space is made available by the microgrid, but this value varies depending on the number of buildings served.
- A participant asked whether standby charges were incorporated into the model. Kelly clarified that standby charges were incorporated in the relevant jurisdictions.
- A participant commented that a recent study that looked at electrifying all buildings with renewable energy would require substantial grid upgrades for the scenario. Microgrids are an alternative to this idea and can help reduce the needed for costly upgrades on the system, while reducing emissions and improving resiliency.

Multi-User Microgrid/DE Legal Issues and Potential Solutions in Massachusetts, New York, and Washington, D.C.

Seth Hoedl of the Harvard Law Clinic delivered a presentation to the group that described the legal hurdles for microgrids in Massachusetts, New York, and Washington, D.C. Hoedl's presentation can be accessed here. After the presentation, Hoedl fielded questions from the audience, which are captured below.

- A participant asked how a third-party owned generation asset may change the presented legal analysis for Massachusetts. Hoedl explained that if the 3rd-party owned asset is on the customer's property, it would be considered to be in the customer's control. Therefore, irrespective of how the energy is paid for, the property owner would be considered to have control of the energy and therefore the legal analysis would not differ for a 3rd-party owned asset on the customer's property.
- Several participants commented on the lack of a written franchise for PEPCO in Washington D.C. One participant commented that Georgetown Law also researched this issue and could find no evidence of a written record of a franchise dating all the way back to the 1870s.
- A participant asked how 3rd-party generation ownership may impact the legal analysis for Washington D.C. Hoedl relayed that his understanding is that it would be allowed, but that the degree of regulation is unclear. The definition of an electric company in DC is any entity which physically transmits or distributes electricity in DC to retail customers, but retail customer is not defined in the code, which provides some flexibility for interpretation.
- A participant commented that a microgrid operator could choose to be licensed as a retail electric supplier and have the utility own the wires in a microgrid, which may reduce regulatory burden.
- A participant asked for additional information/clarification on legal issues regarding the assurance of safety in DC. Hoedl responded that DC code has complete jurisdiction over ensuring safety of physically distributing electricity. Therefore, it does not matter who the entity is distributing electricity, the authority always rests with DC to regulate for safety.
- A participant asked if there are any current examples of a joint venture microgrid in Massachusetts. Hoedl responded that he was not aware of an example in existence.
- A participant asked whether a microgrid operator may be considered an electric company under New York's Public Service Law. Hoedl responded that, as written, a microgrid operator may be regulated as an electric company.
- City of Boston representative expressed its thanks for Hoedl's analysis and stated that the City is ready for a pilot project that is a distribution company owned model.
- MA DPU Chair commented [in response to Boston's comment] that the commission has not stated its position on whether utility-owned or privately-owned microgrid models (or both) are preferable. Currently there is interest in both models.
- A participant commented that the NY Prize program in New York will feature many different microgrid demonstrations. This may be a good source for exploring possible business models.

Top Potential Benefits and Barriers

Within their stakeholder groups, participants were asked for brainstorm the biggest potential benefits and barriers of microgrids. Each stakeholder table's responses are listed below.

State Regulators	
Benefits	*Barriers*
• Increased Efficiency -> Lower GHG • Increased reliability to microgrid participants and possibly increased resiliency to surrounding areas (community stewardship) • Deferment or elimination of utility capex to address load growth and power quality (reliability) • Fast-acting ancillary services to the distribution system • Security advantages of distributed generation (less vulnerable than centralized generation) • Total cost of energy decrease • Energy infrastructure expenditure decisions possibly made closer to the customer	• Obligation to serve • Safety, reliability oversight • Wholesale FERC regulation • Risk averse utilities • Exclusive franchises • Attracting third-party investment • It may make more sense for generation to sell into RTO -> sustainable business model • Less distribution wires, less revenue to distribution utility, what's the ratebase? • CHP Air -> air+noise permitting

Federal Agencies / Utilities	
Benefits	*Barriers*
• Customer services; improvement of power quality • Cost savings • Environmental benefits • Resiliency with a payback	• Crossing rights-of-way • Siting; selecting appropriate locations • Load profiles

Cities (Table 1)	
Benefits	*Barriers*
• Many possible value streams • Resiliency	• Finding the right business model • Finding a long-term reliable thermal load customer • Reliability of control technology • Navigating building codes, permitting processes

Cities (Table 2)	
Benefits	*Barriers*
• Keeping capital local • Supporting new jobs for both mature companies and innovative start ups • Helping economically challenged areas with new development • Resiliency	• Conventional real estate development practices that are typically ad hoc; even though there is a commitment for master planning, it is still typically done parcel by parcel instead of holistically • Quantifying the savings and attributing them to different stakeholder groups • Utility revenue model; what is the right space to have this discussion? How do you scale from a pilot to an actual rate that will cover an entire territory?

Core Workshop Team	
Benefits	*Barriers*
• Applications for hospitals, waste water treatment plants, datacenters • Ability to differentiate transmission and distribution costs	• Finding the right business model • Finding long-term reliable thermal load customer(s) • Reliability of control technology • Navigating building codes, permitting processes

Highlights of Microgrid Scoping Paper

Dan Leonhardt of the Pace Energy and Climate Center delivered a presentation covering the microgrids white paper developed for the workshop. The presentation can be accessed here. Following the presentation, Leonhardt fielded questions from participants as captured below.

- A participant asked if any of the case studies highlighted microgrids with multiple owners. Leonhardt confirmed that none of the case studies feature this type of system and highlighted the fact that the purpose of the workshop is to push for these systems which have historically been difficult to bring to fruition.
- A participant commented that coordination with transportation departments is critical; as they dig up the roads, many other improvements can be made concurrently.

Delineation of a straw-proposal for a multi-user microgrid

Travis Sheehan of the Boston Redevelopment Authority provided an overview of the straw proposal and contract pathways. The presentation can be accessed here. Sheehan than fielded several clarifying questions as described below.

- A participant asked for clarification on a microgrid-as-a-service fee. Sheehan clarified that it is a fee for the service of providing microgrid distribution infrastructure including islanding infrastructure to the microgrid.
- A participant asked whether the load is known in this scenario. Sheehan responded that is necessarily known since in this example we assume the microgrid is already built.

Small Group Scenario Planning Exercise

Workshop participants were broken into groups based on location (D.C. / NYC / MA) and asked to identify deal makers and deal breakers for each contract path within the straw proposal from the perspective of their own jurisdiction (each group had a representative of each stakeholder). The contract paths are based upon the "3rd Party is Microgrid Operator" scenario on Slide 10 of Sheehan's presentation.

Massachusetts (Table 1)	
Contract Path 1 | Distribution Company ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Distribution company's relation with customers is important to keep • Interconnection service agreement serving as groundwork for "premium service" fee • Distribution company owning and operating switches is preferable	• Microgrid operator handling billing is deal breaker for distribution utility
Contract Path 2| Distribution Company ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Microgrid operator working in conjunction with distribution utility • Microgrid operator acting as entity that responds to price signals for entire microgrid	
Contract Path 3 | Microgrid Operator ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Competitive supplier is microgrid operator • Contract structure to provide lowest cost and highest reliability	• Securitizing capital assets is complex, generally requires long term PPA which may be a deal breaker for customers
Contract Path 4 | Competitive Supplier ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Competitive supplier is microgrid operator	
Contract Path 5| Local Gas Supplier ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Receiving efficiency credits (e.g. MIT cogeneration plant receives efficiency credits / funding through MOU with Eversource)	

Massachusetts (Table 2)	
Contract Path 1 | Distribution Company ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Microgrid as a "service fee" is deal maker for distribution company • Relative value of resiliency for customer compared to fee will determine if fee is deal maker or breaker for customer	• Customers' ability to opt out of microgrid
Contract Path 2| Distribution Company ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Microgrid operator providing T&D related services • Microgrid operator has special contract	• Unclear delineation of responsibility for safety assurances
Contract Path 3 | Microgrid Operator ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Microgrid operator entering into thermal purchase agreement with customers	• Lack of thermal load
Contract Path 4 | Competitive Supplier ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Diverse selection / direct access to supply • Relationship directly between supplier and customers	• Microgrid operator may be one handling competitive supply; this may be giving operator a very complex task that may not be compatible with other tasks
Contract Path 5| Local Gas Supplier ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Duel fuel ability	• High premium for firm gas service

Massachusetts (Table 3)	
Contract Path 1 | Distribution Company ← → Microgrid Customers	
Deal Maker	Deal Breaker
	• Standby charges and tariffs • Unclear rules around obligation to serve
Contract Path 2| Distribution Company ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Demand response and/or curtailment agreement that create additional revenue	• Scenarios where the utility can force the microgrid to island – who decides this?
Contract Path 3 | Microgrid Operator ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Resilient service to critical loads • Optimization of thermal load • Tiered pricing based on criticality of load	• Ability to sell energy based on entity structure • Social equity pressures on serving critical loads
Contract Path 4 | Competitive Supplier ← → Microgrid Customers	
Deal Maker	Deal Breaker
	• Ability to source in a many to many layout; the complexities of retaining choice but having a practical and financeable system is tough
Contract Path 5| Local Gas Supplier ← → Microgrid Operator	
Deal Maker	Deal Breaker
• New revenue • More resilient / cleaner fuel supply compared to diesel	• Gas service and/or gas capacity constraints

<table>
<tr><th colspan="2">New York City</th></tr>
<tr><td colspan="2">Contract Path 1 | Distribution Company ← →Microgrid Customers</td></tr>
<tr><td>Deal Maker</td><td>Deal Breaker</td></tr>
<tr><td>• Utility bills for wires</td><td>• Unclear which T&D charges will remain
• If utility doesn’t own wires, then there has to be an arrangement where customers remain liable for operations should the parent company fail</td></tr>
<tr><td colspan="2">Contract Path 2| Distribution Company ← →Microgrid Operator</td></tr>
<tr><td>Deal Maker</td><td>Deal Breaker</td></tr>
<tr><td>• Microgrid as a service fee must be regulated
• Clarity on fees and incentives
• Tariffs based on microgrid classes (e.g. similar characteristics) after initial individually negotiated rates</td><td>• Inability to negotiate charges with distribution company on a long term basis
• Uncertainty about future charges
•</td></tr>
<tr><td colspan="2">Contract Path 3 | Microgrid Operator ← →Microgrid Customers</td></tr>
<tr><td>Deal Maker</td><td>Deal Breaker</td></tr>
<tr><td>• Microgrid operator provides 100% of energy
• Existing AMI
• Microgrid operator should be an ESCO</td><td>• Uncertainty around who bears expenses for billing mechanisms, software, other infrastructure
• Remaining NERC compliant</td></tr>
<tr><td colspan="2">Contract Path 4 | Competitive Supplier ← →Microgrid Customers</td></tr>
<tr><td>Deal Maker</td><td>Deal Breaker</td></tr>
<tr><td>• Competitive supplier working through microgrid operator (as opposed to directly with customers)</td><td>• Direct supply from an ESCO to customers (billing/metering is too complex)</td></tr>
<tr><td colspan="2">Contract Path 5| Local Gas Supplier ← →Microgrid Operator</td></tr>
<tr><td>Deal Maker</td><td>Deal Breaker</td></tr>
<tr><td>• Dual fuel flexibility</td><td>• Firm rates
• Emission impacts from dual fuel</td></tr>
</table>

Washington D.C.	
Contract Path 1 | Distribution Company ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Clear rules on who pays / cost sharing • Avoiding utility capital expenses • Customers share savings of avoided investments	• Utility asks developer to pay for all of the infrastructure but then hand over ownership of infrastructure to utility • Cross subsidization issue would be issue for regulators • Complex if DISCO just owns wires. Would be simpler if they did all or none
Contract Path 2| Distribution Company ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Clear regulatory guidance for all parties • Liability on operations should be placed on the operator and not the utility	• Reliability risk of operator (deal breaker for Utility) • High entry barriers placed by utility company such as asking for a cost prohibitive feasibility study (deal breaker for Customers/Microgrid Operators)
Contract Path 3 | Microgrid Operator ← → Microgrid Customers	
Deal Maker	Deal Breaker
• Stable long term revenue stream (deal maker for Microgrid Operator) • Lower cost for power, stable, predictable, resiliency (deal maker for Customer) • Clear rules for demand response • Some exit mechanism (deal maker for Customer)	• Too easy exit mechanism (deal breaker for Customer) • Costs are high (deal breaker for Customer) • No recourse or ability to exit (deal breaker for Customer) • Complexity
Contract Path 4 | Competitive Supplier ← → Microgrid Customers	
Deal Maker	Deal Breaker
• May be able to get a premium on supply contracts (deal maker for Competitive Supplier); needs to be clarity on type of services provided by competitive supplier	• May be a very complicated scenario • Complicated load profiles • Inflexible supply contracts
Contract Path 5| Local Gas Supplier ← → Microgrid Operator	
Deal Maker	Deal Breaker
• Long term contract with clear prices • Existence of firm gas contract (for gas supplier)	• Volatile prices for natural gas • Capacity constraints / infrastructure costs for gas supply

Straw Proposal Critique

Workshop participants were asked to review the last two pages of the straw proposal on roles and responsibilities of different microgrid stakeholders (pages 6 and 7) and offer specific changes and critiques. Each table reviewed the proposal as a group. Due to time constraints, groups were asked to focus on a specific stakeholder groups first to ensure that all the groups were covered by at least one group. Specific changes and critiques are presented below by group and by straw proposal entity. [Note: Following workshop, our team reviewed the changes and updated the straw proposal roles and responsibilities based on workshop input—see redline changes in **Appendix B** and clean version in **Appendix C.**]

Massachusetts (Table 1)

Electric Distribution Company (DISCO)

- The first bullet point under "the DISCO may" should be moved to "The DISCO will" section. It is vital for the DISCO to recover costs.
- The second and third bullet points under "the DISCO may" are connected; the DISCO could serve as Microgrid Operator which would include owning/managing battery energy storage systems

Massachusetts (Table 2)

Electric Distribution Company (DISCO)

- General comment: resiliency is a social benefit; how do we take existing system benefits charge and other added charges within cost of electricity and have creative examination to see how these can help finance and capture social benefits of microgrids
- General comment: How does role of DISCO help reduce total cost of customers?

Massachusetts (Table 3)

Microgrid Customer

- The second bullet point under "the Microgrid Customer may" should be moved to "the Microgrid Customer will". The Microgrid Customer will enter into an agreement with the Microgrid Operator.
- Language should clarify what type of energy—thermal and/or electrical—is being contracted.

Thermal Distribution Company (TeCO)

- The third bullet point under "the TeCO will" should be moved to "the TeCO may". The TeCO may set rates to recover the cost of the distribution assets with end users.

Microgrid Operator

- The fourth bullet point under "the Microgrid Operator" may should be split into two bullet points.
    - The Microgrid Operator *may* own generation
    - The Microgrid Operator *will* be an entrant in the energy market (ISO New England)

New York City

Microgrid Customer

- The second bullet under "the Microgrid Customer may" should be moved to "the Microgrid Customer will". The Microgrid Customer *will* enter into an agreement with the Microgrid Operator.

- The second bullet point under “the Microgrid Customer will” should be moved to “the Microgrid Customer may”. The Microgrid Customer *may* enter into a Power Purchase Agreement with the thermal energy provider

Microgrid Operator / Thermal Distribution Company

- General comment: Microgrid Operator and Thermal Distribution Company should be combined. The TeCO may be a subset of the Microgrid Operator.
- General comment: The Microgrid Operator should apportion value on behalf of the microgrid customer.

Washington D.C.

Electric Distribution Company (DISCO)

- The first two bullet points under “the DISCO will” should be moved to “the DISCO may”. Depending on the scenario, the DISCO may or will ensure safety of interconnection and distribute locally produced electricity with the microgrid
- The third bullet point under “the DISCO will” should be amended to say that the DISCO will distribute power into the microgrid to a point of common coupling (and remove reference to individual meters)
- The first bullet point (regarding recovery of costs) under “the DISCO may” should be moved to “the DISCO will”. An edit as follows “recover…and operating expenses INCURRED by DISCO unique…”
- The third bullet point under “the DISCO may” should be amended to remove “battery” in front of storage to broaden the type of storage the microgrid may contain; and add language as follows “…distribution resource WITHIN THE MICROGRID if it…”
- An additional bullet point should be added under “the DISCO may” that says the DISCO may provide demand (and generation) response capabilities to microgrid customers

Generation Operator

- Change “Generation Operator” in title to “Distributed Energy Resource Operator”

Appendix A – Workshop Attendees

USDN Microgrid Workshop – June 29, 2015 - Attendance			
First Name	**Last Name**	**Title**	**Company**
Nina	Axelson	Vice President of Public Relations	Ever-Green Energy
Daniel	Bartman	Senior Planner	City of Somerville
Dhruv	Bhatnagar	Energy Regulatory Analyst	Massachusetts DPU
Gerry	Bingham	Senior Coordinator of DER	MA-Division of Energy Resources
Thomas	Bourgeois	Director	US DOE Northeast CHP TAP
C. Baird	Brown	Counsel	Drinker Biddle & Reath
Jorge	Camacho	Interim Chief, Infrastructure & System Planning	DC Public Service Commission
Anna	Chittum	President	Gridkraft
Susan	Cohen	Assistant Commissioner	NYC DCAS; Division of Energy Management
Bronwyn	Cooke	Sustainability Planner	City of Cambridge
Anthony	Fiore	Director of Energy Regulatory Affairs	NYC Mayor's Office of Sustainability
Bryan	Glascock	Senior Advisor-Regulatory Reform	BRA
Patrick	Haswell	Business Development Manager	Veolia Energy North America
Seth	Hoedl	Fellow	Harvard Law
Kate	Johnson	Climate Change Program Analyst	District Dept of the Environment
Betty Ann	Kane	Chairman	DC Public Service Commission
John	Kelly	Leon Lowenstein Fellow	Green Business Certification, Inc.
Jonathan	Koehn	Regional Sustainability Coordinator	City of Boulder
Shannon	Lawrence	Head of Energy Initiative	C40 Cities Climate Leadership Grp.
Daniel	Leonhardt	Senior Energy Policy Associate	US DOE Northeast CHP TAP
Melissa	Liazos	Senior Counsel	National Grid
Jim	Lodge	VP, Alternative Energy Solutions	NRG Energy
John	Lombardi	Dir. of Facilities Departments	Cooley Dickinson Healthcare
Jalal	Mapar	Dir. Resilient Systems Division	Dept of Homeland Security, Science & Technology
Nicholas	Martin	Energy Policy Associate	US DOE Northeast CHP TAP

Appendix A – Workshop Attendees

USDN Microgrid Workshop – June 29, 2015 - Attendance			
First Name	**Last Name**	**Title**	**Company**
Cheryl	Martin	Founder	Harwich Partners
Chris	Mason	Energy & Sustainability Officer	City of Northampton
Thomas	Mimnagh	Department Manager	Con Edison Co. of NY Inc
Galen	Nelson	Director of Market Development	MassCEC
Thomas	Nyquist	Executive Director	Princeton University
Angela	O'Connor	Chairman	MA DPU
Luis	Ortiz	Program Manager Microgrids	Anbaric Microgrids
Cathy	Pasion	Senior Policy Advisor	NYC Mayor's Office of Sustainability
Jonathan	Raab	President	Raab Associates
Laxmi	Rao	Director	IDEA
Susanne	Rasmussen	Dir of Environ & Transport. Plan.	City of Cambridge
Paul	Renaud	Vice President, MA Engineering	Eversource Energy
Brian	Ritzinger	Public Utilities Engineer	MA DPU
Oliver	Sellers-Garcia	Dir. of Sustainability & Environment	City of Somerville
Travis	Sheehan	EcoDistricts Energy Fellow	BRA
Ken	Smith	President & CEO	District Energy St. Paul
Bradford	Swing	Director of Energy Policy & Programs	City of Boston
Claudia	Tighe	CHP Deployment Program Mgr	U.S. Dept. of Energy
Bill	Updike	Interim Deputy Dir, Urban Sustainability	District Dept of the Environment
Edward	Yim	Associate Director, Energy Policy & Compliance	District Dept. of the Environment
Peter	Zschokke	Director, Regulatory Strategy	National Grid