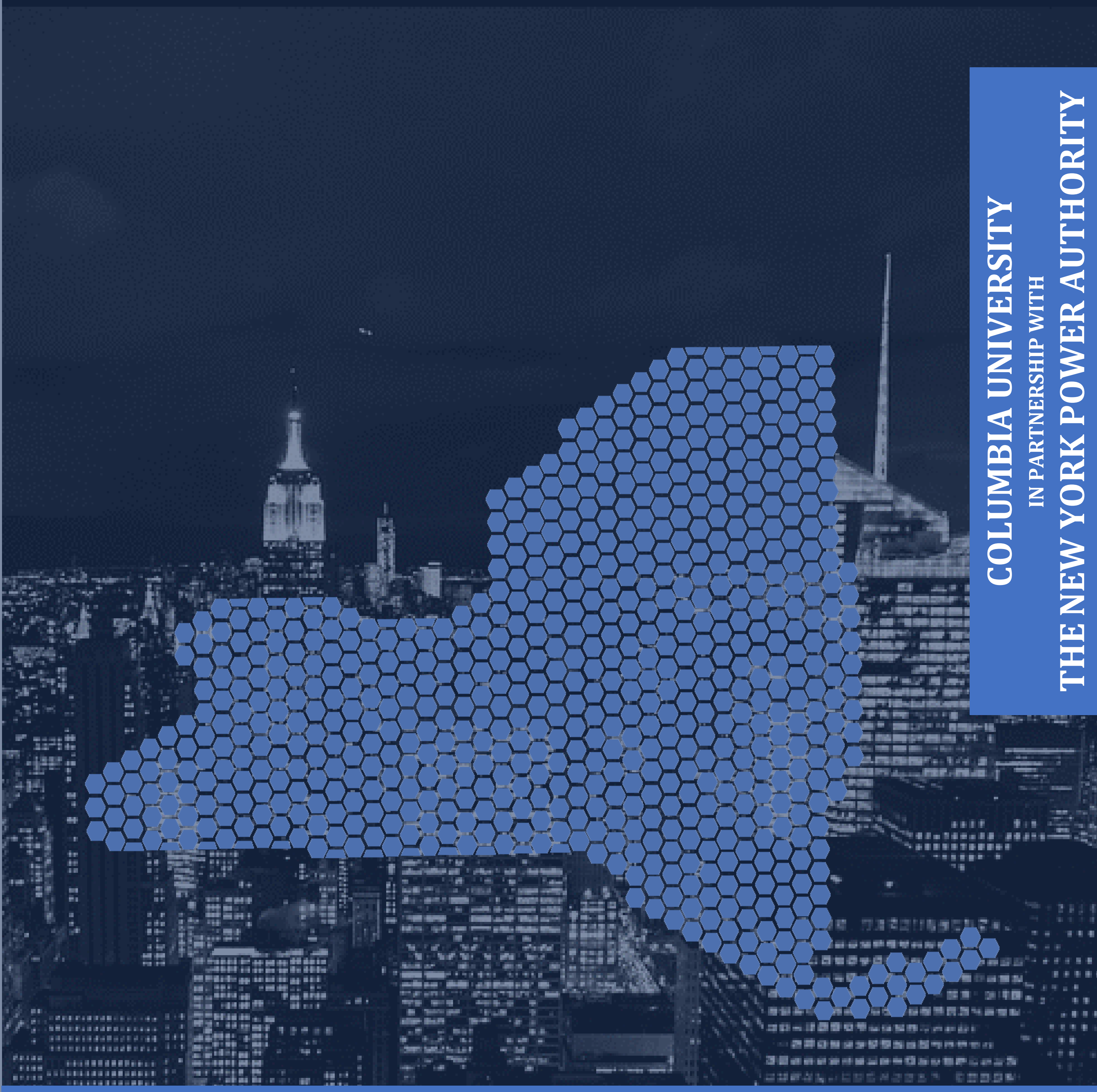

COLUMBIA UNIVERSITY

IN PARTNERSHIP WITH

THE NEW YORK POWER AUTHORITY

MICROGRID INTEGRATION IN NEW YORK

Challenges & Opportunities

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About New York Power Authority & this Project

The mission of the New York Power Authority is to "Power the economic growth and competitiveness of New York State by providing customers with low cost, clean, reliable power and the innovative energy infrastructure and services they value." The New York Power Authority has been a leader in the implementation of New York State's Reforming the Energy Vision, which seeks to create a dynamic, clean energy economy through the development of distributed energy resources. In addition to upgrading their own infrastructure, The New York Power Authority has actively collaborated on projects that align with Reforming the Energy Vision's goals to modernize the electricity system including BuildSmart NY, K-Solar, Solar MAP, and Reforming the Energy Vision Campus Challenge. It is imperative that the New York Power Authority continue to evolve as New York State continues its energy transition. In light of Reforming the Energy Vision, identifying opportunities for the New York Power Authority in the areas of microgrid and distributed energy resource development will be particularly important.

Our research team aimed to develop recommendations for the New York Power Authority regarding their role in the rapidly evolving Reforming the Energy Vision future. Specifically, our team investigated the technical, regulatory, and financial opportunities that the New York Power Authority should capitalize on in an energy system that favors microgrid and distributed energy resource development.

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Executive Summary

The New York energy sector is undergoing transformative changes, driven in part by a fundamental shift in the way the electricity is produced. The centuries-old method of generating electricity at a few large, centralized power plants is being replaced by a distributed model where energy is produced at many points on the grid, and closer to the point of consumption. Nationwide, distributed generation capacity is expected to more than double from 1,200 megawatts to 3,000 megawatts by 2020, with the majority of growth from renewable sources.[1] The integration of intermittent renewable generation technologies is already straining existing grid infrastructure, which was designed and built around the old technologies of the centralized model.

Microgrids present one part of the pathway toward modernizing New York's electricity system. Microgrids are networks of generation, distribution, and storage infrastructure that can exchange electricity with the main grid. Smart meters and electronic controls are used to network microgrids together, creating system-wide benefits to stability, resiliency, and efficiency that provide similar services to traditional infrastructure upgrades (e.g. peaker plants or new substations) at a much lower cost. Individual microgrids projects are small enough that they can be designed, built, and financed by a residential community or commercial entity. As such, they represent a cost-effective means of creating a modern and efficient grid system that meets the future needs of New York.

Despite the potential benefits of microgrids, and despite initiatives to kickstart microgrid development within New York, their expansion has been slow. The technical challenges created by microgrids and renewable integration are well understood, and solutions to them have been outlined elsewhere. The research conducted in this report shows that technological innovation is not the major barrier to microgrid deployment. Rather, progress is constrained by an outdated regulatory system that slows project development, and by the absence of financial and ownership models that align the incentives of grid operators, producers, consumers, and the myriad stakeholders comprising the power sector.

This report draws on expert knowledge from more than 40 electricity industry representatives and a selection of case studies to illuminate the regulatory and financial barriers to grid modernization in New York. It seeks to address these barriers through a set of five interrelated recommendations for the New York Power Authority. The New York Power Authority should (1) Forge a cross-cutting working group to build internal capacity and create a long-term focus on microgrid development; (2) Create a replicable financial model to support microgrids that can be customized to fit the needs of each project; (3) Experiment with hybrid ownership models for microgrids with the aid of partners like the New York Green Bank; (4) Pilot applications of cutting-edge smart grid technologies like blockchain smart contract technologies; and (5) Build on the New York Energy Manager platform to establish itself as a centralized data and energy aggregator.

Taken together, these recommendations outline a strategic pathway for New York Power Authority to lead the transition to the modern energy system laid out in New York's Reforming the Energy Vision initiative, while accessing emerging market opportunities and fulfilling its mission to "Power the economic growth and competitiveness of New York State by providing customers with low cost, clean, reliable power and the innovative energy infrastructure and services they value."

Key Terms

Blockchain

Cryptocurrency | *A digital currency which employs cryptography for security, and can be securely exchanged and utilized independent of a central banking system.*

Private Blockchain | *Technology for storing and validating data that enables automatic and confidential transactions between energy producers and consumers. Within a private blockchain network access and exchanges are overseen by an intermediator.*

Public Blockchain | *Technology for storing and validating data that enables direct and confidential transactions between energy producers and consumers. Within a public blockchain, these exchanges can be tracked and cannot be manipulated, eliminating the need for centralized monitoring.*

Peer-to-Peer Network | *A decentralized network in which individual users are able to exchange resources with one another.*

Smart Contract | *A computer program capable of self-executing and self-enforcing a pre-programmed contract using blockchain technology. The autonomy of smart contracts allows multiple parties to anonymously interact without the need of an intermediary.*

Smart Meter | *An electronic device that records customer energy consumption and reports back to the utility, and enables two-way exchange of data between the customer and the provider.*

Electricity

Base Load | *The minimum amount of electricity required to support an electrical system over 24 hours.*

Distribution | *The movement of electricity from the transmission system to end users.*

Generation | *The conversion of other forms of energy into electrical energy.*

Load Balancing | *The storage of electricity during low demand periods, and the release of stored electricity during high demand periods.*

Non-Wires Alternatives | *Investments by electric utilities that postpone or replace the need for costly transmission projects by reliably reducing transmission congestion at times of maximum demand in specific grid areas.*

Resiliency | *The ability for a system to tolerate and recover rapidly from a disruption.*

Utility | *An organization that generates, transmits and/or distributes electricity for sale.*

Financial

Offtaker | *An entity that is purchases power from a solar, wind or other renewable project at an agreed upon price.*

Power Purchase Agreement | *A contract between an electricity generator (seller) and an electricity purchaser (offtaker).*

Organizations

New York Prize | *A statewide competition awarding up to $40,000,000 in financial support to microgrid developments. Prizes are awarded in three-stages, design, planning, and build-out. The objective of the program is to promote community scale microgrid developments in New York State.*

Public Service Commission | *The organization which regulates and supervises the electric, water, gas, and telecommunication industries within New York state.*

Reforming the Energy Vision (REV) | *New York State's comprehensive energy strategy which aims to transition New York to a more affordable, modern, efficient, and clean energy system. The development of distributed energy resources and microgrids plays a vital role in achieving REV's goals.*

Microgrid

Behind-the-Meter | *Energy technologies, including generation, storage, and efficiency resources, that are installed on the customer side of an electricity meter.*

Distributed Energy Resources | *Technologies, typically located at or near a customer, that provide demand response, generation, or storage.*

Grid-connected Microgrid | *A localized system of electricity resources that operates in connection with the traditional centralized energy grid.*

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[1] Pyper (2015).

Introduction

The energy sector is undergoing rapid and transformative changes both within New York and across the United States. Emerging technologies and mechanisms for generating, distributing, and managing electricity are driving the evolution of utilities and regulatory agencies. The result is a transformation of the products of a centuries-old, centralized, and fossil-fuel based energy system, and these changes are taking place against the background of global climate change driven by rising concentrations of greenhouse gases in the atmosphere.

Climate change threatens New York's outdated electricity infrastructure

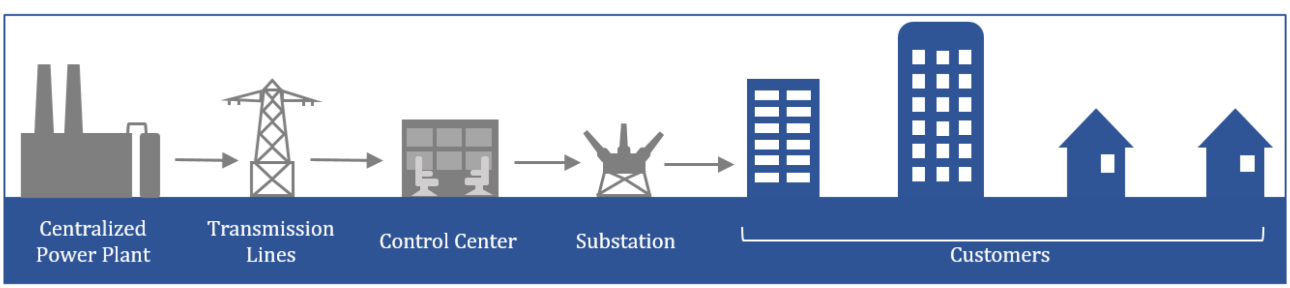
Within the United States, a third of greenhouse gas emissions originate from fossil fuel combustion and inefficient transmission and distribution within the energy sector.[2] Electricity infrastructure is highly vulnerable to the impacts of climate change, which cause in excess of $1 billion in damages annually in the US.[3] Severe storms, flooding and wildfires can destroy transmission and distribution lines, cutting millions of consumers and critical facilities off from the electricity required to power their essential services. Such events are projected to increase in severity and frequency as mean global temperatures increase.[4]

New York's energy system experienced the destructive impacts of extreme weather, likely made worse by climate change, during Superstorm Sandy in 2012. An explosion at a single Con Edison distribution substation caused more than 250,000 residents of Lower Manhattan to lose power.[5] Overall, 8.7 million customers across 20 states were caught in blackouts that persisted on average for eight days.[6] Crises like these highlight the vulnerability of a grid system where electricity is generated at a few centralized locations and fed to millions of consumers through vast, sprawling networks of fragile and interdependent infrastructure. The sheer age of New York's electricity infrastructure, the oldest in the nation,[7] exacerbates its fragility and inefficiency.

> "Crises highlight the vulnerability of a grid system in which electricity is generated at **a few centralized** locations and fed to **hundreds of thousands** of consumers through **vast, sprawling** networks of **fragile and interdependent** infrastructure."

Any attempts to address the challenges of climate change impacts and aging infrastructure in New York must also recognize that the population of New York City is expected to grow from 8.53 to 9 million people between 2016 and 2040.[8] The additional residents will further strain the electricity system, particularly during periods of peak electricity consumption such as the hottest days of the summer. Besides

Figure 1 New York's traditional energy system.



diversifying energy generation and increasing capacity, improving efficiency at all steps of the electricity pathway—generation, transmission and distribution, and consumption—will be key to accommodate growing demand and ensure a reliable electricity supply for all customers.

New York's Reforming the Energy Vision: Imagining the grid of the future

In 2015, New York Governor Andrew Cuomo unveiled the Reforming the Energy Vision (REV) initiative. REV is a comprehensive strategy to promote clean, low-emissions electricity generation and improve the resiliency and affordability of New York's electricity infrastructure while stimulating economic growth and innovation in the state. REV's goals for 2030 include generating 50 percent of electricity from renewable sources, reducing electricity consumption of New York buildings by 23 percent, and reducing greenhouse gas emissions from the power sector by 40 percent, all of which will require a fundamental shift in the status quo in the sector. REV instructs that these goals be achieved "through the fastest, most cost-effective means." [9]

REV and related initiatives have profound implications for private and public organizations involved in the New York electricity system as well as for the regulatory systems that govern generation, transmission, and distribution of electricity. Renewable resources, for example solar photovoltaic panels, can be consumer-owned and located at the consumer site behind the electricity meter (e.g. on a residential or commercial rooftop). These distributed energy resources build resiliency by giving customers an independent source of electricity that can continue to operate when the main grid fails. However, the current electricity system was designed strictly to deliver electricity in one direction: from a few centralized generation points to a large number of end consumers. To maximize the benefit of on-site distributed energy resources, excess electricity generated during periods of high renewable availability (e.g. high wind speeds for wind generation or particularly sunny days for solar photovoltaics) must be relocated to meet demand elsewhere, or stored to supplement supply during periods of peak demand. This requires a two-way exchange of electricity between the consumer site and the main grid.

Integrated microgrids and smart grid technologies: electricity infrastructure 2.0

Microgrids provide an avenue toward meeting the efficiency, resiliency, and affordability goals outlined in REV. A microgrid is defined as a self-sustaining electrical infrastructure network with internal, interconnected loads and generation resources.[10] Their design mirrors that of the main grid, but at a small (campus or community) scale delineated by clear electrical boundaries. Microgrids were originally envisioned to support critical facilities such as military installations, universities, schools, and hospitals that require a dedicated electricity supply at all times regardless of the operational status of the main grid. Such systems create a great deal

Figure 2 Energy system envisioned within New York's energy vision.

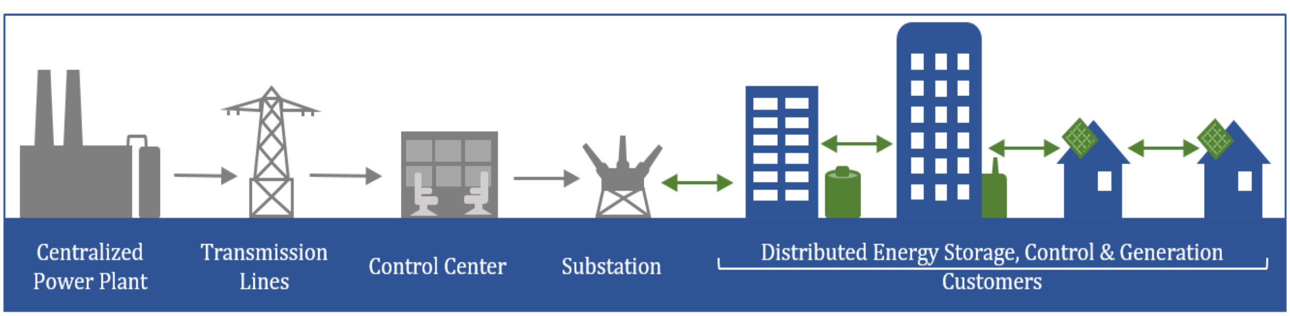
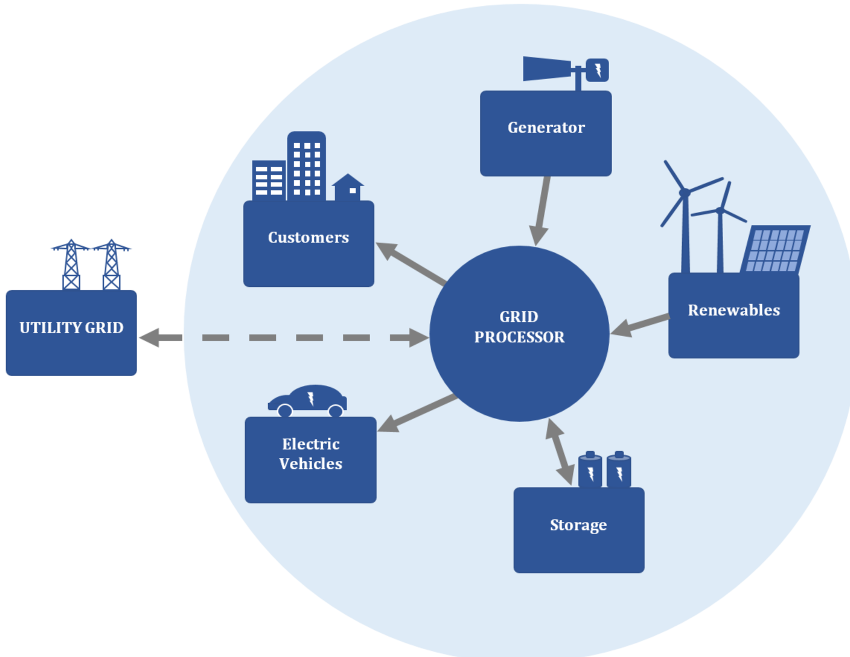


Figure 3 Distributed energy generation and microgrid infrastructure. Adapted from: Energycenter.org



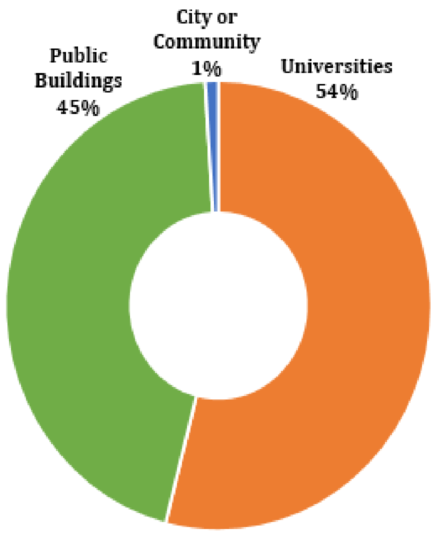
of value at the local level for critical facilities or isolated, remote communities.[11] However, they provide no grid-wide benefits and do not accommodate industry trends toward distributed generation and renewable resources.

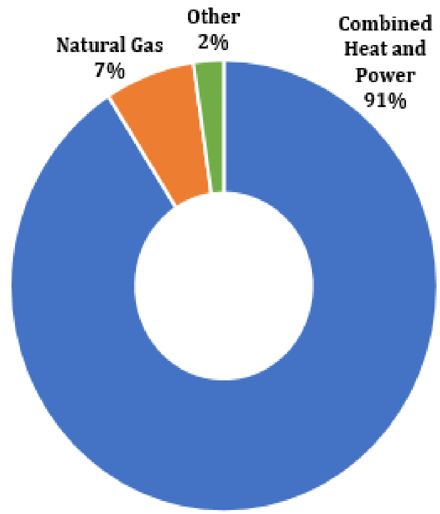
The future energy system envisioned by REV requires integrated microgrids that augment core infrastructure and support customers at the community and city scale. Therefore, for the purposes of this study, we define an integrated microgrid as an electricity network that shifts between islanded and 'grid-connected' states, operating either in isolation from or in concert with the main grid as circumstances require. Smart meters and electronic data-gathering technologies that monitor both sides of the connection can automate shifts between states to optimize grid-wide benefits within current operating conditions.

The small size of individual microgrid projects makes them an attractive stepwise means of modernizing New York's electricity infrastructure, as they can be built without interrupting the centralized system and integrated as they are completed. They are also affordable—a well-organized community group can design and build a microgrid tailored to their needs, as evidenced by the numerous emerging projects across New York State. Under some conditions distributed renewable resources produce excess electricity that can be stored for later use or sold back to the grid—assuming that the technology and regulatory frameworks are in place to do so—creating a revenue opportunity for the owner(s) of the generation capacity. These properties allow developers to cut the development costs of modernizing infrastructure by assembling manageable, self-contained segments while integrating new generation capacity from distributed and renewable resources. While microgrid technologies are relatively new and still largely in the pilot phase, their benefits to resiliency, energy affordability, and efficiency are already becoming clear; microgrids are a key component of REV and will be necessary, though not sufficient, to meet its goals.

As of 2015, the majority of the 20 active microgrid projects in New York were designed to function solely in isolation from the main

Figure 4 New York Microgrid Capacity by location. Source: Tweed (2015).





grid. Of the 220 megawatts of microgrid capacity in the state, 54 percent supports universities and 45 percent supports public buildings, with 1 percent of capacity utilized at the city or community scale (see Figure 4).[12] Combined heat and power facilities supplied 200 megawatts of this capacity, with natural gas supplying an additional 15 megawatts—reflecting the needs of facilities that cannot afford to rely on intermittent renewable resources. If any excess electricity is produced at these sites, it must be stored or lost.

The New York Prize competition, organized by the New York State Energy Research and Development Authority, aims to propel microgrids into the commercial and residential markets, providing grants to support feasibility studies for 83 projects in the state. The trend toward distributed resources and renewable generation in microgrids is expected to continue as nationwide microgrid capacity grows to 3,000 megawatts by 2020.[13] This growth represents an annual market opportunity of US$830 million.[14] The two-way electricity exchange enabled by integrated microgrids allows for new models of electricity management that allow consumers with distributed energy resources (e.g. rooftop solar) to monetize the surplus electricity they generate. Because an integrated microgrid functions as a single controllable entity, such arrangements can provide a mechanism for financing projects at the community scale. The most radical emergent models include automated trading markets that utilize blockchain technology to allow participants in a microgrid project to securely buy and sell electricity directly from one another.[15] Models like these challenge utilities and grid operators to evaluate whether their business models will be consumer-facing or if they will play a role as a supply facilitator.

In this report

The recent interest in microgrid expansion presents a number of challenges to the energy sector. While the number of proposed microgrid projects has grown at the city and community scale, the current regulatory framework is designed around large, utility-owned projects. Consequently, community-scale microgrid projects often stall in the planning phase for months while waiting for approval from the Public Service Commission to be exempted from cost-prohibitive regulations. In addition, there is no standard development or financial model for the financing or operation of integrated microgrids, creating uncertainty for the communities that want to develop these projects and for the organizations that seek to integrate them into their current business models.

Utilities, tapped by REV to become the 'distributed system platform providers' of the future, are caught between rapidly advancing technologies, initiatives mandating rapid progress, and regulatory systems impeding the rollout of new models for electricity management. The state must establish a clear vision for what the utility of the future – not just the grid of the future – should look like to fulfil the goals of REV and create a resilient, high-efficiency energy system that can serve as a model for the rest of the country.

In this report, we seek to address some of the uncertainty surrounding the role of New York Power Authority (NYPA), the state's largest public utility company, in the energy future envisioned in REV. While NYPA functions primarily as an electricity generator and transmitter, they also interact with developers and with the Public Service Commission. Their status as a public entity enables them to undertake cutting-edge, experimental programs that may be too risky or unproven for the private sector. Our recommendations focus on the key operational, regulatory, and technical barriers to the advancement of microgrids in New York and the suite of business opportunities that they enable. Each recommendation includes a case study that highlights an organization that has successfully navigated New York's regulatory system and implemented an emerging technologies or business model. We use these examples to generate some conclusions about growth and evolution of the power sector over the next 10 to 20 years.

2 Energy Information Administration (2016).
3 National Oceanic and Atmospheric Association (2016).
[4] Intergovernmental Panel on Climate Change (2014).
[5] Sugarman (2016).
[6] US Department of Energy (2013).
[7] Thomas Edison set up the first commercial electricity distribution system, Pearl Street Station, in New York City in 1882.
[8] New York City Department of Planning (2016).
[9] New York State (2014).
[10] NYSERDA (2014).
[11] RMI (2014).
[12] Tweed (2015).
[13] Pyper (2015).
[14] Saadeh (2015).
[15] This model is being pursued by LO3 Energy and Transactive Grid as part of the Brooklyn Microgrid project.

Recommendations

I. NYPA to spearhead an inter-agency working group

The New York Power Authority's in-house team working on smart grid technology and microgrid development should be restructured to reflect the interdisciplinary nature of the barriers to microgrid development, and tasked to produce a manual on regulatory compliance.

In 2005, the New York Power Authority (NYPA) created an Integrated Grid team under the Energy Solutions Group, tasked with taking microgrids from the conceptual stage to completion and supporting the REV initiative through distributed energy resources, such as solar and electric vehicles. In our assessment of our research findings, we have determined that the regulatory and financial barriers to microgrid development are crucial, and thus this in-house NYPA group addressing this topic should include experts on not only the technical issues but also on the regulatory process and the financing mechanisms. Given these integrated barriers to microgrid development, the current working group is insufficient. By organizing and participating in this working group, NYPA will show investors and developers that it is a leader in microgrid advancement. This leadership and reputation will give NYPA power in the market to acquire funds for project development and increase leverage to use for other projects. The working group will become a significant source of knowledge on microgrids and will therefore be able to exert greater influence when advancing certain recommendations or mandates to groups of authorities like the Governor and the Public Service Commission.

In addition to NYPA's current in-house working group, an existing inter-agency working group's focus should be redirected towards addressing regulatory issues. This inter-agency working group must be well-equipped to address the varied and complex barriers to microgrid development. These barriers include financial and regulatory inefficiencies that create risk for microgrid developers. By becoming the expert group on how to navigate the financial and regulatory institutions needed for microgrid development, NYPA and the other organizations in the group will generate intellectual capital that they can potentially monetize. To address regulatory barriers, the group will be tasked with creating a best practices manual to reduce the time spent on regulatory compliance, and working with the Public Service Commission to change Public Service Law to more clearly define microgrids and qualifying facilities. The task force will also address financial barriers by creating a financial model for developers to determine the best financial model for microgrid financing (see Recommendation II).

"In nearly every state, the legal and regulatory challenges to implementing microgrids are by far the biggest hurdle. [...] The technology is there. We have nationally recognized interconnection standards that would allow microgrids to be connected to the electric grids. **What we don't have is a legal framework for private or public-private microgrid owners and operators who are not public utilities to create microgrids without having to go through years of legal and regulatory hurdles**."

—Sara C. Bronin,
Professor of Law & Program Director for the Center for Energy and Environmental Law, University of Connecticut

Best practices manual on regulatory compliance

The best practices manual will address the issue of the amount of time it takes for microgrid projects to be approved by the Public Service Commission and describe the optimal pathway through the regulatory system as it currently stands.

The manual will include:

1. Timeline of process for becoming a "qualifying facility";
2. Contact information for experts at NYPA, Pace Energy and Climate Center, and other organizations that can help microgrid developers navigate the process;
3. List of "best practices" recommendations for speeding up the Public Service Commission case process.

Our findings show that it takes an average of 407 days for an initial petition to become a final order for microgrid projects (Table 1). Raising capital to finance microgrids requires accounting for transaction and compliance costs, currently a large percentage of capital outlays.[16] This added time can cost a project large amounts of money and shift the entire timeline of the project. This inhibits microgrid development by increasing the financial risk of the projects, thus reducing their attractiveness to investors interested in financing microgrid projects.

We have also found that certain types of microgrid projects take longer to complete the regulatory process than others. These observations could be generalized to suggest types of projects that are likely to take less time to get Public Service Commission approval.

Best practices gleaned from observations on case timelines include:

- The cases with the shortest time between initial petition and final order were those with "at or near" findings for related cogeneration facilities or campus properties and water services involved for many. While "at or near" qualifications are determined on a case by case basis, cases with up to a 4.2-mile reach were deemed "at or near" by the public service commission while those above 9.5 miles were deemed not "at or near." Therefore, the best practices manual could include recommendations on distances between generation and consumption.
- The cases with the longest time between initial petition and final order were "at or near" findings for farther away wind generation sites, net metering issues, or pipeline transfers.

> ***Case Highlights*: New York University Microgrid**
>
> The New York University (NYU) microgrid is in a dense urban area and interconnects multiple loads that are separated by public streets within the service territory of a franchised, investor-owned utility. To proceed with the development of its microgrid, NYU had to obtain permission from local and state authorities addressing technical issues such as emissions from the system's engines and boilers as well as procedural issues raised by the need to cross public streets in lower Manhattan with conduits carrying electric and thermal distribution lines. There were several related regulatory issues such as sub-metering for existing campus housing units and interconnection with Con Ed's network. NYU's microgrid developed from its original steam plant. The cogeneration expansion in the 1980s represented the first time that NYU sought to deliver energy to one of its buildings across a street.
>
> *Source:* Magill (2013).

Advocating for regulatory change

While working with communities and developers to navigate the regulatory requirements current for microgrids, the working group will also be tasked with discussing ways that public service law could

Table 1 Sample of 8 recent microgrid project cases and their approval timelines.

Case	Name	Details	Start Date	End Date
07-E-0802	Burrstone Energy Center LLC	Line connecting several cogeneration units on separate property deemed at or near	7/6/07	8/28/07
09-M-0776	Griffiss Utility Services Corporation	3,500-acre campus not except, at or near finding of fact needed, no follow up	10/27/09	2/17/10
14-M-0508	Halletts Vendee LLC	Water products manufactured for special uses, chilled water for AC, not regulated under PSL	11/25/14	3/25/15
13-M-0028	RED-Rochester LLC	Eastman Park Proceeding, RED authorized to provide suite of services, electric, gas, steam, water to customers located within electrically islanded site extending several square miles	1/22/13	6/13/13
06-E-1203	Steel Winds Project LLC	1 mile range from users to substation deemed at or near 20MW wind	1/19/06	12/13/06
07-E-0674	Advocates for Prattsburgh	Lines 4.2 miles in length deemed at or near 2,500-acre wind farm	6/8/07	5/22/08
14-E-0422	Solar Energy Industries Association	Petition of Solar Energy Industries Association, Alliance for Clean Energy New York, the Vote Solar Initiative, the National Resources Defense Council and The Alliance for Solar Choice to Clarify the Process for Utilities to Seek Relief from Net Metering Caps	9/18/14	12/16/16
09-G-0490	Alliance Energy Transmissions, LLC Seneca Power Partners, L.P.	Transfer of gas pipeline for Seneca co-gen facility	6/11/09	2/1/13

be changed to better accommodate and facilitate microgrid development. Currently, microgrids are regulated by *ad hoc* Public Service Commission rulings designed around the old centralized electricity system, and it remains unclear how they will be regulated in the future.

REV mandates provide an opportunity for NYPA and the proposed working group to advocate for changes to the current regulatory environment. This could move the Governor or the Public Service Commission towards drafting new legislation and public service law that includes specific provisions for microgrids.

Changing geographic reach requirements to qualify as an exempt microgrid

The geographic range of a microgrid is one of the factors that determines whether the project can be considered a "qualifying facility" and thus exempted from regulatory burdens that apply to utilities.

Public Service Law states that a generation facility can be considered a qualifying facility if it is located "at or near" the site of electricity consumption. However, the law does not include a clear definition of "at or near." The Public Service Commission rules differently depending on the project. For example, in one case the Commission ruled that a 4.2-mile distribution line for a 2,500-acre wind met the requirement for "at or near" (Advocates for Prattsburgh), but in another case determined that a 9.5-mile gas line to a cogeneration plant did not qualify as "at or near" (Project Orange Associates LLC). In addition, the public service law does not define land-use rules regarding the site infrastructure required for microgrids.

> ***Case Highlights:***
> **Burrstone Energy Microgrid**
>
> Burrstone is a precedent-setting microgrid project in New York State because its infrastructure crosses a public way in order to serve different customers with electricity from its generation facilities. The Public Service Commission ruled the microgrid and its related distribution facilities as a single "qualifying facility" under state law, making it exempt from regulation as an electric corporation. This exemption effectively allowed the project to go forward without the risk of onerous—and likely costly—regulatory requirements and oversight from the Public Service Commission, which can include rate regulation and various administrative, financial and reporting requirements.
>
> Burrstone's distribution lines were considered "related facilities" under PSL §2 (2-d), the Project (generating facility and distribution lines) was a "cogeneration facility," and therefore qualified for the exemptions discussed in PSL §§ 2(3), 2(4), 2(13), and 2(22). As a result, Burrstone was found not to be a "corporation," "electric corporation," "steam corporation," or "person" and therefore, except for PSL Article VII, exempt from the Public Service Law.
>
> *Source:* NYSERDA (2010).

Physical infrastructure is also a challenge. While the microgrid is required to be located near the properties being served, zoning ordinances usually prevent large-scale mechanical equipment from being situated in the dense urban areas that microgrids aim to serve.

Crossing a public street should no longer be a limiting factor

Current public service law limits the reach of microgrids according to urban planning lines. This restriction can inhibit microgrid development, as many microgrids operate in dense urban areas and must cross public streets and public property to reach consumers.

Currently, if a local microgrid project needs to run a wire across a public street, the owner is subjected to the same regulations that large utilities are required to comply with. The resulting costs likely make the project less financially viable. Additionally, running that wire requires both city and state approval, but the specific regulations that apply are not always clear[17].

Connecticut passed a law in 2013 legalizing microgrids that distribute electricity across public streets, as long as the power source generates less than 5 megawatts of electricity. New York could follow suit to pass a similar law legalizing microgrids that distribute electricity across public streets with clear limits on the size and reach of the project.

Business Case for NYPA

Spearheading an in-house microgrid development team will establish NYPA as a leader and expert in the barriers facing microgrid development. Creating an interdisciplinary group with financial, regulatory, and technical expertise will give NYPA leverage among policymakers and customers as their position as a public utility will be cemented with knowledge as power. This reputation will give NYPA access to development markets not otherwise accessible and financial institutions that only work with leaders in the field of microgrid development. By creating a "best practices" manual, NYPA will receive inquiries from potential developers seeking more information and with be able to find more potential projects by being an information center.

Allowing for more diverse ownership models

Restrictions on acceptable types of ownership models also limit microgrid development. If a group of neighbors want to develop a microgrid in their area, what business form would they take? Most states need "to enact legislation that allows private parties to organize into specialized entities that will allow them to own and operate microgrids".[18] The inter-agency working group should also aim to address these ownership issues by encouraging legislation that allows for diverse models.

Case Highlights:
San Diego Gas & Electric Microgrid

From a regulatory standpoint, the challenges of setting up this microgrid have much less to do with its fundamental legality—as might be the case with a non-utility owned system—than with other regulatory issues such as cost recovery, customer integration and participation, and cost-effective program design.

Source: Razanousky (2010).

Key takeaways from Case Highlights

1. *New York University Microgrid*
- It is likely easier to expand existing power generation facilities that it is to build new ones.
- Even facilities in dense urban area that pass public property and/or streets can develop a microgrid but it is easier for a campus based institution.
- It is easier if developer owns property between generation and consumption facilities.

2. *San Diego Gas & Electric Microgrid*
- Municipal utilities have a unique position and face fewer questions about fundamental legality.

3. *Burrstone Energy Microgrid (New York State)*
- Microgrids that cross public property to serve customers can be designated as qualifying facilities by the Public Service Commission, but they must fit within specific public service law criteria.

[16] Adams and Larson (2015).
[17] Magill (2013).
[18] Magill (2013).

II. NYPA to provide blueprint for standardized microgrid financial model

The New York Power Authority's role as a financier has been successful for forays into energy projects so far. The New York Power Authority should expand this role specifically for microgrid projects by partnering with the New York Green Bank to provide a standard financial offering for New York State microgrids.

Currently, the New York Power Authority (NYPA) provides low-cost financing for energy efficiency and other energy projects. Customers for whom NYPA provides financing services include public New York State entities, not-for-profit colleges and universities, and recipients of NYPA's economic development companies, including ReCharge NY companies. To obtain financing through NYPA, customers must be able to estimate energy savings results or meet other agreed-upon criteria and in some cases, additional security pledges may be required. NYPA posits that their mission and financial position allows them to offer "excellent terms and a very straightforward [financing] process"[19].

NYPA's current financing value proposition offers the following advantages to customers:

- No upfront capital outlay required for many projects
- Competitive lending rates
- Access to NYPA, the New York State, the U.S. federal government financing as well as other grant mechanisms aimed at advancing cleaner, more resilient energy
- Turn-key project solutions as part of comprehensive financing packages
- Option to pair NYPA financing with other financing programs and incentives, or as a separate loan[20]

To date, NYPA has provided $2.3 billion in financing for energy projects, including 5,700 buildings financed with energy efficiency improvements statewide and a resulting 1,374 gigawatt hours of energy saved annually from such projects. An example of microgrid-specific projects financed by NYPA include the State University of New York (SUNY) New Paltz $1.37 million campus microgrid. The project is designed to supply power when the central grid is not functioning. Additionally, the SUNY microgrid project utilizes combined solar and storage to power the university gymnasium during peak demand. NYPA is serving as the project lead and providing more than $580,000 in debt financing. The project also received $271,720 from NYSERDA and $210,000 from Central Hudson Gas and Electric, the local New Paltz utility.[21]

While NYPA has proven expertise with financing energy efficiency projects, the organization has not yet developed a standardized financial model for facilitating microgrid projects. The SUNY New Paltz example is a step in the right direction. However, the project is not necessarily scalable for other microgrid ownership models, such as community microgrids where there are various stakeholders involved rather than one public entity. As New York State's Energy Czar Richard Kauffman stated, "Community microgrids are a vital component of Governor Cuomo's REV strategy to modernize our energy infrastructure and ensure reliability and resiliency for the grid."[22]

At present, the need for financing microgrids is fulfilled partially through the New York Prize initiative (NY Prize). NY Prize is a competition to help communities create microgrids through awarding different phases of funding. The competition offers support for feasibility studies (Stage 1), audit-grade engineering design and business planning (Stage 2), and project build-out and post-operational monitoring (Stage 3).[23] Creating a standardized financial model would assist with the proliferation of community microgrids across the state and prove particularly valuable as NY Prize funding phases out after 2018.

There are various shortcomings to the current financing landscape for microgrids, which NYPA can help overcome through financing. Salient shortcomings include access to financing and disjointed incentives for various ownership models.

Access to financing

Currently, residential level "behind the meter" solar and utility level solar projects enjoy access to financing while community-scale sized projects have not yet achieved this same financing success. There are various unknowns for this size of a model which have not yet been institutionalized, including structuring projects to achieve a viable credit and deal size (smaller deals will not necessarily be attractive to investors).[24]

Disjointed incentives for various ownership models

Certain microgrid benefits do not always accrue to microgrid owners, depending on the type of financial model utilized. For instance, the tax benefits available to for-profit entities, such as the Investment Tax Credit (ITC) and the New Markets Tax Credit (NMTC), cannot be claimed if a public sector or non-profit entity is the sole owner of a microgrid. Conversely, if a private sector entity owns the microgrid entirely, the non-monetary benefits such as environmental, social and health benefits, do not accrue to the owner. Rather, they accrue to the users or community, who might not be supporting the costs of the project.

Create a standard financial offering for New York State microgrids

To overcome financial hurdles for microgrid projects, NYPA should create a standard financial offering for community microgrids across the state. A standard financial offering would serve as a blueprint with best practices for obtaining microgrid project financing. It should include information on implementing financial ownership models and financial agreement terms and conditions, as well as identifying debt and equity partners for microgrid projects.

A natural partner for NYPA in developing a standard microgrid financial offering is the New York Green Bank, whose core mission is to transform the clean energy financing market in New York State. Additionally, the New York Green Bank has experience in financing microgrids, as they are expected to facilitate up to $50 million in financial assistance to Stage 3 NY Prize winners.[25] In partnership with the New York Green Bank, NYPA should derive a standardized financial model for its clients. While the New York Green Bank will likely be chiefly involved in the financing details, NYPA should serve as the liaison between the New York Green Bank and NYPA clients.

As part of the standard financial offering, NYPA and the New York Green Bank should identify debt and equity partners available to microgrid projects. NYPA should consider serving as a debt provider for projects as they have expertise in this area. The New York Green Bank should vet equity providers and develop a standard list of useful providers. Criteria for equity partners might include agreement on financing rates that are viewed as both reasonable and affordable, longer-term maturities to reduce up-front capital

A standard financial offering would serve as a blueprint with best practices for obtaining microgrid project financing. It should include information on **implementing financial ownership models** and **financial agreement terms and conditions**, as well as **identifying debt and equity partners** for microgrid projects.

cost, and ensuring minimal level of support or credit enhancement from the New York Green Bank. [26]

NYPA should also consider serving as the energy off-taker for microgrid projects through a standard power purchase agreement (PPA) model. Serving as an energy off-taker would help bolster microgrid project credibility and attract capital investors, as NYPA is guaranteeing revenue for the project. NYPA would benefit from serving as an energy off-taker for microgrid projects as they would ultimately own and enjoy distribution capabilities over the energy generated from microgrid projects. This would assist NYPA with achieving greater access to energy data for data aggregation, as they would ultimately own data for all microgrid projects where they serve as off-takers. Additionally, owning and having transmission capabilities would be useful if NYPA decided to implement grid-scale storage, as NYPA would be able to more easily direct energy to storage facilities as necessary.

In developing the standard financial offering, NYPA and the New York Green Bank should address public/private ownership models where municipalities are participatory owners of their microgrids. In this way, local communities would have to provide up-front costs associated with microgrid project implementation, more appropriately matching them to the environmental and social benefits associated with microgrids. With a private financial institution providing equity as a part owner, the project will be able to utilize the

Business Case for NYPA

Serving as an energy off-taker for microgrid projects would position NYPA to own and enjoy distribution capabilities over the energy generated from microgrid projects. This strategy will allow NYPA to obtain greater access to energy data for data aggregation, as they would ultimately acquire data for all microgrid projects where they serve as off-takers. Additionally, owning transmission capabilities would be useful if NYPA decided to implement grid-scale storage, as NYPA would be able to more easily direct energy to storage facilities as necessary.

***Case Highlights*:**
Public-Private Partnership with PPA in Minster, Ohio

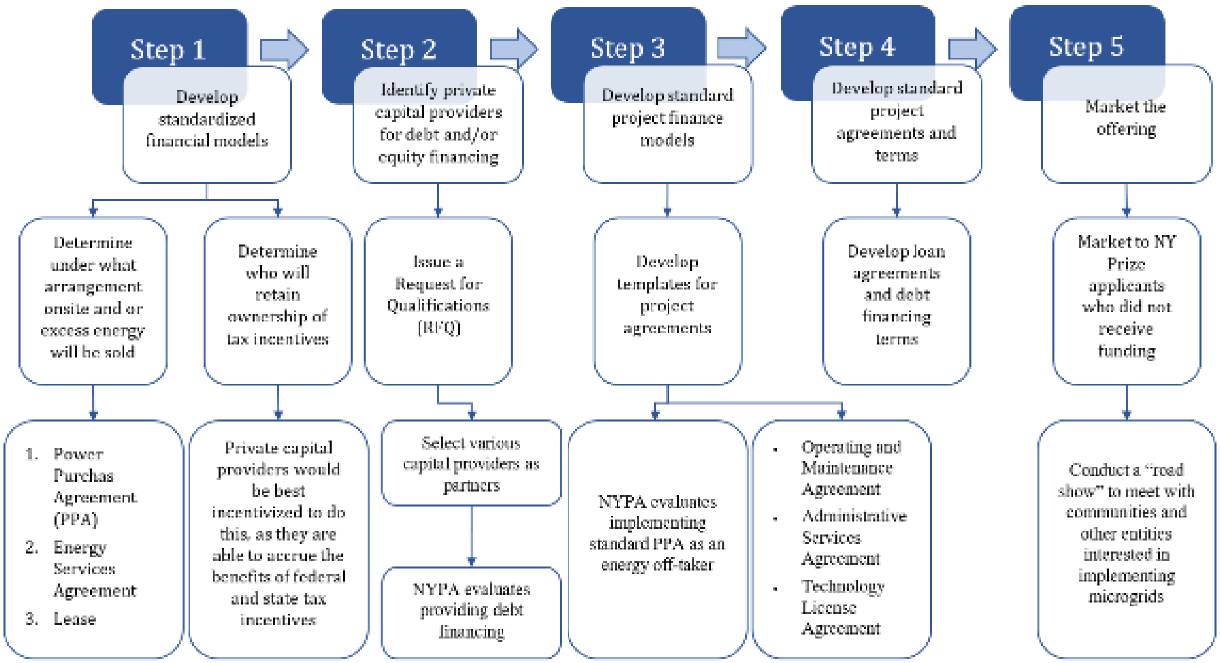
The municipal utility of the Village of Minster, Ohio engaged in a public-private partnership to finance a solar-plus-storage power generating facility with the intention of expanding the project into a microgrid. The Village of Minster utility supported the project through a PPA and was able to obtain private financing through a third-party entity, Half Moon Ventures. The PPA terms allowed the Village to break even on power transactions with customers and achieve significant savings in other ways, such as more efficient peak demand management. The third-party financing supported the up-front capital costs for the 3MW solar array and 7 MW lithium-ion energy storage system.

The Village views the microgrid as an economic development tool. The microgrid ensures a guaranteed power supply to vital businesses that employ a majority of the community's population—two large metal working companies and Dannon Yogurt. Thus, implementing a microgrid would result in independence from Dayton Power and Light, the regional utility, in fulfilling electricity demand.[1]

Since the Village Minster will benefit on a community-level from the microgrid, it is logical that the municipality is participating in the ownership model as an energy off-taker. Through their guaranteed revenue commitment, the village was able to achieve attractive financing terms with a private capital partner who is able to take advantage of federal and local tax credits.

Source: Trabish (2016a, 2016b).

Figure 5 Step-by-Step Process of Creating a Standardized Financial Offering



federal and state tax incentives available, thereby increasing financial feasibility

In order to promote the standard microgrid financial offering, NYPA should facilitate meetings with potential customers interested in commencing microgrid projects. A marketing pitch including information on the standard financial offering and financial resources available to communities on commencing a microgrid project should be developed.

Implementing a standard financial offering for microgrids would assist with advancing microgrid development in New York State, particularly as NY Prize initiatives begin to phase out. Additionally, NYPA and the New York Green Bank becoming more involved in the microgrid financing process would help alleviate perceived regulatory risk, as market participants would observe that New York agencies are investing in microgrids and thus are serious about their continued deployment.

A step-by-step example of the process for developing a standard microgrid offering is provided in Figure 6 above.

Key takeaways from Case Highlights

- The Village of Minster, OH utility supported a solar-plus storage power generating project through a PPA and obtained private financing through a third-party entity.
- The PPA terms allowed the Village to break even on power transactions with customers and achieve significant savings
- The public-private partnership ownership model benefited both the community and third-party private financiers.

[19] NYPA (2017).
[20] NYPA (2017).
[21] Wood (2016).
[22] New York State Governor's Press Office (2017).
[23] NYSERDA (2017).
[24] Coleman et al. (2017).
[25] Coleman et al. (2017).
[26] Connecticut Green Bank (2016).

III. NYPA to provide the industry blueprint for microgrid clusters/ community microgrids

The New York Power Authority's role in facilitating distributed energy resources is to "lead by example." One approach to doing so could be by deploying large-scale storage coupled with public purpose microgrid clusters for NYPA's clients.

The New York Power Authority (NYPA) is currently involved in demonstration projects to showcase the feasibility of microgrids and is exploring various facilitative roles for itself, including project financing and energy off-taking. However, these projects are currently limited to campus-style microgrids at universities, hospitals and a few other conducive locations. These types of initiatives may not help to achieve the scale that the Reforming the Energy Vision (REV) initiative aspires to realize.

NYPA's current REV-related activities also do not help to solve the issue of ownership of the various aspects of distributed energy resources. Several stakeholders have pointed out that coordinating the ownership of multiple components within a distributed energy resource system is one of the main barriers to microgrid adoption under REV[27]. On the one hand, REV supports competitive markets for distributed energy resources and therefore allows utilities to own distributed energy resource assets only under special circumstances. On the other hand, the current ownership structure is too complicated for even interested investors to finance with confidence, and it hinders the development of a replicable financial model such as a power purchase agreement that could streamline relationships between electricity producers and consumer.

Under current ownership models, utilities are barred from owning any form of distributed generation, with a few exceptions (for example, projects developed solely for demonstration purposes). The result is that distribution utilities are only able to develop one-off projects every few years, as observed with Consolidated Edison and the Brooklyn-Queens Neighbourhood Program. NYPA, on the other hand, is uniquely positioned to own generation assets, and could potentially own or deploy distributed energy resources and large-scale storage that can participate in the

Table 2 New York's Independent Service Operator's vision of future distributed energy resources participation in wholesale markets.

FUTURE WHOLESALE DISTRIBUTED ENERGY RESOURCES PARTICIPATION				
		Capacity	**Energy**	**Ancillary Services**
Reliability	Non-Dispatchable	SPECIAL CASE RESOURCE PROGRAM • Manual activation • Receives capacity payment	EMERGENCY DEMAND RESPONSE PROGRAM • Manual activation • Voluntary load reduction	
Economic	Non-Dispatchable	LOAD MODIFIER • Self-managed load reductions to reduce capacity obligations	PRICE CAPPED LOAD BID • Economic day ahead load procurement	
Economic	Real-Time Dispatchable	BEHIND-THE-METER NET GENERATION • Comparable to a generator • Fully integrated in both capacity and energy markets • Capacity with daily energy must-offer obligation		
Economic	Real-Time Dispatchable	DISPATCHABLE DISTRIBUTED ENERGY RESOURCES • Comparable to a generator • Fully integrated in both capacity and energy markets • Capacity with daily energy must-offer obligation • Flexible performance & payment options		

> ### ***Case Highlights*:**
> ### **World's First Microgrid Cluster Proposed in Illinois**
>
> Under the Future Energy Jobs Bill, the utility Commonwealth Edison submitted a proposal to implement a cluster of 6 microgrids, with an investment of around USD 200 million over a five-year period. This would include the existing cutting edge microgrid facility located at the Illinois Institute of Technology. The cluster is proposed as a public service to enhance resiliency and reliability, and is not intended to impede competition in the retail market.
>
> *Source:* Marotti (2016).

wholesale markets. There is an opportunity to accelerate the transition to microgrid clusters by developing these for NYPA clients with the objective of resiliency and reliability. In other words, they could pilot microgrid clusters, ensuring that they do not negatively impact private developers, since the purpose would be to offer a public service rather than to competing in the retail market.

A combination of regulatory proceedings, public agency initiatives and blueprints are currently underway in New York State, which provide NYPA with a viable business model to implement such a solution.

Distributed energy resources roadmap for New York's wholesale electricity markets

NYPA would benefit from aligning its initiatives more closely with the New York Independent System Operator (NYISO)[28] roadmap for integrating distributed energy resources into the wholesale energy markets[29]. The roadmap envisions wholesale market participation by distributed energy resources across the energy, capacity and ancillary markets, as dispatchable resources, in addition to their current role as behind-the-meter net generators.

NYISO acknowledges it would be beneficial to aggregate individual distributed energy resources into bundles, thereby allowing them to participate in the wholesale market. These bundles of distributed energy resources are organized on the step-down transformer side of transmission substations, thus reinforcing the need to resolve transmission constraints in the system. NYISO envisions that this aggregation could include different technologies such as load reduction, generation, and storage that meet NYISO's dispatch requirements. A distributed energy resource coordination entity (DCE) aggregates distributed energy resources and interfaces with NYISO. As defined in the roadmap, a direct customer, a third-party aggregator similar to a Responsible Interface Party in the Special Case Resource (SCR) Program, or a Distribution Service Platform Provider (DSPP) could function as a DCE.

Value stack proceeding

The New York Public Service Commission (NYPSC) approved the Value of Distributed Energy Resources order last month, signalling the state's transition away from net metering towards a more accurate compensation of the various value components of DERs. Dubbed the "Value Stack", this proceeding lays the framework for compensation on energy, capacity, environmental, demand reduction and locational system relief value, with scope for more granularity in the future. The order also directs utilities to each deploy at least two energy storage projects as non-wires alternatives at distribution substations or feeders, by the end of 2018.[30]

This, along with the Distributed Energy Resources Roadmap a clear regulatory signal as to the business model envisioned for the future grid, and therefore it would make sense for NYPA to invest in resources that are aligned to such revenue mechanisms.

Case Highlights: California's Energy Storage Mandate

California was one of the first states to identify the need for grid-scale storage, given its high penetration of renewable resources. In 2013, it became the first state in the nation to enact a storage mandate requiring investor-owned utilities to purchase 1.325 gigawatts by 2020 (AB 2514). In September 2016, the state enacted four new bills that would boost both utility and behind-the-meter energy storage capacity. AB 2868 in particular requires California's three IOUs to accelerate the deployment of distributed energy storage by filing applications for new programs and investments of up to 500 megawatts, in addition to AB 2514's 1.325 gigawatts. Utilities in Southern California has already deployed substation battery storage in response to the Aliso Canyon natural gas leak last year.

Source: Burger (2016).

New York Energy Highway goals

From a larger perspective, NYPA is spearheading the New York Energy Highway initiative, a precursor and complement to REV that aims to modernize the state's energy system, through electric transmission and generation construction, development of renewable energy sources, and upgrades to electric and natural gas infrastructure. The Energy Highway Blueprint specifies 13 actions broadly categorized into four categories, namely, expansion and strengthening of the Energy Highway, acceleration of construction and repair, facilitation of clean energy deployment, and technology innovation advancement.[31]

The challenges that this blueprint aims to address are interrelated, and could be addressed simultaneously, through microgrid clusters and large scale storage. They would serve as alternatives to capital investments in transmission upgrades, as discussed below.

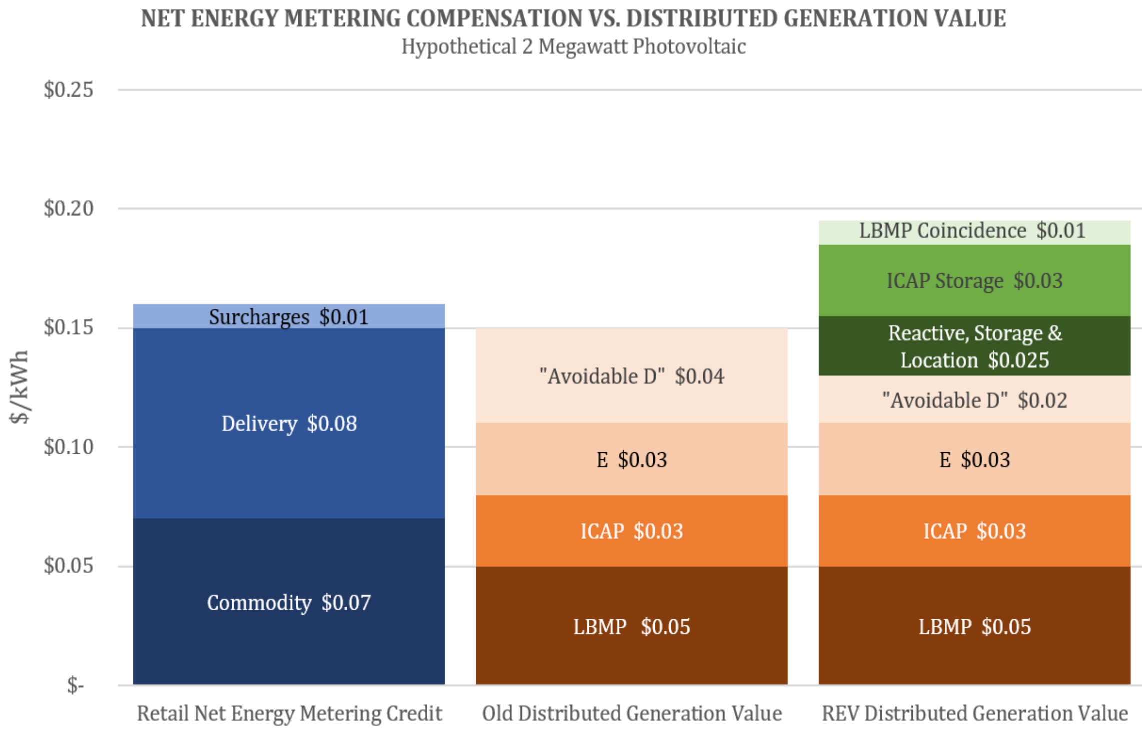
As it stands, NYPA's current activities may be insufficient to fulfil the organization's "lead by example" role as defined under REV. Furthermore, given the scale of NYPA's general business activities, there is a need to cement NYPA's role and relevance in the long-term distributed generation future envisioned by REV. Taking advantage of the current scenario detailed above, NYPA could deploy a microgrid cluster for its clients as a public service to provide resiliency and reliability. This could be paired with substation-level storage, stacking the value of storage to ensure a viable business model.

Implementation of public service microgrid cluster

NYPA should tap on existing campus-style microgrids and explore opportunities to site critical facility microgrids nearby, with the goal of deploying a microgrid cluster. This would provide a blueprint to transition to community microgrids as envisioned by REV. Given the NYISO's roadmap to integrate DERs, such an initiative would be able to generate revenue through participation in the wholesale market.

The proposed microgrid cluster detailed in the case study above was deemed too expensive given the cost-of-service model in Illinois which would pass on the cost to the consumer. However, the Value Stack proceeding detailed earlier suggests that the regulatory paradigm in New York state is conducive for such a project. Given that preparations are underway to integrate distributed energy resources in the wholesale market as well, NYPA could tap on its unique expertise to implement a pilot public service microgrid cluster. This could be coupled with large-scale storage as detailed below.

Figure 6 FERC Proceeding, Storage as a NWA to transmission upgrades Source: New York Public Service Commission Staff Report on Value of Distributed Energy Proceeding (Oct. 2016)



Deployment of storage at the substation level

Historically, the electric grid was designed for electricity to flow in one direction, from a centralized power plant to consumers through a maze of transmission and distribution lines, transformers, and substations. Under this model, any increase in demand in specific areas of the grid was met through transmission infrastructure investments to relieve congestion and thermal overload, add generating capacity etc.

Today however, the energy industry is transitioning to a decentralized grid with a more dynamic two-way power flow system, similar to the grid future envisioned by REV. In this new paradigm, energy storage and other distributed energy resources can help to modify loads and shift the location of generation centers and potentially offset transmission and distribution investments. An important new area of regulatory focus is energy storage as a non-wires alternative (as opposed to traditional "wires" – lines, transformers, and new substations) that relieves congestion and defers equipment upgrades or replacements. This is because of the multiple advantages offered by large-scale energy storage solutions:

- Energy storage as an alternative to traditional wires solutions offers the benefit of reduced environmental impacts. This because energy storage has far fewer infrastructure siting concerns as opposed to traditional wires solutions, and also offers the additional benefit of integrating intermittent renewables.
- They are also an attractive option to mitigate urgent and rapidly emerging transmission and distribution upgrade needs, since they can be deployed much more quickly than traditional upgrades which typically require 5-10 years.
- They can be deployed in a modular fashion, allowing for incremental development aligned more closely to

emerging transmission needs. This presents reduced financial risk compared to large, long-term lump-sum investments in traditional upgrades, which are typically borne by ratepayers.
- Energy storage can also provide reliability advantages through geographically diverse siting. They can also reduce transmission losses when sited closer to the load.

Therefore, one of the ways NYPA could address the issues and potential opportunities mentioned above is to deploy large scale energy storage solutions at the substation level. In view of the restrictions on distribution utilities owning distributed energy resources, NYPA is uniquely positioned as a public authority to own substation level energy storage. Large scale deployment of storage would further reduce lithium ion prices, and enable increased renewables on the grid. The deployment of substation level storage could help NYPA to facilitate microgrid clusters for its customer base. This includes the over 100 public entities in New York City and Westchester County. It could also help improve resiliency, for instance in the case of an extreme weather event that causes transmission lines to go down. NYPA could work closely with Public Service Commission to facilitate this model and smoothen potential interconnection issues. Coupled with the implementation of a public service microgrid cluster as well as increased renewables under such a structure, NYPA could also work with the Public Service Commission to further research the need for a storage mandate.

The NYPA Strategic Vision stipulates the need for investment in energy storage system technologies such as long-duration storage, and identifies that this would pave the way to "reduce pressure on the traditional electric power infrastructure" and help address "short term challenges concerning reliability, power quality and spikes in consumption created by the increased presence of renewables on the grid."[32] NYPA could therefore take on a leadership role in energy storage, as this would be a significant aspect for microgrids, as well as NYPA's Strategic Vision. This could be accomplished by investing in technology development or deployment of large scale storage solutions. Large scale energy storage solutions could also decrease dependence on natural gas peaker plants, which are at odds with REV's greenhouse gas reduction goals.

Large scale energy storage can deliver revenues as a flexible peaking resource. Battery systems are able to participate in wholesale energy markets as per recent Federal Energy Regulatory Commission (FERC) orders and perform functions such as frequency regulation, energy arbitrage, and even demand response. The New York Independent System Operator and Pennsylvania, Jersey, Maryland (PJM) Interconnection energy markets have enabled participation from energy resources, and multiple battery installations are being supported by revenue generated in this manner. At the substation level, storage can provide overload support in the case of aging equipment or substantial load growth arising from unexpected increased demand. Energy storage systems could also provide a solid revenue stream through daily voltage[33] and ancillary services support[34].

Implementation of potential financial model

To implement this strategy, NYPA needs to work with its customers and other stakeholders to estimate substation storage capacity needed to facilitate microgrid adoption for its customers and to serve as a flexible peaking resource.

As discussed in the previous recommendation, NYPA could create a financial model that helps customers adopt microgrids or deploy distributed energy resources, and also allows NYPA to recoup the investment. Energy storage can currently participate in the wholesale market as a flexible peaking resource and generate revenue through peak shaving, energy arbitrage, time-of-use and potentially resiliency.

Currently, the New York Independent System Operator has several resource classifications that can accommodate participation of storage in the wholesale markets, including the Energy Limited Resource (ELR), the Limited Energy Storage Resource (LESR), the Demand Side Ancillary Services Program (DSASP) and the Special Case Resource program mentioned earlier.[35] Given that NYPA already functions as the Responsible Interface Party in the SCR Program, the organization could potentially function as the distributed energy resources Coordination Entity (DCE) that aggregates distributed energy resources as detailed in the New York Independent System Operator roadmap. This also aligns well with the proposed deployment of a microgrid cluster.

Large scale storage at the transmission level could be deployed at large central generation stations, transmission lines, transmissions substations, or transmission-connected customers. By deploying storage at the transmission substation level, NYPA could utilize storage to provide multiple services like transmission congestion relief, peak shaving, energy arbitrage, integration of large scale variable renewables, as well as the deployment of microgrid clusters for their customers.

NYPA could partner with companies like AES and Eos Energy Storage, that have deployed grid-scale, transmission-connected batteries participating in wholesale markets. AES and Eos Energy Storage are reportedly directly competing with natural gas plants to set the market clearing price for flexible-ramping wholesale electricity market products.

Case Highlights: Southern California Edison's (SCE) Approach to Energy Storage

In order to deploy grid energy storage, Southern California Edison adopted a valuation approach based primarily on application development as opposed to technological capability. The utility employed a four-step process, first identifying operational uses mapped to a specific location on the electric value chain as well as a minimum duration of expected continuous energy output. Next, these operational uses were "bundled" together i.e. they served as "building blocks" to define several representative practical applications, each with individual requirements and preferences. These requirements and preferences were then used to match each application with "best fit" technology options, based on their capabilities, cost projections, and commercial availability timelines. Finally, high-level assessments of these application-technology pairs were developed from economic and feasibility perspectives.

In 2014, Southern California Edison announced the procurement of a substantial amount of energy storage (more than 250 megawatts), over five times the amount required by California's energy storage mandate. This level of deployment potentially set new standards for incorporating distributed and customer-owned energy assets into grid operations. Over 50% of this was large-scale in-front-of-the-meter, while the remaining was small, aggregated, and located behind the meter. Southern California Edison has also purchased 20 megawatts of energy storage from Tesla, deployed at the transmission level in response to the Aliso Canyon natural gas leak. As a means to reduce Southern California Edison's dependence on natural gas peaker plants, the batteries would charge during off-peak hours when demand is low, and deliver electricity during peak hours, helping to maintain reliability. In addition, San Diego Gas & Electric has contracted AES Energy Storage, and AltaGas has contracted Greensmith Energy Partners for similar types of storage, and will bring the total up to 77.5 megawatts of storage capacity on the grid.

Sources: Rittershausen et al. (2011), Bade (2015), Penn (2017).

Key takeaways from Case Highlights

1. *California's Energy Mandate*

- California demonstrates the path forward for utilizing grid-scale storage as renewable resources enter the grid.

2. *Illinois Microgrid Cluster*

- Regulatory incentives could be aligned through REV to support the creation of a similar microgrid cluster in New York State.

3. *Southern California Edison*

- Identifying and matching use demand with technological applications is a more efficient valuation approach.

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[27] Interview informants 6, 8, 11 in Supplementary Information B.

[28] NYISO is a not-for-profit corporation responsible for operating the state's bulk electricity grid and ensuring its reliability, administering New York's competitive wholesale electricity markets, and planning for the power system of the future.

[29] NYISO (2017).

[30] Kuser & Heidorn (2017).

[31] NYPA (2017).

[32] NYPA (2014).

[33] The value of frequency regulation, although high in the PJM market, is not substantial in NYISO.

[34] NEMA (n.d.)

[35] NYISO (2016).

IV. NYPA to pioneer blockchain and smart grid technology

The New York Power Authority (NYPA) can advance its innovation vision by going beyond the adoption of smart metering to a next-generation technology that will likely underpin smart grids: blockchain.

The New York Power Authority (NYPA)'s strategic vision emphasizes the importance of accurate, real-time data gathering and aggregation and automated response processes. Building digital capacity is an essential step in forecasting and balancing electricity supply and demand as more distributed and renewable generation resources are connected to the grid under REV. NYPA recently launched a pioneering "Digital Avatar" program based on data from its 16 generation facilities and 1,400 miles of transmission infrastructure that can simulate and model the effects of proposed system alterations. The next goal in this process should be data collection at commercial and residential scales, following the shift in generation emphasis from a centralized to a distributed model. The Advanced Energy Innovation Laboratory for Energy was created in recognition of this need.[36]

Data tracking through smart meters

The first step to acquiring these data is the installation of smart meters that can track electricity consumption and production in real time across NYPA's consumer base. Smart meters provide usage data in near-real time (sub-hourly intervals rather the monthly intervals on traditional meters) that can be visualized in the form of web or smartphone applications for public use. Such applications can empower consumers to track their own electricity usage and the information can enable them to adjust their behavior autonomously, an important component of energy efficiency and consumer choice.

Other New York utilities are also aggressively deploying smart meters. For example, ConEd has launched a $1.5 billion program to replace more than 4.7 million traditional meters across New York City over the next eight years, funded by a rate increase.[37] In addition to laying the groundwork for efficient demand response, smart technologies can greatly accelerate the process of locating faults and other disruptions across the infrastructure network. NYPA, too, has built a smart meter

Case Highlights:
Brooklyn Microgrid and TransActive Grid

LO3 Energy, a private technology company, launched the Brooklyn Microgrid in an attempt to promote local, renewable electricity generation and to pilot new market strategies for buying and selling electricity. In the pilot, five households with rooftop solar are interconnected with a further five households with no distributed generation capacity. The goal of the project was to develop a secure, digital electricity trading platform—built atop existing electricity infrastructure—through which the homeowners with solar capacity could sell the excess electricity they generated directly to the other five households on the microgrid. The entire system is interconnected with the main transmission grid and can draw resources from it when the need arises.

The pilot's digital electricity trading platform, TransActive grid, is built on a public blockchain architecture and uses automated smart contracts and to monitor and record the precise amount of electricity generated in each household. TransActive grid is the first application of these technologies to the energy sector. Within the platform, smart contracts move any excess units of electricity produced onto the market, where other households can purchase them via payments made through PayPal. The first of these peer-to-peer transactions was completed in April 2016. Eventually, LO3 Energy envisions all electricity transactions taking place in a smartphone application, through which users could set their preference for the source of their electricity and/or set preferences for rate costs.

Source: Scott Kessler, Director of Business Development, LO3 Energy (2017).

aspect into the Strategic Vision for 2014-2019. Thus, the importance of developing this capacity rapidly and completely is palpable.

Blockchain as underpinning technology in smart grids

If smart metering technologies are the first step in the evolution of the modernization and computerization of the electricity sector, blockchain technology is the second. Blockchains are virtual data structures stored on a network of interconnected computers that create an encrypted, tamper-proof, and continuously verified record of digital transactions across discrete time units.[38] The purpose of blockchain is to enable direct and secure peer-to-peer transactions without routing transaction through an intermediary organization. Blockchain was first used in the financial sector, where it enabled the secure exchange of 'cryptocurrency' (most notably Bitcoin) without the need for a central bank to verify and guarantee the security of the transaction.

A blockchain may be either public, where users are assigned unique identification codes but their actual identities are kept anonymous, or private, where the identities and transaction histories of all invited users are visible within the network of participants. Every transaction contained in the blockchain is verifiable from any computer in the network—a tradeoff that exchanges some degree of privacy for complete transparency and guaranteed security. Public blockchain networks are free to access, while users must be invited to a private blockchain. Private blockchains therefore leave room for an operator that controls participation. Meanwhile, operators of private blockchains can control participation within the network and can charge a fee for access as a service (the cost of which is effectively zero), potentially allowing banks and bank-like entities to preserve a part of their current business model.[39] The financial sector is already using both public and private blockchains for a variety of purposes. What remains a key question for the energy sector is which model will gain the most traction.[40]

NYPA's strategic vision emphasizes smart data aggregation and usage without mentioning blockchain—an oversight that should be rectified. While some industry experts believe that blockchain technologies have a long way to mature before they are ready for deployment in the electricity sector,[41] NYPA must, as a public utility, plan its strategies over a time horizon longer than five or 10 years. This is particularly true given that there are already examples of successful blockchain-based energy projects in New York City, such as LO3 Energy's Brooklyn Microgrid (see case study).

Smart grids underpinned by blockchain technology present potential in the form of smart contracts, enabling automated load balancing, electricity distribution and even peer-to-peer electricity trading.

Projects like the Brooklyn Microgrid synthesize microgrids (infrastructure and connectivity), distributed energy resources (generation capacity/supply), and blockchain and smart contracts (load balancing and electricity management) into discrete packages, and provide the best present-day indication of what the future grid, envisioned by REV, may look like. If the speed at which blockchain spread through the financial sector can be taken as predictive, then the utilities that function as the intermediary 'banks' of the electricity industry must begin to develop business strategies that integrate blockchain and its auxiliary technologies or risk being left behind.

Blockchain enables the next evolution of electricity markets

Importantly, blockchain enables the development of 'smart contracts'—protocols that automatically execute when certain pre-determined conditions are met. In the electricity sector, a combination of smart contracts and smart meters could take on difficult tasks associated with distributed energy resources. For instance, automated load balancing, moving electricity between generation sources and consumers on a microgrid, or between a microgrid and the main grid, can take place according to the needs of the moment. Additionally, blockchain enables automated load balancing to take place without the risk of user error or the need for manual site visits. Similarly, they could be employed to track ownership and manage characteristics of the smart assets that make up the 'internet of things', such as governing transactions between an electric car plugged into charging stations and a nearby generation source.

Smart contracts could also be used as a payment enforcement method, automatically cutting a customer off from electricity supply in the event of a failed payment. Notification systems could even deliver a warning message to an integrated mobile smartphone application and restore the flow of electricity when full payment is made. As in the previous example, no intermediary parties or site visits by personnel are necessary, and the continuous verification of blockchain records ensures that no actions are taken in error or as a result of tampering.

As discussed in the case study below, blockchain and smart contracts support enable peer-to-peer electricity trading directly between producers and consumers, or, through a similar process at a larger scale, emissions trading schemes. The peer-to-peer model represents the pinnacle of customer choice in electricity consumption, particularly when paired with a mobile application that enables customers to set their own terms for when electricity should be bought, sold, or even donated, and from what sources. For example, a prosumer with rooftop solar photovoltaic that produces an energy surplus could utilize a smart contract with her neighbor to sell him excess electricity. No in-person interactions or negotiations would be necessary; the prosumer simply elects to put her surplus energy on the market, which could be done through a smartphone application, and her neighbor elects to purchase energy when rates fall within a price window of his choosing—also specified through an application or website. This model is already being introduced into the Brooklyn Microgrid project.

NYPA should actively pilot private blockchain models

The evolutions heralded by blockchain and smart contracts threaten traditional utility business models, as they demonstrate a potential future in which many of the services currently provided by electricity generators, transmitters, and distributors are diminished in importance or altogether unnecessary. One common trend, however, is the need for smart infrastructure. Though many steps of the energy pathway are vulnerable to automation

The evolutions heralded by blockchain and smart contracts threaten traditional utility business models, as they demonstrate a potential future in which many of the services currently provided by electricity generators, transmitters, and distributors are *diminished in importance or altogether unnecessary*.

and computerization, electricity exchanges must take place through physical infrastructure, and for the reasons discussed in this report, microgrids are likely to be the most cost-effective and plausible method of modernizing the grid.

Thus far, no New York electricity company has publicly piloted a controlled private blockchain model that preserves a role for a managing intermediary (as previously mentioned, LO3 Energy uses a public blockchain system, Ethereum, as the foundation for their project). In the medium term, private blockchain models represent a balance between the status quo and a smart energy revolution. They enable experimentation with smart contracts, but those contracts can be used to replace existing demand response and enforcement processes instead of serving as the foundation to an entirely new (i.e. prosumer-driven) system. As such, NYPA could adapt to fit this model without scrapping their fundamental organizational structure or role in the electricity sector, and doing so would present a number of business opportunities.

In order to begin evaluating the capacity of blockchain and smart technologies in earnest, NYPA should:

- Select 1-3 integrated microgrid projects currently in the demonstration phase within which to pilot blockchain and smart contracts and fully deploy smart meters and other necessary infrastructure at these sites.
- Choose a project partner that can develop a private blockchain structure on which to build smart contracts for NYPA.
- Develop smart contracts that automate the data-gathering processes that NYPA already conducts [as part of New York Energy Manager].
- Augment current processes with two-way smart contracts that both collect and act on usage data, for example by autonomously balancing loads from distributed renewable resources.
- Experiment with integrating local and substation battery storage into smart contract protocols.

Key Takeaways from Case Highlights

- LO3 Energy is pushing past regulatory and financial barriers to pioneer the first uses of blockchain, smart contracts, and peer-to-peer transactions in the electricity sector.
- The Brooklyn Microgrid shows enormous potential for computers to automate complex processes related to grid operation, demand response, and load balancing, which requires investment in modern smart meters and control.

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[36] New York Governor's Office (2015).

[37] Giambusso (2017).

[38] All transactions undertaken between users in the network that take place over a discrete time interval, for instance an hour, are grouped together and stored as a data 'block' linked to the block compiled over the previous hour. Together, the system of data blocks forms a blockchain, which functions as a complete transaction history.

[39] PwC (2017).

[40] PwC (2017).

[41] Interview informant 2 in Supplementary Information B.

V. NYPA as data and energy aggregator

The New York Power Authority's role as a data and energy aggregator can be implemented to facilitate research and development for microgrids and distributed energy resources. The role of an aggregator can be accomplished through its New York Energy Manager resources and its new Predix software capabilities.

Microgrid and power quality assessment through data aggregation will allow the New York Power Authority (NYPA) to operate its systems at an optimal level. Distributed energy resources require new models for both the planning and operation of a digitized energy system, and microgrids will be able to offer different levels of power quality depending on supply and demand for the system. Up-to-date data aggregation will allow distributed energy resources and microgrids to achieve what is known as real-time control.[42] The increased complexity that comes with grid modernization demands more intricate models and algorithms for energy transfer. It is important for NYPA to leverage its data aggregation investments with its current commercial programs: The New York Energy Manager (NYEM) and General Electric's (GE) Predix software.

Electricity system operations face significant changes in light of the deployment of distributed energy resources and microgrids. Traditionally, the grid consisted of centralized generating units, but it is found that distributed energy resource aggregators are necessary to allow these updated systems to operate at a successful scale. An aggregator is defined as "a company who acts as an intermediary between electricity end-users and distributed energy resource owners and the power system participants who wish to serve these end-users or exploit these services."[43] Aggregators have the potential to create system value by managing and eliminating information gaps, lack of engagement, and market complexities.[44]

NYPA's current work: New York Energy Manager & Predix

Currently, NYPA's New York Energy Manager[45] utilizes comprehensive data analytics to evaluate over 3,000 public buildings' efficiency.[46] Using energy use data in real-time, software and extensive analysis helps track performance trends and expose inefficiencies. Currently New York Energy Manager is focused on:

- Improving energy management and operations of state facilities
- Driving down government operating expenses
- Reducing Greenhouse Gas Emissions
- Job creation in the green economy

The New York Energy Manager allows government building operators to be better informed when making real-time energy management decisions and account for a shift in energy use.[47] The goal is to gain approximately $250 million in savings in 10 years.[48] Its advanced digital platform has provided facilitators with easily accessible information that push the customers toward sustainability.[49] The data services are heavily used throughout the state, and include different levels of data collection. New York Energy Manager simply collects and reports the data without playing an active role in controlling the demand.

NYPA also plans to address its REV goals through data analytics in their main 16 generation facilities. Due to a new partnership with General Electric, NYPA will embed sensors in machines to pull data from existing enterprise management systems and supervisory control and data acquisition.[50] The asset management performance software is known as Predix, and it will allow NYPA to better evaluate its capacity during peak times and play a role in predictive analytics for grid assets.[51]

Opportunities for NYPA

The New York Energy Manager program is currently targeting NYPA's Reforming the Energy Vision (REV) goals for building efficiency initiatives. Specifically, it addresses the BuildSmart NY goals to reduce energy use by 20 percent in state government buildings by 2020.[52] However, data aggregation also plays a key role in microgrid development. The New York Energy Manager's role should be scaled up in order to address various data gaps in reaching REV goals. The largest gap is the lack of data surrounding the difference in microgrid operations with various distributed energy resources and customer base.

Case Highlights: California's Distributed Energy Resources & Independent System Operator Market

The California Independent System Operator (CAISO) works to create a reliable and accessible power gird, while meeting the needs of California citizens through a competitive power market.[1]

California is working on integrating distributed resources into this market through its Distributed Energy Resource Provider (DERP) initiative. This initiative will allow the aggregator (a utility or entity) to have access to the Independent System Operator electricity market. This example is applicable to NYPA's role as energy aggregator as recommended. The CAISO is currently working on stakeholder proposals, as they bring proper aggregation techniques to the table in order to facilitate distributed energy resources in the wholesale power market. The CAISO's plan focuses on expanding its metering techniques and technologies necessary to update the grid. The various distributed energy resources will not require a specific resource ID, so CAISO acts as energy aggregator that span multiple resources sending electricity to the grid and then taking electricity from the grid.

Sources: California ISO (2017); Trabish, H. (2015).

The Predix software will help NYPA move toward renewable energy investment, as their generating facilities collect more data on these technologies. This supports REV's 40 percent emissions reduction by 2030. Scaling down Predix modeling software for distributed energy resources and microgrid evaluation presents an opportunity to address other REV goals as well.

Finally, NYPA should act as the energy aggregator on a partnered microgrid project in order to act as the appointed intermediary between distributed energy resource owners and electricity users. The role of energy aggregator would allow NYPA to create value to the power system transitions, promote economies of scale in distributed energy resource development, and manage uncertainties. The energy regulates power flow and actively manages load to capitalize on price differentials. This allows the entity to ensure system reliability.

Data aggregation for load management

NYPA should expand its New York Energy Manager program to evaluate microgrid development and act as the data aggregator for load management. Utilities currently lack the data infrastructure necessary to effectively manage microgrids. At a granular level, they need real time loading data and a better understanding on the availability of distributed energy resources.[53] As utilities struggle, NYPA has the tools and software to become the centralized data aggregator. By expanding the New York Energy Manager's focus toward localized microgrid demo projects, NYPA would be able to model participation and performance factors for effective demand response management in the long-run. However, in order to do this New York Energy Manager would need to model the mix of distributed energy resources and customers.

NYPA's role: Microgrid taskforce

The development of a microgrid taskforce within New York Energy Manager would be in control of data aggregation for the microgrid projects and their responsibility would move from one-way data research to energy flow control. NYPA would back and compile data on various microgrid projects involving different distributed energy resources in order to effectively model their findings. These efforts will assist in NYPA's ambitious goal to digitize the grid, which necessitates a long-term planning period.

NYPA will be held responsible for identifying scalable programs that demonstrate immediate value to the customer. These types of projects would show how the customer is guaranteed kilowatt savings. Implementing a range of data driven and economically feasible project series will engage customer and also show the potential value of distributed energy resources.

Once studies and demo projects are concluded, NYPA has the opportunity to produce and operation and maintenance guide for microgrids with various distributed energy resources. This would also be essential to pushing market growth.

Implementation

Dual-pronged approach to implementation with the New York Energy Manager:

1. *Create a New York Energy Manager and microgrid demonstration project inter-working group to evaluate microgrid performance with different distributed energy resources.*

The group would be held responsible to identify and/or develop different microgrid projects with varying customer base and distributed energy resources.

The New York Energy Manager team would be in charge of accumulating data for different types of renewable power generating technologies to understand their operations with microgrids. This data would be combined with New York Energy Manager's findings on supply and demand for load management. Predix will be used to create a digital thermal footprint of the buildings it services. This data will be evaluated on the potential for efficiency

Figure 7 Diagram showing implementation strategies

NY Energy manager and microgrid inter-working group

Responsibilities:

- Identify & develop microgrid projects
- Accumulate data for diverse renewable generating technologies & microgrids
- Digital Thermal Footprint savings for buildings

Outcomes:

- Deliver comprehensive operation and maintenance guide
- NYPA takes on role as Energy Aggregator
  - Operates demand response programs

Public Housing DEMO & Interdisciplinary Working Group

Responsibilities:

- Develop incentivizing program for meter installations in public housing
- Front costs for initial metering installations
- Discount customers who use less energy
- New York Energy Manager in charge of data aggregation

Outcomes:

- Drives customer value
- Drives energy efficiency
- Addresses social needs of clean, efficient, and affordable energy options

and savings, and the performance analysed in relationship to specific distributed energy resources. NYPA would utilize these findings to deliver a comprehensive operation and maintenance guide for microgrids.

These findings would guide NYPA to effectively shift loads as energy aggregator and grow a valued customer base. The aggregator would act as a market participant that purchases or sells electricity products on behalf of two or more consumers/ generators/distributed energy resources.[54] In a large microgrid, NYPA would aggregate and contract with the operator.[55] NYPA would manage the demand-response programs to improve end user return on investment.[56]

2. *Create a Public Housing demonstration project with a working group.*

NYPA would develop a program that incentivizes meter installations in the public housing space. NYPA could front the costs for initial metering installations and provide discounts for customers who use less energy than neighbours. This drives customer value and incentivizes energy efficiency.

New York Energy Manager would analyse the public space for energy efficiency data aggregation and creates opportunities to expand potential distributed energy resource projects, while meeting REV energy efficiency building goals. This also addresses social needs of clean, efficient, and affordable options for tenants.

These findings would guide NYPA to effectively shift loads and grow a valued customer base. With successful implementation, NYPA would be able to promote energy efficiency initiatives and possibly influence green building retrofits due to growing market space by showing residents that green solutions are technically feasible and economically viable.

Key Takeaways from Case Highlights

- California is implementing the Distributed Energy Resource Provider initiative to allow aggregators access to the independent service operator market.
- The initiative focuses on expanding metering techniques and policies for distributed energy resources.
- NYPA has the potential to implement their role as energy aggregator through this initiative.

Business Case for NYPA

The New York Power Authority would benefit from serving as an energy aggregator as they would be in control of multiple resources sending electricity to the grid while taking it from the grid as well. Their role as a data and energy aggregator can be implemented to facilitate research and development for microgrids and distributed energy resources. The role of an aggregator can be accomplished through its New York Energy Manager resources and its new Predix software capabilities. Simply scaling their resources in place toward microgrid projects is an easy way to grow their own business while adhering to REV goals. Owning and controlling these types of assets would be useful as NYPA continues to expand its business, while implementing other types of projects like grid-scale storage.

[42] Parhizi et al. (2015).
[43] Burger et al. (2016).
[44] Burger et al. (2016).
[45] General Electric (2016).
[46] New York Power Authority (2015).
[47] Greenspan (2016).
[48] New York Governor's Office (2014).
[49] New York Power Authority (2015).
[50] Fox (2016).
[51] Fox (2016).
[52] New York State Governor Cuomo (2014).
[53] Mehta (2017).
[54] Burger (2016).
[55] Burger (2016).
[56] Dohn (2011).

Summary & Conclusion

In 2015 Governor Cuomo released the State's energy strategy, Reforming the Energy Vision (REV), a blueprint for the modernization of New York's aging energy system. REV highlights microgrids as particularly important components of New York's energy future. However, the existing energy regulations and institutions in New York State were formed to manage an outdated energy system and currently hinder the development of microgrids.

Governor Cuomo directed the New York Power Authority (NYPA) Cuomo to move New York's power sector forward through leading by example. Before the widespread development of microgrids in New York, the State must resolve key institutional and policy barriers. Addressing these barriers to microgrid development presents dual opportunities for NYPA. First, by removing barriers to microgrid development, NYPA furthers its mission of providing customers with affordable energy, supporting the State's economy, and developing an innovative infrastructure. Second, leading the advancement of microgrid development positions NYPA as a leader in New York's energy future and opens up new avenues for revenue. The key barriers identified in this study are regulatory challenges to development, disjointed ownership incentives, a lack of scalable financial models, uncertainty about the role of a utility in a distributed system, and the need for real time data management.

The recommendations proposed in this report are designed to balance NYPA's interests as a business and as a mission driven organization. We recommend NYPA develop a standardized microgrid financial model to provide microgrid developers access to financial investment while also opening up new revenue streams for NYPA. We also recommend NYPA adopt the role of a data aggregator, to pilot utilities' future role as service providers and to offload the challenges of data management and battery ownership from microgrid owners. Additionally, we propose that NYPA begin integrating blockchain technology into demonstration projects, to enable microgrid stakeholders to interact automatically and dynamically, and allow NYPA to determine how to best fit this technology to their organizational purposes. To facilitate each of these recommendations, we suggest that NYPA restructure the Grid Integration Team. Specifically, we propose that this team be tasked with resolving the regulatory barriers that currently hinder microgrid development, in addition to implementing the recommendations mentioned previously. Better utilizing this team would provide NYPA with the skillset needed to advance this study's recommendations and grow as a leader in the State's energy future.

New York's energy sector is in a state of transition. As an energy authority, NYPA has been instructed to champion the energy system's modernization. Removing key barriers to microgrid development will move the implementation of REV forward. We recommend that NYPA move forward with the recommendations detailed in this study, as they combine NYPA's mission and business interests and places it in a position of success in the energy future of New York State.

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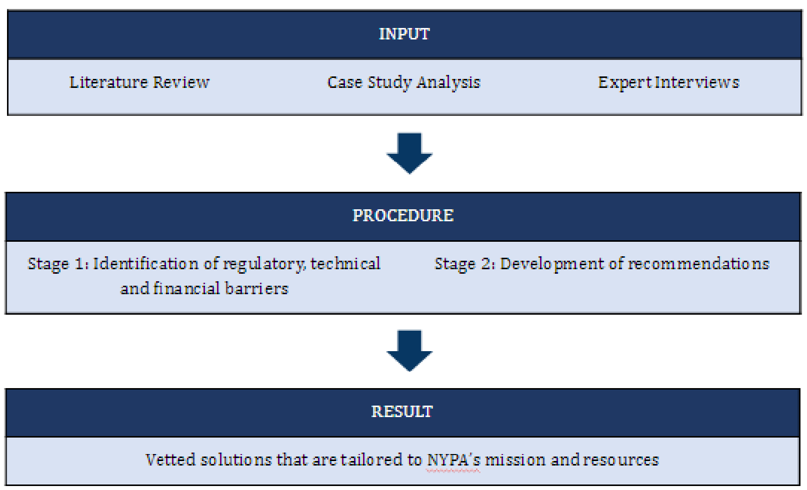
Supplementary Information

A. Research Methodology

The team was divided into three parallel research units: regulatory, financial, or technical issues. Research took place in two stages. The first stage of research concentrated on identifying barriers to distributed energy resources in New York State. Many of the barriers identified fell under the focus of multiple research units. For instance, it was found that a single regulatory approval for a microgrid development in New York State takes on average 407 days, which creates not only a regulatory challenge, but also financial uncertainty for potential investors. Regular discussion between all three research units was a vital part of holistically understanding distributed energy resource barriers.

Once the primary regulatory, financial, and technical barriers were understood, the research units then began crafting recommendations. The criteria used when developing recommendations were three-fold: first, the recommended action aligned with the New York Power Authority's (NYPA) mission; second, the action took into account NYPA's unique expertise; and third, the action would significantly impact the barriers identified during the first research stage. The outcomes from both stages of research were based on extensive data collection, which took place throughout the duration of the project.

Figure 8 Methodology of data collection and workflow



Three methods were used to collect data, including literature review, expert interviews, and case study analysis. The literature review consisted of government publications, industry reports, scientific journals, and newspaper articles. These were primarily used to gain a baseline understanding for the status of distributed energy resources. Case studies were collected from New York State and California. California was included due to its pre-eminence in energy advancement. Case studies were used to highlight challenges to distributed energy resources in New York State, and innovative solutions. Finally, nineteen expert interviews were conducted, spanning the public, private and non-profit sectors. A sample of the organizations represented within the interview population include NYPA, Con Edison, Peak Power LLC, Willdan Group, the New York State Energy Research and Development Authority, and LO3 Energy. In addition to providing industry expertise, interviews served an additional purpose of substantiating the soundness of recommended actions.

B. Research Informants

Below is a list of the 19 informants who have contributed to our research through agreeing to be interviewed. Some have chosen to remain anonymous, and thus their names are excluded and organization names redacted.

Table 2 Stakeholder interviews by date

#	Contact Name	Organization	Interview Date
1	**Mike Razanousky**	New York State Energy Research and Development Authority	1/26/2017
2	**-**	[Think Tank]	1/20/2017
3	**-**	[Consulting Firm]	1/20/2017
4	**John Saintcross**	New York State Energy Research and Development Authority	2/2/2017
5	**Kristin Barbato**	Edison Energy LLC	2/2/2017
6	**-**	[Consulting Firm]	2/10/2017
7	**-**	[Nonprofit Research Center]	2/13/2017
8	**Zachary Suttile**	Willdan Group	2/14/2017
9	**-**	[Private Utility]	2/17/2017
10	**-**	[Nonprofit Research Center]	2/20/2017
11	**Ben Pickard**	Peak Power LLC	2/22/2017
12	**Dan Leonhardt**	Pace Energy and Climate Center	2/28/2017
13	**-**	[Independent Consultant]	2/28/2017
14	**-**	[Private Utility]	3/1/2017
15	**-**	[Consulting Firm]	3/3/2017
16	**Scott Kessler**	Brooklyn Microgrid	3/7/2017
17	**-**	[State Energy Agency]	3/15/2017
18	**Mehdi Ganji**	Willdan Group	3/31/2017
19	**Doug McMahon**	New York Power Authority	4/6/2017