NYS SmartGrid Consortium

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November 20, 2017

Puerto Rico Energy Commission
Commonwealth of Puerto Rico
World Plaza Building
268 Muñoz Rivera Ave,
San Juan, PR. 00918

Case No.: CEPR-IN-2017-0002

Subject: Request for Public Comments.

Issue: Implementation of regulatory actions to facilitate the tasks of restoring electric service and encourage the deployment of new technologies.

Dear Mr. Rivera de la Cruz and Mr. Roman Morales:

The New York State Smart Grid Consortium (NYSSGC) is pleased to respond to this request for comments from the Puerto Rico Energy Commission. **We also appreciate this opportunity to offer our assistance in conducting advanced grid simulations and in preparing an Advanced Grid Roadmap for Puerto Rico, at no cost to your Commission or PREPA.**

The NYSSGC is a unique public-private partnership established in 2008 as a not for profit entity to advance grid modernization in New York State. The mission of the NYSSGC is to promote the broad statewide implementation of a safe, secure and reliable smart grid. Members include the world's leading power utilities, technology providers, research institutions and government policy makers. Recently we helped facilitate the stakeholder efforts for market design and technology as part of the New York Public Service Commission's Reforming the Regulatory Vision (REV) proceeding. Most recently, the NYSSGC has been working to facilitate the deployment of microgrids across New York State, and to develop advanced grid simulation tools to better understand the value that can be realized through the increased integration of distributed energy resources and smart grid technologies.

Importantly, the Board of Directors of the NYSSGC has agreed to sponsor the fast track development of a Grid Modernization Roadmap for Puerto Rico using the advanced grid simulation tools described below. A description of this proposed project, to be conducted by our contractor ProsumerGrid and to be carried out in collaboration with

PREC and other stakeholders you recommend, is attached to this filing and labeled Appendix A. As noted above, this study would be conducted at no cost to the Puerto Rico Energy Commission or PREPA. Also attached, for your reference, is a microgrid case study report completed by the NYSSGC in 2015 that addresses many of the questions you asked in this request for comments labeled Appendix B.

General Comments

While the destruction and devastation to the electric infrastructure of Puerto Rico caused by Hurricane Maria is among the worst ever endured, it is now imperative that we move beyond the disaster to build a 21st Century electric utility that can provide the level of reliability, sustainability, and resilience that Puerto Rico needs at reasonable cost.

We believe that to simply rebuild the infrastructure according to the prior or existing model of generation mix, transmission / distribution system, and markets, will cause the utility system to suffer from the same drawbacks as before the storm and will not provide the level of resilience needed against future severe weather events nor will it provide for the development and use of modern grid technologies. We clearly understand that the most important mission in the short term is to restore power to those locations on the island that have the ability to receive service. However, an integrated plan should be developed specifying what improvements should be implemented with the reconstruction, such as an Advanced Metering Infrastructure system (AMI), underground distribution lines in urban areas, incentives for roof top solar for re-construction, microgrids, and the improved integration of distributed energy resources of all types.

The utility should be planning and building a distribution system that incorporates key elements of sustainability and resiliency, and at the same time, delivers power at affordable prices. The NYSSGC is proposing to sponsor the development of the above-described plan, in collaboration with PREC and PREPA.

We feel that it is therefore important to analyze a broad set of options to maximize the impact of future critical infrastructure investments. Although not as urgent and extensive as the situation now in Puerto Rico, similar analyses are now being carried out by many utilities and states in the continental US and Hawaii. They are interested in redesigning their electric systems to better support their public policy and corporate strategic objectives while also benefitting from operational efficiencies.

While the PREC Request for Comments primarily focuses on microgrids and distributed generation, we believe PREPA also needs to be considering the broader picture of what the distribution system operator (DSO) of the future should look like. Among critical questions are: a) what are the new energy resources that would form an optimal energy mix for Puerto Rico, b) how should all forms of distributed energy resources (DERs) be integrated into the transmission and distribution system, c) what new information technologies, sensors, and communication systems must be deployed, d) how system coordination can be improved through advanced control systems, and e) how all stakeholders can receive the appropriate incentives for investment and participation in the expanding energy service marketplace. This requires that

PREPA have the planning tools and expertise to perform analysis of not only how microgrids can prove valuable to customers, and but also to the distribution system as a whole and at various layers.

The challenge in conducting such analyses has been the lack of an integrated simulation capability that incorporates all source options including distributed energy resources (DERs), as well as the impact of new smart grid technologies, innovative market propositions, and policy options. We are proposing to provide you with that simulation capability for the purposes of developing an integrated grid roadmap.

The NYSSGC was established to accelerate and better coordinate grid modernization activities in the State of New York, and to assist in the deployment of smart grid technology and market development. The NYSSGC is collaborating with ProsumerGrid, under sponsorship of the Department of Energy's Advanced Research Project Agency-Energy (ARPA-E) to develop an advanced grid DER simulation software system suitable for complex electricity system redesign analysis. ProsumerGrid is working with key utility partners conducting assessments of a set of use cases involving combined T/D analysis, DER scheduling operations, DER hosting capacity analysis, Distributed System Operator (DSO) market design, and multi-stakeholder DER valuation. This DSO simulator has unique capabilities not available otherwise in the industry and can help address many of the analysis needs. We believe the DSO Simulator can be of great help to the activities of the Commission, PREPA, and others in helping redesign the grid in Puerto Rico.

What Needs to be Done?

The problem of redesigning the Puerto Rico electricity system is complex and structural. No single technology or initiative alone can address it. Similar to efforts such as New York's Reforming the Energy Vision (REV), and California's DSO development initiatives, which require integrated design, the analysis needs to include elements and options at the interdependent layers listed in Table I.

Table I: Multi-Layer Classification of Future Grid Elements

Layer	Main Elements
1. Device layer	Devices that carry electric energy, e.g.: conductors, batteries, generating machines, solar panels
2.Device control and sensors layer	Elements that support stand-alone local control and monitoring of power devices, e.g.: smart inverters, smart meters, intelliruptors, PMU, etc.
3. Cyber layer	Communication networks, data models, computing systems
4.System coordination layer	Software applications, process and methods to ensure system level functionality, e.g.: balancing, scheduling, secure dispatch, resilience, etc.
5. Market layer	Structures that support participation of all actors, and that determine quantities and prices of products and services, e.g.: pricing, rate-design, real-time markets
6. Business layer	Models that allow actors to profit by meeting customer energy service needs, e.g.: ownership, business model, risk, valuation

There need to be strategic meetings among electricity sector leadership and stakeholders to develop a vision for the future of the electricity sector and to identify the strategic objectives and considerations applicable to Puerto Rico. Metrics associated with the objectives, and with the ongoing recovery and restoration efforts can be brought into the analysis to determine suitable constraints of transitioning options.

The portfolio of technology options can draw from the trends of state-of-the-art technologies as well as from existing recoverable infrastructure. The portfolio shall include a broad set of options including local and distributed generation options, including DERs such as solar PV, energy storage, and wind. It shall consider smart controls such as intelliruptors and smart inverters, and IT technologies such as smart sensors and smart grid. System coordination and economic layer options should include elements such as microgrids, autonomous and cooperative energy scheduling, and various pricing and rate design options.

Techno-economic analysis of the most promising options can be developed and compared with the business as usual or base case reference. This analysis is intended to be integrated, considering transmission and distribution simultaneously, and considering the realities and constraints of balanced and unbalanced grids, including grid restoration.

Responses to Specific Questions
Below, we provide responses to close to 100 questions. The questions have been tabulated based on the six layers, and assigned short term (operational) and long-term (planning) categories. It is to be noted that:
a) There are numerous additional issues not directly addressed through the Commission's questions that correspond to the various grid architecture layers such as cyber and local grid control, and
b) Similarly, because this RFI focus is almost exclusively on microgrids, there are many other topics not addressed in the RFI but that need to be carefully considered to obtain a comprehensive system redesign.

Sincerely,

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Table II: Questions and High Level Answers

1. Microgrid Organization:	**Layer**	**Time Scale**	**Response**
1.1. What legal authority does the Commission have to regulate actors and actions involved in microgrids? Consider the following actions, among others: Creation of a microgrid business, interconnection with other microgrids, interconnection with PREPA's transmission or distribution system, sales of microgrid output to PREPA (for resale), sales of microgrid output to retail customers (with or without participation by PREPA).	Market	Planning	The Commission should have full authority to oversee and regulate the operations and planning of the microgrid at all the six layers.
1.2. What are the advantages and disadvantages of alternative microgrid ownership structures (e.g., third-party, customer co-op, anchor load)? Consider such factors as reliability, economics, accountability.	Business	Planning	Ownership, Location, and Operation Control Authority (who operates) are the factors determining the final allocation of the surplus and corresponding value streams of services. This allocation varies drastically and the permance metrics of the system change depending on the factor design.
1.2.1. For each possible ownership structure, what actions by the owners, users and customers should be guided, constrained or rewarded through regulatory actions?	Market	Planning	Initial incentives are advantageous to be provided to foster the penetration of technology and business models. Market design must ensure that participants behave appropriately, but have the incentives to participate.
What regulatory actions are necessary?	Market	Planning	This can be answered with an integrated system redesign simulaton.
What regulatory actionsmight be unnecessary or problematic?	Market	Planning	An integrated system based on distributed operations such as involving microgrids is complex. The Commission must implement the system and market design. Other actions such as specifying how much a paritcipant can sell and when may be unnecessary. To the extent possible, and with appropriate consumer protections, market based means should be relied on to proved advanced energy services to consumers.
1.3. Are there legal or practical obstacles to any desirable ownership structures?	Market	Planning	No, but they need to be simulated to provide sufficient insight and trust before they specific options are allowed. Please see NYSSGC 2015 case study of of Microgrid design issues.
If so, what are the solutions, within and outside the Commission's authority?	Market	Planning	The more the actual demands of customer/prosumers are understood, and the more the market and system is designed to meet those demands, the higher the chances to achieve success and have a high-performance integrated system.
1.4. What financing sources are available to support various ownership forms? Consider private investment (both independent investors and commercial entities like large stores), government investment, and foundation and other non-profit sources.	Market	Planning	There must be clarity in the vision, market and system design, and allowing appropriate incentives to meet customer needs. Private and public investment can then be sustained.
1.5. What types of expertise (e.g., planning, engineering, customer education, other) are necessary to make the planning, development and operation of microgrids a success? What are current examples of success and failure?	System	Planning	There are multiple pilots of microgrids around the World that provide anectodal information. California and New York are ongoing system redesign under DSO and REV. All these efforts point to simulation of the system, before Again, please see NYSSGC 2015 case study of microgrid design issues.
2. Microgrid placement and availability: Given the Commonwealth's need and desire to getting service restored to all customers as soon as possible, consider these questions:			
2.1. What are the advantages and disadvantages of focusing microgrid development on specific types of customer loads (e.g., large industrial loads, urban loads, rural loads, residential neighborhood loads)?	System	Planning	It is important to prioritize and focus the effort based on the criticality of customers. Facilities that provide basic services such as hospitals, food, etc are critical and should be restored first.
Are some types of load profiles, or some geographic areas, better suited than others?	System	Planning	Yes, it depends on the level of destruction of infrastructure, criticiality, etc. Systematic analysis of images coupled with priority rankings of sites and paths could be used to maximize the impact and speed of restoration.

What data exist to support your answer?	System	Planning	NASA images, system modeling, customer classifications, historical restoration processes after storms, etc.
2.2. Regardless of the possible priorities to place on different types of loads, what are the most cost-effective paths to getting microgrid service universally available to all customers regardless of their locations?	Market, Business	Planning	Most likely universal microgrid deployment will be too costly. There are other service sharing options that can result in optimal design. The most cost-effective path can be determined through an integrated simulation that focuses on reliability, resilience, and redesign. The outcome of this simulation can provide a formally optimal sequence of planning actions.
2.3. What level of financial assurance will microgrid developers reasonably require before investing their own funds in Puerto Rico microgrids?	Business	Planning	It boils down to reasonable RoR with a given level of risk. To analyze this there has to be a market redesign.
2.4. What can the Commission do to facilitate universal service in the restoration?	Market	Planning	There are many options beyond microgrids that increase resilience of the system and diminish restoration time after events.
3. Microgrid Regulation			
3.1. What form of registration and/or approval by the Commission should be required for microgrids?	Market	Operations	Micorgrids/prosumers must register including legal organization, market in which they are participating, level of customers allowed, etc.
3.1.1. What regulatory changes would be needed to permit various microgrid arrangements?	Market	Operations	A market redesign is suggested to study the expected performance of various microgrid design options.
3.1.2. What aspects of microgrid operations should be regulated?	Market	Operations	What services shall the microgrid provide, in what markets it can participate, physical electrical behavior, etc.
3.1.3. What are the advantages and disadvantages of the Commission establishing technical and financial qualifications for the microgrid developers?	Market, Business	Operations	Quickly screening applicants that can actually provide the necessary services at a given location and the determination of value streams for participants and the system.
3.1.4. What are the risks of incompetent or unscrupulous developers and what are reasonable ways to prevent such problems?	Market, Business	Operations	Significant. Including safety, equipment damage, cyber attack, loss of energy to customers, and financial losses.
3.2. What technical standards should apply to islanded microgrids?	All	Planning	Dozens of standards may be applicable. A suggestion is that all the six layers are covered by standards.
3.2.1. What safety standards should apply?	Device	Planning	
3.2.1.1. Are the existing standards—IEEE Standard 1547 for design; UL Standard 1703, UL Standard 1741, or IEEE Standard 1547 for equipment; and the 2011 National Electric Code—sufficient?	Device	Planning	No, standards are evolving. For instance, 1547a must be considered. There are dozens of standards that apply.
Why or why not?	Device	Planning	These standards are incomplete. They do not cover things such as smart inverter operations, and barely touch the cyber layer. Few standards also cover the system control layer dealing with coordination of operations.
3.2.2. What are the advantages and disadvantages of requiring inspections? If the Commission requires inspections, what types of professionals and entities should be responsible for conducting them and certifying compliance? Consider registered engineers (working for the developer, for the Commission or for some other independent entity, municipal construction permit inspectors, others). What technical specifications should apply to the process of interconnecting a microgrid to PREPA's transmission or distribution system?	Device	Planning	PREPA should be in charge of certification of inspections.
3.2.3. Based on what factors should the Commission determine whether microgrids be interconnected only to PREPA's distribution system vs. to PREPA's transmission or sub-transmission system?	All	Planning	There are various options for connection. Factors involve: a) services provided, b) level of voltage, c) level of power/energy, d) type of organization, e) market design at wholesale or retail or downstream, f) ownership, g) reliability constriants, h) information exchange requirements, etc.
3.3. How should the location of microgrids be determined?	All	Planning	Integrated optimal simulation with inputs such as existing loads, demographics, resource potential, DER penetration scenarios, prices, etc. Diversity of microgrid customer types is important for customer equity and fairness reasons.
3.3.1. Should the Commission establish limits on the size of a microgrid?	All	Planning	Yes, and determine an easy to understand classification. For instance T or D, commercial or residential, etc.
On what factors should that limit be based (geographic extent, capacity, number of customers, other)?	All	Planning	There are about 200 factors that play into the design of optimal mirogrid design. Suggest dividing these into the six layers

3.3.2. Should the Commission issue franchise rights for microgrids?	Market	Planning	This is an option that could be analyzed through techno-economic simulation.
What conditions should be applied for a franchisee to maintain franchise rights?	Market	Planning	Clear definition of objectives and performance metrics: reliability, cost, sustainability, resilience, etc.
3.4. What consumer protections are required, and how should those vary with the ownership of the microgrid?	Market	Planning	Levels of performance related to reliability, capital cost, and cost of energy and services. Consumers/prosumers services must be fair prices. The best approach is a market with corresponding protections for gaming.
3.4.1. Prices and costs.	Market	Planning	
3.4.1.1. Assuming (for purposes of this question) that microgrid owners can sell their output directly to retail customers, what are the advantages and disadvantages of different pricing methods (including traditional cost-based pricing, price caps based on reasonable projected cost, and allowing market forces to set prices)?	Market	Operations	Traditional pricing methods do not provide the necessary incentives for users to purchase the technology or services, and for providers to offer the technology. A price based design is much more likely to be sustainable in the long term. Experiences suggest that the optimal design of rates is a very difficult problem.
Is it reasonable for there to be an administrative charge to cover the Commission's oversight costs?	Business	Operations	Yes.
3.4.2. Contract terms.	Business	Planning	It should be simplified and abstracted. There are too many details in the microgrid technologies to address all of them in the contract. If instead the contract focuses on functionality, it is manageable and more clear.
3.4.2.1. What are the advantages and disadvantages of the Commission establishing standard contract terms for retail and wholesale (to PREPA) sales?	Business	Planning	There are Many advantages to design a few clear standard contracts. A way to do this may be to model microgrids as prosumers.
3.4.2.2. How does the answer to the preceding question vary by customer group?	Business	Planning	Precisely because there are too many customers types, demographics, geography, voltage and power level, etc. It is important to abstract as prosumers that exchange energy and energy related services.
For example, should standard terms be required only for residential and small-commercial customers?	Business	Planning	It may be imporant to differentiate, but ultimately the grid is just a circuit with injections and extractions of power.
3.4.2.3. Should the standard terms be required only for microgrids owned or operated with the main purpose of selling energy at retail?	Business	Planning	It will be very beneficial to establish standardized contracts at all levels. But the contracts must be abstracted reflecting a variety of energy and energy services. There are more than 30 types of services that a prosumer microgrid can provide.
3.4.2.4. Should contract provisions be subject to Commission review?	Market	Planning	Yes
3.4.2.5. Should the Commission set limits on contract duration?	Market	Planning	Yes
3.4.2.6. How should the Commission address customers who decide they no longer wish to be part of a microgrid?	Market	Planning	Yes
3.4.2.7. Should the development of microgrids require unanimous approval of customers within the area to be served by microgrids?	Market	Planning	Depending on the design each customer could be a microgrid. Aggregations of customer resources may be utilized to present an interface for procurement or delivery of energy services.
3.4.2.8. What are the advantages or disadvantages of allowing specific customers to opt in or opt-out from being served by a microgrid?	Business	Planning	It could be as simple as Uber. If customers want to participate, then they apply and start offering services by their resources (energy, DR, etc).
3.4.3. What types of pre-payment or deposits are appropriate?	Business	Planning	It depends on the program
How does the answer vary by customer group?	Market	Planning	It is fundamentally a matter of scale, but abstracted services are similar.
3.4.4. Are non-discrimination rules necessary?	Market	Planning	Yes
3.4.5. Are other protections necessary?	Market	Planning	Yes, because of gaming, the issue of scale must be designed to avoid large microgrids affecting smaller ones.
3.5. Must all microgrids (at least those serving multiple customers) charge for services by metering delivered energy, or are other pricing structures acceptable?	Market	Operations	Other pricing structures are acceptable, including on the spot peer to peer transactions. It depends on the market design, which depends on the functionality needed.
3.6. To ensure that a microgrid project is cost-effective, safe and reliable, what information should the Commission receive from a microgrid developer prior its connecting customers? For example, should the Commission require developers to specify:	Market	Planning	Each customer may be a microgrid. Information should be related to point of connection, load and load profile, all resources and capability, and characterization of resources, list of services desired to produce or consume.
3.6.1. Maximum set of customers to be served? Type of customers to be served?	System	Planning	Any. The optimal sizes of microgrid can be determined through simulation.
3.6.2. Maximum generation and storage capacity anticipated?	System	Planning	Any. The optimal sizes of microgrid can be determined through simulation.

3.6.3. Costs?	Market	Planning	Cost of DERs is attractive for PR. It makes sense if the system and market has appropriate design.
3.6.4. Pricing?	Market	Planning	Services, market-based
3.7. What timing requirements, in terms of the development process, must the Commission take into account, when determining how long it will take to approve or reject a microgrid proposal?	System	Planning	It depends on the simulation technology used. Simple PV interconnections in the continental US can range from months to a few hours. Existing technology could allow fully detailed assessment of microgrid interconnection in the matter of minutes.
4. Microgrid Generation Technology: Solar photovoltaics, supplemented with storage, have been employed to power microgrids. The Commission is interested in the range of other options for reenergizing the disconnected portions of the island.	Device, System	Planning	All distributed resources must be included in the analysis. This is an "integrated simulation". DERs include solar PV, concentrated solar, batteries and other forms of storage, small wind, micro turbines, CHP, electric vehicles, demand response, etc.
4.1. Information provided to the Commission by Pattern Santa Isabel, LLC suggests that the Santa Isabel wind farm is operable, but lacks load and a source of energizing power. This condition could affect other renewable independent power producers, whose installations are operable but require power from PREPA to get back online.	System	Planning	
4.1.1. Is there a technical solution to add a small solar or diesel generator to restart the wind farm, and storage to firm up the supply?	System	Operations	Yes. It should be technically feasible. All options must be explored.
4.1.2. Is there load close to the wind farm that could be served from a microgrid based on the wind farm?	System	Operations	Possibly.
4.1.3. What legal or contractual obstacles would prevent or limit the ability of the Santa Isabel wind farm from (i) procuring a small-scale generation source to power up its turbines and (ii) serve surrounding communities directly through the use of microgrids?	Market	Planning	There has to be a market so that these transactions and contracts can be establihsed in a streamlined manner.
4.2. Are there any existing solar facilities that could be firmed up with storage and connected to load?	System	Operations	No response
4.3. For generation facilities under contract with PREPA, how would use of those facilities to serve a microgrid affect PREPA's contract?	Market	Planning	Simulation can determine short and long term prices of any arrangment proposed. The outcomes could be utilized by the parties to establish appropirate contracts.
4.3.1. Can a party other than PREPA develop a microgrid from such a facility?	All	Planning	Yes. It depends on the regulatory framework.
4.4. Can any of PREPA's hydro-electric facilities be firmed up with storage and connected to load?	System	Planning	Most likely this is not needed since hydro will provide storage
4.4.1. Can other parties use those facilities to serve local load?	System	Planning	No response
4.4.2. What arrangements would be needed with PREPA to implement this option?	All	Planning	A simulation needs to be performed that explores all options including some expansion.
4.5. Is it legal, practical, and necessary for solar-storage or wind-storage microgrids to have some fossil fuel back-up capacity?	System	Operations	Yes
4.5.1. How much fossil fuel based back-up capacity can be used in a microgrid without compromising its renewable status and ability to sell to customers?	System	Operations	Depends on the regulation limits for sustainability requirements. Given the reslience requirement of the island, it may be advisable to have some level of fossil fuel back-up, at least for the next decade or so.
5. Restoring operation of existing industrial generation using combined heat and power (CHP) systems.			
5.1. How much CHP is currently installed on the island? (The Commission would be interested in anecdotal information about specific facilities, as well as more comprehensive data.)	System	Operations	No reponse
5.1.1. What portion of the installed CHP capacity is operating interconnected with PREPA?	System	Operations	No reponse
5.1.2. What portion of the installed CHP capacity is operating in islanded mode, without PREPA supply?	System	Operations	No reponse
5.1.3. What portion of the installed CHP capacity is physically capable of operating, if utility power were restored to the host facility?	System	Operations	No reponse
5.2. Are those systems capable of operating in islanded mode?	System	Operations	No reponse
5.2.1. For those that cannot operate islanded, would a small amount of additional on-site generation allow the CHP to restart?	System	Operations	No reponse

5.3. For CHP installations that could operate now, but are sitting idle, what else would be needed to bring those plants back into service, to serve the host facility, feed power back to PREPA and/or power a microgrid?	System	Operations	No reponse
5.4. Do any CHP facilities have unused electrical capacity that could be delivered to PREPA or a microgrid?	Device	Operations	No reponse
5.5. What regulatory actions would be required to allow a CHP to sell excess power to PREPA?	Market	Operations	Market design
5.6. What regulatory actions would be required to allow a CHP to sell excess power to a microgrid?	Market	Operations	Market design
6. Coordination of Islanded Microgrids with PREPA:			
6.1. To PREPA: Please provide the Commission with any information relating to plans for serving rural communities with solar/storage microgrids. Such information should include responses to the following questions:	System	Planning	No reponse
6.1.1. What details are available regarding this plan?	All	Planning	No reponse
6.1.2. When will the first of these systems be installed?	All	Planning	No reponse
6.1.3. What duties does PREPA propose to assume for these communities?	All	Planning	No reponse
6.1.4. How would PREPA's rates and role in these areas differ from areas served by central generation?	Market	Planning	No reponse
6.1.5. For all commenters: What are the advantages and disadvantages of the Commission requiring PREPA to develop microgrids in some areas?	System	Planning	We suggest the Comission and PREPA simulate the operation of the microgrid and do an integrated techno-economic assessment of the microgrid to determine all the costs, value streams, and allocation of benefits. Without a simulation there is high risk on the potential outcome.
Would such a requirement avoid duplication of effort and conflict?	System	Planning	If there is a study providing the recommendation, the decision is easy to support and justify.
Would it discourage competitors from entering the Puerto Rico microgrid market?	Market	Planning	It makes sense to initially determine critical areas, and then expand to more.
6.2. Are there areas that should be reserved for PREPA restoration, or should microgrids be encouraged everywhere?	System	Planning	There should be a priority list and then general promotion. Even then, 100% penetratio shall not be the goal, but rather to optimize global metrics such as overall island resilience.
7. Use of Stranded PREPA Equipment: This set of questions addresses the possibility of assisting microgrid development by using existing PREPA equipment that PREPA is temporarily unable to use.	System	Planning	
7.1. Should microgrids be allowed to deliver power to customers through existing PREPA metering equipment?	Local Control	Planning	Yes
7.1.1. If so, how and when should PREPA be compensated for that use?	Market	Planning	Market design through simulation
7.1.1.1. Should the Commission set a fixed rate per meter, based on the average embedded costs of PREPA meters?	Market	Planning	Market design through simulation
7.1.1.2. Should the microgrid pay a monthly fee, or purchase the equipment outright?	Market	Planning	Market design through simulation
7.2. Should microgrids be allowed to purchase distribution equipment (poles, primary lines, secondary lines, service drops, and transformers) that PREPA is not currently able to use due to lack of connection to central generation?	Market	Planning	Market design through simulation
7.2.1. If so, how and when should PREPA be compensated for that use?	Market	Planning	Market design through simulation
8. What tools are available to the Commission or other parties to enable behind-the meter resources in areas without electric service?		Planning	
8.1. Are there technical resources (such as pile drivers for ground mount systems) in short supply in Puerto Rico? If so, what can be done to alleviate those shortages?	Device, Local Control	Planning	No response
8.2. Do firms that are new to Puerto Rico need information about local design and approval processes and standards? If so, how can that information be efficiently shared?	System	Planning	Yes. Today software systems allows massive and nearly instantaneous broadcasting of needs and opportunities to parties involved. The professional communities and industry associations can reach to hundreds of potential parties. The most important aspect is that the offers and propoals are received, that there be a powerful computational system to support streamlined evaluation of those proposals, and accurate decision making that ensures the success of each approved project/microgrid.

ProsumerGrid

Appendix A

October 10, 2017

Mr. James Gallagher
Executive Director
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Reference: Proposal to Assist NYSSGC with Redesigning Puerto Rico's Electricity System

Dear Mr. Gallagher:

We are pleased to provide the New York State Smart Grid Consortium with this proposal to develop a roadmap for Redesigning Puerto Rico's Electricity System. This study will provide a vision and assessment of a portfolio of development options at the levels of physical power infrastructure, cyber and IT technologies, system coordination, markets, and business models. The study will propose a specific system architecture as well as a set of recommendations. In order to develop this challenging study, ProsumerGrid will use its novel DER Simulation Studio tool, developed in collaboration with several US utilities under sponsorship of DOE's Advanced Projects Research Agency-Energy (ARPA-E).

We would like to work with you on developing this roadmap for development to maximize the chances of an electricity subsector viable in the long term, in support of strategic economic, resilience, and sustainability objectives of the Island.

Sincerely,

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Vice President of Industry Engagement

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Redesigning Puerto Rico's Electricity System

Proposal by ProsumerGrid, Inc.
October 10, 2017

Introduction

A large portion of the electricity infrastructure in Puerto Rico has been destroyed due to Hurricane Maria. Before the hurricane hit the Island, the infrastructure already required substantial upgrades in generation, transmission, and distribution that were delayed due to financial limitations. The overall situation of the electricity sector on the Island was difficult. After the devastation from the hurricane, it has been determined that rebuilding the infrastructure according to the existing model of generation mix, T/D, and markets will suffer from the same drawbacks and will not provide the level of resilience needed against future severe weather events. It is therefore important to analyze a broad set of options to maximize the impact of future critical infrastructure investments. Although not as urgent and extensive as in Puerto Rico, similar analysis is being carried out by utilities and states in the continental US, who are interested in redesigning their electricity systems to better support their state strategic objectives. A challenge to such analysis has been the lack of integrated simulation capability that incorporates all source options including distributed energy resources (DERs), as well as the impact of IT and smart grid technologies, innovative market propositions, and policy options.

ProsumerGrid, under sponsorship of the Advanced Research Project Agency-Energy (ARPA-E) is developing an advanced grid DER simulation software system suitable for complex electricity system redesign analysis. ProsumerGrid is working with key utility partners conducting assessments of a set of use cases involving combined T/D analysis, study of DER scheduling operations, DER hosting capacity analysis, Distributed System Operator (DSO) market design, and multi-stakeholder DER valuation. The proposed study will utilize this novel simulation capability to study Puerto Rico's energy redesign options.

Project Objectives

1. Develop a vision and strategic objectives for Puerto Rico's electricity system.
2. Develop a portfolio of options supporting the strategic vision and objectives.
3. Develop techno-economic assessment and comparison of system redesign options.
4. Develop a multi-layer system architecture and redesign.
5. Develop recommendations for the electricity system that support a viable subsector in the long-term, while considering high resilience and reliability, sustainability, economics, and customer participation.

Approach:

The problem of redesigning the Puerto Rico electricity system is complex and structural. No single technology or initiative can alone address it. Similar to efforts such as NY REV, and CA DSO, which require integrated design, this study will be integrated and it will include elements and options at the following interdependent layers:

1. Device layer: e.g. conductors, batteries, generating machines, solar panels, etc.
2. Device controls and sensors layer: e.g. smart inverters, smart meters, intelliruptors, etc.
3. Cyber layer: e.g. communication networks, data models, computing systems, etc.
4. System coordination layer: e.g. balancing, scheduling, secure dispatch, resilience, etc.
5. Market layer: e.g. pricing, rate design, real-time markets, etc.
6. Business model: ownership, business model, risk, and valuation.

Strategic meetings with electricity sector leadership and stakeholders will take place to develop a vision for the electricity sector and to list all the strategic objectives and considerations applicable to Puerto Rico. Metrics associated with the objectives, and with the ongoing recovery and restoration efforts will be brought into the analysis to determine suitable constraints of transitioning options.

The portfolio of technology options will draw from the trends of state-of-the-art technologies as well as from existing recoverable infrastructure. The portfolio will include a broad set of options including local and distributed generation options, DERs such as solar PV, energy storage, and wind. It will consider smart controls such as intelliruptors and smart inverters, and IT technologies such as smart sensors and smart grid. System coordination and economic layer options will include elements such as microgrids, autonomous and cooperative energy scheduling, and various pricing and rate design options.

A techno-economic analysis of the most promising options will be developed and compared with the BAU reference. This analysis will be integrated, considering T and D simultaneously, and considering the realities and constraints of balanced and unbalanced grids, including grid restoration. The team will seek to work closely with the PREPA transmission and distribution planning functions. ProsumerGrid will require knowledge of the pre-hurricane T and D models to develop a reference. Estimated recovery costs and times will be input in order to assess the reference BAU case, and to develop appropriate comparison with the redesign portfolio.

A multi-layer system architecture and redesign will be proposed that includes elements in the six layers above. The architecture will point out how the various elements interact with each other and how the functionality enabled by the technology and elements will serve to realize the strategic objectives. A set of specific recommendations and steps will be developed at the end of the study.

Work Plan

Task Description	**Month**			
	1	**2**	**3**	**4**
1. Develop vision and strategic objectives	■			
2. Develop portfolio of technology options	■	■		
3. Develop techno-economic assessment of portfolio options		■	■	■
4. Develop multi-layer system architecture and redesign				■
5. Develop recommendations				■

Deliverables:

1. Strategic Objectives Memo: Month 1
2. Portfolio of Technology Options Memo: Month 2
3. Set of Recommendations Memo: Month 4
4. Final Project Report: Month 4

Project Team:

Dr. Santiago Grijalva, Chairman and Principal Consultant
Dr. Umer Tariq, Chief Software Architect
Mr. John Higley, Vice President of Industry Engagement
Mr. Marcelo Sandoval, Chief Operating Officer and Senior Consultant

NAVIGANT

Appendix B

Community Microgrid Case Study and Analysis Report

Analysis and Action Recommendations for the Advancement of Community Microgrids in New York State Based on an Assessment of Prominent Global Community Microgrid Projects

Prepared for:
New York State Smart Grid Consortium

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Reference No.: 170645
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Acknowledgements

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Consortium Members

The following Consortium Members helped to guide the scope of the analysis and provided insightful feedback and review of the report.

Brookhaven National Laboratory	Stephanie Hamilton	Smarter Grid R&D Manager
Con Edison	Candice Tsay Chris Raup Tom Mimnagh	Distributed Generation Specialist Manager, State Regulatory Affairs Department Manager
Clarkson University	William Jemison	Vice Provost for Research
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New York Independent System Operators (NYISO)	Mike Swider Gary Davidson	Senior Market and Technologies Strategist Team Leader, Strategic & Business Planning
New York State Energy Research and Development Authority (NYSERDA)	Michael Razanousky Micah Kotch	Project Manager, Clean Energy and NY Prize Director of NY Prize and Strategic Adviser for Innovation
Stony Brook University	Jim Smith	Assistant Vice President, Economic Development

Project Representatives

The following individuals provided invaluable information in interviews that served as the basis for the case studies. They also assisted in providing feedback and validation on the written content.

Borrego Springs	Tom Bialek	Chief Engineer, Sempra Energy
Stafford Hill Solar Farm	Josh Castonguay	Director of Generation and Renewable Innovation, Green Mountain Power
Bornholm Island	Maja Felicia Bendtsen	Civil Engineer, Oestkraft
Co-op City	Lewis Kwit	President, Energy Investment Systems
Hamden Microgrid	Steve Pullins	Co-founder and Chief Strategy Officer, Green Energy Corp
Hudson Yards	Charlotte Matthews	Vice President, Sustainability, Related Companies

Other Contributors

Several other individuals made significant contributions to the report. Rich Barone assisted in preparing initial drafts; Sam Crawford managed document production to incorporate diverse feedback from multiple stakeholders; Laura Vogel assisted in revising and enhancing the documents; and Nancy Doon assisted in reviewing the documents.

This report was prepared by Navigant Consulting, Inc. for the New York State Smart Grid Consortium. The work presented in this report represents the authors' best efforts and judgments based on the information available at the time this report was prepared. The information has been obtained from sources believed to be reliable, and Navigant provided individuals associated with each project the opportunity to review and validate the information contained herein. However, Navigant does not make any express or implied warranty or representation concerning such information and is not responsible for the reader's use of, or reliance upon, the report nor any decisions made based on its content.

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1. Executive Summary

1.1 Study Goals and Contributors

The primary goal of this study is to present New York State Smart Grid Consortium (Consortium) Members and other Consortium stakeholders with information and analysis to increase their understanding of community microgrids. The secondary goal is to provide support for future policy-making and advocacy action through the development of recommendations that these audiences may consider to advance the development of community microgrids within New York State, in places and cases where such development may have merit.

To achieve these goals, the Consortium retained Navigant Consulting, Inc. (Navigant) to perform the study and analysis tasks and to develop the information and recommendations that fulfill these goals. Selected Consortium Members and project representatives also contributed guidance, direction and information to this effort.

1.2 Scope and Methodology

Supporting these goals, the scope and methodology for this study was executed in three performance steps:

1. **Study Projects:** Navigant and the Consortium selected six representative community microgrid projects—drawn from North America and Europe—for investigation. These projects are grid-connected, serve multiple buildings and end users, incorporate assets owned by multiple parties, and exhibit other desirable characteristics defined by the Consortium. These projects were studied through Navigant's performance of primary interviews and secondary research, resulting in five in-depth case studies that are each organized into nine common investigation sections, and one less-in-depth highlight study organized into six sections.
2. **Assess Project Information:** Following these project studies, Navigant and the Consortium together identified sixteen community microgrid project analysis areas. Navigant identified and analyzed each of the five case study project's success and failure factors within each of the analysis areas. Navigant then performed a cross-project success and failure factor analysis to identify four principal community microgrid success and failure factor trends and themes.
3. **Develop Recommendations:** The study and assessment steps were followed by Navigant's identification of actual or potential interest alignments and conflicts among eight common community microgrid stakeholders. Using this understanding as a context and basis, Navigant developed 54 practical action recommendations from across the sixteen analysis areas, which are organized into seven broad recommendation themes. These recommendations draw upon the previous success and failure analysis and are addressed to a broad audience of stakeholders that may desire to pursue the goal of building and operating more community microgrids in New York State.

1.3 Projects Selected

The six selected projects each exhibit distinctive attributes and a diverse range of characteristics that together provide a representative sample of community microgrid success and failure drivers and outcomes. The projects are summarized as follows:

Case 1: Borrego Springs (San Diego County, California) demonstrates how utility-owned and operated microgrids, with regulatory approval and financial support from state and Federal agencies, can be successfully financed and operated to provide measurable resiliency benefits, including the provision of reliable places of refuge during major weather events. This project also pioneered approaches to demand response (DR), dynamic electricity pricing, energy storage, and the control technology necessary to integrate and operate these systems in concert.

Case 2: Stafford Hill (Rutland, Vermont) may be the first grid-tied microgrid project powered solely by solar and battery backup, the first to provide full backup to an emergency shelter on the distribution network, and the first to site solar arrays on brownfield land once used to bury waste.

Case 3: Co-op City (The Bronx, New York City, New York) is one of the largest residential end-use customer microgrids in the world. This project provides thermal and electric energy for apartments with 50,000 inhabitants in New York City, as well as thermal energy to six schools and a commercial district. Since the microgrid is owned by a self-governing cooperative of apartment tenants, the co-op has the freedom to pursue cost-saving energy innovations.

Case 4: Hamden Plaza (Hamden, Connecticut) provides insight into the opportunities and risks that third-party developers perceive when considering microgrid development and demonstrates how the regulatory environment, utility attitude toward customer-owned generation, physical density of buildings, and community attitude toward energy independence are key factors impacting microgrid development.

Case 5: Bright Green Bornholm Island (Bornholm Island, Denmark) is both a microgrid and a virtual power producer that seeks to achieve 100% renewable supply by 2025 through the use of near real-time pricing and automated demand response. Considered one of the most advanced smart grid projects in Europe, this project demonstrates the importance of community engagement to accommodate a high penetration of intermittent renewable generation and demand response on the grid.

Highlight Study: Hudson Yards (Manhattan, New York City, New York) offers important lessons due to its location, design, complexity, and challenges encountered. It provides particular insight in the areas of business model design, legal, policy and regulatory navigation, and early stage development within one of the most complex and challenging project development environments.

1.4 Principal Lessons Learned

The success and failure factor analysis performed across the five case study projects resulted in four principal lessons learned:

1. Only certain community microgrid benefit streams may be monetized; similarly, the method of monetizing such benefits will differ based on the microgrid's ownership structure. Therefore, **asset ownership has a significant impact on business model viability.**

2. There are a diverse range of value streams potentially available to be monetized by community microgrid projects. However, actual monetization is a factor of microgrid design, business model, regulatory jurisdiction, and other drivers. **Diversification of monetization strategies can enhance access to capital, mitigate financial risk, and optimize economic value.**
3. Increasing the complexity of loads served and generation and demand response resources employed can lead to increased economic value. However, with increasing complexity comes the need for more robust system control in order to ensure high asset utilization, seamless transition to islanded mode, and real-time balancing of load and generation. **Optimal system design and experienced operation are keys to optimizing community microgrid customer and economic value.**
4. Project development, valuation, and operation are simplified when fewer parties are involved, while chances of project success are increased when all project stakeholders (community members, vendors, distribution service provider and regulators, among others) are engaged early and with focus. Therefore, minimizing **the number of redundant stakeholders while maximizing the effectiveness of engagement with necessary stakeholders is a key to community microgrid project success.**

1.5 Recommendation Themes

Drawing upon these principal lessons learned and the deep understanding of success and failure drivers fostered through examination of the six project studies, Navigant developed 54 practical action recommendations. These recommendations, if taken, may facilitate the growth of community microgrids in New York State through the further enablement and optimization of available community microgrid business models and the optimization of individual project development and delivery.

From among these recommendations, seven key themes under two overarching categories emerge as the most critical levers that policymakers, advocates and other stakeholders may use to advance their microgrid proliferation goals:

1.5.1 Business Model Enablement and Optimization

1. *Reduce Legal and Regulatory Barriers to Development:* Reduce barriers by increasing the standardization and transparency of the interconnection approval and cost assessment process, reducing prohibitions on third-party use of public right-of-ways and distribution utility ownership of distributed generation assets, and increasing direct access to wholesale energy and ancillary service markets.
2. *Enable and Encourage Comprehensive Benefit Monetization:* Promote the standardization of benefit valuation. Permit and encourage fee-for-service models that align cost recovery to localized direct—and potentially indirect—benefit recipients. Permit and encourage asset ownership models, business models, and contracting practices that maximize opportunities for diverse, secure, and controlled revenue capture. Encourage broad-based identification, evaluation, and planning of benefit realization to optimize value creation.
3. *Enable and Align Full Cost Recovery to Cost Causation and Benefit Receipt:* Design fixed and variable cost recovery structures to align project costs with benefits. Optimize distribution utility regulated return models to align investment incentives to both community microgrid needs and

cost recovery requirements. Permit and encourage selective rate-basing[1] of community microgrid investments to align cost recovery to benefit recipients. Permit and encourage consolidated billing to enable third-party cost recovery for providing end-user services.

1.5.2 Project Development and Delivery Optimization

4. *Enable and Encourage Optimal Project Development and Finance:* Provide project development guidance to optimize project siting and interconnection location. Encourage and incent greenfield project development and incremental minimum viable scope development. Raise awareness of and encourage application to the full range of financing sources, both private and public. Provide support and incentives for the un-financeable early stage development phase. Provide support to private sector financing. Enable and promote securitization that ties assets to property (not owners).
5. *Encourage Early and Robust Stakeholder Understanding and Engagement:* Promote projects to perform early and robust engagement with and provision of education to regulators, customers, and vendors. Assess and understand technology readiness through engagement with suppliers.
6. *Encourage and Require Standardization of Key Processes, Requirements, Technologies and Agreements:* Encourage or require the standardization of interconnection applications and design and cost assessments. Standardize local codes and permitting requirements. Standardize project development agreements and forms of contract. Promote the development of technology standards.
7. *Encourage and Support Best Practices for the Optimization of Project Design, Operation and Technology Utilization:* Encourage and promote project development choices that are more likely to lead to optimal outcomes.

[1] Selective rate-basing includes both recovery of investment costs through a targeted fee for service to certain customers, or selecting certain microgrid projects as system assets that benefit all customers and are therefore eligible for rate-based cost recovery.

2. Introduction

2.1 Study Goals

The primary goal of the Community Microgrid Case Study and Analysis report is to present to New York State Smart Grid Consortium (Consortium) Members and other Consortium stakeholders information and analysis that may increase their understanding of community microgrids and provide support for future policy-making and advocacy action.

The secondary goal of this study is to present recommendations for action that the Consortium, its Members, and/or its stakeholders may consider taking to advance the development of community microgrids within New York State in places and cases where such development may have merit.

2.2 Study Scope

The scope of the study includes six projects that were selected from an extensive candidate list of both U.S. and international projects identified by Navigant and down-selected using Consortium-supplied selection criteria. Selected projects may be privately or publicly developed, community-led or community-involved, and may include such stakeholders as project developers, technology solution providers, owners, operators, customers, and distribution utilities, among others.

2.3 Study Performance Roles

The roles of the three primary contributors to this work are described in Sections 2.3.1 to 2.3.3.

2.3.1 Consortium

The Consortium contributed to the framing and direction of this study by contributing to the scope definition and analysis methodology of this study. The Consortium directed the definition of selection criteria used to determine the case study and highlight projects. The Consortium also played a defining role in the analysis framework used to structure each case study. Finally, the overall report structure and content were reviewed multiple times to ensure quality of content and alignment to overall Consortium objectives for this study.

2.3.2 Member Working Group

The Consortium convened a Working Group drawn from among its Members to support the development of this study. The Working Group provided guidance and input to the scope definition and analysis methodology of this study, as well as detailed comments and suggested edits on an advanced draft of the study report.

2.3.3 Navigant

This study was performed by Navigant Consulting, Inc. (Navigant) on the behalf of the Consortium and its Members. Navigant's charge was to provide sufficient research, analysis, and documentation to enable the Consortium, its Members, and its stakeholders to objectively understand the ultimate drivers of community microgrid cost, revenue, and risk. Each selected project case study was developed through primary source interviews and secondary research performed by Navigant, followed by single project and cross-project analysis, the development of findings and lessons learned, and the development of practical action recommendations. This work was performed within the scope defined by and using the analysis methodology agreed upon with the Consortium and the Member Working Group, as well as with input from a variety of perspectives and sources as provided throughout the report.

3. Analysis Scope and Approach

3.1 Analysis Objective

The analysis objective for this study was to develop incremental knowledge about success and failure drivers for community microgrids of interest through two complementary approaches:

1. Development of project **case studies** as a means through which selected project success and failure characteristics may be identified, defined, and understood (what is).
2. Development of **practical action recommendations** that the Consortium, its Members, and its stakeholders may take to advance the development of community microgrids within New York State in places and cases where such development may have merit (what is needed).

3.2 Analysis Scope

Using this analysis objective as a guide, Navigant agreed to limit the scope of this study to three broad analysis areas that each include various parameters relevant to community microgrid project design, economics, and business models. These in-scope analysis areas are defined and described in Sections 3.2.1 to 3.2.3.

3.2.1 Projects of Interest

For the purposes of this study, Navigant defined the scope of the initial consideration of example projects to the following in-scope and out-of-scope characteristics as described below:

Desirable In-Scope Characteristics for this Study:

- » Significant community participation, involvement, or leadership with multiple customers (i.e., multiple, independently controlled and/or owned connected loads);
- » Private sector involvement (i.e., significant nongovernment development, ownership, and/or operation role(s));
- » Commercially (economically) viable (i.e., government funding/subsidy is limited or absent);
- » Both within New York State and global.

Undesirable Out-of-Scope Characteristics for this Study:

- » All nanogrids, which are defined as single-building deployments of less than 100 kilowatts, for the purposes of this project (kW);
- » Campus microgrids (such as those typically found at universities or hospitals);
- » Standalone and permanently grid-disconnected;
- » Government funded or heavily subsidized.

Optional Characteristics for this Study:

- Grid-connected microgrids, in general, must address the technical challenge of interconnection operations including the pick-up of load at the start of islanded operation and the drop of load upon reconnection to the macrogrid at the end of islanded operation. In-scope characteristics may include either seamless or non-seamless operation of this interconnection load transition.
- Community microgrids offer a variety of unique benefits. In-scope characteristics may include:
    - Adaptability and scalability to accommodate future changes to generation and load;
    - Integration of plug-in electric vehicles;
    - Integration of renewable distributed generation (DG);
    - Demand response (DR) via controllable loads.

3.2.2 Implications of Interest

For the purposes of this study, Navigant focused on the identification and assessment of learning implications within the following groups of potential project impacts and outcomes:

Microgrid and End-Use Customer Implications:

- Reliability
- Resiliency
- Environmental impacts
- Power cost/bill impact
- Power quality
- Distribution utility-related services cost (e.g., standby power)
- Distribution utility-related capital cost (e.g., interconnect)
- Government subsidy/grant funding
- Load balancing/grid optimization
- Local community and environmental impacts

Microgrid to Point of Common Coupling (POCC) Integration Technical Requirements:

- Islanding operation and limitation
- Utility and/or system operator control capability
- Utility backup supply and service obligations

Distribution Utility (Local Grid) Financial and Operational Implications:

- Technology, innovation, and employee training and development
- Relationship with microgrid-served customer(s) (win-win or win-lose)
- Microgrid-connected planning, operations, and energy delivery

- Continuing (or stranded) asset and service cost recovery
- Service reliability
- Asset and operation resiliency
- Asset and operation efficiency and energy loss reduction
- Asset utilization and investment or deferral

Generation and Transmission Power System (the Macrogrid) Implications:

- Capacity, congestion and energy supply
- Energy efficiency (EE) and load reduction
- Active load management/demand management/DR
- Ancillary services
- Asset and operation efficiency and energy loss reduction
- Asset utilization and investment or deferral

3.2.3 Practical Actions of Interest

For the purposes of this study, Navigant focused on the development of recommendations within the following broad areas of potential recommendation topics:

Utility Interconnection Policy:

- Capital cost recovery allocation and schedule
- Standby power and other services pricing and service level

Regulation:

- Microgrid owner/operator legal entity recognition, rights, obligations, and limitations
- Asset and system ownership options

Finance:

- Customer credit quality
- Taxation
- Rates, exemptions, deductions, credits, and depreciation schedule
- Economic externality valuation and credit (e.g., value of carbon reduction)

Business Model:

- Specific company/general business type/attraction measures
- Local-/city-/region-/state-level measures to address business model barriers
- Revenue stream enablement or enhancement steps

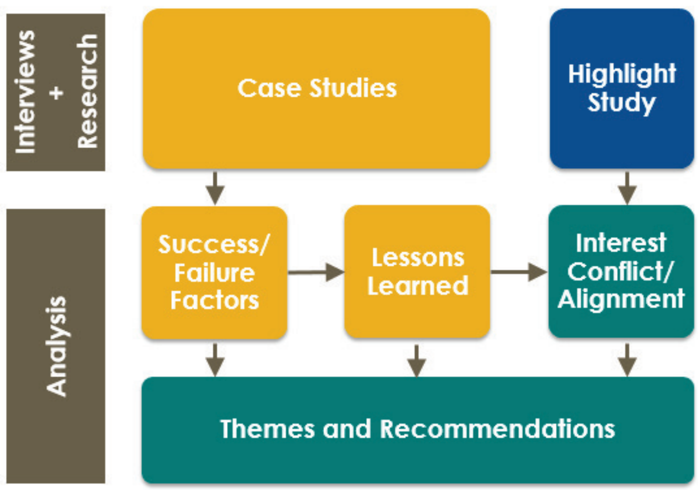
» Cost recovery enablement or incentive steps

» Benefit and cost allocation method improvement steps

3.3 *Analysis Methodology*

In order to achieve this study's goal, Navigant developed a robust methodology for identifying themes and recommendations. As depicted in Figure 1, this process utilized in-depth interviews and multi-faceted analysis to arrive at key conclusions. Success and failure factors were determined for each project and were synthesized to identify lessons learned and, in turn, the alignment and conflicts of interest between stakeholders. Together, this analysis was used to extract key themes and recommendations.

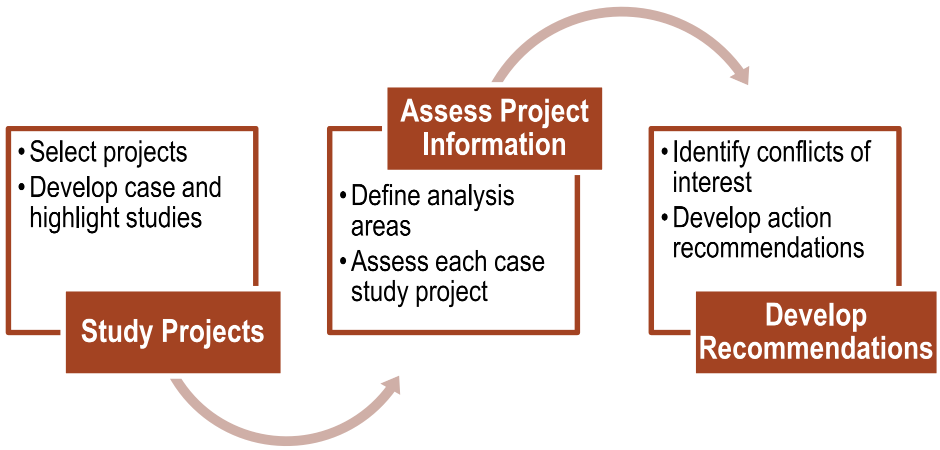
Figure 1. Analysis Methodology



Source: Navigant

For each individual project, Navigant applied a three-step process to study selected projects, assess the information developed, and develop recommendations. Navigant's approach for each of these steps is defined further in the following sections and is summarized in Figure 2.

Figure 2. Project Analysis Approach



Source: Navigant

3.3.1 Performance of Project Studies

The initial step in the process was the selection of community microgrid study projects. Starting with the in-scope and out-of-scope characteristics defined in Section 3.2, Navigant, with significant Consortium input, developed the following community microgrid project selection criteria:

» The project meets the U.S. Department of Energy's definition[2] of a microgrid and also exhibits:

- Diversity of residential and commercial customers;
- Collection of companies financing and providing tools;
- Major incorporation of EE, DR, and load optimization;
- Diversity of distributed energy resources (DER);
- Utility/community involvement in management and operation.

These selection criteria were applied against the microgrid project inventory previously developed for the Consortium by Navigant. This application resulted in the identification and selection of specific projects for inclusion in the scope of the study.

Navigant then developed individual case studies for each selected project. Navigant collected data to inform these studies primarily through phone interviews with project representatives, supported by relevant secondary research.

After collecting significant project information through interviews and supplementary research, Navigant developed five case studies. One limited project highlight study was developed for a project still under development in New York State, with only partial information available due to the preliminary nature of the project development stage.

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[2] "Microgrid Definitions," Microgrids at Berkeley Lab, 2015. Available at: https://building-microgrid.lbl.gov/microgrid-definitions>

Navigant organized the case studies to address seven general microgrid project elements as depicted in Figure 3.

Figure 3. Elements of a Community Microgrid Project

Source: Navigant

The case studies have a consistent template used in all cases. This template ensures comprehensiveness and facilitates comparison among the cases. After the data collection process, Navigant enhanced certain sections of the template on a case-by-case basis in order to highlight the most important lessons learned from each specific microgrid project. The template for each case of the five case studies includes nine sections, as outlined below.

1. Background and Project Objectives
2. Microgrid Characteristics
    a. Microgrid Classification
    b. Location
    c. Ownership Model
    d. Project Development Roles
    e. Role of the Local Community
    f. Key Dates and Milestones
3. Technical Components
    a. System Characteristics
    b. Generation Capacity
    c. Physical Characteristics
4. Operation
    a. Grid Interconnection
    b. Dynamic Load Capability

   c. Islanding Mode

5. Permissions and Regulatory Matters
6. Financial Model
   a. Total Project Cost
   b. Project Financing
   c. Cost Recovery
   d. Customer Types
   e. Services Provided to Participating Customers and Corresponding Pricing Models
7. Microgrid Benefits
   a. Energy Benefits
   b. Utility Benefits
   c. Environmental Benefits
   d. Cost-Benefit Analysis (CBA)
8. Lessons Learned
   a. Success Factors
   b. Challenges and Recommendations
9. Contacts and Sources

3.3.2 Assessment of Project Information

The second step in the process was to identify analysis areas and to then perform an analysis within each area to determine success and failure factors for each studied project.

Navigant, with significant Consortium input, identified and defined 16 specific project analysis areas, as depicted in Figure 4.

Figure 4. Project Analysis Areas

Source: Navigant

Navigant then analyzed the information gathered from each project to identify the successes and failures within each project analysis area. This analysis was performed on an objective, balanced basis to uncover both strengths and weaknesses that may together inform lessons for future projects and the policymakers that take action to influence the environment in which these projects are developed.

Navigant acknowledges that there will be no absolute successes and failures, as these terms must be applied relative to the unique context and circumstances of each project. Therefore, this will be a qualitative analysis that is intended to produce findings of general applicability to most community microgrid projects but may not, in fact, be applicable to certain specific projects due to the situation-specific limitations of the information upon which these findings are based.

3.3.3 Development of Recommendations

The third step in the process was to identify potential conflict among and between community microgrid stakeholders, followed by the development of practical action recommendations that projects and policymakers may take to advance their community microgrid project development interests.

Navigant first identified the typical project participation interests of eight specific community microgrid stakeholders. These stakeholders include:

1. Communities
2. Utilities
3. Regulators
4. Developers
5. Community energy managers
6. Technology vendors
7. Financiers
8. Regional system operators
9. Microgrid operating entities

Navigant then identified and assessed the most important areas of interest alignment and conflict among and between these eight stakeholders.

Finally, Navigant considered the previously developed success and failure factors, the stakeholder interest alignments and conflicts, and the desired recommendation topics of interest to develop practical action recommendations within each of the 14 project analysis areas.

These recommendations are addressed to a broad audience of New York State energy policymakers, influencers, and other community microgrid stakeholders that desire to pursue a goal of increasing the quantity of community microgrid projects within the state and ensuring their subsequent success.

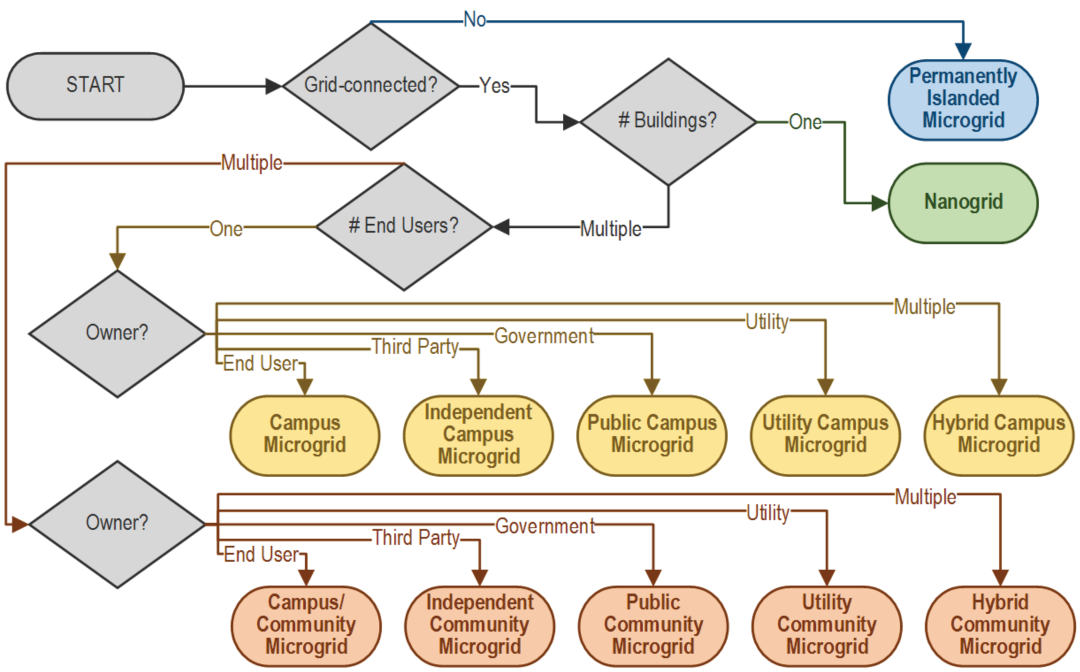
4. Project Studies Overview

The sections that follow present the aforementioned project case and highlight studies. Together, these project studies demonstrate a variety of microgrid designs and business models.

4.1 Project Classification

All selected projects are community microgrids, meaning that they are grid-connected microgrids serving multiple buildings and multiple end users.[3] Single-building projects are designated as nanogrids. Remote (not grid-connected) microgrids were designated as permanently islanded microgrids. For projects with multiple buildings, those with a single end user are designated as campus microgrids, while those with multiple end users are classified here as community microgrids (See Figure 5). It is worth noting that the defining characteristics of community microgrids, for these classifications, are not predicated upon the provision of emergency community services during an outage.

Figure 5. Microgrid Classification Methodology



Source: Navigant

The resulting microgrid classifications for projects included in the scope of this study are defined in Table 1.

[3] An end user is defined here as an individual (e.g., resident) or organization (i.e., commercial, industrial, or governmental) that owns or leases property within the microgrid for a purpose other than operation of the microgrid and has direct control over loads served on that property. Residents in multi-family buildings are considered to be part of the same organization as the owner of the building. All commercial end users are considered separately.

Table 1. Microgrid Classification Definitions

Microgrid Classification	Classification Definition
Campus/community microgrid	Projects serving multiple buildings and multiple end users and are owned by one or more end users
Independent community Microgrid	Projects serving multiple buildings and multiple end users and are owned by one or more third parties, which are private non-utility organizations that are not end users served by the microgrid
Public community microgrid	Projects serving multiple buildings and multiple end users and are owned solely by governmental organizations
Utility community microgrid	Projects for which the distribution utility solely owns and operates the microgrid distribution assets, which serve multiple buildings and multiple end users
Hybrid community microgrid	Projects serving multiple buildings and multiple end users and are owned by a combination of two or more of the following organizations: utilities, end users, third parties, and/or governmental organizations

Source: Navigant

4.2 Case Study Project Selection

Navigant selected the five case study projects listed in Table 2. This decision considered the desired project characteristics, the state of the project, depth of available information and the expected depth of information available.

Table 2. Matrix of Navigant-Selected Microgrid Projects

Metric	Co-op City	Hamden Plaza Microgrid 1	Stafford Hill Solar Project	Bornholm Island	Borrego Springs
Diversity of residential and commercial[4]	√	√	√	√	√
Collection of companies financing and providing tools	√	√	√	√	√
Major incorporation of EE, DR, and load optimization		√		√	√
Diversity of DER		√		√	√
Utility/community involvement in management and operation	√		√	√	√

Source: Navigant

4.3 Highlight Study Project Selection

In addition to these five case study projects, Navigant also developed a highlight study for the Hudson Yards project. As this project is still in the planning stages it cannot offer sufficient data to present a complete case study; however, the development of this project and its drivers are of interest in developing recommendations relative to this report. Navigant has developed a highlight study in order to present relevant information where available.

[4] Projects may not always include both residential and commercial customers but a mixture of customer classes (e.g., institutional, commercial, industrial, etc.).

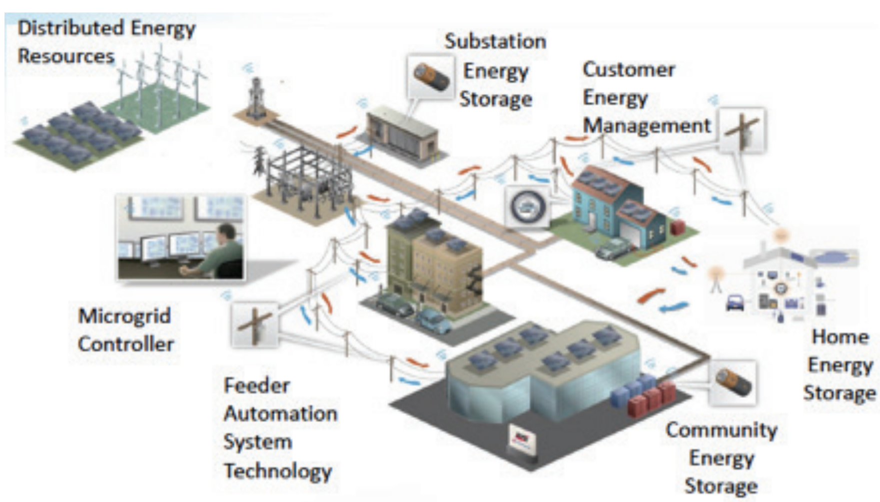
5. Project Studies

5.1 Case Study 1: Borrego Springs Microgrid

The town of Borrego Springs is a remote community situated at the end of a single, radial 69-kilovolt (kV) transmission line. Brief, powerful storms with lightning and heavy rain often result in a loss of power for extended periods of time in Borrego Springs. San Diego Gas & Electric (SDG&E) traditionally responds to severe events that leave its customers unexpectedly without power by dispatching troubleshooters and field crews to locate and repair the problems. Borrego Springs was a good candidate for a pilot project funded by the U.S. Department of Energy (DOE) and the California Energy Commission (CEC), with the dual goals of reducing peak load on local feeders and improving the reliability of energy services. SDG&E expanded on these goals by installing several measures—collectively creating a microgrid (Figure 6)—which allows service to customers to be restored while islanded from the main grid until equipment repairs can be completed.

This case is an excellent example of a utility-owned and operated microgrid, with regulatory approval and financial support from state and Federal agencies. Furthermore, project representatives claim the microgrid saved dozens of residents' lives when it successfully islanded during an emergency storm event in 2013. Finally, this case is on the forefront of pioneering approaches to DR, dynamic electricity pricing, energy storage, and the control technology to integrate and operate these systems in concert.

Figure 6. Borrego Springs Microgrid Project



Source: Green Energy Corp[5]

5.1.1 Background and Project Objectives

Borrego Springs was originally conceived in 2005 as a research and development (R&D) project developed in response to a Request for Information from the DOE regarding Renewable Distributed

[5] "Borrego Springs Microgrid Project." Web. Green Energy Corp, 2015. Available at: www.greenenergycorp.com/borrego-springs-microgrid-project/

Systems Integration (RDSI). The initial goal of the project was to reduce peak loading on feeders. Specifically, one requirement of DOE funding was a 15% reduction in feeder peak load by utilizing DER. Neither the ability to island nor official designations as a microgrid were original requirements of the project.

The project started as an examination of the technology solutions SDG&E could leverage to achieve a 15% reduction of peak load. Though diesel generators (typically used by SDG&E during outages) were sufficient to satisfy DOE requirements, the scope of the project quickly expanded into the integration of DG, energy storage, volt ampere reactive (VAR) management on the grid, automation of critical load islanding, and the examination of information technology tools to manage the complex integration of these technologies. The utility opted for EE and DR integration as an opportunity to pilot these technologies and use the diesel generators as little as possible. According to SDG&E, it was well-positioned to pioneer this effort, as DG and disaster response are not new challenges for the utility:

"We as a utility (SDG&E) had historically looked at microgrids and islanding customers as something that was a normal course of business. If you look back at the 2003 and 2007 wildfires that occurred in San Diego County, we had a fleet of diesel generators we would roll up and connect to critical loads (pumps, cell towers, etc.) and connect those loads for the duration of the disaster."

The project tested how an investor-owned utility (IOU) could develop a microgrid to serve an entire circuit, incorporating customer-owned solar PV systems into the generation mix as well as home energy management and distribution automation technologies. An unanticipated—and positive—consequence of these integration efforts was greatly enhanced grid reliability, as shown by the successful emergency islanding efforts at Borrego Springs.

Borrego Springs is the first large-scale utility-owned microgrid to integrate a diversity of residential and commercial loads and successfully island in a real-world situation. SDG&E engaged a broad consortium of stakeholders to provide the financing and tools to make this project a reality. The DOE and CEC provided $10.8 million of the total $18 million for the project, while Lockheed Martin, Oracle, Tendril, and many other technology vendors supported the effort with generation, DR, and control technologies.

SDG&E developed a first-of-its-kind microgrid activity visualizer and forecaster that allows them to optimize utilization of load control. Tendril introduced home control technologies to give customers choices and capabilities to control their loads. These individual home controls interface with the actual controls on the circuit, respond to dynamic shadow prices, and serve as the first resource called when SDG&E needs to reduce peak load on the feeders. Defining critical loads offers a form of DR during emergencies, as described by a project representative at SDG&E:

"If you define critical loads, you can drop down to those critical loads, and these generators can carry critical loads to ride through extended outages."

Once the reliability benefits were realized, SDG&E reconfigured the microgrid circuit to back-feed into the 12 kV bus at the Borrego substation and used the microgrid resources to carry the critical load on the two remaining circuits. According to calculations, it can carry critical loads for up to 2,500 customers for several consecutive hours. This ability was soon proven when the microgrid reacted to a real catastrophic outage during the storm of September 6, 2013.

5.1.2 Microgrid Characteristics

a. **Microgrid Classification:** Utility community microgrid

b. **Location:** San Diego County, California

c. **Ownership Model:** Utility-owned

d. **Project Development Roles:**

   i. Owner/developer: SDG&E

   ii. Grant funding: DOE and the CEC

   iii. Vendors/other:

   - Pacific Northwest National Laboratory (PNNL)
   - University of San Diego
   - Lockheed Martin
   - Tendril
   - Horizon Energy Group
   - Xanthus Consulting

e. **Role of the Local Community:**

SDG&E created a microgrid pilot program to actively involve customers. Utility representatives went to the community and solicited residential customers to participate, providing them with home area network (HAN) technologies such as smart thermostats. SDG&E sent price signals to the HAN devices simulating real-time prices, and the technology automatically participated in DR based on the price it received and the settings provided by the customer. SDG&E would forecast DR based on California Independent Systems Operator (CAISO) price forecasts, and it was the first resource called to serve load in Borrego Springs. However, the pricing demonstration had limited success in the community, as the pilot was not conducted in the summer months and did not have the effect of substantially reducing customer bills.

Is the local community willing to pay for the services provided by the microgrid? It is unclear whether residents in Borrego Springs, if given the choice, would opt-in to participation in the microgrid. For its part, SDG&E believes there is a certain level of societal good from reliable backup of critical loads, and to the extent the California Public Utilities Commission (CPUC) agrees there is a societal good, community resilience microgrids should be built and costs should be recovered from all customers. According to a project representative at SDG&E:

"The Borrego Chamber of Commerce was actually expecting people to die (in the September 2013 storm), because they were told the power would be restored in three days. By dropping to critical loads, what we were able to do was to allow for designated cool zone areas where people could go to get out of the heat. At the time it was 105 degrees at noon, going up to 115. The community was very grateful that occurred."

f. **Key Dates and Milestones:**

   i. 2005: First DOE solicitation released

   ii. 2007: SDG&E responded to second DOE solicitation

   iii. 10/2008: Project initiated and funded by DOE

   iv. 11/2011: Integration of existing DG and VAR

v. 9/2012: Integration of outage management system (OMS) for the microgrid

vi. 10/2012: Integration of advanced energy storage

vii. 2/2013: Integration of Price-Driven Load Management (PDLM)

viii. 3/2013: Integration of Feeder Automation System Technologies (FAST)

ix. 9/2013: First real-time islanding event

x. 10/2013: DOE involvement ends

xi. 2/2015: SDG&E received a grant from the CEC to expand Borrego and connect to the 26 MW Borrego Solar Facility

xii. Q1 2015: Project team anticipates release of commercially available, universal microgrid controller system for application to other microgrids

xiii. Q2 2016: Expected completion of microgrid expansion to incorporate Borrego Solar Facility

5.1.3 Technical Components

a. System Characteristics:

i. DG: Diesel generators, solar PV, energy storage, and DR

ii. Customers: The Borrego Springs microgrid serves 2,800 customers, 2,500 of which are residential customers.

iii. Load and End Use: 15 MW peak demand for the entire substation and all 2,800 customers

b. Generation Capacity:

i. Diesel generators: Two 1.8 MW generators

ii. Solar PV: 700 kilowatts (kW) of distributed, rooftop, and ground mounted solar arrays

iii. Substation energy storage (SES): 500 kW (1,500 kilowatt-hour [kWh] duration)

iv. Community energy storage (CES): Three 25 kW (50 kWh duration) storage systems

v. DR: HANs and smart thermostats

c. Physical Characteristics:

i. Number of buildings: 2,800

ii. Number of metered points: 2,800

iii. Use of public rights-of-way: Utility-owned generation uses existing distribution, including areas crossing public rights-of-way.

5.1.4 Operation

a. Grid Interconnection:

i. The microgrid is grid-connected and serves primarily local loads.

   ii. Impact on utility operation and economics: All operations are controlled by the utility, and all economics are the responsibility of the utility. Costs and savings are passed on to ratepayers.
   iii. Interaction with wholesale markets: Providing ancillary services to the main grid was not the original objective of the project; however, it did demonstrate the ability to provide VAR support to the grid with the help of generators and energy storage.

b. **Dynamic Load Capability:**

   Borrego Springs incorporates significant EE and DR. SDG&E developed a first-of-its-kind microgrid activity visualizer and forecaster that allowed it to maximize utilization of load control. Tendril introduced home control technologies to give customers choices and capabilities to control their loads. These individual home controls interface with SDG&E's call for DR by responding to dynamic shadow prices and event calls and serve as the first resource called to reduce peak load on the feeders.

c. **Islanding Mode:**

   i. Transfer time, duration, protocols: Unknown
   ii. History of successful attempts:
      - 6/23/2012: Planned transmission outage—microgrid islanded 2,128 customers for 5.5 hours
      - 4/8/2013: Windstorm-induced outage—microgrid provided power to 1,225 customers for six hours
      - 8/25/2013: Flash flood outage—CES islanded six customers for 5.5 hours
      - 9/6/2013: Thunderstorms struck transmission pole—microgrid islanded 1,056 customers for more than 20 hours

5.1.5 Permissions and Regulatory Matters

Numerous regulatory issues were encountered due to necessary approvals from regulators for permitting, air quality/emissions, and flood mitigation.

Project representatives believe there is a regulatory responsibility to determine how to pay for utility investment in microgrids. For this microgrid, there are no additional charges to ratepayers that directly receive the microgrid benefits, yet higher costs for premium service is a regulatory consideration in the future. The CPUC has developed a microgrid whitepaper on future regulatory activities related to this topic.[6]

5.1.6 Financial Model

a. **Total Project Cost:** $18 million, ongoing operating costs
b. **Project Financing:**

[6] Christopher Villarreal, David Erickson, and Marzia Zafar, "Microgrids: A Regulatory Perspective," California Public Utilities Commission, April 14, 2014. Available at: www.cpuc.ca.gov/nr/rdonlyres/01eca296-5e7f-4c23-8570-1eff2dc0f278/0/ppdmicrogridpaper414.pdf

i. Major funding was provided by DOE ($8 million) and the CEC ($2.8 million), with the latter amount matched by private funding from SDG&E and other vendors.

ii. SDG&E was able to recover its investment through electricity rates for the general rate base beyond what was provided by DOE and CEC.

c. Cost Recovery:

The cost of the investment by SDG&E and future savings are recovered through ratepayer charges in the SDG&E general rate base; these investments were approved as an addition to the rate base by the CPUC. A SDG&E representative offered the following insight on rate-based cost recovery for microgrids:

"For microgrids that are for specific customers, the costs should be recovered from that specific customer. To the extent the utility can develop a cost-effective microgrid as an alternative to the traditional grid, that cost should be recovered from all customers. Due to advances in technologies and IT systems, this is becoming an increasingly likely scenario in areas with grid congestion like Borrego Springs."

d. Customer Types:

i. Primary customers:

- *Normal operation:* Rate-paying customers located near the project (primarily residential)
- *Islanded operation:* Critical loads such as evacuation centers, water pumps, cell towers, refrigerators, freezers, and conditioned spaces

ii. Other customers: Because this project is ratepayer-funded, all SDG&E ratepayers are secondary customers. According to SDG&E, all ratepayers also benefit from the project's improvements in overall grid resilience discussed above.

e. Services Provided to Participating Customers and Corresponding Pricing Models:

During normal operation, the microgrid provides peak shaving and ancillary service benefits to the macrogrid. In island mode, the microgrid provides disaster insurance for customers in the form of a more reliable electricity supply. According to SDG&E, these services increase overall grid resilience.

Developers at Borrego Springs see reliability not as a choice between a complete outage versus full service energy supply but as a spectrum of critical and non-critical loads. The focus of SDG&E's efforts to ensure reliability at Borrego Springs is to define and prioritize the critical loads such as IT communication infrastructure, gas stations, food markets, traffic lights, refrigerators, freezers, and conditioned spaces—which critically provide residents safety from temperatures over 100 degrees Fahrenheit. This focus on DR and critical loads decreased project costs, improved resilience (as defined by SDG&E), and allowed SDG&E to serve a larger number of customers for longer duration during islanding events. A SDG&E representative believes critical loads and microgrids are key factors for resilience:

"If you were to redesign a system around resiliency as a goal, could you incorporate microgrids into that design? If you think about that in the context of critical loads, then the answer is yes."

From the customers' perspective, the main service provided by the Borrego Springs microgrid is disaster insurance. However, the total cost for the project is recovered through the general rate base of all SDG&E customers, and there are no added fees or charges for services to microgrid customers during islanded operation. At the moment, SDG&E believes it is the responsibility of the CPUC to determine the value of service reliability and price it accordingly.[7]

5.1.7 Microgrid Benefits

a. **Energy Benefits:** Peak shaving and energy delivered to ratepayers during normal and islanded operations

b. **Utility Benefits:**

   i. Improved stability of the macrogrid for customers

   ii. Improved effective capacity of feeders and substations

   iii. Pioneered IT interface to increase visibility of microgrid operations

   iv. Enabled customers to become more active in managing their energy use

   v. Availability of power from the microgrid during emergencies

c. **Environmental Benefits:**

   The generation, demand response, and load control systems allow for integration of a higher penetration of renewables on the microgrid, lowering the overall emissions intensity relative to the macrogrid. On February 17, 2015, SDG&E announced receipt of a $5 million grant from the CEC to expand the microgrid to connect to the nearby 26 MW Borrego Solar facility.[8] With this additional capacity, the microgrid has the capability to potentially operate solely on renewable energy and storage.

d. **Cost-Benefit Analysis (CBA):** Provided as part of DOE reports

5.1.8 Lessons Learned

a. **Success Factors:**

   The Borrego Springs area was a good candidate for an island-able microgrid because it experiences regular outages in storms due to the fact it is a remote community, served by only one transmission line, and previously waited for grid repairs to restore service during emergencies. While islanding was not the original intention of this project, it was eventually seen as a driver for the microgrid.

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[7] For a proposed methodology, see the discussion on the value of reliability set forth by Lawrence Berkeley National Laboratory in which they derive an avoided cost associated with greater reliability (Sullivan, Michael et al. "Estimated Value of Service Reliability for Electric Utility Customers in the United States." Lawrence Berkeley National Laboratory. LBNL-2132E, June 2009).

[8] "SDG&E Receives $5 Million Grant To Expand Borrego Springs Microgrid, San Diego Gas & Electric, February 17 2015. Available at: www.sdge.com/newsroom/press-releases/2015-02-17/sdge-receives-5-million-grant-expand-borrego-springs-microgrid

Including designated critical loads on a separate circuit as a form of emergency DR is important for extending the duration of islanding events. Early customer outreach and education is key to the success of any microgrid, particularly if it involves DR.

Funding provided by DOE and the CEC helped cover the project's upfront cost and agreement by regulators that the microgrid provided added benefits to all ratepayers allowed it to be rate-based.

The success of this project has prompted SDG&E to consider additional installations including solar and storage.

b. **Challenges and Recommendations:**

Control technologies are needed for optimal operation and management of the energy supply and loads. SDG&E and DOE originally intended to develop a universally applicable microgrid controller, yet the stakeholders in the project were unable to come to terms with vendors and technology providers to make this a reality. Instead, they created a microgrid visualizer, which enables monitoring of all microgrid operations but not universal control. One project representative said:

"Don't underestimate the work it will take to integrate the systems in the microgrid, and don't underestimate the effort it will take to come to contractual terms with your vendors and technology providers."

SDG&E is still independently hoping to develop an energy resource management system that can be made commercially available for other utilities and jurisdictions. SDG&E expect to release a universal control sometime in early 2015.

At Borrego Springs, SDG&E learned the importance of significant customer outreach and education. Even though SDG&E was providing no-cost HAN devices to residents, there was a natural fear among residents of having "Big Brother" watching them and controlling their devices. This was partially mitigated with opt-out provisions. Additionally, SDG&E could have spent more time working with regulators to gain approval for its dynamic pricing models.

5.1.9 Contacts and Sources

"Borrego Springs – Interview with Thomas Bialek, Principal Investigator at SDG&E Borrego Springs Project." Telephone interview. November 6, 2014.

"Lessons Learned in Borrego Springs." San Diego Gas & Electric, June 2014. Available at: www.smartgridlibrary.com/2014/06/16/four-important-lessons-from-the-borrego-springs-microgrid-pilot/.

"San Diego Gas & Electric (SDG&E) Borrego Springs Microgrid." U.S. Department of Energy, September 2013. Web. Available at: www.smartgrid.gov/sites/default/files/pdfs/project_desc/NT02870%20RDSI%20Fact%20Sheet%20SDG%26E%20Borrego_3.0.pdf.

Villarreal, Christopher, David Erickson, and Marzia Zafar. "Microgrids: A Regulatory Perspective." California Public Utilities Commission Policy & Planning Division, April 14, 2014. Available at: www.cpuc.ca.gov/NR/rdonlyres/01ECA296-5E7F-4C23-8570-1EFF2DC0F278/0/PPDMicrogridPaper414.pdf.

5.2 *Case Study 2: Stafford Hill Solar Farm*

The Stafford Hill Solar Farm is a solar + storage microgrid project under development by Green Mountain Power (GMP) in Rutland, Vermont, partially funded by a Federal/state/nongovernmental (NGO) partnership involving the State of Vermont, U.S. DOE's Office of Electricity, and the Energy Storage Technology Advancement Partnership (ESTAP). ESTAP is managed by the Clean Energy States Alliance (CESA) and Sandia National Laboratories.

According to the DOE, the Stafford Hill Solar Farm is the first project to establish a microgrid powered solely by solar and battery backup, the first to provide full backup to an emergency shelter on the distribution network, and the first to site solar arrays on brownfield land once used to bury waste. The solar array is pictured in Figure 7, below. The $10 million project is expected to be completed in 2015.

Figure 7. Stafford Hill Solar Farm

Source: Green Mountain Power[9]

5.2.1 Background and Project Objectives

In 2012, GMP merged with another utility (CVPS), which was headquartered in Rutland. As part of an effort to demonstrate continued commitment to the City of Rutland, the new company deemed Rutland the solar capital of New England and set the goal of installing the most solar per capita in New England. Shortly after this, GMP leased an old landfill (capped by the City of Rutland 30 years ago) that would become the site of the Stafford Hill Solar Farm. As there was no more landfill gas to be extracted from the site, the city agreed to lease the land to GMP. GMP designed the 2.5 MW solar project to occupy 11 acres of the landfill.

The development and permitting process began as a standard utility-scale solar PV plant. However, midway through the project design phase, GMP began to explore the prospect of installing energy

[9] "The Stafford Hill Solar Farm." Web. Green Mountain Power, 2015. Available at: www.greenmountainpower.com/innovative/solar_capital/stafford-hill-solar-farm/

storage in partnership with DOE and the State of Vermont. After exploring the opportunity, GMP decided to restart the permitting process as a solar + storage microgrid package.

In addition to developing the partnership with DOE, GMP was able to orchestrate many stakeholders to develop the project. Dynapower, a local company based in South Burlington, Vermont, assisted with the proposal for the DOE grant, and provided engineering and procurement services for the power systems technology. Dynapower also coordinated a bid to procure the most cost-effective battery storage technology. GroSolar was the winning bidder on the solar installation, and it is responsible for integrating the solar into the power electronics and the inverter. Vermont Energy Investment Corporation (VEIC) is working to develop educational tools for the project, and will be installing digital kiosks in the school to demonstrate real-time performance of the solar and storage. Finally, the City of Rutland was glad to lease the site and the landfill to GMP to fulfill its renewable energy goals.

The project site and design offered myriad benefits, including the opportunity for brownfield redevelopment, backup power and islanding capabilities for an emergency shelter in the neighboring high school, the ability to provide ancillary services to the New England-Independent System Operator (NE-ISO), and peak shaving of GMP's load with timed battery discharge. Additionally, the site in Rutland provides positive publicity for both the community and the utility and fulfills renewable energy goals for the city. As one project representative stated:

"The selling point—the pitch—we wanted to really test was to see how many different value streams we could really extract from this project. We have already tested and we have done a lot of solar. Energy storage is brand new to us."

Since the project was new to both the utility and the regulator, the process for permitting the development was educational for both parties. GMP finally received the green light from the regulator to develop the project in July 2014, and the project is now in the final stages of construction. Locating the project on a landfill added a new level of complexity to the development. For example, the drawings for the old landfill were inaccurate. They discovered trash where they needed to sink foundations into solid ground, which forced a project delay and redesign. The solar installation was complete as of March 2015, the containers with the battery storage are installed, and GMP is targeting activation in early June 2015. As construction finishes, the foremost concern is proper commissioning. The last remaining tasks are to program the control system for the storage and ensure the solar and storage are integrated to work in concert.

After that, the utility will transition to day-to-day operations of the plant, which could pose a challenge as GMP has no experience operating storage on the grid. Through careful planning, consultation with experts, and deliberate self-education, GMP is hoping to maximize economic value with intelligent microgrid operations as soon as possible. Sandia National Labs will also be monitoring the project's performance, with particular attention to tracking the ISO and peak reduction revenues from the project.

GMP sought to own the project from the beginning because it is self-defined as a progressive, future-oriented utility operating in a regulatory environment that allows utilities to own generation and storage. GMP acknowledges there is a risk to owning and operating the plant because the concept is new and the technology is not yet proven in this exact context. However, the ability to capture as many value streams as possible was an alluring prospect to GMP, and, according to project representatives, served as justification for utility ownership of the asset:

"For a third-party, you could theoretically develop a PPA structure to accomplish the same thing. However, we want to own it so we can pass all the value streams and cost savings on to customers."

Finally, GMP views Stafford Hill as a gateway project on the way toward developing many more microgrids in its service territory (all managed by a centralized control system), with the intention of accommodating higher penetrations of renewable energy while enhancing service reliability.[10]

5.2.2 Microgrid Characteristics

a. **Microgrid Classification:** Utility community microgrid

b. **Location:** Rutland, Vermont

c. **Ownership Model:** Utility-owned

d. **Project Development Roles:**

   i. Owner/developer: GMP

   ii. Grant funding: DOE, State of Vermont

   iii. Vendors/other:

      - Dynapower: Smart inverters and procurement for storage
      - groSolar: Designed and installed the solar array
      - Vermont Energy Investment Corporation (VEIC): Performed community outreach and plans to design a kiosk for local students to view system performance
      - Sandia National Laboratories: Monitoring the performance

e. **Role of the Local Community:**

   The City of Rutland leased the land to GMP, and the development is helping to achieve the city's goal of obtaining the highest solar capacity per capita in New England. GMP engaged in significant community outreach efforts to earn support for this project.

   GMP is currently actively marketing the benefits of the project to all customers and the local community. As a utility, GMP does not engage in paid advertising, so for this project it used social media and newspaper articles to explain how the value streams from the project would impact customers and community members. GMP is proud to mention on its website that rates recently decreased by 2.5%, while renewable penetration increased in the portfolio. Project representatives noted that some customers call and want to learn everything possible about microgrids, while others only pay attention to the tangible benefits of rate decreases or reliability improvements. One GMP employee noted:

[10] For example, if this project is a success, GMP hopes to provide different municipalities with a large-scale solar and storage emergency disconnection package to replace backup diesel generators. For all residential customers that already have solar, GMP hopes to develop a cost-effective neighborhood package to turn that solar into emergency generation by adding storage. The storage would be utility owned and have the additional benefits to GMP of reducing peak demand on the system.

"It is still so new for everyone [in the community] that they are mainly curious what it does, how will it benefit the grid and how will it benefit them—the customer. Education is key with any of this stuff. We're doing a lot of different things right now—this microgrid work is one piece of it. There's EV work going on, there's full e-home retrofit work where people can do a complete energy makeover on their homes. We are into a lot of stuff right now, and that educational piece is critical."

Finally, after hurricane Irene, grid reliability is a high priority for the local community. GMP understands that customers expect utilities to be proactive about ensuring grid reliability in emergency situations. In the words of one representative:

"In the wake of Irene in Vermont, Rutland was hit really hard—there was lots of flooding and damage. Having the ability to keep some critical infrastructure up and running during a time like that…it's priceless."

f. Key Dates and Milestones:

i. July 2013: Regulatory filing

ii. May 2014: Regulatory approval obtained

iii. July 2014: Construction began

iv. June 2015: Anticipated commissioning

5.2.3 Technical Components

a. System Characteristics:

i. DG: Solar PV, lithium ion (Li-ion), and lead-acid battery storage with a multi-port inverter. Power electronics and smart inverters enable optimization of PV and battery operations in response to weather, grid, and battery conditions.

ii. Customers: The system is grid-connected and rate-based, so all GMP ratepayers are indirect customers of the microgrid. During islanded mode, the single end-use customer is the local high school.

iii. Load and End Use: The system is normally grid-connected and serves GMP's system load. During islanded operation, the load is restricted to the local high school, which serves as a public emergency shelter. The solar and storage are sized to back up the emergency loads in the high school indefinitely. The project will also be part of the larger microgrid control system that GMP is implementing in partnership with NRG and Spirae—this system will incorporate the Stafford Hill project along with other solar and customer devices such as water heaters.

b. Generation Capacity:

i. Solar PV: 2.5 MW DC

ii. Li-ion battery storage: 2 MW/1 MWh

iii. Lead-acid battery storage: 2 MW/2.4 MWh

c. Physical Characteristics:

i. Number of buildings: The project intends to have at least the high school building as an emergency shelter and potentially surrounding neighboring residential customers.

ii. Number of metered points: None yet

iii. Use of public rights-of-way: Utility-owned generation uses existing distribution, including areas crossing public rights-of-way.

5.2.4 Operation

a. Grid Interconnection:

i. The microgrid is grid-connected and serves primarily local loads.

ii. Impact on utility operation and economics: All operations are controlled by the utility, and all economics are the responsibility of the utility. Costs and savings are passed on to ratepayers.

iii. Interaction with wholesale markets: Batteries participate in ancillary services market in ISO-NE.

b. Dynamic Load Capabilities:

Not applicable at this time; GMP has the ability to add additional islanded loads in the future, which will be managed with switches. GMP will be deploying a broader microgrid control system in the summer of 2015, which will integrate end-use devices with the Stafford Hill Project.

c. Islanding Mode:

i. Transfer time, duration, and protocols: During islanded mode, GMP allows electricity to flow from the project to the local high school. The school can be powered indefinitely during islanded mode.

In the future, GMP intends to add other loads that will be served during islanded mode. After testing, they will be working to include grocery stores and restaurants as potential islanding loads as well. As all loads are connected to the distribution system, it is easy for GMP to add more islandable loads. This expansion flexibility is another reason why GMP sought to own the project. Islanding capabilities at this site could be expanded without any additional cost or regulatory approval. As one GMP representative said, "It requires the placement of a few switches."

ii. History of successful attempts: The system will be commissioned in June 2015, so there is no history available yet.

5.2.5 Permissions and Regulatory Matters

The project encountered minimal issues and received all necessary regulatory approvals. GMP communicated frequently with regulators during the design phase of the project to ensure there were no surprises from the regulators' perspective. Early, frequent, and direct contact with regulatory decision-makers was important to permitting the project. This was true not only at the state level, but at the local level for construction, fire safety, and land development permits.

GMP sought permission for construction under Section 248 of regulations, which includes a requirement for an environmental impact statement (EIS) and a cost-benefit analysis. Since the technology—in particular the large-scale storage—was new to both the utility and the regulator, the process for permitting the development was educational for both parties. The favorable and progressive regulatory environment in Vermont enabled approval. As a GMP representative involved in the regulatory process said:

"We can pick up the phone, schedule a meeting, go down, sit down, and just talk through these things [with the regulator]. [The process] is just as much educational as it is policy—and regulation—oriented."

GMP and regulators spent significant time evaluating how the facility would function and interact with the macrogrid. Ultimately, regulators and GMP were able to agree on an assessment of the value of solar and storage and demonstrate positive value to all ratepayers, thus allowing GMP to finance this project through its rate base.

5.2.6 Financial Model

a. **Total Project Cost:** $10.77 million of which $285,000 is funded by the DOE and the State of Vermont; ongoing operating costs

   Solar: $5.77 million, $2,308/kW; storage: $5 million, $1,250/kW (GMP estimates)

b. **Project Financing:**

   The microgrid is utility-owned and operated. Upfront costs for the project were paid by GMP, with costs for both solar and storage passed onto ratepayers after passing the requirements of Section 248 in Vermont state regulatory proceedings.[11] Supplementary financing for the storage was sourced through a grant totaling $285,000 from the DOE and the State of Vermont. There are some tax benefits from the project such as the Investment Tax Credit (ITC) for the solar PV and inverters. There is also a sales tax exemption for components used to generate electricity. Ongoing revenue/savings streams include:

   i. Ancillary services and frequency regulation provided to ISO-NE[12]
   ii. Peak shaving for GMP
   iii. The ability for GMP to accommodate higher penetrations of renewable energy
   iv. The ability to reenergize customer-owned PV through the distribution grid during emergencies
   v. Deferral of future transmission and distribution investments

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[11] State of Vermont, Public Service Board, May 28, 2014, "Docket No. 8098." Montpelier: 2014. Available at http://psb.vermont.gov/sites/psb/files/orders/2014/2014-07/8098%20Final%20Order.pdf.
State of Vermont, General Assembly, May 28, 2014, "Docket No. 8098." Montpelier: 2014. Available at http://legislature.vermont.gov/statutes/section/30/005/00248.

[12] Regarding ancillary services, GMP is currently paid for their share of capacity they contribute to the market on the one-hour peak of the year. The capacity market is presently valued at $30 million, yet GMP expects the value to increase to $100 million within several years. The regional frequency regulation market is entirely novel, so the revenue projections from this service remain to be determined.

vi. Emergency preparedness for the community (not yet monetized)
vii. Payments from satisfied customers who increasingly demand environmentally friendly electricity

Furthermore, any remaining life in the system beyond the 25-year financing horizon will accrue as benefits to the utility and ratepayers, which is generally not available from solar resources procured through power purchase agreements.

Upfront investment and ongoing net costs/savings are rate-based and passed on to all rate-payers. At this time, there are no additional payments from local customers benefiting from islanded power, though GMP is investigating this service option.

c. Cost Recovery:

In regulatory filings, GMP has provided a range of value streams for each of these benefits, with total benefits from $350,000 to $700,000 per year in the near term. Over the long-term, GMP estimates the total value of these revenue streams at $2.8 million to $6 million. GMP estimates that the nominal levelized cost of power from the solar component over an assumed 25-year project life will be $0.171 per kWh. The value of the energy, capacity, transmission, ancillary services, and renewable energy credits (RECs) generated by the solar component will be approximately $0.187 per kWh. The value of the storage component is captured through regulation service, avoided capacity charges, avoided Regional Network Service (RNS) charges, and energy arbitrage opportunities.

d. Customer Types:

i. Primary customers:

– *Normal operation:* Rate-paying customers located near the project

– *Islanded operation:* Local high school in Rutland

ii. Other customers: all GMP ratepayers

e. Services Provided to Participating Customers and Corresponding Pricing Models:

During normal operation, the microgrid provides benefits to the macrogrid of peak shaving, frequency regulation, and improved resilience. The Stafford Hill solar + storage microgrid has black-start capability, so in the event of an emergency, the utility can use the energy stored in the batteries to re-energize portions of its service territory. While the ratepayers (customers) of the macrogrid do not see these benefits directly, GMP is working to educate its customers about the value streams from the project and how this project (in addition to other measures) has recently helped reduce rates by 2.5%.

During islanded operation, GMP uses the microgrid to provide emergency backup power for the local high school. Currently, this is the only islandable load for the microgrid and there is no additional price on these services; however, GMP is investigating the opportunity to include other customers within the islanding capability of the microgrid, as well as the option for these customers to pay a premium for such a service.

Other services include the following:

i. Higher quality power and precisely balanced voltage for nearby customers

ii. Black-start capability helps to reenergize local portions of the macrogrid after outages, including providing power that allows other nearby solar to redistribute energy using the GMP grid infrastructure during a large-scale outage

GMP is optimistic about its ambitious microgrid agenda due to substantial support from customers. Project representatives claim there is survey data throughout Vermont showing overwhelming support for cost-effective renewable energy developments. One representative characterized the utility's efforts as the following:

"Just like anything, there is a sloppy way to do things. You can go and deploy a ton of renewables without thinking about cost, and drive prices and rates up like crazy. Or you can take the approach we do, which is deploying renewables cost-effectively. We just had a 2.5% rate decrease at GMP while other state in New England are having 30-40% increases while we are developing and deploying all of these projects."

5.2.7 Microgrid Benefits

a. Energy Benefits:

i. Peak shaving

ii. ISO ancillary services for frequency regulation

iii. Energy provided to the high school during islanded operation

b. Utility Benefits:

i. Emergency preparedness

ii. Demonstrated ability to accommodate high penetration of renewable energy

iii. Meet customer demands of environmentally friendly electricity

iv. Deferred future transmission and distribution investments

v. Ability to reenergize the grid and other solar installations during an outage

vi. Ability to pilot and test microgrid technology to serve as model for future development

vii. Reduced line congestion and line losses

c. Environmental Benefits: Zero emissions from renewable energy

d. Cost-Benefit Analysis (CBA):

A more detailed cost-benefit analysis is available in regulatory filings. Because much of the value from this project remains uncertain, in the Section 248 filing GMP assigned a low-high range for benefits, which resulted in an overall project range from a slightly negative NPV to a decently positive NPV. These ranges were discussed at length during the regulatory process before GMP obtained approval. GMP perceives this project as having greater benefits that cannot be represented in the NPV calculation:

"When you go to build a substation because your load is growing or your reliability is not great, you don't try to do an economic benefit analysis down to the last cent. You say, 'we need this substation to feed these customers reliably and keep this level of service up.' And you do it. There is real customer value that comes out of that."

5.2.8 Lessons Learned

a. Success Factors:

Early and ongoing education of the public and support from local officials and regulators helped this project develop smoothly. By working with regulators, GMP demonstrated the value of solar and storage to the macrogrid as well as locally during outages. GMP was able to help them understand the process, avoid surprises, and work through issues. This same process applies to local permits including construction, fire safety, and land development. Local community support was strong for this project because GMP engaged the public with education efforts, and Rutland has the goal of being the solar capital of New England.

Utility ownership allows the capture of all possible value streams in one place, and the utility can pass those on to both the local and broader customer base. GMP captured many value streams in the form of cost savings, revenue increases, and customer/community satisfaction. Additionally, funding provided by DOE and the State of Vermont helped cover project costs.

b. Challenges and Recommendations:

GMP admits it should have spent more time up front reviewing the project's controls and operation protocol to ensure long storage asset life and capability for the batteries to capture all desired revenue streams. Technical constraints can have a significant effect on project economics. The control system issues were ultimately solved, but focusing on this up front would reduce project complexities. In the future, GMP plans to spend more time on designing the battery charging, dispatch, and operations to optimize system peaks, energy arbitrage, and battery life and effectiveness.

The team also related that it should have spent more time up front identifying and specifying exactly how the utility would monetarily capture all of the benefits provided by the microgrid. After reflecting on the lessons learned from the project, a representative offered this statement:

"[Effective microgrid development] is about asking: What do you want this microgrid to do? What are all the value streams you are going to extract from that? How are you going to physically set that up and control that?"

The outlook of GMP's executive leadership is unconventional compared to most utilities. Stafford Hill encountered few internal barriers to development, as GMP is pursuing a number of cutting-edge projects in demand-side management and renewable energy. GMP's executive leadership anticipates that customers in Rutland and elsewhere in their service territory will continue to demand a higher penetration of renewables on the grid, and wants to stay ahead of customer demand for solar integration. According to one GMP employee:

> ***"Customers in Vermont want to continue to go solar. We need to make sure we stay ahead of it. We don't want to ever get to the point where we have to limit…if the customer wants to go solar I don't want to ever be in the position where we have to throw up our hands and say 'we can't take anymore!' so I want to figure this all out in advance."***

5.2.9 Contacts and Sources

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State of Vermont, Public Service Board. May 28, 2014. "Docket No. 8098." Montpelier: 2014. Available at http://psb.vermont.gov/sites/psb/files/orders/2014/2014-07/8098%20Final%20Order.pdf.

State of Vermont, General Assembly. May 28, 2014. "Docket No. 8098." Montpelier: 2014. Available at http://legislature.vermont.gov/statutes/section/30/005/00248.

5.3 *Case Study 3: Co-op City*

Co-op City hosts one of the largest residential end-use customer microgrids in the world. It began as a district heating and cooling system located in the Northeast portion of the Bronx, providing thermal and electric energy for apartments in New York City with 50,000 inhabitants, as well as thermal energy to six schools and a commercial district. Due to its size, the development is referred to as a city within a city (Figure 8).

Since the microgrid is owned by a self-governing cooperative of apartment tenants, the co-op has the freedom to pursue cost-saving energy innovations. Co-op leaders have ambitious plans for future projects, including PV on parking garages, expanding electricity service to the nearby school, police station, and shopping centers, and an onsite sewage treatment plant. However, projects face various regulatory challenges that have impacted the economics of the microgrid. The Co-op City case demonstrates the significant effect of regulations and describes the ongoing push for reform and further cooperation with the utility.

Figure 8. Co-op City in the Bronx

Source: Forbes[13]

5.3.1 Background and Project Objectives

Co-op City began in the mid-1960s as a district heating and cooling system using hot and chilled water for air conditioning, space heating, and domestic hot water. At the time, it did not generate its own electricity and received a special rate structure (SC13) from Con Edison established to provide low-cost bulk electricity to the development.[14] Electricity does not come directly from the grid to each building,

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[13] William Pentland, "Lessons From Where The Lights Stayed On During Sandy," *Forbes*, October 31, 2013. Available at: www.forbes.com/sites/williampentland/2012/10/31/where-the-lights-stayed-on-during-hurricane-sandy/

[14] "Service Classification No. 13 Seasonal Off-peak Firm Sales Service," ConEdison, March 01, 1999. Available at: www.coned.com/documents/gas_tariff/pdf/0007-Seasonal_Off_Peak_Firm_Sales_Service.pdf

but rather through four master-metered points in the development where it is then distributed via Co-op City's own underground electricity grid. This pre-existing configuration serves to distribute the power generated by the combined heat and power (CHP) plant to the development in a microgrid configuration. The pre-existence of this configuration enabled conversion to a CHP-powered microgrid.

Located in the northeastern part of the Bronx, Co-op City is frequently referred to as a city within a city. Were it an official city, it would be the tenth largest in the state, with 50,000 residents. Co-op City is an affordable housing community structured as a limited equity cooperative, meaning tenants can only sell a unit for what they paid, plus improvements. The units are not subject to real estate market rates, making the development a unique, affordable Naturally Occurring Retirement Community (NORC).

Co-op City's buildings are 30 to 35 stories high. For senior citizens living in high-rise apartments, a blackout accompanied by high temperatures is a life-threatening event. This led to CHP development as a way to secure greater reliability of electricity supply and protect residents during these events. After the Northeast blackout of August 14, 2003, Co-op City recognized there were financial and reliability benefits from onsite generation. By 2007, the development was able to secure financing to build the CHP plant to generate its own power and use the waste heat to meet thermal loads.

Co-op City leaders have several ambitions for future innovative energy projects. They plan to add 5 MW of solar PV capacity on parking garages, expand electricity service to the nearby school, police stations, and shopping centers, as well as add an on-site sewage treatment plant to convert sewage to grey water for use in the cooling towers. The plant would save 300,000 gallons of potable water daily. Furthermore, onsite sewage treatment would allow for use of methane as a source of power for the CHP plant. Finally, project representatives want to add regenerative drives to generate electricity from the 200 elevators in the complex. However, Co-op City has struggled to finance these investments. Project representatives attribute this lack of financing in part to various regulatory challenges that have significantly eroded the economics of the microgrid. Still, representatives are hopeful that with the right financing, Co-op City has sufficient scale, independence, self-governance, and community motivation to become an urban laboratory for integrating smart grid technology into affordable housing initiatives. One representative stated:

"You can't find a better place for an incubator of technologies, because if it works, you can do it right away!"

5.3.2 Microgrid Characteristics

a. **Microgrid Classification:** Campus/community microgrid
b. **Location:** The Bronx, New York City, New York
c. **Ownership Model:** Privately owned and operated
d. **Project Development Roles:**
    i. Owner/operator: RiverBay Corporation on behalf of Marion Scott Real Estate, Inc. (represented by Co-op City)[15]
    ii. Developer: Co-op City

[15] RiverBay is responsible for all financial transactions associated with fuel and electricity purchases, and the company has its own staff for operating and maintaining the CHP.

e. Role of the Local Community:

As a community-owned organization, the co-op represents the interests of the local community of electricity consumers. RiverBay Corporation manages the microgrid and represents the needs of the community. RiverBay actively works to lower energy and maintenance costs so savings are passed directly to tenants. A project representative articulated the community benefits in this way:

"[Co-op City managers] are not entrepreneurial fat cats. The savings you have here actually promote the affordability of living for 50,000 people. In this type of situation, [microgrids are] much more powerful as a policy argument…because you are actually fusing the use of renewables, energy efficiency and cogeneration with affordable housing, which is a priority of the city."

Apart from the high-rise tenants, the local community also benefits from space conditioning for the schools and shopping centers that utilize district heating from the CHP. Finally, the community witnessed the value of Co-op City's reliability during Hurricane Sandy, when many other areas in New York City boroughs were without power, yet energy services were uninterrupted on campus.

f. Key Dates and Milestones:

i. 1960s: District heating and cooling system was installed

ii. 2007: Secured financing for installation of the CHP plant

5.3.3 Technical Components

a. System Characteristics:

i. DG: Gas and steam turbines for CHP, additional thermal energy demand met by large gas boilers

ii. Customers: 50,000 inhabitants and businesses on 330 acres

- 15,372 apartment units
- 35 high-rise buildings
- 3 shopping centers
- 6 schools (thermal load only, no electricity)

iii. Load and End Use: 25 MW electric load, consisting primarily of residential users in high-rise buildings

b. Generation Capacity:

i. Total capacity: Approximately 40 MW

ii. Gas turbines: Two 12.5 MW turbines

iii. Steam turbines: One 15 MW turbine

c. Physical Characteristics:

i. Number of buildings: 44 total buildings

ii. Number of metered points: 4 main meters to the complex; tenants are not individually metered

iii. Use of public rights-of-way: Not applicable—power is distributed using existing infrastructure between buildings

5.3.4 Operation

a. Grid Interconnection:

i. The microgrid is grid-connected, which allows the microgrid to engage in energy transactions with the macrogrid. Energy purchased from the macrogrid can enhance reliability and operational flexibility. Energy sold to the macrogrid is compensated at the Locational Marginal Price, and the microgrid has the opportunity to create further value through participation in Con Edison's distribution-level DR programs.

ii. Impact on utility operation and economics: As thermal load is used to serve cooling demand, the microgrid provides a source of electricity generation for the distribution system during summer peaks. The utility earns revenue from standby charges for the cost of providing standby service to Co-op City. The microgrid sells excess electricity to Con Edison through the Buy-Back tariff (SC 11). Project representatives support grid interconnection and acknowledge the societal benefits of working together with the macrogrid:

"The state is promoting the interaction between microgrids and the primary grid. The reason really isn't for the microgrid itself, but rather what the microgrid can do for the outside grid (the macrogrid). It is recognized that if you have a microgrid you won't have as many regulatory barriers to introduction of smart grid technology—interval pricing, renewables, electric storage, thermal storage. So all of that will be easier to implement within a microgrid because the microgrid will be self-governing."

b. Dynamic Load Capability:

Not applicable; the use of four master meters for the entire complex limits the ability to use smart meters or individual DR.

c. Islanding Mode:

i. Transfer time, duration, protocols: Unknown

ii. History of successful attempts: The complex successfully islanded during Hurricane Sandy throughout local power outages using Siemens' standard SCADA-based microgrid controls platform. The electrical and thermal infrastructure was protected from the storm because it is underground.

5.3.5 Permissions and Regulatory Matters

In 2012, under technical bulletin 217 (TB 217), the New York Independent System Operator (NYISO) clarified that load served with base-load generation is not eligible to participate in the NYISO's Special

Case Resource (SCR) program.[16] From NYISO's perspective, it issued this technical bulletin to eliminate the double-counting of cogeneration facilities (under both SCR curtailment and NYISO capacity obligation). According to Co-op City representatives, this eliminated an estimated $1 million in annual revenue from the project. The NYISO is currently developing market rules that will allow behind-the-meter generation in excess of host load to sell capacity into the wholesale market. These rules could enable Co-op City to capture future revenue in the wholesale capacity market.

On the other hand, Co-op City is eligible to enroll the cogeneration capacity in two distribution-level demand response programs offered by Con Edison in its service territory. These programs are the Distribution Load Relief Program (DLRP) which is focused on demand response during contingency periods and the Commercial System Relief Program (CSRP) which focuses on Demand Response to shave system peaks.[17]

Project representatives argue for regulatory reform to allow the co-op to capture value from adding DER to the microgrid. Solar PV was offered as an example. The co-op would like to install 5 MW of PV at the site; however, since the solar would generate at off-peak times for the co-op (the peak is usually 7 p.m. to 9 p.m. within the complex), the co-op would need to sell most of the electricity generated. It would do so at the wholesale rate rather than the higher retail rate because the state's net metering rules specify a PV project cap of 2 MW for net metering eligibility.[18] While the installation of PV would reduce fuel costs and emissions, project developers are primarily seeking lower electricity costs for their tenants. Furthermore, solar PV would not reduce the peak demand of the facility, since solar cannot provide firm capacity due to intermittent solar irradiance and would therefore not reduce Contract Demand.[19] Finally, at the time of interviews with project representatives, Co-op City's master meters were ineligible for the New York State Energy Research and Development Authority (NYSERDA) residential/commercial solar PV incentive programs, because 200kW was the maximum load for any meter in the program.[20]

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[16] SCRs are a capacity market product, and are required to reduce demand upon direction from the NYISO. The logic behind this rule is that a reduction of demand that is being served by base-loaded DG does not reduce system load at the time of a resource adequacy event and therefore has no reliability benefit to the system. Behind-the-meter generators that reduce system load can receive payments under the SCR curtailment program. However, loads may not avoid a capacity obligation with a baseload generator and receive a capacity payment for the same megawatts of capacity. For more information on TB 217, SCR, and capacity markets see the following sources:
www.nyiso.com/public/webdocs/markets_operations/committees/bic_prlwg/meeting_materials/2012-03-29/TB_217_Comments_-_Con_Ed_LIPA_NYPA.pdf
www.nyiso.com/public/webdocs/markets_operations/documents/Manuals_and_Guides/Manuals/Operations/icap_mnl.pdf
www.nyiso.com/public/webdocs/markets_operations/committees/bic_miwg/meeting_materials/2015-01-29/agenda%207%20BTMG_MIWG_012915_final.pdf

[17] More information available at: www.coned.com/energyefficiency/demand_response.asp. See also tariff leaves 254-267 (for CSRP) and 277-291.1 (for DLRP) at www.coned.com/documents/elecPSC10/GR24.pdf.

[18] Net metering rules available at: http://codes.lp.findlaw.com/nycode/PBS/4/66-j.

[19] The Standby Service tariff allows for reduction in Contract Demand through a customer's implementation of energy efficiency measures, installation of load-limiting equipment, or removal of electricity-consuming equipment.

[20] In April 2015, NYSERDA released a large PV incentive program called NY Sun. These recent changes would presumably render Co-op City eligible for NY Sun incentives, though project representatives have not confirmed eligibility as of this writing. NY Sun program details are available at: http://ny-sun.ny.gov/Get-Solar/Commercial-and-Industrial.

In order to become a self-generator, the campus needed permission from the New York Public Service Commission (PSC) for the grid interconnection; Con Edison prepared the interconnection agreements and the PSC approved them. The project incurs regulation-defined standby service and interconnection charges as part of the interconnection approval. These charges are paid to the utility to ensure that 1) tenants have guaranteed access to electricity even if the microgrid generation assets are offline and 2) to support interconnection infrastructure depreciation, operation, and maintenance. These rates have been implemented by the utility in accordance with PSC guidelines, which set forth a combination of Contract Demand (fixed) charges and daily, as-used demand (variable) charges to recover total costs of delivery service to standby customers.[21] Con Edison representatives reported that the utility is actively seeking ways to minimize interconnection costs for DG project developers.[22]

The co-op seeks regulatory reform to change the way these charges are calculated, particularly concerning the Contract Demand charges based on the total facility demand. From Co-op City's perspective, requiring the microgrid to pay the full costs of standby service and macrogrid interconnection infrastructure provided by the utility establishes the wrong incentives for DG customers. The co-op argues that costs should be shared more equitably, because both the utility and the microgrid receive benefits from one another. For example, the co-op provides available peak electrical capacity during summer heat waves, which is compensated through incentive payments from Con Edison's DR program. Even with this added compensation, project representatives do not believe the cost of the standby charges justify the benefits of grid connection, as they claim it would be more cost-effective for Co-op City to generate all of its own electricity and disconnect completely from the grid. Co-op City representatives recognize complete disconnection would be detrimental to the grid overall, which is why they advocate for reform of the standby rates. Project representatives offered the following viewpoints:

"The standby cost point of view is, why should it be a one way street for the microgrid to pay the utility company when the utility is also using the microgrid [for power supply]? Where is the reciprocity there?"

"Without relief from standby charges, a convincing economic argument could be made for severing [Co-op City's] grid connection. With almost 100 percent system redundancy, the complex would save about $2 million a year, and the macrogrid would lose the [benefits] that Co-op City provides…"

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[21] The guidelines are in place to recover the utility's costs of delivering power and energy used to replace and/or supplement the power and energy ordinarily supplied by a utility customer's on-site generating facility. According to Case 99-E-1470 – Proceeding on Motion of the Commission as to the Reasonableness of the Rates, Terms and Conditions for the Provision of Electric Standby Service, Opinion and Order Approving Guidelines for the Design of Standby Service Rates (issued Oct. 26, 2001): "The utilities would use the contract demand charge, to the extent possible, to recover the costs of 'local' facilities, those that are closer to a customer's site and were put in place mostly to serve the individual customer. The Guidelines provide that these fixed, contract demand charges should apply to the customer's maximum annual demand…. Delivery system facilities located further from customer sites are considered 'shared' facilities, and… ought to be recovered in a manner that recognizes the customers' overall coincidence of the service classification, through as-used demand charges."

[22] One example offered by Con Edison representatives is the utility's offset tariff, which allows campus-style DG systems to connect generation resources ahead of the meter instead of behind the meter. This reduces project development costs by eliminating the need for the project developer to build distribution infrastructure, which is typically expensive in dense urban environments.

Of course, there is a cost associated with providing backup power to Co-op City in the event of an outage, and Co-op City residents do value enhanced reliability of electricity supply from the macrogrid. Furthermore, regulated utilities are obligated to serve customers as the provider of last resort. However, project representatives take issue with the price of the reliability enhancement provided by Con Edison. The appropriate price for standby services relates to a common question associated with microgrid development: how do we value reliability and the risk borne by the provider of last resort? This debate is already underway and will continue as part of the REV regulatory reform process in New York State.

Con Edison representatives recognize the viewpoints of Co-op City representatives and state that they are committed to engaging owners of DG to determine the fair price of services exchanged between microgrids and macrogrids. They recognize that a "distribution-level market" that monetizes the value of DG's capacity as separate from standby charges (designed to recover the cost of the delivery service and infrastructure) would be ideal, yet requires significant regulatory reform in the long term. In the meantime, Con Edison has implemented changes that give customers the opportunity to reduce fixed charges immediately by embedding a performance credit in the Contract Demand charge, allowing proactive customers to reduce the charge.[23] This performance-based credit provides an incentive for their customers to operate DG reliably—a key performance requirement for the utility to realize deferred investment, planning and operational value from DER.

With respect to rate design, Con Edison is obligated to maintain revenue neutrality in its rates. However, higher penetration of DER complicates this calculus. For a customer that owns DG, the costs of building DG and buying/selling power from Con Edison may turn out to be higher than only buying power from Con Edison without DG. In this case, from Con Edison's perspective, they see lower consumption and no corresponding reduction in infrastructure costs. In turn, these costs must be recovered from other customers on the electricity grid. From Con Edison's perspective, this amounts to an unfair cross-subsidization from those who receive 100% of their energy from the utility's distribution system to self-generators. Con Edison representatives believe effective regulatory reform must consider these issues concerning cross-subsidization and the socialized costs of the power delivery infrastructure.

5.3.6 Financial Model

a. **Total Project Cost:**

   Original costs include a $68 million cogeneration plant. Ongoing costs include fuel, internal operations costs, maintenance fees, and standby fees to Con Edison. Co-op City purchases natural gas for the CHP on interruptible rates, so in extreme cases, they are required to run the CHP on oil, which can be very expensive (up to $250,000 per day). In these cases when their gas service is interrupted, it is more cost-effective for the co-op to purchase as much electricity as possible by taking Con Edison's standby electric service.

b. **Project Financing:**

   All tenants pay for the electricity and maintenance services as part of a monthly bundled charge. Because it is a cooperative, RiverBay does not profit from the maintenance charges; charges are

[23] Con Edison's proposed tariff modification in 2015 allows customers to earn Contract Demand credit for consistent generator performance during system peak periods from June to September. If a DG project is able to consistently generate a minimum output during peak periods over two consecutive summers, Con Edison will provide a Contract Demand credit for that minimum output delivered by the project.

simply passed through to the tenants at cost. RiverBay pays for natural gas and oil for cogeneration to satisfy all thermal and electric loads on the campus, often selling excess electric generation to the macrogrid and occasionally purchasing from the macrogrid.

The initial project was supported by the U.S. Department of Housing and Urban Development (HUD) for financing and insurance. All improvements have since been paid for by the co-op.

c. **Cost Recovery:**

Depending on the year, the CHP plant satisfies 90% to 95% of the communities' electric needs. It sells power back to Con Edison at the wholesale LMP via the Buy-Back Tariff (SC-11).[24] In total, Co-op City is selling approximately $1 million dollars a year back into the power grid, essentially as an independent power producer (IPP). The complex receives an average $62 per MWh for electricity supplied to the grid.

Co-op City exported 10,700 MWh in 2013, most of it in December during the unprecedented polar vortex. At the time, Co-op City was running CHP to serve onsite thermal loads and selling abundant excess electricity to the utility. In the summer, space cooling for co-op tenants is provided by chilled water from the CHP absorption chiller. Therefore, the co-op does not have a summer peak, and is able to provide electricity to the macrogrid during Con Edison's peak demand period. During a heat wave in July 2013, Co-op City sold 1,608 MWh, for which it was paid $74.37 per MWh based on the ISO LMP. During this time period, the CHP plant received payments for its energy export valued at the prevailing market price, and payments for DR events called by Con Edison with values set by the corresponding tariffs.[25]

From Co-op City's perspective, utility delivery rates, including standby and interconnection charges, have been significantly detrimental to the overall project economics. Although delivery rates are only one of many factors that impact microgrid project economics,[26] this factor is particularly salient in this case, as Co-op City representatives perceive the standby charges as unfair.

The charges for standby service consist of both a fixed charge and a variable charge. The fixed charge, known as the Contract Demand charge, is designed to recover the costs of the local distribution facilities required to serve the customer's full load.[27] The Contract Demand charge is not dependent on the DG customer's variable usage. The variable charge, known as the As-Used Daily Demand charge, is designed to recover the costs of the T&D facilities in place to supply the

[24] Information on this tariff is available at: www.coned.com/documents/elecPSC10/SCs.pdf#nameddest=sc11.
[25] The value of Demand Response in July 2013 was $10 per kW for participation in the Commercial System Relief Program (CSRP) and $3 per kW for participation in Distribution Load Relief Program (DLRP). For example, a pledged level of 6 MW would result in a reservation payment of $60,000 and $18,000 respectively. It would also yield over $75,000 in CSRP energy payments if the customer performed adequately for all events in July of 2013.
[26] Other such factors that greatly affect microgrid project economics in New York City include: cost of space to host generation assets; escalating construction, labor, and materials costs; tax rates and eligibility for tax credits; and volatility of commodity prices (natural gas in this case).
[27] Examples of local distribution facilities might include: service cable to the customer's premises, network transformers to the customer's service, secondary and primary feeder cables.

customer's demand coincident with overall demand on those facilities. The As-Used charges depend on the DG customer's maximum demand drawn from the utility system each day.[28]

Contract Demand charges apply even when the microgrid produces enough generation for its tenants. The logic for this is, from the utility's perspective, Con Edison has an obligation to serve the entire load of Co-op City in the event the CHP plant goes offline. The Contract Demand charge must consider the total facility load regardless of the energy that is actually purchased by the co-op. In other words, through the combination of the Contract Demand and As-Used Daily Demand charges, Co-op City is paying for Con Edison to reserve the standby capacity over its delivery infrastructure to back up the CHP generator when it is needed.

Because Co-op City buys only 5% to 10% of its power from Con Edison in a given year, the average cost per megawatt-hour purchased by Co-op City (including both variable commodity costs as well as delivery components of the electric bill) is substantially higher than the calculated cost per MWh paid by typical master-metered apartment buildings without onsite generation under SC 8 rates.[29] The per-MWh rate is higher with the CHP plant because the generating facility disproportionately reduces Co-op City's volumetric energy purchases (measured in kWh) in comparison to the total demand (measured in kW), which is the basis for the delivery charges from Con Edison.

Project representatives consider the standby charges to be unfair and would prefer to change the way standby charges are calculated. This issue is discussed in greater detail previously in Section 5.3.5.

d. Customer Types:

i. Primary customers: Co-op City residential tenants

ii. Other customers: Schools (thermal loads only) and commercial facilities

e. Services Provided to Participating Customers and Corresponding Pricing Models:

The microgrid provides thermal (heating and cooling) services and electricity to the tenants of Co-op City. All operating costs, including the costs to operate the CHP, are paid by tenants as a maintenance charge, which is approximately $200 per unit per month. Because there are only four main meters for the complex, RiverBay is unable to separately charge tenants for these services. Consequently, most tenants think of energy as free, or at least something for which they have no control over price.

Reliability is a service customers recognize. Most tenants at Co-op City understand that their power is generated on site, and they value the reliability of service after the negative experience of the 2003 blackout (before the microgrid) and the potential for increased reliability (after the installation of the microgrid).

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[28] Examples of the facilities further upstream from the DG customer might include: transmission cables and substations. Distribution-level area substations make up both 'local' and 'upstream' facilities.

[29] See Leaves 431-437 at: www.coned.com/documents/elecPSC10/SCs.pdf. Delivery charges for the SC 8 service class are primarily based on kW demand for both standard rates (SC8 Rates I, II, and III), and standby rates (SC8 Rates IV and V).

5.3.7 Microgrid Benefits

a. **Energy Benefits:** The CHP plant provides electricity, heating, and cooling onsite to the residents and electricity externally to the macrogrid.

b. **Utility Benefits:** Emergency preparedness and ability to provide islanded electricity; formerly provided DR in wholesale markets

c. **Environmental Benefits:** Because the natural gas-fired CHP plant follows thermal load, it has a lower greenhouse gas emissions factor than the macrogrid. There are no local complaints about emissions or noise.

d. **Cost-Benefit Analysis (CBA):** None available. In the case of Co-op City, the generation serves both the thermal and electric load, which complicates decisions about the addition of DER to the microgrid. For example, implementation of certain EE measures may reduce electric load but would require Co-op City to make up deficits in hot or chilled water supply by using backup boilers and chillers. At the moment, RiverBay does not know enough about the interaction of thermal and electricity demand to accurately calculate cost-effectiveness.

5.3.8 Lessons Learned

a. **Success Factors:**

By owning and operating the project on behalf of the tenants, the co-op is able to provide a central decision-making point, where incentives (lower costs) are aligned with benefits to the energy consumers (tenants). And because the project is owned and operated by the same community that receives the benefits (the co-op and its tenants), decisions can be made in the best interests of the community. Self-governance, self-ownership, and independent control of the facility allowed Co-op City to experiment with CHP and will allow the organization to continue innovating into the future.

Because cogeneration, or CHP, provides cooling to the complex, the plant generates excess electricity during summer peak periods which can be sold back to the grid and earn incentive payments from Con Edison's distribution-level demand response programs.

Initial support from HUD helped finance the upfront construction costs of the project. Additionally, the existing electrical infrastructure, including the four main meters and underground conduits, simplified design and installation due to minimal regulatory issues related to right-of-way.

Notably, the project successfully islanded during Hurricane Sandy, which increased support for the project among residents of the campus and the surrounding community.

b. **Challenges and Recommendations:**

The CHP plant controls and operations could be designed to maximize economic return rather than always following the thermal demand, as it operates now. The project was originally designed to serve thermal loads first, but project economics may be improved if controls are designed to optimize cost-effectiveness and revenue. The co-op would like to pursue additional energy innovation projects but must consider economic performance of the project first and foremost.

Co-op representatives believe that reform of standby charges and incentive program eligibility would increase their options for energy project innovation. RiverBay hopes to use the REV proceedings as a platform to voice its concerns with regulatory issues such as standby charges, interconnection fees, and DR program participation.[30]

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[30]"I.D. No. PSC-36-14-0008-P Case 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision," Real Estate Board of New York, October 27, 2014. Available at: http://sallan.org/pdf-docs/REBNY_REV_Comment.pdf.

5.4 Case Study 4: Hamden Plaza Microgrid

The Hamden Plaza microgrid is under development to fulfill the dual goals of disaster resilience and customer cost savings. Current constituents include a shopping mall, grocery store, and ice rink, as well as a high school designated as an emergency shelter (pictured in Figure 9). While the Town of Hamden has endorsed the project and is a partner in the project's development, the microgrid is privately owned and operated and seeks competitive economic returns for investors.

Although this project is not yet complete, the case provides great insight into the opportunities and risks that third-party developers perceive when considering microgrid development. Furthermore, the case demonstrates how the regulatory environment, utility attitude toward customer-owned generation, physical density of buildings, and community attitude toward energy independence are key environmental factors for successful microgrid development.

Figure 9. Hamden High School

Source: Hamden High School[31]

5.4.1 Background and Project Objectives

The community of Hamden has supported the microgrid project from its inception, as residents have experienced many extended outages as a result of major storms in recent years. Additionally, both residential and commercial utility customers have been subject to consistently rising costs in the Hamden area—even as energy consumption remains relatively stable.

The town of Hamden makes decisions relatively autonomously. Hamden has an independent energy commission able to pursue energy initiatives on behalf of its residents. The extended outages experienced by its residents, combined with a high awareness of climate change and desire for low environmental impact among community members, led the Hamden energy commission to consider microgrids as a path to low-carbon energy independence. The project developer said of the Hamden town government:

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[31] Hamden High Class of 1973. Web. Available at: www.hhs1973.com/scrapbook.htm

"The energy commissions within each town clearly see the need to become more resilient from a reliability perspective and also an economic perspective. To have the ability to hedge and be less dependent upon the ups and downs of prices passed through by the utilities. There is a long-term strategy in Hamden to become much more self-sufficient and less dependent on regional and national resources for energy."

The project developer, Green Energy Corporation, is seeking to facilitate the shift away from backup generators that run less than 1% of the year towards solar, storage, and building controls to serve loads year-round and during emergencies.

The physical structure of the Hamden community made it a viable candidate for microgrid development, as much of the urban center is dense commercial development in large blocks. For example, Hamden Plaza is owned by a single property owner with 31 businesses; it is 100% occupied and is directly adjacent to the high school and the town-owned ice arena. As such, developers did not encounter regulatory issues with rights-of-way. The intention is to use the high school and ice rink as emergency shelters during major outages.

Currently, the microgrid plan only incorporates the high school, Plaza common areas, grocery/pharmacy store, and ice arena. After Phase 1, the developers plan to add many of the 31 other businesses that are located in the Plaza. The initial generation and storage resources are sized for these four off-takers, but the microgrid is designed to expand to add other customers and additional generation resources.

5.4.2 Microgrid Characteristics

a. **Microgrid Classification:** Independent community microgrid

b. **Location:** Hamden, Connecticut

c. **Ownership Model:** Third-party ownership by special-purpose entity, Hamden Microgrids LLC

d. **Project Development Roles:**

   i. Owner: Hamden Microgrids LLC

   ii. Developer: Green Energy Corporation

   iii. Community: Town of Hamden, represented by Sleeping Giant Energy Corporation

   iv. Vendors:

      - Schneider Electric
      - A/Z Corporation

e. **Role of the Local Community:**

   Community support for the project is discussed above in Section 5.4.1.

   The community places a strong emphasis on affordable, reliable, and environmentally friendly electricity supply. In light of recent utility rate increases attributed to volatile fossil fuel prices and a series of outage events in the community, the town government decided to pursue a microgrid initiative. The town supports the development of this project through its representative, Sleeping Giant Energy Corporation. Founded by several chairmen of the Hamden Energy Use and Climate Change Commission, the corporation facilitates development of microgrids in Hamden by issuing a series of Requests for Proposals to third-party microgrid service providers. Project developer Green Energy Corp. secured necessary permissions for the project from the town government and community leadership. For these approvals, Hamden acted more quickly than the local utility, which is still deciding on a final interconnection agreement.

f. **Key Dates and Milestones:**

- Project is currently in the development phase
- July 2015: Anticipated completion of power purchase agreement (PPA) contracts and interconnection
- November 2015: Anticipated commissioning

5.4.3 Technical Components

a. **System Characteristics:** According to project representatives, Hamden uses a "portfolio resource approach to actively manage" generation assets for high utilization, improved economics, reliability, and emissions reduction.

   i. DG: Natural gas CHP, fuel cells, solar PV, battery storage, and backup diesel generators

   ii. Customers: 34 metering points, including a high school, grocery store, ice arena, and other commercial businesses

   iii. Load and End Use: Mix of residential and commercial end users; the load profile is an extended-day, flat-peak typical of commercial building operations

b. **Generation Capacity:**

   i. Total capacity of 1.68 MW

   ii. Diesel generator: 120 kW

   iii. Natural gas CHP: 700 kW

   iv. Fuel cell: 400 kW

   v. Solar PV: 300 kW

   vi. Li-ion energy storage: 160 kW (960 kWh duration)

c. **Physical Characteristics:**

   i. Number of buildings: 7 buildings

   ii. Number of metered points: 34 metering points

   iii. Use of public rights-of-way: Not applicable

5.4.4 Operation

a. **Grid Interconnection:**

   i. The microgrid will be grid-connected but serves primarily onsite loads. See Section 5.4.5 for an in-depth discussion of grid connectivity issues.

ii. Because the microgrid is a consumer of macrogrid energy (14% of the site's annual use), the interconnection is greatly simplified. A reverse-power trip at the POCC alleviates most of the utility's safety concerns.

iii. Impact on utility operation and economics: Because the microgrid intends to generate approximately 86% of the site's annual use, the utility will earn significantly less revenue from the sale of electricity to these facilities.

iv. Interaction with wholesale markets: None planned at this time

b. Dynamic Load Capabilities:

During islanded operations, the microgrid uses dispatchable load modulation, DR, and load prioritization.

c. Islanding Mode:

i. Transfer time, duration, and protocols:

- Transfer time: Less than 1 second, automatic when loss of the grid
- Duration: Indefinite
- Protocol: GreenBus® via AMQP, DNP3, Modbus TCP/IP

ii. History of successful attempts:

- System is not yet operational, so there is no history for this site.
- The GreenBus® technology is currently being proven at a 1 MW microgrid at North Carolina State University's Future Renewable Electric Energy Delivery Management (FREEDM) Systems Center.[32]

5.4.5 Permissions and Regulatory Matters

The project is currently in the middle of the interconnection process with the utility, so actual interconnection costs/requirements and potential standby fees are unknown. The developer is concerned that the utility has the advantage in this process and fears that the utility may leverage high interconnection costs to discourage the project. If these costs are high, the developer believes they will have no recourse or appeal process to pursue.

Connecticut is one of the few states that allows neighbors to provide power to other neighbors across the street on a case-by-case basis without being qualified as a utility. Applicability of this law is limited to municipalities and state agencies and may not apply in this case. Regardless, the business model for this microgrid relies on interconnection to the macrogrid.

The microgrid customers will still use energy from the macrogrid, and they will still receive a bill from the utility (electric and gas) as well as a separate bill from the microgrid special-purpose entity (SPE). The project developers believe it would be best for the customer if all of the bills could be managed through the SPE, and the customer would receive only one bill. However, utilities are currently unable to accommodate an intermediate entity that buys power from them and re-sells it to the end user.

[32] More information from Green Energy Corporation on the FREEDM center may be found at: www.greenenergycorp.com/freedm-1-mva-green-energy-hub-microgrid/.

It is the view of the Hamden Plaza project developers that regulators should work to align the interests of utilities and private microgrid developers. Pricing the services provided between these two entities is a key element of aligning these interests. The project developers believe that they should not incur fixed charges for macrogrid infrastructure development in the form of a net metering surcharge or departing load charge. According to the developer, these mandatory charges would significantly undermine the economics of the microgrid market, and further encourage developers to completely island from the macrogrid, which is beneficial to neither party. The project developer stated:

"Whether the regulator introduces a new policy is immaterial, as long as the regulator is not requiring mandatory payment for the infrastructure costs no matter whether the customer uses the grid or not."

From the utilities' perspective, if utilities have the regulatory obligation to serve microgrid customers in the event that the microgrid is offline, there must be a means for the utility to recover the cost for meeting this regulatory mandate (see the Co-op City case for a deeper discussion of these issues). Realistically, regulators will need to reconcile these viewpoints and price grid interconnection services fairly and transparently for both parties.

5.4.6 Financial Model

a. **Total Project Cost:** $7.7 million to install the project, to date (interconnection costs unknown); ongoing operating costs

b. **Project Financing:**

   The microgrid is privately owned and operated by a SPE with a PPA to serve four customers. The rates offered by the microgrid are lower than those offered by the local utility (United Illuminating). The project is expected to earn its off-takers an unlevered rate of return of 10% over the life of the PPA.

   Approximately 86% of the microgrid customer load served will come from generation assets owned by the developer, and 14% will come from the utility. This split is considered a "sweet spot" for economical operations, with the utility primarily serving shoulder operations in the late morning and early evening. The developer plans to continue to expand the service territory of the microgrid to other businesses within the strip mall, simultaneously adding capacity to serve larger loads and acquiring more customers.

   Three elements must be in place for financiers to commit to investment in a private microgrid development such as Hamden Plaza. The first is a customer—also known as a long-term, credit-worthy off-taker that has signed a PPA. Equally important is an interconnection agreement with the utility, so the microgrid and macrogrid can both benefit from energy transfers. Finally, construction of the generation and distribution resources must be permitted and in compliance with safety and environmental building codes.

   There is significant upfront cost associated with achieving bankability for a third-party microgrid project. Representatives interviewed for this case study reported approximately $200,000 to $400,000 dollars in feasibility expenses, prior to securing the interconnection agreement with the utility.

c. Cost Recovery:

The electricity from the microgrid will be sold to the four major off-takers at a rate still under negotiation, but currently estimated at $0.13 per kilowatt-hour. This would be 4% to 8% cheaper than current utility rates, and would also be subject to a lower price escalation (in the range of 2%-2.5%). The project may also benefit from other incentives for the use of renewable fuels (such as the ITC and/or RECs), but the specifics are unknown.

The project is expected to earn an internal rate of return of 10% on cash and tax equity investments.

d. Customer Types:

i. Primary customers:

- *Normal and islanded operation:* Hamden Plaza, high school, ice rink, grocery/pharmacy store

ii. Other customers: To be added as part of Phase 2

e. Services Provided to Participating Customers and Corresponding Pricing Models:

The microgrid will provide electricity to the four main district customers. The CHP also provides thermal benefits to some off-takers. The pricing for these services is set and contracted through the PPAs with the off-takers.

The high school and ice rink will also receive the benefits of islanded electricity; however, the pricing models for these services are unknown.

5.4.7 Microgrid Benefits

a. Energy Benefits:

- Electricity and thermal services are sold to public and private off-takers at rates 4% to 8% less than retail electricity rates
- Energy is provided to the high school, ice rink, grocery/pharmacy store, and Hamden Plaza during islanded operation

b. Utility Benefits:

- Emergency preparedness
- Provides a hedge to volatile retail electricity prices
- Ability to expand loads to provide better project economics
- Reduced line congestion and line losses

c. Environmental Benefits:

- Low local emissions from use of natural gas CHP
- Zero emissions from renewable energy

d. Cost-Benefit Analysis (CBA):

Developers conducted a cost and benefit analysis examining two scenarios. The first was a backup generator to serve the high school in emergencies. This option had lower upfront costs yet a much higher cost per kilowatt-hour as the generator would be rarely utilized. ($3.3 million upfront; $0.95 per kWh when used over a 20-year lifetime). The microgrid option offered the ability to serve multiple loads continuously, though it required much higher upfront cost ($7.7 million); however, by promoting higher resource utilization achieved through "active management" of generation and loads, the 20-year lifetime cost of the electricity was only $0.115 cents per kWh. Given the electricity rates in the Hamden area, the microgrid provided a more economical option. Furthermore, the developers expect the cost per kilowatt-hour will continue to decline as more resources and customers are added to the microgrid.

5.4.8 Lessons Learned

a. Success Factors:

Local support of the project helped to secure multiple, diverse off-takers (including a shopping mall, high school, and ice rink) with minimal acquisition costs. Project profitability is secured through long-term revenue contracts, aligned with savings to the off-takers, which has helped developers secure financiers willing to pay upfront development costs. Using GreenBus integration and control software[33] will help to manage a variety of generation sources and load profiles to optimize system operation by actively managing generation, load, and transactions with the macrogrid. Developers and financiers were willing to take risks on upfront development and high capital costs with the expectation of realizing long-term returns.

By connecting to and properly managing a diverse set of loads and using highly reliable individual generators, the microgrid can maintain high utilization, which improves project economics and reliability. Hamden Plaza project developers do not believe that greater absolute megawatt capacity equates to higher reliability. A diversity of highly reliable individual resources, actively managed and monitored for lower capacity but higher utilization can be more reliable than a grid designed for capacity only. The developers believe that active management is key for true reliability, and minimizing the cost per kilowatt-hour is the economic justification for this approach. By designing to the energy rather than capacity needs of the customers, Green Energy Corp. has every incentive to encourage energy efficiency as they directly capture incremental benefits of on-peak and off-peak savings.

"When you are building a microgrid, you first need to pay attention to energy. You need to match your generation to your load, or sometimes your load to your generation. It needs to be looked at from an energy content perspective. Our traditional approach in the industry is to design around capacity, which ends up resulting in low asset utilization."

[33] Green Energy Corp's GreenBus microgrid solution is a cloud-based software interoperability platform, provided through an open source software subscription model. The software enables the adoption of smart grid technologies and integration with legacy power and communications infrastructure. More information at: www.greenenergycorp.com/solutions/green-bus-software-platform.

Local support of the project helped speed development because of key project drivers, including frequent power outages in the community, high and volatile electricity prices, community support for lowering emissions, and desire for resiliency.

The project may benefit from other incentives for the use of renewable fuels (such as the ITC and/or RECs), but the specifics are not finalized.

b. Challenges and Recommendations:

Upfront costs and risks can be barriers to development—minimizing these can help developers more easily execute contracts and secure financing. The developer takes on all the upfront risk in developing the project until it finds a financier to purchase the project and agree to reimburse development costs. The Hamden Plaza developer is working on creating a development fund with a few financiers that would reduce the risk of recouping upfront investment, which would improve efficiency of the development process and reduce costs.

The interconnection process, requirements, and costs are a major unknown risk in the development process. Because this microgrid is third-party owned and purchases some energy from the macrogrid, customers will inconveniently receive two electric service bills. The developers are also skeptical that they will receive fair treatment from the utility during the interconnections process, which they believe to be opaque. The developer volunteered the following perspective:

"The [interconnection agreement] process is a black box. The next thing I expect to see is a bill from United Illuminating saying 'pay us the $55,000 spent on the interconnection agreement and oh, by the way, it didn't pass.' That will be my next touch point with them, and that is a very uncomfortable position. I have millions of dollars sitting on the sideline waiting for that project to kickoff, and it could be somebody that I don't know inside United Illuminating [who] just doesn't want to see the microgrid built, and there is no recourse."

Expedited development and execution of the PPAs would minimize the risks and costs to the project by minimizing changes to project economics. Also, while multiple customers (off-takers) improve economics and operations, they add complexity and time to the contract development process.

Finally, the ultimate owner of the project will be a group of financiers (through the SPE) who are unfamiliar with the operations of a microgrid. Thus, the project developer intends to contract with a system operator that is familiar with the microgrid and will be sure to include adequate budgeting for operations and maintenance expenses in the contract.

5.4.9 Contacts and Sources

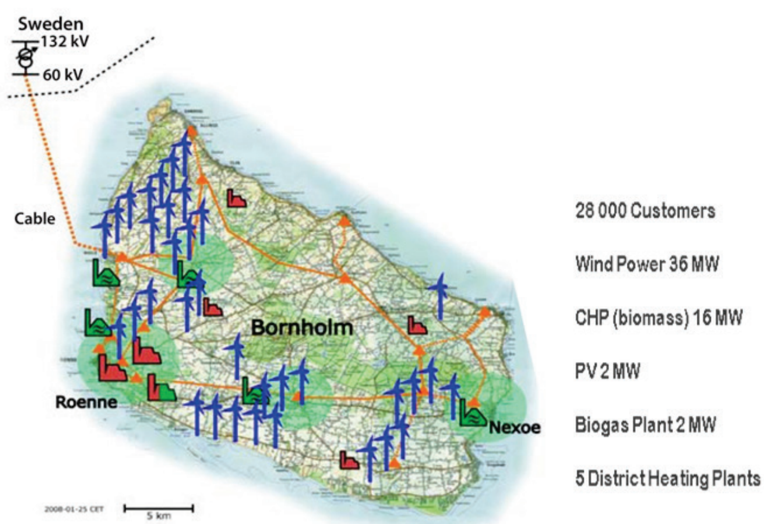
"Hamden Microgrid - Interview with Steve Pullins." Telephone interview. October 23, 2014.

5.5 Case Study 5: Bright Green Bornholm Island

Bornholm Island hosts the EcoGrid EU project, which is considered to be one of the most advanced smart grid projects in Europe. The Bornholm Island test site (pictured in Figure 10) is both a microgrid and a virtual power producer (VPP).[34] The primary goal of the microgrid is to use near real-time pricing and automated DR to fully accommodate high penetrations of renewable energy. Among other initiatives, the project has a goal of 100% renewable supply by 2025, increasing local wind supply by 60 MW in addition to 30 MW of existing wind capacity. In 2012, the project tested out use of electric vehicle batteries to firm up variable wind power.

Emergency resilience is not a focus of Bright Green Bornholm; instead, the project tests how their portfolio of generation and DR resources reacts to near real-time pricing. With a 55 MW peak load, Bornholm is the largest project considered in this report. Though large, the project still meets the selection criteria and definition of a microgrid detailed in Section 3.3.1. While this project is significantly government funded, it is included in this report to demonstrate the importance of community engagement to accommodate a high penetration of intermittent renewable generation and DR.

Figure 10. The Bornholm Test Site



Source: EcoGrid[35]

5.5.1 Background and Project Objectives

The Danish transmission system operator (TSO) started the EcoGrid EU project to experiment with advanced strategies for integrating high penetrations of wind and solar power into the grid (which is needed to meet Denmark's goal of 100% renewable generation by 2050). The project continued as a R&D venture designed to create a real-time market for ancillary services from a variety of DER, allowing retail-level resources to solve transmission-level grid challenges arising from the volatility of Denmark's

[34] A virtual power producer is an entity that aggregates DG resources.
[35] "The Bornholm Test Site," Web, EcoGrid, 2015. Available at: www.eu-ecogrid.net/ecogrid-eu/the-bornholm-test-site

large-scale wholesale wind power fleet. Although this demonstration project is rarely referred to as a microgrid (and it is not focused on emergency power), it satisfies the DOE's definition of a microgrid, possesses significant DG resources, has islanding capability, and interacts with wholesale power markets.

The project operates with an energy spot market that is 15 minutes ahead. In this market, the price reflects the near real-time load and generation mix of the island's power system. This allows grid operators to experiment with several market participation models to test the effect of price signals on residential (and limited commercial/industrial) energy consumption. In one example, as further described herein, residential participants were recruited to participate in a new market for dynamic pricing in real time where spot prices were set every five minutes. Approximately 500 participants received cues on real-time prices from in-home displays, and manually responded to the changes in prices. 1,100 participants have HAN installed which automatically responds to the changing prices. In total, the island has 1,900 residential DR installations and 20 industrial DR installations.

As the project progresses, it remains to be seen how many customers will maintain their commitment to load management on the island. Initially, there was a surge of interest in participation in real-time markets, yet interest has waned as some customers realized they needed to make incremental lifestyle sacrifices, and the high fixed costs of the utility bill moderate any potential financial savings from these sacrifices. In light of this, EcoGrid has redoubled community engagement efforts as described below.

5.5.2 Microgrid Characteristics

a. **Microgrid Classification:** Hybrid community microgrid

b. **Location:** Bornholm Island, Denmark

c. **Ownership Model:** Combination of utility-owned and third-party owned assets

d. **Project Development Roles:**

   i. Developer: Danish TSO, the government of Denmark, and EcoGrid EU

   ii. Owner: Utility and third-party IPP ownership for generation; private ownership for DR equipment

   iii. Vendors/Other:

      - Siemens
      - IBM
      - Oestkraft
      - The Technical University of Denmark
      - Energinet.dk

e. **Role of the Local Community:**

   While the local community was not involved in the design of the project, the success of the program depends on the participation and active involvement of the community. Initially, there was a surge of interest in participation in real-time markets, yet interest has waned as some customers realize they need to make incremental sacrifices, and the high fixed costs of the utility bill moderate any potential financial savings from these sacrifices.

In light of this, EcoGrid has redoubled its efforts at community engagement to emphasize the environmental and societal benefits of demand-side management rather than the personal financial gains of participants. While the project is still a work in progress, this strategy for community engagement has achieved a positive response within the environmentally-conscious Danish culture, and among the community-oriented residents of the island. A project representative commented:

"We rely on the community responsibility and 'good feeling' argument to encourage participation more than the financial argument, because the financial argument is not really there…So we have decided to focus on the fact that, by participating, the customer does his/her part for enabling renewable energy and securing a reliable power system."

EcoGrid invites island inhabitants to community events with coffee and cake, to educate them about how the microgrid operates and explain the demonstration project. It focuses significant marketing efforts on schools because children have proven to be strong advocates for the project in their households, and teenagers are among the largest energy consumers. Furthermore, EcoGrid offers training to participants by inviting small groups of residents to tour the EcoGrid demonstration home—used to showcase smart grid technologies. The demonstration home is deliberately modeled after an old existing house with typical Danish architecture to be more familiar to everyday residents of the island. The difference is that the demonstration house has a HAN system, advanced metering, smart appliances, and solar PV. According to EcoGrid, these visits have been very effective at motivating community involvement in the project.

To maintain consistent engagement in residential DR initiatives, the project relies on customer education and automated DR technology. This technology allows the customer to remain passive after he or she has opted into the program, rather than requiring the development of new, consistent habits. This technology limits the need for continuous and resource-intensive customer engagement and enhances the reliability of DR resources.

EcoGrid is encouraging installation of solar PV as another method for residential participation in the real-time spot market, especially for those customers not interested in changing habits or making sacrifices on the demand side. As of November 2014, the island had 6.5 MW of solar PV installed, most of which are customer-owned rooftop systems.

Finally, the persistence and optimism of the EcoGrid team in community engagement efforts has contributed to the ongoing success of the project. EcoGrid representatives believe their team has a positive attitude in the face of technical difficulties, which allows them to respond to upset customers and encourage customers to be patient as the technology continues to develop. They also believe the project would be more successful at attracting customers if it had a smaller pool of potential participants, yet the goal of the microgrid is to develop a strategy for widespread engagement of everyday people. An EcoGrid representative stated:

"[EcoGrid's] role in this project is binding people and technology together. We are the link between the technology providers and the customers. We are the translators."

f. Key Dates and Milestones:

- 2010: EU procurement for project funding
- 2011: Project begins—Design phase, recruitment communication activities
    - October 2011: Siemens announces participation in the EcoGrid project, providing load and building management solutions[36]
- 2012: Recruitment, installation of advanced meters and other smart appliances in homes and companies of participants on Bornholm
    - February 2012: Official recruitment kickoff held (goal of 2,000 participating customers)
    - June 2012: 370 customers on Bornholm have signed up to participate[37]
- 2013: Design and recruitment ends, testing begins
    - March 2013: Milestone—more than 1,500 households on Bornholm have been enrolled in the EcoGrid project[38]
    - May 2013: First phase of field test—live real-time pricing[39]
- Spring 2015: Planned demonstration project completion

5.5.3 Technical Components

a. System Characteristics:

i. DG: Diesel generators, oil-fired steam generators, CHP (oil, coal, and wood), wind, solar PV, biogas, electric vehicle battery storage

ii. Customers: Approximately 28,000 customers (metered points) on the island including a mixture of residential, commercial, and small industrial loads

iii. Load and End Use: 55 MW peak load; approximately 300 customers consume more than 100,000 kWh annually

b. Generation Capacity:

i. Diesel: 34 MW (backup capacity)

ii. Oil-fired steam generators: 25 MW (backup capacity)

iii. CHP: 16 MW

iv. Wind: 29 MW

v. Solar: 6.5 MW

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[36] Siemens Press Release, October 24, 2011. Available at: www.eu-ecogrid.net/images/News/120328Siemens_press_release.pdf
[37] "EcoGrid EU: A Prototype for European Smart Grids," EcoGrid. Available at: www.eu-ecogrid.net/images/Pdf/Template/160712_ecogrid_eu_a_prototype_for_european_smart_grids.pdf
[38] "More than 1500 households on Bornholm have submitted to EcoGrid EU," Web, EcoGrid. Available at: www.eu-ecogrid.net/rss-feed/52-more-than-1500-households-on-bornholm-have-submitted-to-ecogrid-eu
[39] "EcoGrid EU: From Design to Implementation," EcoGrid. Available at: www.eu-ecogrid.net/images/News/131004_%20edk%20a4_ecogrid%20eu%20project_web.pdf

vi. Biogas: 2 MW

vii. Electric vehicle battery storage (under development)

c. Physical Characteristics:

i. Number of buildings: Participants in the DR program include approximately 1,800 to 1,900 residential homes and 20 commercial and industrial buildings (including public institutions).

ii. Number of metered points: Approximately 28,000

iii. Use of public rights-of-way: Both private party and utility-owned generation uses the existing distribution, including areas crossing public rights-of-way; regulatory rules determine the price for use of the distribution grid and whether generators received a fixed feed-in-tariff.

5.5.4 Operation

a. Grid Interconnection:

i. The microgrid consists of several grid-connected thermal and electric resources (generation and DR).

ii. Impact on utility operation and economics: The microgrid is designed to have a positive impact on utility operations by showcasing a new market design that relies on regional distributed resources to firm up power supplies on an island, which has a high penetration of wind.

iii. Interaction with wholesale markets: The utility of Bornholm interacts with the Nordic Power Pool wholesale market.

b. Dynamic Load Capabilities:

Demand-side management and storage measures include HAN for residential DR, electric vehicles, heat pumps with smart grid applications, micro-CHP, process industry pumps, purification plants, and emergency generators.

Participants and technologies for the residential DR program include 350 houses with smart meters but no market information; 400 to 500 households with smart meters and market information; 650 semi-automated households with smart meters, smart appliances, and market data; 450 fully automated households with appliances responsive to prices; and 20 commercial, industrial, and public institution customers with smart meters and smart appliances. In addition to curtailing load, the automated DR technologies can also increase the load while the price is low (increase domestic hot water (DHW) temperature, for instance).

However, the project has limited options for diversifying the load, as most commercial and industrial customers on the island have significant barriers to participation in DR initiatives. First, customers on Bornholm in these sectors (and elsewhere in Denmark) typically have district heating and do not use electricity for heating or cooling (natural ventilation satisfies most cooling loads during moderate summers). Therefore, the DR potential in commercial and industrial contexts is limited to lighting, where there is little potential as most facilities have already installed energy efficient lightbulbs and lighting is typically considered essential for normal operations. Furthermore, for industrial facilities, it is difficult to shift electricity load without adversely affecting plant operations. Finally, for commercial and industrial customers, control systems are often already established and proprietary to the energy management company, so there is no standardized DR control solution that EcoGrid can offer commercial facilities (as it can with residential customers). In industrial contexts, EcoGrid focused DR efforts on electric forklift charging and manure mixers, both of which can be timed to take advantage of low prices on the grid.

c. **Islanding Mode:**

   i. Transfer time, duration, and protocols: During normal operation, Bornholm is interconnected to the Nordic power system by a sea cable to Sweden, through which power is imported and exported on a daily basis. The Bornholm utility trades power on the Nordic power market. When the sea cable is disconnected, either for planned maintenance or because it is destroyed, Bornholm enters islanding mode. In this case, the Bornholm utility assumes responsibility for balancing consumption and generation.

   ii. History of successful attempts: No specific examples—program is ongoing.

5.5.5 Permissions and Regulatory Matters

One challenge to the real-time pricing model is that taxes make up approximately 60% of the utility bill. The remainder of the bill comprises basic electricity charges, a public obligation fee,[40] and fixed fees that include an electricity subscription fee and grid subscription fee. Bornholm's real-time pricing mechanism only affects the basic electricity charges—it does not affect the taxes and fees levied on electricity consumption. Therefore, these fees moderate the impact of the real-time price signal on the bottom line of the customer's utility bill.

The government of Denmark has been supportive of this project because it is using the project as a test case to prepare the Denmark power system for the future. However, if the goal of the project is to provide a replicable model for other areas of Denmark, regulatory changes are needed to encourage the distribution system operator (DSO) to use distributed resources and DR to support the macrogrid, even if it means deferring utility infrastructure investments which would otherwise be rate-based. In the current deregulated market, the DSO is separated from retail providers and is not permitted to profit. If there is an issue with congestion or capacity, it is solved by the DSO reinforcing the grid with new infrastructure and recouping investment costs through electricity rates. Within this paradigm, there is no incentive for the grid company to seek DER from customers in the area of congestion. In fact, the DSO cannot recoup costs by engaging customers to develop a virtual power plant, as this customer engagement does not always involve addition of physical assets to the grid and hence would not qualify for reimbursement through rates.

5.5.6 Financial Model

a. **Total Project Cost:** €21.7 million

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[40] The public obligation charge covers the statutory payment for tasks that are payable by all consumers, such as expenses for research and development and extended use of green electricity (DONG Energy, available at: www.dongenergy.dk/privat/Kundeservice/elkunde/InvoicesinEnglish/Onaccountinvoice/Pages/page3.aspx).

b. Project Financing:

This is a government-funded demonstration project, which serves as a test venue for vendors to pilot new technologies for DR, renewables integration, electric vehicle integration, and customer engagement. The goal is to find a program that is replicable elsewhere in Denmark and Europe. The project received €10.5 million in direct financial support under the European Union's 7th framework program.

c. Cost Recovery:

The EcoGrid EU is a demonstration project largely funded by the European Union. To power the country, the Danish TSO pays for wind power from IPPs regardless if it is needed. In the case where it is not fully needed, the TSO exports the power to neighboring countries, often at lower prices than what they pay to the Danish IPPs. Conversely, when the winds are not favorable, Denmark must pay high prices to import power from neighboring countries. The Bornholm demonstration project tests the feasibility of DR on granular time scales and assesses whether the Danish population at large would be receptive to such a market to allow the TSO more flexibility in energy transactions between both domestic IPPs and other international TSOs.

The program has been publicly funded as a demonstration, so it is unclear how the benefits of this project are captured and/or monetized by the TSO.

d. Customer Types:

i. Primary customers: All customers of the island including a mixture of residential, commercial, and light industrial

ii. Other customers: If generation exceeds load on the island, the microgrid can export energy to the Nordic Power Pool serving Scandinavia

e. Services Provided to Participating Customers and Corresponding Pricing Models:

This program allows for customers to see energy pricing in real time and take necessary actions to manage energy usage and bills. To support these services, the program offers free or discounted HAN for automated DR on thermostats and water heaters, in-home displays for manual DR, and free education for participants.

The DR program works in conjunction with many other generators and DR resources to provide for better stability of the grid on the island, thus mitigating issues related to wind operations and pricing.

5.5.7 Microgrid Benefits

a. **Energy Benefits:** Electricity is primarily provided by wind; DR and other generators are used to mitigate the effects of the variability in wind.

b. **Utility Benefits:** The primary goal of this project is to pilot several different technologies and outreach programs to test the feasibility of widespread DR.

c. **Environmental Benefits:** By using renewables and DR, the microgrid is able to reduce its use of diesel, coal, and oil resources to help meet Denmark's goal of 100% renewable energy by 2050.

d. **Cost-Benefit Analysis (CBA):** Not available

5.5.8 Lessons Learned

a. Success Factors:

Community outreach, education, and support is one key to the project's success. The goal of the project is to demonstrate the viability of widespread customer participation in demand-side management initiatives, and so customer education and engagement has been a major component of the DR program on Bornholm Island. EcoGrid, the entity responsible for community outreach, has been successful in using community spirit as a motivating tool and has reached a broad range of residents through mailings, community events, and schools. EcoGrid also helped address upfront technological issues to maintain customer interest in the program. The Danish government supported the project as a test site for DR to help balance the effects of variable renewable generation.

EcoGrid employees learned early that it is difficult for the average customers to understand electricity prices on five-minute intervals. Therefore, the DR products and options offered to customers must be carefully tailored to the customer interests and tested for technical reliability to convey information to the user in a meaningful way. A project representative stated:

"Just like we sort our household waste, we should also participate in demand response and help the power system. The big challenge of course is that demand response is so much more difficult to explain."

Despite setbacks, Bornholm stands as a successful model that pioneered real-time markets among "real people"—a large population of average residential consumers. From the beginning, EcoGrid has been conscious of community spirit as a motivational tool and has emphasized community involvement in all of their communication efforts.

b. Challenges and Recommendations:

The project experienced challenges with the standardization of technology communication protocol. Multiple vendors and control technologies for demand-side management did not integrate well with various retail electricity providers. The HAN technology could be improved to provide information on energy services, which is more meaningful to participants than kilowatt-hour units of energy. In Denmark, customers can choose their retail electricity provider, yet each one has a different method for interfacing with the HAN system, so this caused compatibility issues that limit consumer choice of retail providers. Also, the program has yet to determine a viable commercial solution for DR automation.

There has been some attrition from the program as it took several months between the recruitment processes and installation of HAN technology, in which time some participants lost interest. Participants also criticized the automated DR for negatively affecting their lives (e.g., turning off hot water for showers). Additionally, high fixed charges in electric bills moderate the effects of real-time pricing for participants of the program. Successful DR in real-world towns and communities requires significant ongoing community education and outreach. EcoGrid is still managing issues with customer complaints through consistent and optimistic community engagement.

5.5.9 Contacts and Sources

"Bornholm Microgrid - Interview with Maja Felicia Bendtsen." Telephone interview. November 19, 2014.

5.6 Highlight Study: Hudson Yards

The Hudson Yards community microgrid project is only in the beginning stages of its development and, therefore, not suitable for inclusion as a case study with complete success and failure analysis. However, the location, design, complexity, and challenges this project has already encountered offer significant lessons of interest to the Consortium, its Members, and stakeholders. Therefore, the following highlight study presents preliminary project information that supports the achievement of the study goal.

Figure 11. Master Plan of Hudson Yards (Left) and Tri-generation System (Right)

Source: Hudson Yards

5.6.1 Background and Project Objectives

The microgrid serves Phase 1 of a 28-acre mixed-use development project (see Figure 11, above). Led by Related Companies and Oxford Properties, Hudson Yards is the largest private real estate development in the history of the United States. The project is located above the Long Island Rail Road's Penn Station storage yards on Manhattan's West Side. The site plan includes more than 17 million square feet of commercial, residential, retail, cultural, and educational space, five state-of-the-art office towers, more than 100 shops, a collection of restaurants, approximately 5,000 residences, a unique cultural space, 14 acres of public open space, a 750-seat public school and a 200-room luxury hotel. The developers estimate that, once completed, the project will serve more than 24 million visitors annually.

5.6.2 Technical Components

The following microgrid design components make this project unique:

a. **System Characteristics:**

   i. Generation Capacity: 14.5 MW

   ii. Peak Demand: 38.4 MW

iii. Annual Energy Consumption: 127,350 MWh

b. **Energy Supply Sources:**

i. Two CHP tri-gen plants: 13.3 MW above retail space and 1.2 MW at 10 Hudson Yards

ii. Five buildings provide additional redundant/backup thermal energy supply from boilers and chillers

iii. Central Thermal Exchange Loop (TEL) connecting the larger 13.3 MW CHP tri-gen plant to all buildings

iv. Grid interconnection and electric standby service provided by the distribution service utility Con Edison during normal grid-connected operation

v. Diesel generation capacity will supply emergency power and DR potential when installed

c. **Tri-Gen Plant Generation:**

i. The CHP (tri-gen) plants generate power and hot water, as well as chilled water, and can operate independently from the macrogrid when in islanding mode

ii. The 13.3 MW plant exports thermal energy to the TEL[41]

iii. Approximately two times the efficiency compared to generating these utilities independently/conventionally

d. **Thermal Exchange Loop Distribution:**

i. Building energy consumption imports: All five Eastern Rail Yard buildings import hot water; four of these buildings also import chilled water.

ii. Building energy production exports: 10 Hudson Yards exports hot water and chilled water, 20 Hudson Yards exports hot water and 30 Hudson Yards can export chilled water, at the anchor tenant's discretion. These exports serve as capacity backup in case of central plant shortage. Each of these buildings may also monetize excess chiller and boiler capacity through economic dispatch to serve other connected buildings' energy needs via the TEL in combination with bilateral thermal exchange agreements. Such thermal exchanges are, however, at the will of the microgrid operator, so as not to undercut the microgrid's return on investment.[42]

5.6.3 Operation

a. **Grid-Connected Mode:**

i. The microgrid assets—including the two CHP plants, the DR-ready diesel generators, and certain controllable loads—will be normally controlled through an economic dispatch control system that modifies asset operation in response to both market and equipment conditions.

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[41] Heat exchangers keep the building and thermal loops separate, so only thermal energy is exchanged.

[42] This was a modification to the initial vision for the thermal exchange, when the microgrid developer was faced with the realities of first cost (and reaching necessary ROI) and underwriting for financing.

ii. The diesel generators are equipped with sound insulation, pollution controls, and automatic transfer switches and connected to base building loads, to enable use for DR.

b. Grid Interconnection:

i. The key design element at the POCC interconnection with the macrogrid is the use of remotely controlled and automated isolation breakers.

ii. These breakers serve to connect or disconnect the 13.3 MW from the utility distribution system and may operate in automated mode or be remotely controlled by the distribution utility or plant operators. .

c. Islanding Mode:

i. In the event of an electric distribution service outage, each CHP unit provides islanded mode electric service to selected buildings. This service is enabled through automated switches, load monitoring programs, and use of an extensive metering system, among other system design features.

ii. 10 MW of normal peak load in 30 Hudson Yards will be served by the 13.3 MW CHP plant by contract. This allows for 1 of the 4 generators to be down for maintenance. If all generators are operational at the time of the utility grid outage, additional power will be available to 20 HY.

5.6.4 Financial Model

a. Asset Ownership:

i. The Hudson Yards Microgrid Company (HYMco) will be established to lease and operate the microgrid assets. This will be a legal entity wholly owned by the two real estate developers.

b. Major Energy Supply Revenues:

i. Building tenants will pay HYMco for their energy consumption at retail rates equivalent to what would otherwise be available to them through the market.

ii. All power generated by the 1.2 MW CHP plant is fed directly into 10 HY, which owns the 1.2 MW plant. The plant will follow load.

iii. In contrast, the 13.3 MW plant will maximize energy generation over the summer months to meet new Offset Tariff Standby Rate requirements for a Contract Demand credit. Generation in excess of concurrent demand by the tagged loads, will be sold to Con Edison at the prevailing wholesale rate.

iv. Hudson Yards' buildings with distributed generation expect to receive market DR payments in the future once the diesel generators are installed and operated coincidently during system peak hours.

v. TEL-connected buildings will earn credit toward Leadership in Energy & Environmental Design (LEED) certification by receiving efficient thermal energy through the TEL.

c. Major Avoided Microgrid Distribution Infrastructure Costs:

i. During normal operation, the 13.3 MW CHP plant feeds power directly into the utility's distribution service grid.

ii. The power generated by the CHP plants offsets the grid consumption measured by selected microgrid-sited building electric meters (tagged loads).

iii. The exchange of this CHP supply and tagged meter demand is billed through Con Edison's Offset Tariff.

iv. This Offset Tariff serves to enable the project to distribute CHP power to neighboring loads with the same account owner through the Con Edison owned and operated distribution infrastructure.

v. Meters are selected (tagged) for inclusion in this offset such that the combined load profile of included meters yields a reasonably flat load shape equal to the available CHP capacity of 13.3 MW. Meter inclusion will be revisited periodically to accommodate changes over time in individual meter load shapes.

d. Other Major Development and Operating Costs:

i. Real estate and building space development costs are estimated to be approximately 20% of the total cost and is the most significant single cost category for the project.

ii. Significant costs are incurred for consultants to assist the owners in conducting the engineering review process, developing the application and assessing the calculation method for Con Edison's Offset Tariff.

iii. New York State regulated electric standby services, per Standby Service Tariff (General Rule 20.2.1(A)(2)), are assessed at a rate of 12.1% of the capital cost of the interconnection to cover property taxes and O&M.

iv. Tax concerns significantly affected the structure of the partnerships formed to execute the project. This was an unanticipated cost that changed the initial legal structure of the development company. A project contact suggested that future projects consult tax professionals early in the process:

"Because this stuff is all new, no one has a clear cut answer. Taxes themselves are very hard to interpret…projects should hire a tax specialist to address this in advance."

v. HYMco incurs an incremental retail electric service expense for all tagged accounts within the Offset Tariff. This expense is the difference between the electric delivery service "Rate II" generally applicable to large customers[43] and the "Rate V" applicable to projects with large cogeneration plants.

vi. The standby service premium (also referred to as Contract Demand) is also incurred by HYMco.

[43] Specifically, "Rate V – General – Large – Standby Service" has a high monthly Customer Charge, which is not included in the "Rate II – General – Large – Time-of-Day." Details may be found under the Service Classification No. 9: www.Con Edison.com/documents/elecPSC10/SCs.pdf.

vii. From Con Edison's perspective, it has an obligation to build and reserve capacity on its electric delivery infrastructure to serve the full load of Hudson Yards' customers in the event of a plant shutdown. The cost of that reserved capacity is represented in the standby charge. However, Con Edison representatives state that they recognize the viewpoints of the project and that they are committed to both engaging owners of DG and participating in regulatory processes to determine the fair price of services exchanged between microgrids and macrogrids. They recognize that a distribution-level market with capacity payments as separate from standby charges would be ideal—yet requires significant regulatory reform in the long term. In the short term, Con Edison has implemented changes that give customers the opportunity to reduce DG project costs by 1) providing the Offset Tariff option to reduce microgrid distribution infrastructure development costs and 2) embedding a performance credit in the standby charge that allows proactive customers to reduce their Contract Demand charge.[44]

viii. The developers experienced unanticipated costs as negotiations and regulatory reform efforts continue in New York State. Decisions made by Hudson Yards representatives during the project development cycle had grid interconnection cost implications. The developers expressed hope that the REV process will be an opportunity for them to continue negotiations regarding the appropriate interconnection costs in this case, stating:

"You think you model the economics of a DG project based on utility rates set in stone and make a go/no go decision. It turns out that rates are negotiated and New York State is in the midst of a major energy regulation "reformation." The promise of a better future state on the tariffs has kept our project on the development track, but also never given us certainty about the project economics. It's been a very long and stressful process."

5.6.5 Challenges, Lessons Learned, and Recommendations

i. The value of DG to ratepayers has not been fully translated into the current utility tariff structure.

ii. Community microgrid development requires significant time investments upfront working with building owner and tenant stakeholders to build their trust of district energy systems. Individual building owners are still not comfortable with a non-utility operating the plant that supplies their energy needs. For example, to develop the financial case for investors and architects, the developer needed to build counterfactual financial scenarios to represent the energy costs for each building without the existence of district energy. A Hudson Yards contact relayed the following experience with customers:

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[44] Con Edison's proposed tariff modification in 2015 allows customers to earn Contract Demand credit for consistent generator performance during system peak periods from June to September. If the project is able to consistently generate a minimum output during peak periods over two consecutive summers, Con Edison will provide a Contract Demand credit for that minimum output delivered by the project. For further discussion of these topics, see the Section 5.3.5.

"The first major impediment is that [customers] are mistrustful of third-party energy providers. People are used to having utility providers…but a lot of our tenants want control over their own plant. They felt wary of having an external plant owned by a third party. They don't like the idea of shouldering the costs of infrastructure in their overall project costs, but they also don't look at avoided costs of energy."

iii. The community of project professionals responsible for construction of each building was highly involved in the development and design decisions associated with the microgrid. The microgrid design accommodated concerns and requests of individual building developers. The original community design intent was to allow each building to have its own hot and chilled water plant onsite. However, as they examined costs, four of the five buildings eliminated chiller and/or boiler plant from their building, choosing instead to rely on the thermal output of the 13.3 MW plant and TEL.

iv. Hudson Yards is a new neighborhood, built primarily over a rail yard. Much of the surrounding land is also being redeveloped. Consequently residents outside of Hudson Yards were not involved in any development or design decisions.

v. Because CHP-based microgrids like this one often rely on natural gas as a fuel sources, developers need to consider challenges of securing natural gas supplies.

6. Project Success and Failure Analysis

6.1 Identification of Success and Failure Factors by Project Analysis Area

The following subsections summarize each case study project's key successes and failures. These subjective assessments are primarily from the perspective of project and utility representatives interviewed to develop the content of this report. In certain cases, perspectives from Navigant's experts influenced these statements, particularly when success or failure is defined relative to other projects or industry standards of which interview contacts were unaware.

6.1.1 Case Study: Borrego Springs

Table 3 depicts the successes and failures found in the Borrego Springs microgrid project.

Table 3. Successes and Failures of Borrego Springs Microgrid

Category	Project Successes	Project Failures
Ownership	Utility ownership helped the development of this project because SDG&E had the resources to mobilize all financers and vendors and was able to recover project costs through rates.	None.
Cost	Costs for storage were kept low by focusing only on backing up critical loads. Vendors provided free development services because it would help them enter the market for their products.	Integration costs for multiple resources were high due to difficulty in aligning all resources and vendors.
Finance	The project qualified to be rate-based, allowing for simplified financing. As this is a demonstration project, additional funding was provided by outside parties such as the DOE and CEC.	By rate-basing the project, some ratepayers are paying for the microgrid investment that does not directly benefit them, especially during islanded mode.
Regulation	Regulation allowed for this project to be rate-based.	SDG&E attempted to launch a program to send price signals to users to help serve DR needs, but this program had limited success due to poor timing.
Development	SDG&E realized early in the process that this project had much greater potential than simply the peak shaving it was originally intended to provide, and the utility took necessary actions to pursue added functionality. In Feb. 2015 they added utility-scale solar to the microgrid.	The universal controls for the project were never settled upfront because vendors could not agree on an approach. Development of this control was significantly delayed and is still underway.
Technology	The project demonstrated the use of many DR measures and successful islanding storage to serve critical loads.	Multiple vendors and controls added complexity to the project and it was difficult to fully integrate all of the measures the utility intended to use. Desired controls are not yet fully realized and instead the utility resorted to developing a monitoring system only.

Category	Project Successes	Project Failures
Interconnection	The microgrid has a single point of interconnection, which simplified the process and design.	Only minimal critical loads are served during islanded mode (though they anticipate adding additional solar and storage to expand this capacity).
Operations	The utility operates the system, allowing for full control and a single point of responsibility. The microgrid was able to successfully island during major storm events and outages during 2013, and by using load prioritization, the utility was able to maintain critical loads throughout the outage (over 24 hours).	The project experienced difficulty in syncing the controls of the many different resources.
Energy Delivery	During normal operation, the microgrid is able to serve the full community and provide peak shaving for the utility, but is also able to prioritize delivery to critical loads during islanded operation.	None.
Vendor Relationships	The utility engaged a broad consortium of stakeholders to provide the financing and tools to make this project a reality. The DOE and CEC provided $10.8 million of the total $18 million for the project, while Lockheed Martin, Oracle, Tendril, and many other technology vendors supported the effort with generation, DR, and control technologies.	Vendors were never able to come to terms to develop the universal microgrid controller, and vendor contractual terms required a high level of effort from the developer.
Community Relationships	SDG&E established relationships with the Borrego Chamber of Commerce, and convinced them of the reliability benefits of the project. The community was very grateful to have islanding capability during the storm of September 2013.	The utility did not engage sufficiently with the community upfront, which led to some resistance to oppose the use of HAN. The timing of the dynamic pricing program led to little to no customer bill impacts, so it was not appropriate for rallying community support.
Benefits	The microgrid project realized the desired benefits of reduced peak load, pioneering DR and storage, reduced dependence on diesel, and avoided upgrade costs. The community benefits from critical loads being served during islanded operation.	The project was unable to realize its goal of creating a commercially viable and market-ready universal controls platform.
Revenue	Utility receives revenue from customer rate payments. The project garnered interest in funding from diverse public funds such as the DOE and CEC.	Utility is not monetizing any additional revenue for resiliency enhancement or islanded power.
Business Model	The business model recognizes the potential savings from deferring transmission and distribution upgrade costs by installing the microgrid. The project was approved by regulators, allowing the costs to be passed to all utility customers.	At this time, customers do not pay a premium for emergency backup power from the grid.
Customer Impact	The microgrid community benefits from the ability to serve critical loads during islanded operation; the main service is disaster insurance.	By rate-basing the project, all ratepayers in SDG&E's service territory are paying for the microgrid that does not directly benefit them during islanded mode, while customers that do directly benefit during emergencies are paying no additional charges.

Category	Project Successes	Project Failures
Energy Efficiency	EE is a priority at Borrego on island-capable circuits, to increase the energy services that can be offered during islanding events.	None.

Source: Navigant analysis, 2015

6.1.2 Case Study: Stafford Hill Solar Farm

Table 4 depicts the successes and failures found in the Stafford Hill Solar Farm microgrid project.

Table 4. Successes and Failures of Stafford Hill Solar Farm

Category	Project Successes	Project Failures
Ownership	Utility ownership allows utility to capture all possible value streams and pass benefits on to ratepayers.	None.
Cost	By using dual-purpose, smart-islanding inverters, they were able to save $700,000 on cost compared to using separate inverters for solar and storage. Modeling demonstrated that storage would be cost-effective in this application. No fuel price risk as generation assets are 100% renewable.	Difficulties obtaining UL certification for new technology led to a delay in the project completion date. It remains to be seen whether the project's performance matches modeled projections.
Finance	Utility was able to demonstrate that the project qualified to be rate-based, allowing for simplified financing. Additional funding was provided by DOE.	By rate-basing the project, some ratepayers are paying for the microgrid investment that does not directly benefit them, especially during islanded mode.
Regulation	Regulations allow for utility-owned and operated generation and grid-scale storage. Regulation allowed for this project to be rate-based (i.e., financed through ratepayer charges). Utility representatives spoke with regulators early and often to ensure there were no surprises in the final project proposal.	None.
Development	Project overcame hurdles related to installing the system on a closed landfill. Project construction started promptly after approval.	Controls systems and operation protocols should have been reviewed and finalized earlier in the process. Added complexity due to coordinating two separate installers for solar and storage. Delays related to UL safety certifications for new energy storage technologies.
Technology	Dual-purpose, smart-islanding inverter from Dynapower simplified design and interconnection. By building solar and storage, they were able to use a multi-port inverter and save $700,000 on the cost of inverters that would have been installed for each technology separately.	Batteries were sized based on space constraints at the site and did not involve rigorous sizing evaluations.

Category	Project Successes	Project Failures
Interconnection	The system is 100% grid-connected in normal operation. Island capability can be easily added with simple switches.	Currently, only the high school is able to island (though GMP does intend to expand this in the future).
Operations	Utility operates the system, allowing for full control and single point of responsibility.	The project is not yet commissioned so uncertain if system will operate as desired/expected.
Energy Delivery	During normal operation, system participates in ancillary services market of ISO-NE and provides peak shaving for the utility. During islanded operation, the system provides electricity to nearby high school, which serves as a shelter.	None.
Vendor Relationships	The project received funding through DOE and the State of Vermont to convert from utility-scale solar to a solar + storage microgrid package. GMP is working closely with local vendor Dynapower to provide controls and inverters for the project. Talks with Dynapower had originally led to restarting the process as a solar + storage project.	The project is experiencing delays due to the UL certification of new battery components. Coding and programming of the system is also causing delays in the start date. More time could have been spent reviewing the project's controls to ensure they were optimally designed to extend generation/storage life.
Community Relationships	GMP is led by a forward-thinking CEO and maintains a strong, productive relationship with regulators. GMP maintains a good relationship with the local town of Rutland, which receives lease payments for the use of the landfill. As part of its community outreach efforts, GMP declared Rutland the solar capital of New England and sources control technology for the project from local vendors. GMP partnered with VEIC to perform community outreach and design a kiosk for local high school students to view real-time system performance. Education of the community was a key element of the microgrid development's success. The community favors redevelopment of brownfield sites.	GMP leased the old landfill site from the city, but the drawings were inaccurate, which caused project delays in siting the solar array foundations.
Benefits	Long- and short-term benefits to the grid are monetized by the utility and passed on to ratepayers through lower rates. The community benefits from islanded operation as the school becomes a shelter in emergencies. The project also has black-start capability.	Several of the major benefits are expected to pay over a long time period and there is risk that they may not be fully realized as expected.
Revenue	Utility receives revenue and/or savings from peak shaving, ancillary services in ISO-NE market, and customer rate payments. Town of Rutland receives lease payments.	Not all revenue streams are firm, including revenue from ancillary markets. Utility is not monetizing any additional revenue for resiliency enhancement or islanded power.
Business Model	The business model comprises several revenue and savings streams. This model has been approved by regulators as providing benefit to all ratepayers, allowing the costs to be passed to all customers.	The business case for this project relies on many long-term revenue streams, which may or may not be realized. At this time, customers do not pay a premium for emergency backup power from the grid.

Category	Project Successes	Project Failures
Customer Impact	The community as a whole (not just direct microgrid customers) benefits from islanded operation as the school becomes a shelter in emergencies. GMP is looking into additional payments from these local customers benefiting from the islanded shelter, though presently the ongoing costs/savings are rate-based. The utility claims that investments such as this project have allowed them to decrease rates (by 2.5%) while other utilities in the area are increasing rates.	By rate-basing the project, ratepayers in the broader utility service territory are paying for the microgrid investment that may not directly benefit them if they are not located near the high school's public emergency shelter.
Energy Efficiency	The project is grid-connected, so indirectly benefits from all of GMP's EE programs. Homes in Stafford Hill are also being given full e-home retrofits, in which residents have a complete energy makeover of their homes.	None.

Source: Navigant analysis, 2015

6.1.3 Case Study: Co-op City

Table 5 depicts the successes and failures found in the Co-op City microgrid project.

Table 5. Successes and Failures of Co-op City

Category	Project Successes	Project Failures
Ownership	Because the co-op owns and operates the project on behalf of tenants, incentives (lower costs) are aligned with benefits to the energy consumers (tenants).	None.
Cost	Cost of generating electricity is low because the CHP is primarily used to serve large demand for thermal load.	Standby charges from the utility increase costs.
Finance	Because the complex includes affordable housing, the project received some financing from the state. Additional financing was provided directly by tenants who will benefit from the microgrid.	None.
Regulation	The co-op acts as a single decision-making point, which provides for direct representation of tenant wishes, streamlines operations, and encourages innovation. The co-op is able to aggregate demand among members and participate in some segments of the DR market.	Regulatory issues and changes have eroded project economics (such as NYISO rendering the project ineligible for participation in DR market as a Special Case Resource) and preventing PV net metering incentives (restrictions on PV interconnections per meter).
Development	Congruence between buildings and central co-op organizational structure allowed for a simplified design and deployment to many tenants in a short period of time.	With most users being residential, and the CHP following thermal load, there are times when the CHP plant generates excess power that the co-op cannot use.
Technology	Existing infrastructure (including main meters and underground electrical), simplified the design and installation of this project. CHP is well-suited for residential use because of the heating and cooling it provides.	Due to four main meters only, the project cannot readily benefit from Advanced Metering Infrastructure (AMI) or many other smart grid technologies.

Category	Project Successes	Project Failures
Interconnection	By being grid-connected, the co-op is able to use the macrogrid as backup.	There are fees (standby charges) associated with this interconnection.
Operations	CHP is able to sell excess electricity into the wholesale market during periods when it is not used (such as summer peaks).	CHP is designed to always follow thermal loads, rather than a more sophisticated design that could control operations to maximize economics.
Energy Delivery	Tenants pay a fixed cost for maintenance services, and consider electricity to be a free benefit of CHP.	Due to metering infrastructure, tenants do not see their individual usage and may not be incented to reduce load.
Vendor Relationships	CHP built by Siemens, RiverBay now owns and operates the plant, is responsible for securing contracts for fuel provision and maintenance services. One company to manage these relationships simplifies operation logistics.	Potentially confrontational relationship with the local utility due to perceived lack of fair treatment.
Community Relationships	The co-op is a community-owned organization, so it represents the interests of the local community of electricity consumers, having a positive relationship between the co-op tenants and internal decision makers. Owners actively work to lower energy and maintenance costs to help tenants. The co-op also has a positive relationship with the community as a whole, since it is an affordable housing community in a dense urban environment. The ability to island during Hurricane Sandy garnered additional community support.	None.
Benefits	The low cost of the CHP helps the co-op offer affordable housing. Islanding ability allows the system to provide both electricity and thermal benefits during outages. Due to the CHP following space conditioning load, it can sell electricity to the macrogrid, including during summer peaks.	Other potential macrogrid benefits could be realized by aligning the interests of the project developer and the utility.
Revenue	90% to 95% of electricity is used by the co-op and tenants pay service fees needed to support the project. Additional revenue from some sales of electricity to the macrogrid when not used by tenants.	Fixed standby fees erode revenues earned by the project. Revenue from sale into wholesale market is much lower than the price paid by the co-op to purchase electricity; revenue from wholesale DR was removed when CHP was excluded from these programs.
Business Model	CHP plant serves primarily onsite usage and is owned/operated by the same entity that is benefiting from its operation. This has allowed for simplified decision-making and transparent costs and revenues. Other sales to the macrogrid have provided additional revenue.	Business model has been negatively affected by changes in program eligibility, high fixed standby charges, and inability to secure financing for additional measures.

Category	Project Successes	Project Failures
Customer Impact	The low cost of the CHP helps the co-op offer affordable housing. Islanding ability allows the system to provide both electricity and thermal benefits during outages. Due to unique thermal load profile of residential, CHP can sell electricity to customers of the macrogrid via the utility, especially during summer peaks. This may help decrease summer rates for customers outside of the microgrid territory. Customers highly value reliability after the 2003 blackout and Hurricane Sandy.	Due to only four master meters, co-op city residents have no insight into their electricity use, and no incentive for efficiency.
Energy Efficiency	CHP systems, which use thermal energy for heating, cooling, and domestic hot water, are much more efficient than typical combined cycle natural gas plants. The community is highly motivated to take cost-saving EE measures, because the co-op is self-governed and any energy savings are passed directly to tenants; there is no split incentive between tenant and landlord. Co-op City describes the microgrid as a fusion of renewable, EE, and cogeneration with affordable housing.	Because the facility is master-metered at four points, tenants have limited connection between their personal consumption and energy prices, which reduces the incentive for tenants to pursue efficiency on their own. In this case, efficiency measures must be implemented from the top down. Financial savings from EE are difficult to quantify, because of the interaction of thermal and electricity supply, end-use EE may save heat that is then wasted anyway.

Source: Navigant analysis, 2015

6.1.4 Case Study: Hamden Plaza Microgrid

Table 6 depicts the successes and failures found in the Hamden Plaza microgrid project.

Table 6. Successes and Failures of Hamden Plaza Microgrid

Category	Project Successes	Project Failures
Ownership	Despite the complexity of a multi-customer project with diverse generation and load, this project has been able to secure third-party ownership based on its projected profitability.	Third-party owner is financier who is not familiar with microgrid operations.
Cost	Operating costs are lowered through active management of generation and loads to improve resource utilization.	High upfront cost for generators.
Finance	Project is bankable and able to attract third-party investors.	Agreements have yet to be finalized, so it is unclear who is financing the project and how that will affect operations or ownership.
Regulation	Local programs and regulations allow for the microgrid to be installed and may cross right-of-ways if for public use.	Current regulation does not allow the project to monetize benefits provided to the macrogrid by the microgrid. Developers feel that current regulations regarding interconnection do not allow for active, working dialogue with the utility.

Category	Project Successes	Project Failures
Development	Project earned support from the Town. Upfront feasibility studies demonstrate long-term savings of microgrid versus backup generators.	High development costs are at risk until a project financier is secured who is willing to repay these costs. Development is complex because it must satisfy needs of the off-takers (low cost) and needs of the financiers (high returns).
Technology	The GreenBus® technology design and implementation by the development company allows for active management of loads to optimize operational efficiency and seamless transition to islanded mode.	None.
Interconnection	None.	Private development does not have insight into the interconnection process and is subject to requirements and costs imposed by the utility. At this time, interconnection costs are unknown, which could affect project economics.
Operations	Active management of resources and loads maximizes utilization and minimizes operating costs.	The operation of the microgrid is conducted by a third party, and it is unclear how this will be done to manage the needs and expectations of each off-taker.
Energy Delivery	Energy (electricity and thermal) is delivered to diverse sites that are nearby to one another. Electricity is delivered to the high school and ice rink during islanded mode.	Billing system is confusing to customers who will receive two bills, one from the microgrid company and one from the utility.
Vendor Relationships	Using a project finance model, the SPE is the vehicle for accepting contracts and coordinating relationships between the project development companies (Green Energy Corp), vendors, financiers, and off-takers. As the developer, Green Energy Corp is also well-positioned to optimize its GreenBus microgrid integration and control software, pursuing an active management approach to improve project economics and reliability with design and technology.	There is a risk of financiers losing interest in the project if the interconnection agreement with the utility is delayed further. There is also a risk of off-takers attempting to renegotiate the PPA under changing conditions.
Community Relationships	The project has a positive relationship with the local authorities and the Town of Hamden because the local government strongly supports energy independence, reliability and low-carbon energy. The community of Hamden supported the project from its inception because residents have experienced many extended outages from storms in recent years.	Project developers find it difficult to establish a constructive relationship with the local utility and are worried that the project will not be treated fairly (due to potentially high interconnection fees with the macrogrid).
Benefits	Off-takers benefit because purchase of electricity from the microgrid costs less than utility-provided electricity. This project also allows off-takers to have a fixed rate of electricity over the long term, which acts as a hedge to market price volatility. The microgrid offers islanded benefits to two emergency shelters.	Current project does not contemplate any benefits to the macrogrid.
Revenue	Revenues for the project are secured through long-term off-taker agreements with the four main customers.	The project has no interaction with the wholesale markets and does not intend to use net metering.

Category	Project Successes	Project Failures
Business Model	The power purchase model is successful in this case due to the high local electricity rates and the customer's desire for energy independence from the macrogrid. By securing the sale of electricity through the contracts, the project owner is able to minimize risks related to revenue streams.	Third-party development incurs much cost and risk upfront and assumes that long-term contracts will eventually yield returns. Current model does not contemplate other potential value streams such as services in wholesale markets or benefits to the macrogrid.
Customer Impact	Microgrid customers benefit because electricity purchased from the microgrid costs approximately 4% to 8% less than current utility rates. This project also allows customers to have a fixed rate of electricity over the long term, which acts as a hedge to market price volatility. The microgrid offers the community the benefit of two emergency shelters in island mode. Microgrid developers hope that the utility adjusts to the microgrid as being in the best interest of the customer, while the utility can still play a role in customer service.	Microgrid customers will inconveniently receive two electricity bills—one from project company and another from the utility. Utilities are currently unable to accommodate an intermediate entity that buys power from the utility and re-sells it to the end user.
Energy Efficiency	Because the project developer sized generation assets to energy rather than capacity load, it captures significant benefits from EE savings during all hours of the day. Hence, Green Energy Corp has a strong incentive to encourage EE. Increasing efficiency of loads in emergency shelters will increase the duration of services in island mode.	It is still unclear how costs of energy efficient upgrades would be shared by the project developer and the end users.

Source: Navigant analysis, 2015

6.1.5 Case Study: Bright Green Bornholm Island

Table 7 depicts the successes and failures of the Bornholm Island microgrid project.

Table 7. Successes and Failures of Bright Green Bornholm Island

Category	Project Successes	Project Failures
Ownership	Residential ownership of technologies was encouraged and supported by government and grant funding.	Many different owners and participants adds complexity to project economics and evaluation.
Cost	None.	Costs are difficult to assess due to the variety of participants. Real economics and costs are not realized due to heavy grant funding.
Finance	Government/EG grant funding was a primary driver in allowing this project to move forward.	At this time, the project is a government-funded pilot/demonstration project and does not exhibit a market-ready approach to financing.

Category	Project Successes	Project Failures
Regulation	Regulators and government have supported approval for the real-time pricing market and encouraged participation in the program.	Rate structures in the region minimize the benefits of the DR savings to the customer due to high fixed charges. These initiatives may not be replicable, as intended, due to the deregulated nature of the energy market in which the TSO is unable to recover the costs of such programs.
Development	Development of the project considered community involvement from the beginning.	Technology providers were not ready to provide solutions soon after the recruitment process, resulting in attrition from the program.
Technology	Many participants use automated DR equipment, which allows the program to benefit even when the customer is not actively adjusting their usage.	Several issues were experienced with the deployment of the demand response technology due to lack of standardization in design and communications. Some customers found the technology difficult to use and were unhappy with changes made by the automated DR. The HAN equipment required more maintenance than originally expected.
Interconnection	Large generators are connected to the macrogrid and able to sell excess generation into wholesale markets. Interconnection of DR equipment is done at the residential/commercial level, behind-the-meter.	None.
Operations	Pricing signals are set on a five-minute basis, allowing for near real-time reaction to prices by participants. This system is designed to accommodate a high penetration of renewable intermittent wind energy.	None.
Energy Delivery	The wind generators are the primary source of electricity to the island. The other generators and the DR help to address the intermittent nature of the renewable generation.	Customers complain about interruption in their energy services when operation of macrogrid is not fully maintained.
Vendor Relationships	EcoGrid successfully assembled a consortium of vendors to implement DR and smart grid technology, including Siemens, IBM, and Oestkraft. The project serves as a test venue for vendors to pilot new technologies.	There was difficulty with technology integration between HAN systems and various retail electricity providers. Each retail provider has a different method for interacting with the HAN system. Commercial and industrial customers often already have established control systems, so there is no standardized DR control solution.

Category	Project Successes	Project Failures
Community Relationships	EcoGrid maintains ongoing interaction and education with the community to ensure understanding and participation in the program. Active involvement by the community is essential to the success of the project. These interactions have provided feedback that helped shape the way the program is implemented. The demonstration home is particularly effective as a positive community outreach and education tool. The Danish government supports this project as a test site for DR and other strategies to help balance the effects of variable renewable generation.	Some participants have lost interest in the program for several reasons, including dissatisfaction with sacrifices to comfort levels (from cold showers, for example), delayed implementation of HAN equipment, and minimal cost savings for reducing usage.
Benefits	Stability of the macrogrid is improved by other generators and DR helping to smooth power from the wind. The program is eliciting feedback and lessons on the widespread use of residential/commercial DR that the government of Denmark intends to use nationwide.	Customer benefits from participation in the program are not significant due to high fixed costs of utility bills. Overall benefits to the utility and macrogrid are difficult to quantify due to variety of technologies and participants.
Revenue	The TSO benefits from savings when they call upon DR rather than buy power from the wholesale markets.	Little revenue/savings accrues to the participating customers. Use of DR reduces the revenue collected by the utilities.
Business Model	As a demonstration project, this microgrid has helped promote understanding of current drivers and challenges to deploying widespread DR programs.	This project has not fully demonstrated that a similar nationwide program would be effective without government support and/or regulatory changes.
Customer Impact	Customers are motivated to facilitate the integration of renewable energy and demand-side management to support community goals for lower environmental impact. The regional Nordic Power Pool is able to buy excess energy from Bornholm, which could lower prices for Scandinavian utility customers. The microgrid also intends to have a positive impact on the utility by showcasing a new market design that relies on regional distributed resources to firm up power supplies on the island.	Customers are not realizing the financial benefits of real-time pricing due to high fixed costs on utility bills. Some customers report negative experiences with real-time pricing and DR technologies and discontinue participation in the programs.
Energy Efficiency	The prevalence of district heating in Danish buildings decreases overall electricity load and enables the installation of CHP. Residents are relatively receptive to feel good reasons for participating in EE and DR.	High initial penetration of energy efficient lighting and high efficiency appliances requires that more customers participate in DR programs for the program to have a significant effect. Gains for individual customers are also small. This also limits commercial DR potential.

Source: Navigant analysis, 2015

6.2 Success and Failure Trends and Themes

Some aspects of each project went very well—demonstrating new concepts, new structures, and/or new technologies—while other aspects raised concerns, uncovered pitfalls, or demonstrated market or regulatory failures that are noteworthy as the community microgrid industry continues to evolve. After reviewing the project cases studies, several trends and themes identify the overall opportunities, challenges, and best practices to consider when supporting microgrid policy, development, and design.

6.2.1 Impact of Ownership on Business Model

Depending on the ownership model, only certain benefit streams may be monetized; similarly, the method of monetizing such benefits will differ based on the microgrids' owner. For example, under the traditional utility ownership model, regulators typically allow for costs to be passed to all ratepayers (general rate base); under this arrangement, there are no added charges for direct recipients of the benefits (i.e. islanded electricity). Conversely, privately owned microgrids recoup costs from those entities that benefit directly from the microgrids' operation and, for microgrids owned by end users, from energy cost savings. Additionally, utility-owned microgrids capture and monetize many additional value streams that benefit the local grid and the macrogrid (such as through participation in wholesale markets and benefits of deferred infrastructure investments), while privately owned microgrids examined in this report had little to no valuation of these benefits. Instead, privately owned microgrids recoup costs from those entities that benefit directly from the microgrids' operation and, for microgrids owned by end users, from energy cost savings.

Third-party ownership models depend on meticulously negotiated PPAs with various off-takers,[45] but are more flexible in how services are priced. These ownership models are economically viable for customers in areas where volumetric electricity rates are high because they can benefit from PPA rates that are lower than utility electricity rates. Conversely, customers in areas with rates structured to include high fixed or standby charges have yielded little economic incentive, or even a disincentive, to pursue a PPA with a third-party microgrid developer since the volumetric portion of the tariff is likely to increase and, therefore, be uncompetitive with the incumbent's offer.

6.2.2 Monetizing Value and Managing Risk to Secure Financing

Microgrids should be developed, designed and operated to optimize economic value through the use of many diverse revenue streams, to mitigate risk through diversification, and maximize the overall financial return for a single project owner. However, it remains to be seen how some intangible benefits, such as resiliency benefits, may be monetized into revenue streams, particularly for privately owned microgrids.

In the cases reviewed, there is potential for the realization of additional economic benefits if other revenue streams are added and operations are improved. For example, end users in the reviewed cases do not pay a premium fee for power during islanded operation. It is surmised that they would not agree to such fees, though it is unclear why or at what price level they would be willing to pay extra fees. Additionally, for projects that depend on DR, operations could be improved if customer behavior was altered through better understanding of project needs or direct incentives for participation.

Finally, the quality of project financial plans are eroded in cases where costs or revenues are unknown, not secured through long-term contracts (or are only secured with low-credit counterparties), or are at risk of changing. These conditions can cause significant barriers to obtaining financing and maintaining solvency—especially if these changes occur late in the development process or, worse, after the project is operational. These risks must be managed and mitigated to secure third-party private financing. Many

[45] An off-taker is the party who is buying the product/service (power) that the project produces/delivers.

of the cases reviewed in this study benefited from public funding sources (Federal, state and local programs) where such public financiers may view risk differently than private capital sources. In some of these cases, it is questionable whether such projects can really succeed on their own in the absence of public finance.

6.2.3 Design, Operation, and Controls

Most microgrid systems reviewed, especially the privately owned systems, are designed to serve onsite or nearby loads. This is done to reduce costs, meet specific needs, or avoid regulatory issues with crossing public right-of-way. While loads served during normal grid-connected operation vary widely between projects, the choice of critical loads to serve during islanded operation has primarily been public purpose loads such as space conditioning and lighting for emergency shelters. Many projects are considering how they can now modify their original load service design to add other critical and non-critical loads in order to increase their value of service during islanded operation.

While the current trend points to increased interest in renewable generation and CHP, it is also the case that deployed generation and DR technologies vary widely between projects. Renewable generation cannot solely meet the needs of a microgrid due to its intermittency and is often paired with storage, other fossil fuel generators, and/or DR to attempt to mitigate the adverse impact of this intermittency limitation.

It has already been established through prior research[46,47] that the use of CHP as one of the generators for the microgrid can serve to increase benefits and revenue of the project due to the provision of additional value through heating and cooling thermal energy.

Robust controls are necessary for optimal system operations to ensure high asset utilization, seamless transition to islanded mode, and balancing of load and generation; however, control technologies and schemes are often overlooked early in the process and are difficult to design when using multiple generation and demand resources. The microgrid operators should be experienced, such as a utility would be, in operating generation equipment and controlling loads such that they remain in balance.

6.2.4 Engagement of All Stakeholders

Project development, valuation, and operation is simplified when fewer parties are involved, especially when such entities have differing interests and objectives; however, this is most often not the case. Microgrid projects with multiple, differing stakeholders (e.g., customers, owners, and vendors) require extra coordination, time, and expense. Early and frequent interaction with stakeholders improves outcomes.

Community outreach, education, and involvement are critical to project success and should be addressed early in the development process to reduce resistance to and increase active support of the

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[46] A DOE report from April 2002 determined that heat recovery with standard or advanced CHP in a large office building in New York increased primary energy savings by 21% or 31%, respectively. Efficient DG paired with CHP with heating and cooling achieved the highest savings, compared to baseline or DG-only scenarios (www.energy.gov/sites/prod/files/2013/11/f4/chp_benefits_commercial_buildings.pdf).

[47] A Navigant Consulting report for NYSERDA from August 2011 discussed the strong potential benefits for CHP in microgrids, including improving reliability for facilities, enabling larger CHP systems, and increasing flexibility in CHP system design since electrical and thermal generation may serve more than one facility (www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2011ContractorReports/2011-DG-CHP-MCA-Report.pdf).

project—in part by providing opportunity to adjust the project aims and scope in response to uncovered needs and interests of diverse stakeholders. Furthermore, in several of the cases reviewed, working with vendors during development and operation also provided a mutually beneficial relationship in which the project owner/developer benefited from the expertise of the vendor, while the vendor earned market exposure and real-world feedback that could be used to refine future products and service offerings.

For microgrid projects that seek to monetize benefits to the macrogrid, it is also important to educate and involve the incumbent distribution service provider and regulators early in the development process in order to secure buy-in for project value stream monetization as well as to foster a constructive, working relationship needed to work through diverse regulatory issues. This can also be helpful for private developers who anticipate they will have difficulty working through issues directly with utilities—most notably, interconnection processes and standby charges in the cases reviewed.

7. Practical Action Recommendations

Building on the analysis presented in Section 5, the Navigant team developed practical action recommendations to help provide guidance to the Consortium and its stakeholders to enable the community microgrid market in New York State. These recommendations underscore how careful consideration and attention to key project analysis areas, as summarized previously in Figure 4, can improve the chances for success for a given project which, in turn, supports the community microgrid market as a whole.

7.1 Microgrid Advancement Goal

The advancement goal is to build and operate more community microgrids in New York State. This effort begins with identifying key stakeholders within a community microgrid market and any conflicts or alignments among these stakeholder groups. Next, using the previously discussed analysis areas, the goal is to develop a set of recommendations by area that can serve to remove barriers or accelerate benefits, resolve conflicts, and strengthen alignments. The goal is not to be prescriptive but rather to offer communities, regulators, developers, utilities and all other community microgrid stakeholders a comprehensive set of considerations to assess when developing both individual projects and the market as a whole.

7.2 Microgrid Advancement Stakeholders and Interests

Understanding the stakeholder population and what motivates them—or could motivate them—is a fundamental step in identifying advancement opportunities.
Table 8 below depicts a set of community microgrid stakeholders and a corresponding set of potential motivational interests they may have with respect to a functioning microgrid.

Table 8: Community Microgrid Stakeholders and Interests

Stakeholder	Interest
Communities	Resiliency, clean/renewable energy, independence, lower rates
Utilities	Reliable and safe delivery of electricity, shareholder return, stable load/supply forecasting, customer relationships
Regulators (State Commissions)	Reliable and safe delivery of electricity, just and reasonable rates, and balancing interests of multiple stakeholders
Developers	Lowest cost project development, tax credits/benefits, short payback periods, minimal points of contact
Community Energy Managers	Resiliency, low energy costs, clean/renewable portfolio, market participation
Technology Vendors	Technology sales, technology demonstration, new market opportunities, brand marketing or expansion
Financiers	Internal rate of return (IRR), return on investment (ROI), proven or plausible business/revenue model, risk mitigation
Regional System Operators	System reliability, market participants, demand flexibility, ancillary services
Microgrid Operating Entity	Well-defined role, resource control, proper incentives

Source: Navigant analysis, 2015

At a basic level, if a community microgrid cannot deliver the majority of these interests across the spectrum of stakeholders, it is likely that a project will not succeed. Furthermore, if the community microgrid market opportunity at large does not align with these interests, the overall market opportunity may never realize its potential.

7.3 Stakeholder Interest Conflict and Alignment Assessment

After examining this set of stakeholders and their corresponding interests, the team identified areas of both interest alignment as well as conflicts of interest. Before moving forward with the practical action recommendations for each analysis area, Navigant identified these areas of interest alignment and conflict. This identification informs the practical action recommendations that follow this section. Table 9 summarizes these alignments and conflicts.

Table 9. Interest Alignments and Conflicts

Stakeholder	Alignment	Conflict
Communities	• Aligned with technology vendors • Aligned with Community Energy Managers	• May not value relationship with utility • Not interested in higher rates despite higher resiliency
Utilities	• Aligned with system operators • Aligned with community interest in reliability • Aligned with demand flexibility	• Not aligned with interest in lower costs • Not aligned with community independence • Not aligned with lower kilowatt-hour sales • Not aligned with variable load due to islanding capability
Regulators (State Commissions)	• Aligned with communities (reliable, safe, affordable electricity) • Aligned with regional system operators (reliability)	• Not necessarily aligned with utilities (shareholder return) • Not necessarily aligned with operating entities (resource control) • Not necessarily aligned with technology vendors
Developers	• Aligned with community, community energy managers in terms of developing project • Theoretically aligned with financiers	• Not necessarily aligned with operating entities • Not necessarily aligned with communities (too many points of contact, too many varied interests to manage)
Community Energy Managers	• Aligned with communities • Align with operating entities	• Not necessarily aligned with utilities (variability, lower cost)
Technology Vendors	• Aligned with communities (especially clean energy, independence)	• May not be aligned with operating entity or utility if forced to operate hardware or software outside of design specifications
Financiers	• Aligned with communities and community energy managers in enabling the opportunity	• Not aligned with community interest in lower energy costs • Not necessarily aligned with new Technology Vendor interests (risk) • Not necessarily aligned with community interest in clean/renewable energy (cost)
Regional System Operators	• Aligned with communities (flexibility, resiliency, islanding)	• May not be aligned with utilities microgrids' ancillary service, capacity, and DR offerings

Stakeholder	Alignment	Conflict
Microgrid Operating Entity	• Aligned with community energy managers • Aligned with system operators	• May not be aligned with communities (curtailment events)

Source: Navigant analysis, 2015

7.4 Practical Action Recommendations by Recommendation Theme

The following subsections outline practical action recommendations that should be reviewed and considered to support microgrid market development. The recommendations are made in accordance with the analysis areas, and organized by theme. This list of recommendations provides the Consortium and its stakeholders sets of potential actions that may facilitate the growth of community microgrids in New York State. These recommendations are addressed to a broad audience of stakeholders including regulators, policy makers, public policy advocates, distribution utilities, vendors and project developers, among others. Navigant recognizes that there may be differing opinions or motives among these entities.

While Navigant's recommendations are not exhaustive, they do provide a starting point based on the findings of the case studies analyzed herein. Given that regulatory, legislative, and market environments for community microgrids remain in a state of flux, the relative importance of each recommendation will evolve over time.

7.4.1 Business Model Enablement and Optimization

7.4.1.1 Legal and Regulatory Barriers

1. **Permit ownership of assets such that maximum benefit or monetization of value streams accrues to the owner:** When the majority of benefits are realized by the owner, the interests are aligned, allowing for simpler development, financing, and operations, minimized transaction costs, and maximized value of the benefits. Conversely, if the owner of the assets does not directly receive the benefits, they must monetize the benefits that flow to other entities through contractual relationships which can be complex, costly, or even unavailable. Projects owned by utilities, end users, and third parties can all face challenges in monetizing key benefits stemming from the project. Regulation may need to be realigned to allow for optimal ownership and/or monetization of benefits directly to the owner.
2. **Enable third-party crossing of public right-of-way for microgrids:** To support the implementation of diverse types of microgrids, especially third-party owned microgrids, regulators should consider allowing these entities to cross a public right-of-way. This should be done such that these projects are not considered regulated utilities to avoid additional barriers to development and financing. Connecticut is one of the few states that allows neighbors to provide power to other neighbors across the street on a case-by-case basis, without being qualified as a utility. In the majority of states where this is not the case, the utility could coordinate and control the crossing of public thoroughfares without necessarily owning the generation and distribution assets on both sides of the thoroughfare. Regulators should establish mechanisms for utilities to accomplish this.
3. **Open wholesale market programs to any entity that provides wholesale market benefits:** Often wholesale markets are limited to generators of a specific size and restrict participation

from customer-owned and/or behind-the-meter resources. By opening these programs to any entity that provides benefits to the wholesale market, the microgrid can monetize additional benefits.

4. **Create standard, transparent, and efficient processes for permitting interconnection:** Non-utility developers see the interconnection process as a black box in which they have little visibility and unclear expectation of what will be required for the interconnection agreement with respect to design and added costs. This adds uncertainty and can create a barrier to efficient project development. This process could be improved by clearly outlining how applications will be evaluated, creating a regulated timeframe in which utilities must respond, and establishing a grievance process. Furthermore, standardized interconnection agreements encompassing islanding, two-way energy flow, and other relevant exchanges between the microgrid and the utility (e.g., ancillary services) would offer benefits to each party.

7.4.1.2 Benefit Monetization

5. **Identify and demonstrate ownership models which maximize the value of benefits:** The ownership model will dictate which benefits are realized by the owner, which must be monetized through sale to another entity, and which may ultimately go uncompensated. By identifying models that maximize the value of benefits (given current regulations) development may be encouraged to favor those models.
6. **Consider the impact of metering configuration:** Metering arrangements (such as master meters, sub-metering, or utility versus developer meters) can have an impact on the economics and optimal operation of the microgrids. Regulators and developers should consider optimal arrangements that enable complex energy delivery schemes in the microgrid.
7. **Develop standard valuation methods for benefits that may not be directly monetized:** Microgrids can provide many benefits to the macrogrid and society (e.g., deferred investment in macrogrid, emissions reductions, or emergency services), but there is no industry-consistent methodology or tools for evaluating the value of these benefits. Ideally, these benefits would be valued in dollars, and a cost recovery mechanism would be created to pass that value on to the microgrid owner to encourage investment.
8. **Consider in-kind incentives for community benefits:** For benefits that accrue to the community, consider an incentive or recovery mechanism that supports these benefits using similar value streams. For example, tax benefits to microgrid owners that reduce tax expenditures for emergency response.
9. **Survey communities using or interested in microgrids to identify additional revenue streams:** There are some benefits, other than electricity savings, for which participants may be willing to pay a premium. This could include items such as power in islanded mode, hedging against electricity price fluctuations, or low- to zero-emissions generation. Often these potential revenue sources are unknown or undervalued but could add additional revenue or participants.
10. **Emphasize the need for secure, contracted revenue streams:** The overall economic success of a microgrid project will depend on realizing the revenue streams contemplated as part of the development and cost-benefit analyses. This should be done by securing major revenue streams through long-term contracts, whenever possible.

11. **Encourage the use of benefit realization plans:** Going beyond a feasibility assessment or cost-benefit analysis, a benefit realization plan would be used to develop concrete steps needed to secure the contemplated benefits. This can also be used to develop systems and contractual relationships needed to monetize these benefits and should comprehensively capture all value streams, rather than simply one or two main items.
12. **Encourage business models that align ownership with end-user interests:** When owners of the asset(s) (whether they are utilities, third parties, or community co-operatives) are the same entities that receives the majority of the benefits, development and operation of the microgrid is simplified. This should be considered as a preference for microgrid development but should not exclude consideration of multi-participant or community microgrids.
13. **Demonstrate and support business models that consider an "all of the above" approach:** Business models that monetize a diverse set of benefits and revenue streams can provide a higher likelihood of success because their economics are not dependent on a single value stream. Projects that take this approach should be demonstrated to identify additional opportunities and barriers for development.
14. **Enable added charges for islanding benefits of the microgrid:** Similar to selective rate-basing, consider added charges to those entities that receive electricity from the microgrid during islanded operation.
15. **Consider additional charges for microgrid customers that directly benefit from islanded operations**: Although utilities have been able to make the argument that microgrid benefits to grid operations impact all ratepayers, rate-basing microgrid projects may not be the most equitable way to account for costs and benefits when a certain segment of the community has access to emergency islanded operations and others do not.

7.4.1.3 Cost Recovery

16. **Consider the impact of fixed and/or standby charges on behavior and valuation of microgrid benefits:** High fixed charges or small absolute variable costs components that may not be offset by savings or net metering credits provide a disincentive to end users. In this case, there is little benefit that may be realized by reducing load or purchasing power from a third party.

    Additionally, fixed standby charges are meant to reflect the case where the microgrid fails to operate and the utility must step in, but their value and structure does not consider the actual risks of this occurring and, thus, may be disproportionately high. Conversely, utilities often rely on fixed charges to pay for infrastructure as a way to avoid cross-subsidization from customers that do not participate in such programs. This should be considered in valuing the benefits that the microgrid provides to the macrogrid.
17. **Enable selective rate-basing of microgrid investment to benefit recipients:** Rather than rate-basing the costs of microgrid improvements across all ratepayers (which could unfairly burden non-participants) or requiring a single payment of upgrades from the microgrid owner (which could unfairly burden the microgrid when some benefits accrue to other utility customers), consider implementing a selective billing procedure which would rate base the costs of the investment to those entities that receive the benefits of the microgrid.

18. **Realign utility compensation models to incent initiatives, such as microgrids, that improve overall system efficiency while compensating utility for legacy investment:** Reactive capital investment-based profit generation (e.g., rate of return recovery on new transmission/ distribution) discourages investment in developing otherwise equal or better energy resources such as negawatt capacity, dispatchable load curtailment, and generation-load telemetry and control investment that would result in distribution/transmission system optimization. Furthermore, it is unrealistic to expect the utility to be responsible for stranded asset costs from prior investments. This must be broadly reconsidered such that utilities support, rather than oppose, a wide variety of measures, including microgrids that improve operation of their system.
19. **Encourage consolidated billing between utility and third parties:** This simplifies the bills for end users and could enable better customer services and recovery of benefits in one place. This could be done as a pass-through charge to the customer for the electricity rate sold from a third-party to the utility.
20. **Encourage regulators to lower fixed costs on microgrid customer bills:** High fixed costs on utility electricity bills mean that customers benefit much less from purchasing energy from the microgrid and participating in real-time pricing programs.

7.4.2 Project Development and Delivery Optimization

7.4.2.1 Project Development and Finance

21. **Encourage development of new, greenfield microgrids[48]:** New construction can often be done more cost-effectively than retrofit configurations due to the added cost for re-work, in the latter case. This advantage is often not clear to developers because new construction microgrid projects are allocated a greater share of base building costs, making them look more expensive. Additionally, new construction does not initially manifest all its expected energy loads, causing capital costs to be carried forward several years. The new project will also take on the development risks of unknown tenancy and loads. Developers should be made aware of the advantages of new development microgrids, and not confuse microgrid costs and risks with total project costs and risks.
22. **Encourage developers to exhaust all sources of funding and financing:** There are many programs—including Federal, state, and local funding opportunities—that may be leveraged to help fund microgrid projects. Developers should consider all private and public funding programs, even if they are not specifically designed for microgrid applications (e.g., renewable incentives, DR programs, CHP funding).
23. **Support early stage project development:** Project development, including feasibility assessment and contract negotiation, is considered the highest risk phase in the project's life-cycle due to the high cost but uncertain success. Support, through funding and/or educational programs, would help developers by minimizing financial burden while helping to address key questions about project feasibility and risk factors. Smaller funding opportunities for early stage projects should

[48] A greenfield project is a new development without any prior constraints, as opposed to a retrofit that depends upon existing systems. Navigant expects the majority of greenfield microgrid projects to rely upon new DG installations, smart islanding inverters, advanced energy storage, automated DR, and other technologies.

structure the application and award requirements such that they do not present significant barriers to interested parties.

24. **Offer project underwriting, credit enhancement, or other services to support project financing:** Project financiers, including banks, equity providers and other financial institutions, may not fully understand the design, operations, benefit valuation, and business models of microgrids and thus charge a "risk premium" for financing these projects. Support services such as third-party underwriting or credit enhancement could entice additional investors and reduce financing costs.

25. **Consider mechanisms that can tie assets and benefits to property, not entities:** Similar to solar leases or Property Assessed Clean Energy (PACE) financing, mechanisms that tie the assets and revenue of the microgrid to the property can provide for greater certainty of the ability to recover costs in the event of default. This will help to minimize financing risks and concerns of property owners.

26. **Consider tax implications:** The ownership structure of the microgrid, and the regulatory jurisdiction in which the developer intends to operate, can have large impacts on the taxes levied on the project. Due to the variety and complexity of tax situations, there is no general guidance that applies to all or even most projects and jurisdictions. It is important that taxing authorities consider the implications of the taxes they levy on microgrid developments, as they often play a large part in determining the ownership structure and business model of the project. Likewise, as a microgrid developer, it is important to consider tax implications during initial project scoping studies, and include realistic estimates of tax payments (especially property and income taxes) in financial projections.

27. **Encourage development in areas with district heating/cooling:** Using CHP to satisfy both thermal and electric loads adds benefits to end-use customers and revenue streams to the project owner.

28. **Encourage incremental development of microgrid projects:** A roadmap plan may be preferred over upfront identification of ultimate goals for broad microgrid development. In this way, developers or policymakers may adjust their approach and plans based on lessons learned from early adopters.

29. **Identify target, preferred development areas:** Policymakers, utilities, and developers may work together to identify characteristics of optimal microgrid development sites. Using these characteristics, preferred developed sites may be identified which will result in improved and efficient project development.

7.4.2.2 Stakeholder Understanding and Engagement

30. **Assess market readiness of various microgrid technologies:** Adding to the previous recommendation, government agencies should create case studies for specific technologies used in microgrid applications. This would include pre-approved technologies as well as products still under development, demonstrating market readiness or areas that require additional work, in the context of real-world applications.

31. **Educate market participants and regulators on merits of various technical choices:** Design and technology choices can greatly affect the benefits that will result from the microgrid project. As

such, it is important that market participants and regulators understand how to design the microgrid to maximize benefits and how to properly assess the value of these designs. Developing standards and technology case studies (the previous technology recommendations) will help with this but should be further linked to monetary and non-monetary benefits of the microgrid project overall.

32. **Encourage engagement of both customers and stakeholders early in development:** Project development is often focused on securing paid customers and/or design, but can be derailed by entities outside of the project participants. To avoid unforeseen resistance from external stakeholders, project developers or owners should consider community outreach early in the process.
33. **Educate and engage regulators as a complement to formal docket proceedings:** While formal dockets will be used to flush out research, recommendations, and policies, it is also important to educate regulators about what has been successful and about all the possible ways that the benefits of microgrids may be valued—i.e., emphasize that there is not only one answer.
34. **Educate end users about the benefits of modifying usage behavior:** Load management and reduction depends on the voluntary actions of end users or permissions by end users for automated controls. To ensure proper behavior and support, education is needed to emphasize why this is required for optimal microgrid operations.
35. **Educate customers about participation in EE and DR:** Microgrid customers, especially private residents, still retain control over their own energy behaviors. To participate in the efficiency of the overall microgrid, individuals need to be educated through outreach from the microgrid owner. For residents that already have the most EE appliances, learning how to participate in DR is the next step.
36. **Engage a broad consortium of stakeholders**: Financiers, equipment suppliers, and other vendors are crucial for providing the financing and tools necessary to make the project a reality. Engaging with vendors early in the process will help avoid technology conflicts and other potential issues.

7.4.2.3 Process, Requirement, Technology and Agreement Standardization

37. **Develop template codes and education for local permitting:** In addition to state-level regulation, it is important that local authorities having jurisdiction understand how to properly assess and permit microgrids in their communities. This can be done by creating template codes, standards, and review procedures and educating these entities on how to use them. This may include building/electrical permits, emissions permits, fire plans, land rights and permit, and environmental permits.
38. **Create template tools and agreements for developers to use:** By using standard tools, the development process would be simplified, thereby reducing costs, development time, and risks. Such tools could include feasibility assessment criteria, cost-benefit analysis frameworks, or standard off-taker or lease agreements.
39. **Develop design and technology standards for microgrids to improve interoperability and security:** The limitations and challenges of combining multiple technologies and/or vendors can hamper microgrid development and design due to barriers of cost, schedule, and function. By

developing standards or pre-approved technologies, these barriers may be minimized. Government agencies should identify technologies and products that enable the effective and efficient integration of microgrid resources, to serve as a reference for microgrid project developers.

40. **Ensure vendor agreement on a common design:** Vendors in one case study encountered problems on a universal microgrid controller, and were never able to come to terms on it. Avoid this situation by using standardized components and communicating throughout the design process.
41. **Consolidate vendor management:** One company managing vendor relationships simplifies operation logistics and facilitates design and technology agreement.
42. **Create template interconnection requirements and cost expectations:** In conjunction with a clear process for evaluating interconnection, utilities and developers may work together to create a set of templates for developers to use in designing, developing and budgeting for interconnection. In this way, developers will have a checklist of requirements to meet, which will help both parties ensure that applications are complete and address mutually agreed upon parameters.

7.4.2.4 Best Practices for Design, Operation, and Technology Utilization

43. **Design the microgrid such that critical loads are separable from and prioritized over non-critical loads:** By focusing on supporting only critical loads (however, they may be defined for a specific project) during islanded operation, both capital and operating costs may be reduced.
44. **Support ongoing development of improved microgrid controls:** Controls of the microgrid, whether manual or automatic, remains one of the most complex aspects of the microgrid's equipment and operational procedures. Additional R&D is needed to create control devices and systems that may operate seamlessly with many diverse loads and generation sources.
45. **Continue development of smart grid technologies to integrate generation and load control:** Many of the case studies examined in this report use cutting-edge technology solutions as a foundation for their business case. For example, automated DR, home energy management systems, integrated solar and storage, load prioritization, and thermal load-following CHP are all features of one or more of the cases. More options for microgrid business models will arise as new technologies decline in cost and enter the market.
46. **Consider end-user customer needs in deploying automatic load controls:** Automated load controls, set by price signals or a microgrid customer's needs, can provide cost-effective, viable technical solution to realize load shift/shed benefits without the need for behavior change. However, end-users' needs and behaviors must be considered in the design of these controls to encourage acceptance by these entities.
47. **Identify and use experienced microgrid system operators:** The operation of the microgrid, including complex controls of loads, generation, and islanded transition, is best done by an entity with experience and expertise in distribution system operations to improve efficiency of the system, reduce operating costs, and reduce risks of malfunction.

48. **Require management of all resources of the project, including load and generation:** To optimize project economics, revenue generating streams must be maintained and operating costs must be minimized. This can be done through robust system controls and active management of the microgrid's operation—both of which are needed to operate the system as expected as well as respond quickly to problems.
49. **Incentivize desired load management behavior:** Managing load can be done cost-effectively to allow for optimal operation of the microgrid. Incentivizing the end users to manage their loads as desired helps microgrid operators and provides added value to the end users.
50. **Design and operate the microgrid for optimal asset utilization:** To improve project economics, the microgrid should be able to operate and provide benefits on an ongoing basis, not just during islanded operation. This may incur higher upfront capital cost than simple backup generation but will increase overall revenue and economics to the customer.
51. **Encourage individually metering customers for insight into electricity use:** When a project involves a small number of master meters rather than individually metered customers, customers have no insight into their electricity use and, therefore, no clear motivation for EE or participation in DR.
52. **Ensure customers save on energy through program participation:** Microgrid customers and real-time pricing participants can be turned off from the project through negative experiences with programs that adversely affect home comfort for the sake of energy savings, especially when participating in the program shows no real savings on their bills.
53. **Encourage implementing EE measures prior to DG:** Implementing EE measures for the facilities in the microgrid project should occur before sizing the required DG capacity. This rule of thumb applies to other projects, like typical solar PV installations, as well as to microgrids. Having an appropriately sized system will reduce capital costs for the project developer.
54. **Incentivize EE measures for customers, especially low income residents:** Microgrid owners should be encouraged to support microgrid customers' EE activities, as reducing energy consumption directly benefits the owner. Microgrid customers could be provided energy saving devices for free, receive incentives from the owner, or receive assistance for enrolling in utility EE incentive programs.

Appendix A. Glossary of Terms

Active management: Strategy where the system operators make specific decisions to control load and generation in real-time to meet project objectives.

Campus: Campus microgrids generally do not cross public rights-of-way or incorporate public utility infrastructure. Examples include a university, corporate, or government campus, a prison, or a military base.[49]

Combined heat and power (CHP): (also called cogeneration or co-gen) Supplies both electricity and thermal energy.

Community microgrids: A subset of microgrids which serve multiple buildings and multiple end users.[50]

Demand response (DR): Energy loads capable of being reduced, deferred or curtailed in response to signals regarding such conditions as energy prices or system constraints.

Distributed energy resource (DER): Encompasses all smaller-scale, dispersed forms of power generation, storage, metering, and DR.

Distributed generation (DG): Generation technologies that are connected to the distribution grid and/or the customer side of the meter.

Distribution utility: An electric power company that generates (in some cases), transmits, and distributes electricity for sale in a regulated market.

End user: An individual (e.g., resident) or organization (i.e., commercial, industrial, or governmental) that owns or leases property within the microgrid for a purpose other than operation of the microgrid and has direct control over loads served on that property. Residents in multi-family buildings are considered to be part of the same organization as the owner of the building. All commercial end users are considered as separate.

Energy efficiency (EE): A way of managing and restraining growth in energy consumption. This means the energy resource can deliver more services for the same energy output or the same services for less energy output.[51]

Greenfield: Relating to previously underdeveloped sites for commercial development.

Home area network (HAN): A type of local area network with the purpose to facilitate communication among digital devices present inside or within close vicinity of the home.

Islanding: The condition in which a DG continues to provide energy to a load when such load is not receiving energy services from the local utility.

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[49] "About Microgrids," Web, Microgrid Institute, 2014. Available at: www.microgridinstitute.org/about-microgrids.html.
[50] "About Microgrids"
[51] "Energy Efficiency," Web, International Energy Agency, 2015. Available at: www.iea.org/topics/energyefficiency/.

Macrogrid: Refers to a local distribution utility, regional transmission authority, and/or other distributor or transmitter of energy services other than the microgrid or other DER.

Microgrid: A microgrid is a group of interconnected loads and DER within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.[52]

Negawatt: A negative megawatt or a megawatt of power saved by increasing efficiency or curtailing consumption.

Off-taker: Party who is buying the product (energy) or service produced or delivered by the microgrid project.

Point of common coupling (POCC): Point in the electrical system where multiple customers or multiple loads may be connected. This point should be accessible to both the utility and the customer for direct measurement.[53]

Public obligation: Charges which cover the statutory payment for tasks that are payable by all consumers, such as expenses for R&D or energy programs.

Reliability: The ability of an energy source to generate a consistent output and remain available to meet predicted demands.

Resiliency: The ability of an energy source to be prepared, adapt to and recover from actual or potential adverse events (such as a natural disaster) that will result in outages.

Virtual power producer (VPP): Aggregated power generating capacity that is provided by multiple, real DG facilities operating in different locations.[54]

Volt ampere reactive (VAR): A unit in which reactive power is expressed in an alternating current electric power system. Reactive power occurs when the current and voltage are not in phase. Certain forms of DG can provide VAR while others cannot.

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[52] "Microgrid Definitions," Microgrids at Berkeley Lab, 2015. Available at: https://building-microgrid.lbl.gov/microgrid-definitions>

[53] "Tech Notes, Document TN-GENL-2-APQ," APQ Power, 2015. Available at: www.apqpower.com/assets/files/TN-GENL-2.pdf.

[54] "About Microgrids," Microgrid Institute, 2014. Available at: http://www.microgridinstitute.org/about-microgrids.html.

Appendix B. Contact Information

For inquiries regarding these projects, please contact the following:

Table B-1: Contact List

Project	Contact	Organization	Email	Phone
Borrego Springs Microgrid	Thomas Bialek *Chief Engineer*	San Diego Gas & Electric Co. *Project Owner*	tbialek@semprautilities.com	+1.858.654.8795
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