Beyond the Buzzwords: Making the Specific Case for Community Resilience Microgrids

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ABSTRACT

Industry professionals understand broadly that the utility of the future is working with resilient communities to supplement existing energy infrastructure with microgrids—ultimately enhancing sustainability and reliability of local energy services. However, this urban legend is typically short on specifics. Because microgrids are still an emerging concept in a variety of regulatory and market environments, there is no one-size-fits-all microgrid development. What does this emphasis on microgrid development mean for distributed energy resource professionals? Where does energy efficiency and demand side management fit? What are the lessons for resilient community advocates and sustainable urban planners?

This paper will present insights distilled from four case studies examining real-life operational microgrid projects in communities throughout North America. The case studies represent a curated list of some of the most complex and interesting microgrids constructed to date and were selected from Navigant Research's comprehensive Microgrid Project Tracker. Insights applicable to Community Resilience Microgrids from in-depth interviews and cross-project comparison will be presented; including lessons applicable for public and private microgrid developers, financiers, operators, and resilient community advocates. Stakeholders in the microgrid project development process will be mapped in a visual diagram informed by key roles directly from the cases, so interested parties can understand where they might fit in the broader microgrid development ecosystem. While each microgrid is unique, the paper will conclude with a roadmap of generally applicable practical considerations to inform stakeholders at each stage of the project, from planning, through financing, construction, and operations.

Executive Summary

In recent years, microgrids have evolved from a nascent concept to a significant source of opportunity—and concern—to players across the electric power industry. The industry has seen an acceleration of distributed energy resources (DER), but distinct drivers are pushing stakeholders to make the additional, non-trivial, investment in the ability to island. The drivers of this microgrid evolution include the following:

- Increase in frequency and duration of outages due to aging grid infrastructure and extreme weather events, and the recognition of energy resilience[1] as an economic enabler during these times

[1] The terms resiliency and reliability are used frequently within this paper. The authors agree that in terms of microgrid operation, "reliability" describes the ability of a microgrid to provide high power quality and minimize the frequency of outages (related to measures such as SAIDI, SAIFI, MAIFI, etc.) whereas "resiliency" describes the ability of the microgrid to provide power to host facilities to withstand long-term outage events.

- Increase in power quality fluctuations that cause costly interruptions for certain customers, such as medical laboratories and data centers, and the recognition of energy reliability as an economic enabler
- Rise of engaged prosumers (those who both **pro-**duce and con-**sume** energy), communities, and their advocates, which place a higher value on independent control

The budding microgrid industry is marked by complexity and uncertainty, leading many industry players to adopt a wait-and-see approach. Those who are more active, such as suppliers seeking to lead a growing market or utilities expecting growth of microgrids in their territory, are exploring new business models as a result. While most of the focus to date has been in the campus/institutional and commercial/industrial segments, there is a growing trend to expand upon these applications to serve broader needs as communities increasingly view energy resiliency as a valuable component of meeting fiduciary responsibilities for their residents. Applying lessons learned in the more familiar microgrid segments is important for accelerating the Community Resilience Microgrid segment.

This paper codifies the authors' ongoing efforts to understand this emerging market and help stakeholders develop a deeper understanding of, and sharper strategic approaches to, the growing industry. A key tool in this effort is Navigant's comprehensive Microgrid Project Tracker that houses detailed information on some of the most diverse and complex microgrid projects throughout North America and Europe. The tool provided the authors with a landscape view of this emerging market with which to hone in on projects that offer lessons for Community Resilience Microgrids for targeted analysis in this paper.

The paper covers our assessment approach and insights from a comparison of four case studies captured in the tracker that are active microgrids in the advanced markets of New York, California, New Jersey, and Texas. The case studies represent several microgrid segments and deliver insights for Community Resilience Microgrids. Navigant developed these case studies through market research, expert interviews, business model tools, and collaborative stakeholder engagement. The authors have used the following primary findings from these efforts to provide a roadmap of project considerations:

- **Microgrids are complex and do not have a widely accepted definition.**
- **The North American microgrid market is small, rapidly growing, and highly fragmented.**
- **Microgrid business models are not well-established, resulting in significant financial risk—and opportunity.**

The authors' vision for this paper is that interested parties should carefully consider the presented classification framework, market trends, Ecosystem Model, and case study comparison findings to locate their own position within the broader microgrid ecosystem. Once oriented, parties can look to the identified roadmap considerations for plotting their path forward through microgrid planning, financing, construction, and operations.

Microgrid and Community Resilience Microgrid Definition

Microgrids are the most complex and dynamic form of DER. Indeed, the definition of microgrid varies, as it is difficult for market players to agree on a common classification schema and nomenclature. While there is no universally accepted definition for microgrids, the definition that is most commonly cited comes from the U.S. Department of Energy's (DOE's) Microgrid Exchange Group:

> *A microgrid is a group of interconnected loads and distributed energy resources 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.*

Notably, this definition excludes permanently islanded electrical systems that are not connected to a larger grid, as these do not operate in grid-connected mode. However, many would contend that these systems constitute microgrids. Regardless, these remote systems are outside of the scope of this paper, which focuses on grid-connected systems.

Given the lack of an industry-standard definition, Navigant has established a classification framework, described in the following section, which is used to assess the unique properties of a given microgrid, and by which market players can use to establish a common language and begin to understand the complexity of microgrids. This paper focuses on insights for what Navigant has termed "Community Resilience Microgrids," defined as follows:

> *A community resilience microgrid is designed to serve multiple customers located within a community—a neighborhood, district, or local government jurisdiction—and its prime purpose is to provide emergency power during periods of utility power grid outages. While potentially serving the needs of both public and private entities, these microgrids must be connected to a utility distribution network and be capable of some level of safe islanding…and…are dedicated primarily to public purposes such as emergency shelters, critical infrastructure, or vital community services (Asmus and Lawrence 2015).*

Microgrid Classification Framework

Grid-connected microgrids vary across a number of characteristics. Navigant established a classification framework that groups like microgrids into segments based upon key distinguishing factors, which include: (1) grid connection, (2) scale, (3) end users, (4) objective, and (5) load served. The decision tree in Figure 1 represents Navigant's current classification framework, which serves as the basis for Navigant's market segmentation analysis. This framework is likely to evolve as the microgrid market continues to develop.

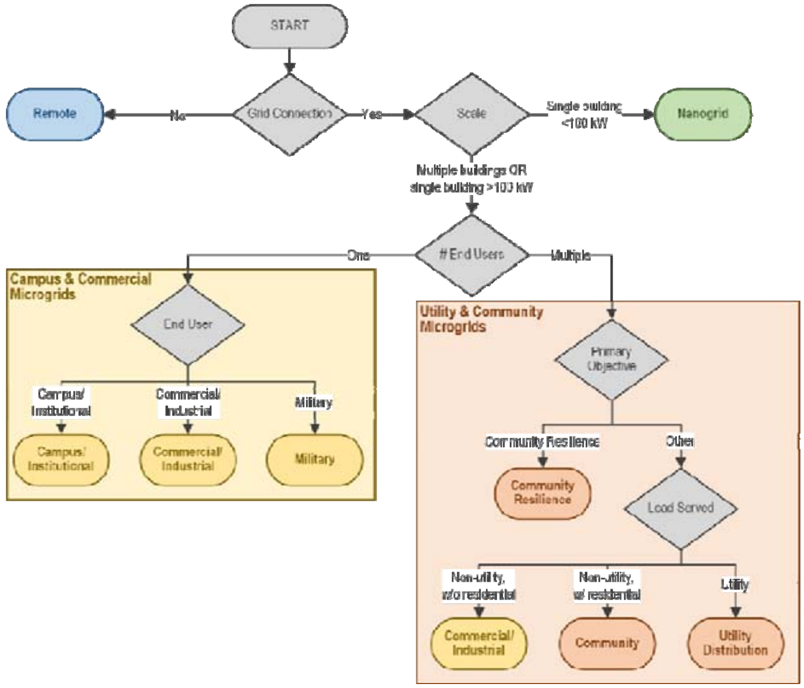

Figure 1. Navigant's Microgrid Classification Framework. *Source:* Navigant 2015b.

Market Trends

Academics from the University of Wisconsin-Madison – an institution often credited with the creation of the modern grid-tied microgrid concept (at least in engineering terms) – predict it could take 30 years for the microgrid to become ubiquitous (IEEE 2010). Yet, current trends toward a more distributed energy future appear to make microgrids an inevitable augmentation of today's centralized grid infrastructure. In the most recent Navigant Research microgrid market forecast (Q1 2016), the Community Resilience sub-segment in particular is the focus of business model innovation for grid-tied market participants, is shown to have broad political support, and is noted as vital for a wider commercialization path for the entire grid-tied market (Asmus and Lawrence 2016). The growing interest in Community Resilience Microgrids is reflected in an 8.8 percent Compound Annual Growth Rate (CAGR) for North America, as seen in Figure 2.

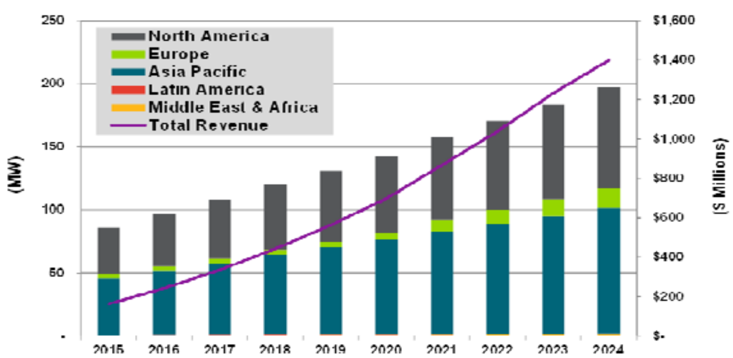

Figure 2. Navigant Community Resilience Microgrid Forecast, World Markets: 2015-2024. *Source:* Asmus and Lawrence 2016.

Community Resiliency Microgrids

Local electric service reliability is the distinguishing factor that drives the additional investment in grid-tied microgrids, as opposed to simply DER, in North America, and particularly in the United States[2]. A defining feature of Community Resilience Microgrids is that they are developed primarily to provide critical community services during prolonged outages, which in turn represent their core value proposition. Outage duration and weather trends provide an explanation for the shifting focus toward resiliency projects:

- **Outage Duration Trending Upward.** Power outages affected over 13 million people in the US in 2015 and electrical outages, surges and spikes are estimated to cost the US economy more than $150 billion in annual damages (Eaton 2015). According to estimates by Lawrence Berkeley National Laboratory outages are generally lasting 5 percent to 10 percent longer over time (Larsen et al. 2015).
- **Weather Impacts**. According to the National Oceanic and Atmospheric Administration (2016), 2015 featured ten weather and climate disasters with losses exceeding $1 billion in damage including a drought event, two flooding events, five severe storm events, a wildfire event and a winter storm event. All of these weather-related events pose risks to traditional grid infrastructure. According to the U.S. Council of Economic Advisers and the DOE, severe weather-related electricity outages cost the U.S. economy between $177 and $335 billion dollars between 2003 and 2012 (DOE 2013). These costs have prompted efforts by both government and industry to harden the grid, make it more resilient and to incorporate critical community assets into long range energy planning.

It is these weather-related and resiliency concerns, as well as other policy objectives to modernize and diversify our energy portfolio, that have driven many of the state programs to support microgrids, including California, Connecticut, Maryland, Massachusetts, Minnesota, New Jersey, and New York. Additionally, technology improvements and cost reductions are making microgrids more accessible, functional, and affordable, and industry standards – including IEEE P2030.7 and IEEE P2030.8 which address microgrid specification and testing, respectively – are changing accordingly to accommodate these new technologies. Furthermore, many are recognizing that the functionality of microgrids could help the overall grid by aggregating DER, increasing cyber security, and facilitating new business models.

Evaluating Community Resilience Microgrids as a Distributed Energy Resource

While the existing transmission grid is projected to still provide the majority of power to the industrialized world, DERs are likely to play a larger role in providing value across the customer, utility, and wholesale market perspectives. These value streams are expected to include, but are not limited to, energy, capacity, reliability, security, ancillary, and customer services and to which stakeholders these values accrue will vary by project.

Navigant is currently evaluating these value streams in an active case study on the Bosch Direct Current Building-scale Microgrid Platform (DCBMP) under demonstration in the

[2] Based on our experience surveying hundreds of North American microgrid projects to develop Navigant Research’s comprehensive Microgrid Project Tracker, see Asmus,P. 2016

California Energy Commission's (CEC) EPIC program. This Bosch DCBMP nanogrid aims to lower the cost of solar and energy storage ownership, improve load efficiencies, smooth PV output to the grid, and provide resiliency to these facilities. Bosch believes this platform provides a more attractive value proposition for electricity ratepayers than existing technologies. Once proven viable, the DCBMP could promote the penetration of those renewable energy and energy efficiency technologies to better serve emission reduction goals.

Like nanogrids, evaluation of Community Resilience Microgrid costs and benefits will be critical to their viability as a provider of services in various value streams. Navigant has developed a robust cost effectiveness framework to evaluate how the costs and benefits of the DCBMP accrue to various stakeholders: participants; program administers; utilities; and society. Navigant will use this methodology to explore the wide range of location-specific costs and benefits to customers from the DCBMP. Navigant's framework for evaluating the DCBMP nanogrid can be used for Community Resilience Microgrids to evaluate its load shaving, shaping, and sharing services across the customer, utility, and wholesale market perspectives.

Microgrid Ecosystem Model

In addition to evaluating the costs and benefits of microgrids, it is necessary to establish a common and consistent way to explain the technical, commercial, and financial aspects of microgrids when describing and defining them relative to business models and strategies. Defining the ecosystem is particularly important as the space broadens from more traditional segments, such as campus/institutional, to include Community Resilience Microgrids. Navigant's Microgrid Commercial Ecosystem Model is introduced here as the basis for the analysis component that is used to describe the commercial and financial aspects of microgrid projects, businesses, and markets (Figure 3). This ecosystem mindset is important for developing a microgrid business model and strategy with a higher likelihood of success.

Entities within the ecosystem, depicted as boxes, are collectively referred to as stakeholders. These stakeholder groups perform various tasks and functions within the ecosystem, referred to as roles. Similarly these stakeholders exchange value, depicted as arrows, in various forms between one another, referred to as value streams. To effectively operate within the microgrid ecosystem, each stakeholder must understand the perspectives and interests of the other stakeholders within the ecosystem and build support by focusing upon areas of common interest and proactively addressing areas of conflict. Ecosystem modeling may be used in either a bottom-up approach to build a model for a specific case or in a top-down approach to test a specific case against a complete model to uncover hidden risks and opportunities, depending on the specific objectives of the given application. While the model serves primarily as a qualitative tool, it can be used as the basis for additional qualitative analysis.

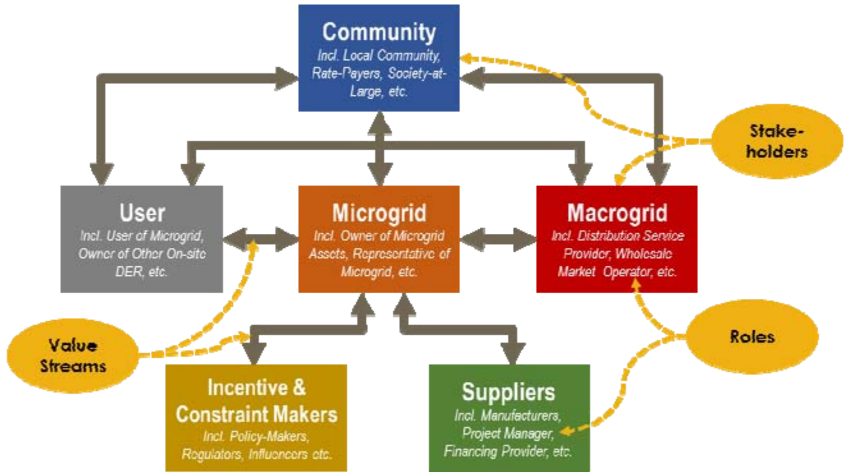

Figure 3. Microgrid Commercial Ecosystem Model and Analysis Components.
Source: Navigant 2015b.

Case Study Comparison

The authors selected four microgrid case studies, developed through a Navigant collaboration with several stakeholders, that serve community resilience roles in the advanced markets of New York, California, New Jersey, and Texas. The case studies were composed of market research, expert interviews, business model tools, and collaborative stakeholder engagement.[3] Mapping these microgrids within the Microgrid Ecosystem Model enabled the authors to highlight key takeaways and value stream implications that should be considered by various stakeholders. While these microgrids are not in and of themselves Community Resilience Microgrids, per Navigant's definition, they do provide examples of applications from which communities can gain insights for future project design and development.

- **Princeton University Microgrid, NJ.** Built as a campus/institutional microgrid, the Princeton microgrid served as a place of community refuge for days during Superstorm Sandy, with first-responders, students, and other community members using the campus for shelter and critical electric power; as such, this project presents findings for the community resilience sector. The microgrid is comprised of a 15 MW CHP plant that supplies the university approximately 50% of its annual electricity consumption, and all of its steam and chilled water, a 4.5 MW solar PV farm that supplies 6% of annual consumption, a 2.6 million gallon thermal water storage facility, and backup diesel generators available to black-start the CHP plant during outages.
- **Borrego Springs, CA.** The first large-scale utility-owned (SDG&E) community microgrid to integrate a diversity of residential and commercial loads and successfully island in a real-world situation, served by Demand Response (DR), PV, storage, and diesel generators for peak loads. The utility distribution microgrid – located at the end of a single, radial transmission line subject to damage during powerful storms – offers resilience to the town of Borrego Springs by providing electricity during macrogrid outages. The microgrid is attributed to saving dozens of lives during a 2013 event. This case is on the forefront of pioneering approaches to DR,

[3] Case studies developed by Navigant through interviews with each facility and through other publically available sources. These case studies were originally published in depth in Navigant 2015a and 2015b.

dynamic electricity pricing, energy storage, and integrating control technologies and provides SDG&E with peak shaving, price arbitrage, PV smoothing, and VAR control.

- **Co-op City, NY.** One of the largest residential end-use customer microgrids in the world (40 MW serving 50,000 inhabitants and businesses on 330 acres), configured with gas and steam turbines for CHP and large gas boilers for additional thermal energy demand. Though the configuration within the Co-op City complex makes it a campus/institutional microgrid, it offers resiliency to its host residents, businesses, and beyond; it successfully islanded during Superstorm Sandy throughout local power outages using Siemens' standard SCADA-based microgrid controls platform, and, in the unprecedented polar vortex of 2013, it was able to export 10,700 MWh to the grid. The CHP plant satisfies 90-95% of the communities' electric needs and sells approximately $1 million of electricity per year back to Con Edison at the wholesale LMP via the Buy-Back Tariff.
- **Oncor System Operating Services Facility (SOSF), TX.** Oncor's SOSF is another campus/institutional microgrid that serves as a test-bed for Oncor to learn about the benefits of resilience in order to better serve their customers in the future. The SOSF is a mission-critical site that supports Oncor's restoration operations during major outages, making resilience a high priority. The SOSF incorporates diesel/propane generators (605 kW), microturbine (65 kW), solar PV (106 kW), and storage (225 kW), and an advanced distribution automation (DA) system. A key characteristic of the SOSF microgrid is that it is built on an underground system of four interconnected microgrids – the sectionalizing scheme increases flexibility and reliability, enabling all four zones to be operated independently or in tandem, with DER serving the loads of different zones.

Project implementation insights are focused on four microgrid analysis themes; technical, operations and maintenance (O&M), financial, and islanding. The questions explored along with insights and accompanying evidence from the case studies are presented below and in Figures 4-7.

Technical

- What are the key technical considerations for the interconnection?
- What technologies are needed to enable microgrids? Where are there gaps in the market?
- How can software and data analytics improve microgrid operations?

Technical Insights	
Princeton	**Design the microgrid's distribution system with operational foresight:** Project has underground distribution with two utility lines serving each substation. PV and CHP intentionally connected to different substations, preventing PV from influencing CHP dispatch.
Borrego Springs	**Microgrids can be used to facilitate grid integration of customer-owned DER: F**rom the utility perspective, the original intention was to reduce feeder peak load by incorporating customer and utility owned DG, DR, and DA under one utility managed control scheme.
Borrego Springs	**Don't underestimate the work to integrate different technologies under one controller:** SDG&E intentionally worked with many vendors, making it difficult to find a satisfactory initial control scheme as the vendors did not have a common or optimized control protocol.
Co-op City	**Use microgrids as a laboratory for piloting smart grid technologies:** Co-op City has sufficient scale, independence, self-governance, and community motivation to become an urban laboratory for integrated smart grid technology into affordable housing initiatives.
Oncor SOSF	**Integration of advanced microgrid controls and existing grid devices will create challenges:** While built from the ground up, Oncor realizes that integrating legacy equipment with advanced control technologies will pose great technical challenges.
Oncor SOSF	**DA greatly increases microgrid reliability (and complexity):** One key characteristic of the SOSF is that switching operations can enable all four zones to be operated independently or in tandem, with different zones being served by DER in other zones.

Figure 4. Technical Insights for Community Resilience Microgrids

Operations and Maintenance

- What are safety and security concerns specific to microgrids?
- What are the largest maintenance considerations for electrical systems?
- What are the key maintenance considerations for thermal systems?

Operations and Maintenance Insights	
Princeton & Co-op	**Steady and reliable fuel supply is critical for microgrid operations:** Princeton relies almost exclusively on CHP, demanding continuous natural gas supply. Co-op purchases natural gas through interruptible rates, occasionally having to run CHP with costly diesel.
Princeton	**Plan for emergency response team needs during major outages:** Princeton requires that its employees receive hands-on and theory training from the manufacturer or vendor for each microgrid component that is installed.
Borrego Springs	**Actively manage microgrid resources even during grid-connected mode:** With 2,800 metered customers on this microgrid, SDG&E needed to put forth effort to educate customers in order to develop a reliable DR resource while maintaining customer satisfaction.
Co-op City	**Consider electric and thermal loads as separate when managing operations:** Co-op City was originally designed to serve thermal loads first, but project economics may be improved if controls are designed to optimize cost-effectiveness and revenue.
Oncor SOSF	**Crew restoration and safety procedures should reflect microgrid deployment:** The implementation phase of the SOSF microgrid project provided Oncor with a first-hand feel for changing utility practices in the face of microgrid deployments.

Figure 5. Operations and Maintenance Insights for Community Resilience Microgrids

Financial

- How can microgrids be operated to maximize value and diversify revenue streams?
- How can benefits be effectively monetized?
- How can contracts be structured to provide both revenue security and operational flexibility?

Financial Insights	
Princeton & Co-op	**A spark spread analysis is the core of the economic potential of arbitrage:** The business case for development generally falls on the most basic measures of arbitrage profitability; the spark spread. What is the gross margin/kWh? What is the local value for thermal energy?
Borrego Springs	**Future projects may necessitate local premium service charges:** No additional fees/charges to local customers during islanded operation. However, financing future projects without the assistance of grants/rate base may demand local premium resiliency charges.
Co-op City	**Consider the financial costs and benefits of grid connection:** Without relief from standby charges, the grid connection could be economically severed. With ~100% system redundancy, the complex would save ~$2M/year, and the macrogrid would lose provided benefits.

Figure 6. Financial Insights for Community Resilience Microgrids

Islanding

- What challenges exist in ensuring reliability and resiliency during an outage?
- What are the challenges in managing load during prolonged outages?
- What factors must be considered during islanding and reconnection processes?

Islanding Insights	
Princeton	**Incorporate grid-independent black-start capability and test regularly to maintain that capability:** During a storm, events leading up to a power outage are unpredictable; so are the ways in which fault detection, tripping, and load shedding sequences may occur.
Princeton	**Consider disconnecting intermittent DER during island mode:** During Sandy, Princeton intentionally tripped their solar PV farm to prevent it from risking the operation of the CHP plant.
Borrego Springs	**Identify and prioritize critical loads – load shedding is often essential for islanding:** Focus on DR and shedding non-critical critical loads decreased project costs, improved resilience, and allowed SDG&E to serve more customers for longer duration during islanding.
Princeton & Co-op	**Protecting microgrid infrastructure increases likelihood of successful islanding**: During Hurricane Sandy, the electrical and thermal infrastructure at both Princeton and Co-op City was protected from the storm because it is underground.
Oncor SOSF	**Islanding should be tested under multiple realistic conditions:** Safety features would lock the control system if operation sequences were out of order; faced failed diesel generator startups due to emission setting requirements and energy storage startups due offbeat signals.
Oncor SOSF	**Consider standards requirements during both grid-connected and islanded mode:** Protection schemes for grid-connected and island mode are completely different. They should now protect against much lower fault currents contributed by inverter-based DER resources.

Figure 7. Islanding Insights for Community Resilience Microgrids

Key Findings

The authors identified the following key findings from these case study comparisons, additional Navigant case studies, and broader microgrid research from which we developed our roadmap considerations for Community Resilience Microgrids:

- **Microgrids are complex and do not have a widely accepted definition.** Microgrids are the most complex and dynamic form of DER. Consequently, the definition of microgrid varies, as it is difficult for market players to agree on a common classification schema and nomenclature. To address this issue, Navigant developed a set of definitions and frameworks, such as the Ecosystem Model (Figure 3), which market players can use to establish a common language and begin to understand this multifaceted DER.

- **The North American microgrid market is small, rapidly growing, and highly fragmented.** There are many challenges to entering and thriving in the North American microgrid market. The market is highly fragmented, making it increasingly important to weave together years of experience from demonstration and commercial projects, digging deeper into each case, to synthesizing lessons learned to apply to future projects. For the Community Resilience segment to fulfill the projected growth rates highlighted above, it is imperative for stakeholders to learn from prior projects to replicate and scale designs and business models.
- **Microgrid business models are not well-established, resulting in significant financial risk—and opportunity.** As seen in this case study analysis and from the authors' overall understanding of the industry, bankability and replicability remain among the biggest challenges for microgrid projects, businesses, and markets. These challenges stem from the lack of clear, identifiable business models that will be profitable. Because the market is in such an early stage of development, technical and legal execution of demonstration projects can eclipse profitability concerns. The market is currently missing a deep-dive exploration of and plan for addressing so-called commercial considerations, including relationships that must be established and maintained to profit from microgrid development; the case studies presented in this paper represent just one means through which the market can learn from past experience and improve future development. First movers to establish winning business models may, therefore, have a competitive advantage within the market segments they choose to serve.

Roadmap Considerations

As the industry is still in its early stages, there is significant uncertainty and several potential directions for industry development. It is possible that Community Resilience Microgrids could expand to reflect the growth projected in Figure 2 above, but it is also possible that the segment could rely on nanogrids as a stepping stone to reach broader community microgrid adoption. The following are key considerations under these two scenarios for stakeholders to consider and evaluate while plotting their path forward through microgrid planning, financing, construction, and operations.

Scenario 1. Direct Community Resilience Microgrid Market Expansion: In this scenario, the market would build upon past successes, as described in this paper. Given the complexities of Community Resiliency Microgrids, Navigant expects the industry to develop slowly at first and then accelerate as the market becomes more adept at addressing the needs of each of these segments, similar to the past several years of development in the solar PV market.

- Regulatory authorities could acknowledge recent technology trends as well as the projected growth in the microgrid sector and develop new rules that reduce the transaction costs associated with microgrid development and open potential markets.
- Financiers and developers interested in resilience projects and their associated technology could become sufficiently comfortable with the microgrid market at-large to identify opportunities for large-scale financing of the industry by institutional investors.

- Customers could range from corporate and university campuses, to community centers, to critical facilities such as labs and data centers, to distribution utilities themselves.

Scenario 2. Nanogrids as a Stepping Stone to Community Resilience Microgrid Expansion: While microgrid-enabling technology are expected to become more advanced and less costly, the challenge of tailoring microgrid services to unique circumstances are likely to persist and could limit the overall scale of the market for Community Resilience Microgrids due to their low replicability. Nanogrids could serve as an interim technology and as the market becomes more familiar with the complexities and best applications for Community Resilience Microgrids.

- In this scenario, the near-term microgrid market opportunity is only large enough to support a handful of players, as the concept is superseded by other technologies with more compelling business models that offer nearly the same services with fewer transaction costs and market barriers. Alternatively, regulatory barriers could prevent microgrid developers from monetizing (and sharing) all potential value streams.
- The monetizable value of microgrids could be captured by a combination of building-scale nanogrids (which provide less resilience at a smaller scale without the complication of serving multiple end users), developing standard plug-and-play nanogrid solutions (which create sufficient monetizable value within certain appropriate combinations of customers, geographies, and markets), and grid-scale storage solutions (which provide ancillary and DER integration services for utilities without necessitating an islanding capability).
- The stakeholders involved with microgrid development become more familiar with the value streams related to resiliency and the market begins to transition to Scenario 1 to recognize benefits on a larger scale.

It is still too early to assign any level of certainty to whether the market will grow through Scenario 1 or 2 or any other for microgrids. These circumstances make this paper all the more timely: stakeholders mulling a proactive or wait-and-see strategic approach to this industry stand to greatly benefit from past microgrid lessons, market forecasts, strategy and business model development tools, and implementation lessons discussed in this paper.

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