Valuing Resiliency: How Should We Measure Risk Reduction?

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ABSTRACT

Combined heat and power (CHP) systems are capable of providing more-resilient, reliable, and higher-quality energy resources compared to the existing grid. This quality of CHP and CHP-based microgrids was in high relief during Superstorm Sandy, when CHP systems up and down the Atlantic coast provided their connected buildings with power, heat, hot water, and other services while the grids all around them failed. These premium resiliency benefits and the increased reliability of these systems on an everyday basis are difficult to quantify and rarely fully valued in financial decision making. Facilities that would benefit from increased resiliency and reliability may choose not to invest in CHP because the resiliency benefits are not fully embedded in their cost-benefit analyses.

Government agencies, insurance-industry partners, and organizations concerned with better quantifying risks around energy quality and security would all benefit from a concerted effort to better quantify the risks associated with the grid and the resiliency benefits of CHP. This paper identifies ways in which these risks could be better understood and ways in which the risk-reduction qualities of CHP could be better assessed. It also explores several efforts across a variety of industries that are working to better quantify and value these benefits for decision making.

Introduction

Amid the devastating news that emerged during and after 2012's catastrophic Superstorm Sandy, one bright spot shone light on a highly resilient aspect of America's infrastructure. Scattered up and down the East Coast were facilities that were able to continue providing power, heating, cooling, and hot water to residents, students, patients, and workers as the grid around them failed. These facilities were those served by onsite combined heat and power (CHP) systems. CHP systems are distributed energy generation resources that generate power and thermal energy in a highly efficient manner. They have long been prioritized as energy resources due to their cost effectiveness, emissions reduction benefits, and overall energy efficiency compared with standard centralized power generation and separate onsite boilers. However Superstorm Sandy revealed the resiliency benefits of CHP on a scale previously unseen. Water treatment centers, universities, hospitals, large apartment complexes, and other buildings that had CHP onsite were able to continue near-normal operations and in some cases became areas of refuge for people trying to find warm and safe places to wait out the storm and its aftermath.

It was clear after Superstorm Sandy that the resiliency and reliability characteristics of CHP were of immense value—to people, to institutions, to cities, to states, and to the region as a whole. State-level programs were designed specifically to encourage greater deployment of CHP and resilient CHP-based microgrids after Sandy. Yet those facilities and organizations that would benefit most from an energy system offering increased resiliency because of CHP—universities, hospitals, insurance companies, utilities, and manufacturing facilities—currently lack a clear mechanism for measuring the value of those resiliency benefits and integrating that value into their investment decision-making activities. This is the fundamental problem that this paper seeks to address.

How CHP Adds Value

There are three different benefits of CHP that all provide value by reducing a system's risk or helping it to avoid a cost. Although these are three different types of benefits, all are able to help facilities reduce instances of unexpected downtime or low power quality, which can negatively impact facilities' bottom lines.

CHP's primary resiliency and reliability benefits are best experienced in systems that can fully island from the incumbent grid, meaning that these systems can completely disconnect from the grid and offer heat or power to their connected buildings even if the local grid fails. This is what the aforementioned systems during Superstorm Sandy were able to do. In an increasing number of cases CHP systems are able to fully island as part of a larger microgrid, which is a system of multiple buildings connected by electric-distribution infrastructure that can disconnect from the larger grid and continue to serve connected loads. Microgrids very often incorporate CHP and sometimes storage—both thermal and electric—and other types of energy generation. This paper is explicitly referring to CHP systems that can island, whether that means that the CHP system alone is islanding or a larger CHP-based microgrid is islanding. Facilities connected to CHP systems that cannot island can enjoy some of the benefits discussed in this paper, but the broader systemwide benefits are best experienced by CHP systems that can island, and they are thus the focus of this paper.

The three benefits of CHP are best understood as the improvement of three major qualities of energy delivery. CHP that is able to island and serves immediately connected facilities can improve energy-system resiliency, overall energy reliability for connected facilities, and power quality for connected facilities and the grid at large.

Improved Energy Resiliency

Energy resiliency is the ability of an energy system to endure and maintain or retain sufficient operational activity during and after a major disruptive event such as a hurricane, a hacking event, or a disruption in fuel supply. It is sometimes described as dealing with "high-consequence, low-probability" events (Watson et al. 2014). It is a multifaceted characteristic that helps describe how quickly a system can return to operation after service is reduced or stopped, how long it takes to reach full operation, and whether it can insulate certain areas or customers from loss of energy services.

CHP systems improve energy resiliency because they are located closer to the site of consumption and so move power over shorter distribution lines, reducing the likelihood that power will be interrupted by falling tree limbs or debris on the (typically aboveground) distribution and transmission lines found around the country. These assets are usually taking advantage of either the reliable natural gas network or onsite fuel stores, and are typically well maintained because they usually operate on a regular basis, providing base load power to connected facilities. This contrasts with certain types of backup power supplies, which have been known to fail during emergencies due to a lack of maintenance while sitting dormant and the fact that diesel generators rely on deliveries of diesel fuel that are often disrupted during disasters (Dawson 2012). CHP systems can also start up faster than many types of standard power generation, allowing them to return to their ideal capacity in a much shorter amount of time. Finally, by directly supplying local loads with power CHP systems can reduce the strain on nearby parts of the distribution grid, alleviating stress and reducing the changes of grid component failure (Chittum and Farley 2013; Moreno-Munoz et al. 2010).

There is no widely accepted standard by which to measure energy systems or rate them for resiliency. In general measures of resiliency are expressed as probabilities of potential consequences: the probability that a major threat will occur, the probability that the system will be able to withstand that threat, and the likelihood that various types of consequences and damages will occur. Probabilities of economic losses, lives at risk, and added operating costs are some common metrics that can help characterize a city or region's degree of energy resiliency (Watson et al. 2014).

Improved Energy Reliability

Energy reliability is the measure of how many seconds, minutes, hours, or days an energy resource is down and unavailable. It is sometimes described as dealing with "low-consequence, high-probability" events (Watson et al. 2014). These might be outages of less than an hour in duration that happen several times a year and are corrected fairly quickly, but are nonetheless costly and problematic, especially for certain types of facilities. CHP systems can help improve individual-facility-level reliability in much the same way that they improve overall system resiliency. CHP systems are regularly maintained and used, unlike traditional backup resources. They use reliable fuel resources located near the point of use, and they provide thermal energy using this reliable fuel source instead of separate fuel oil or another commodity that must be delivered by truck. Unfortunately data are limited on how CHP systems perform relative to local power grids, as there is no concerted effort by the CHP industry to collect performance data and compare them to performance data for area grids. However anecdotal evidence suggests that many companies, such as Sikorsky Aircraft, Harbec Plastics, and J. R. Simplot, have found that their CHP systems offer more-reliable power than their local grids.

There are standard ways to measure some aspects of energy reliability. Commonly used metrics in the electricity sector include the system average interruption duration index (SAIDI) and the system average interruption frequency index (SAIFI). Interestingly the SAIDI and SAIFI metrics for the United States compare very unfavorably to those of other developed countries. These metrics tell only part of the story, however, and often fail to represent poor reliability in certain pockets of the system, such as vulnerable areas served by often-overloaded substations or challenged feeder lines (Rouse and Kelly 2011). Estimates of the cost of poor power reliability vary significantly but are in the tens to hundreds of billions of dollars annually (Rouse and Kelly 2011). The costs associated with poor power reliability are directly related to the cost of not being able to run a business or organization as intended due to downtime. Restaurants must turn away customers, manufacturing facilities cannot fill orders, and hospitals that lose grid power must rely on backup power systems that do not always function as expected. As with poor power quality, discussed below, outages of even a few minutes can ruin entire runs of manufacturing processes or damage equipment that has not been turned off correctly.

Improved Power Quality

Power quality is a measure of how well the electricity provided to an end user maintains its voltage and whether it exhibits harmonics, among other characteristics. Poor power quality often results from disturbances caused by certain types of connected loads. While not necessarily related to catastrophic weather events, variations in power quality nonetheless cause extensive financial losses every year. For some users these split-second variations in voltage are hardly noticeable: for example, someone turns on a vacuum in one room and the lights briefly flicker in another. For others however even brief reductions in power quality can cause serious and costly damage. Today's industrial facilities use highly sophisticated machines with microprocessor-based controls. These microprocessors are very sensitive to changes in power quality, however brief (Ferr 2015). Financial losses due to poor power quality can stem from

- Losses of raw material when a machine unexpectedly stops and perhaps ruins products in the process
- Wasted personnel time, both in working to restart a process and in handling additional outcomes of the work stoppage
- Lost revenue when the malfunctioning machinery is in a retail setting such as a hotel and customers walk away (Bhattacharyya and Cobben 2011)

A 2000 study of the impact of disruptions in power quality in the United States found that an estimated $119–188 billion is lost each year by American businesses (Bhattacharyya and Cobben 2011). That study is now over 15 years old, and in the intervening period we have seen an exponential rise in the use of microprocessors in American business activity.

CHP systems can provide improved power quality compared with relying solely on the local grid (Darrow et al. 2015; Moreno-Munoz et al. 2010). This benefit has driven investment in CHP deployment for a variety of companies that need reliable, high-quality power (Gowrishankar, Angelides, and Druckenmiller 2013).

Metrics describing power quality include the number, size, and type of voltage sags or surges, power factor, and the total harmonic distortion exhibited in the system. Activities and components on the utility side of the busbar as well as activities and equipment on the customer side can affect power quality. For this reason power-quality issues are often difficult to diagnose.

Two Benefit Channels

For the above value streams the benefits to the individual facilities hosting CHP systems and the larger utility systems in which the CHP systems reside are often conflated. Unfortunately this yields a scenario in which a wide variety of users do not receive the maximum benefits.

To the individual facility at which the CHP system is located, improved power quality can often be one of the most critical benefits. An individual CHP system may not improve power quality for a large group of utility-system users, but it is well equipped to improve the power quality at a hyper-local level. These benefits thus must be assessed at the hyper-local level and calculated as benefits either directly to the CHP system host if the host is the entity investing in the CHP system, or, if it is owned and operated by an external third party (such as a utility or private CHP developer), to the individual host within a cost-benefit framework that values individual facility benefits. Absent such a structure, that very particular benefit to the host facility cannot be captured.

The above-discussed benefits of improved energy-system reliability and resiliency are likely best assessed on a systemwide basis, or on a geographic level that parallels the substation or feeder on which the CHP system is placed. The distribution utility would need to conduct such an analysis, using data on the workings and needs of existing infrastructure.

Flawed Risk-Reduction Approaches

A wide variety of entities and organizations experience costs associated with poor energy-system resiliency, reliability, or power quality. Many of these costs are hard to predict and represent significant financial risk for these organizations. At present these entities deploy somewhat cobbled-together efforts to minimize or mitigate the risk presented by less-than-desirable energy resources. Their efforts to quantify the benefits of improved energy resiliency, reliability, and power quality are also not comprehensive. As a result they do not thoroughly consider the full costs and benefits of various energy resource options, and do not allocate capital in a manner that maximizes system resiliency, reliability, and resource quality.

Individual Facilities

Hospitals, universities, multifamily housing facilities, manufacturing centers, schools, and water treatment plants are only a few of the types of facilities that can experience significant financial harm when the energy system does not perform adequately. In order to minimize exposure to costs related to power loss, these facilities may invest in backup power generation. Hospitals for instance typically have backup power generators designed to power their most critical loads such as life-supporting machines. These backup generators are not completely reliable; they are often diesel-based generators with limited capacity and run time, and they require regular deliveries of fuel that might not be available during disasters. During Superstorm Sandy backup generators failed for hospitals in some instances, leaving some with no option other than full evacuation. Multiple facilities reported that their backup generators failed during the storm including

- New York University Langone Medical Center, which had to fully evacuate its patients when both of its backup systems failed
- Bellevue Hospital Center in New York, which experienced flooding and failure of its backup system
- Palisades Medical Center in New Jersey, which experienced the failure of two separate backup generators

Additionally, in New York the Peer 1 Hosting data center saw its backup diesel generator fail when the fuel pumps were flooded and taken offline. The data center was able to stay online only because it leveraged a human-powered bucket brigade to bring the necessary fuel up 17 stories to the site of the generators (Hamblen 2012).

When facilities consider CHP as a potential investment in risk mitigation, they consider a variety of benefits and costs in their decision making: the cost to generate their own energy, the avoided cost of buying power from the grid, the operation and maintenance costs of the system, and the avoided costs of other kinds of backup power systems. What they do not typically calculate however is the economic benefit of the improved system resiliency, reliability, and power quality. They usually understand that a CHP system could help them better weather both catastrophic and routine power outages, but they have no mechanism to fully measure what that means to them in terms of avoided costs. The most sophisticated users might have data on typical power-quality events and might be able to identify how many minutes per year they have been without power. However there is no clear standard for calculating these benefits and avoided costs, and very few facilities will be able to make educated assessments based on resiliency, reliability, and power-quality data for their local grid. As a consequence they do not include these benefits in their cost-benefit analyses, and proposed CHP projects exhibit poorer economics on paper than they would likely exhibit in the real world.

Insurance Companies

A major blackout disrupts almost every aspect of the economy, and exerts a trickle-down negative economic impact felt far beyond the geographic location and far longer than the actual duration of the blackout (Maynard and Beecroft 2015). In recent years insurers have faced immense payouts for catastrophic events, above and beyond predicted maximum amounts (McHale and Leurig 2012). Recently a lawsuit brought by New Jersey's Public Service Electric and Gas (PSEG) utility against its insurance companies was settled, with $264 million awarded to PSEG in previously unpaid coverage for losses that the utility experienced at its power generators during Superstorm Sandy (O'Neill 2015).

Insurance companies are more focused on accurately calculating risk than almost any other industry in the world. A 2012 study of US and international insurance companies found that about a quarter of them were "crafting innovative insurance products" to respond to the risks presented by climate change including, especially, catastrophic weather events (Mills 2012). Increasingly insurance companies recognize that their exposure to these events and other effects of climate change is becoming more pronounced and that their products and services must reflect current climate science and knowledge about mitigation efforts (Mills 2012).

Insurance companies offer various types of products to customers that might be called upon to cover damages related to an insufficiently resilient energy system and resulting business interruptions. These broadly fall into several categories:

- Coverage for power plants and utilities, which might seek coverage for losses related to damaged equipment, the costs of responding to and repairing damages, and costs associated with regulatory fines "for failing to provide power"
- Coverage for a loss of business income (often referred to as business interruption insurance), which can help a company make up for losses associated with many types of disruptions and are often linked directly to the financial value of lost or damaged product[1]
- Coverage for expenses incurred during a business interruption, which can help cover the additional costs a company might incur during a business interruption, such as the cost of hiring additional staff to make up for a mechanical failure
- Liability insurance for a single affected facility, which might be called upon to cover losses related to the cost of failing "to protect its workforce" or to deal with impacts of a poorly managed "polluting accident" or some other effect of a power failure
- A variety of other types of specialty coverage that may be triggered by specific situations such as event cancellation, or the destruction of shareholder value

[1] Standard business interruption insurance may not pay on claims related to the grid going down if the facility that is covered did not experience any direct damage (Bushnell 2015). However specialty insurance policies and contingent business interruption policies often explicitly cover losses related to poor power quality or total power failure, and are typically used in industries in which losses due to power failure can be substantial (Blaine 2015; Bushnell 2015).

brought on by poor management, which could be covered under the liability insurance of directors and officers (Maynard and Beecroft 2015)

In about a dozen interviews with representatives of major US insurance companies, conducted as part of this research effort, none of them indicated that their products explicitly reflect the reduced risk a facility using CHP might represent.[2] In many cases these individuals did not know about CHP and indicated that it would likely be treated like any other backup generator, despite the fact that CHP has a very different risk profile from that of a standard backup generator.

Insurance companies greatly increase their exposure to risk when they are not adequately or accurately measuring it. It is clear that in the case of risks related to the grid (and the reduced risk from installing CHP), insurance companies and their products are not taking into account new information or collecting the right data to make fully informed decisions about how certain types of distributed generation affect the risk profiles of their insured entities.

Local, State, and Regional Governments

Critical public facilities are clearly the entities that would likely suffer most from a catastrophic event as well as from unreliable power or power-quality issues. Wastewater treatment plants, public buildings that serve as areas of refuge, and law enforcement facilities and equipment all require reliable and resilient energy systems. In some cases local authorities must take on risks related to damages that insurance companies will not cover. For instance building and business owners in some areas of Florida that are prone to water- and wind-related damages are not able to get policies to cover certain kinds of damages, as insurance companies have determined that the market will not bear the premium costs required to make up for the risks associated with covering certain damages and perils (Blaine 2015; Bushnell 2015; McHale and Leurig 2012). In these situations local governments are often forced to help pay for or provide services to residents and business owners affected by outages.

Some public facilities in certain states, such as Texas, Louisiana, and Washington, are now required to consider investing in CHP during new construction or major renovations. But there is little effort to consider the various local risks associated with a failed or failing power grid and the costs borne by the public sector when energy resources do not perform as expected. For instance, during Superstorm Sandy, when a Manhattan hospital's backup generators failed city emergency vehicles were dispatched to help transfer critically ill patients to other nearby hospitals. These kinds of costs are not seen as potential costs when cities, counties, or states are considering what kind of energy infrastructure would best meet their needs.

Finally, state-level utility regulators shape the cost-benefit tests that utilities use when investing in their own generation resources as well as when they are acquiring energy efficiency and renewable-energy resources. At present resiliency, reliability, and power-quality metrics are not part of their required assessments of costs or benefits. It is worth considering whether the decision-making construct utility regulators have developed for their regulated utilities is yielding the most resilient energy system we could have. As utility regulators begin to broaden their decision-making parameters for regulated entities to include new parameters such as

[2] This research is part of a project funded in part by the New York State Energy Research and Development Authority (NYSERDA) and has included dozens of first-person interviews with representative players in the insurance, accounting, CHP, microgrid, and utility industries.

emissions, it is critical that system resiliency be included. Some states, such as New York, have begun to structure their utility regulations in a manner that seeks to encourage investments in resiliency-enhancing assets. Unfortunately the vast majority of US states are not considering resiliency in their utility regulatory schemes.

Utilities

Utilities generally plan for future resources using an integrated resource plan (IRP) or other long-range plan that considers a wide variety of potential future resources and other assets. These plans typically consider traditional generation, distribution, and transmission resources and analyze a variety of scenarios to determine which ones would most adequately and cost-effectively meet projected needs. By their very nature these plans do not assess the likelihood that certain distribution resources will be challenged by catastrophic weather events, or whether other types of infrastructure might more cost-effectively mitigate potential damages. They do not assess whether more distributed systems such as CHP, and CHP-anchored microgrids, could address specific resiliency and reliability concerns in a manner that is more cost effective than other types of redundancies and infrastructure investments. In this way the ultimate benefits of CHP are not considered from a systemwide perspective during the initial conception of long-term investment plans.

Utilities thus tend to invest in traditional resources and are not as likely to consider whether those dollars would be better spent on alternative assets that are more cost effective and more resilient. Interestingly a recent review of utility-system investment found that rising levels of investment in distribution and transmission infrastructure "was not correlated … with improvements in reliability in the following year" (Farrell 2016). Utilities are the biggest investors in this country's energy infrastructure, and yet they consistently fail to assess whether more distributed resources, strategically sited, might provide better performance and more cost-effective options for consumers.

Opportunities to Better Assess Risk and Value Resiliency

The current piecemeal approach to measuring and addressing risks related to power outages and other failures ensures that the energy system we are building is not maximizing potential system resiliency, reliability, and quality. Fortunately several current market trends and activities are opening the door to better discussions about how to value and encourage resiliency.

Efforts to Stimulate Resilient Infrastructure

Following Superstorm Sandy governments up and down the affected parts of the Atlantic coast assessed what they wanted a future energy system to look like and how their energy infrastructure could be rebuilt in a more resilient manner. As a direct result of Sandy New York, New Jersey, Connecticut, and other states developed programs and funding mechanisms to stimulate deployment of resilient microgrids, often based around CHP. In most of these programs the microgrids must be able to operate in island mode for multiple days, completely separate from the grid, and operate at very high overall levels of efficiency. These programs have seen very high levels of interest, and in some states, such as New York and New Jersey, additional funding has been secured to help deploy additional projects.

City and state leaders are now putting real resources toward the deployment of resilient energy infrastructure. This has several ancillary benefits including the strengthening of the nascent microgrid market. Utilities, insurance companies, and major institutions are considering the risks of relying solely on the existing grid and the benefits of having CHP and microgrids serving some or all of their critical loads. This represents a significant expansion of potential stakeholders in conversations about how to measure and value resiliency, reliability, and power quality.

In New Jersey and Connecticut, despite the fact that microgrids are encouraged for their resiliency, would-be users of these programs are not asked to quantify the resiliency or reliability benefits of their proposed systems. There is no clear standard that allows potential investors or owners of microgrids to fully account for the costs that their systems help avoid and the potential financial risks of continuing to rely solely on the local grid. For developers of these resilient systems a full accounting of the resiliency, reliability, and power-quality metrics would drive further demand for products and help more projects pass their customers' cost-benefit analyses.

One bright spot is the New York Prize program, which has developed a cost-benefit framework that expressly includes a full valuation of the resiliency and reliability benefits of proposed projects. Further, the New York Prize program has collected data from its area utilities about the locations that could most benefit from strategically sited microgrids, thus enabling developers and facilities to consider the direct grid-boosting resiliency benefits of potential projects (Michael Razanousky, project manager, NYSERDA, pers. comm., May 24, 2016).

To help microgrid developers value the benefits their systems could bring to the area, the New York Prize program offers this type of specific valuation guidance:

- For valuing capacity benefits to the grid developers are instructed to assess the estimated "impact of the microgrid on the distribution capacity" that a utility would otherwise have to maintain, then multiply that by the reported "prices for distribution capacity" collected by the state regulator.
- For valuing reliability benefits the New York Prize guidance relies on the Interruption Cost Estimate (ICE) calculator, a tool developed by the Lawrence Berkeley National Laboratory that assesses the average frequency and duration of outages in a given area and estimates potential losses based on the number and type of customers affected.[3]
- For valuing improvements in power quality, the New York Prize guidance similarly estimates the cost of power-quality events based on the customer type served by the microgrid and asks the customer to self-report the number of power-quality events experienced, as a baseline (Industrial Economics 2016).

The research conducted and guidance developed for the New York Prize program are among the most comprehensive ever for a CHP and/or microgrid deployment program. This recent development is an excellent tool to help other states, utilities, and project developers think about how to begin to value these benefits. However even the New York Prize guidance chooses to use reliability statistics for area utilities that exclude major storms, instead choosing the statistics that represent the outages that are within the utilities' control (Industrial Economics

[3] The Interruption Cost Estimate tool is available only online: www.icecalculator.com.

2016). This discounts the effective benefit to an individual CHP/microgrid-using customer. Nevertheless the New York Prize approach to valuing these and other benefits could be a critical starting point for other efforts to do the same.

Efforts to Encourage Better Risk Disclosure

Along with efforts by insurers to better understand their risk exposure, shareholder advocate organizations have worked to improve transparency at companies that face risks related to climate change and catastrophic weather events. Several efforts are under way to encourage executives at publicly traded companies to better disclose their risks related to power failure, community resiliency, and power quality. The US Securities and Exchange Commission (SEC) has launched a disclosure reform effort to encourage “timely, material disclosure” by companies in order to offer shareholders more-transparent understandings of company performance and risk (R. Ament Marquigny, senior counsel, ombudsman operations, SEC, pers. comm., February 29, 2016). While it is not clear that sustainability issues, and issues related to energy resources and energy resiliency in particular, will be judged “material” by the SEC, a wide variety of sustainability and corporate social responsibility organizations are advocating that they should be. Some in the accounting industry believe that these kinds of disclosures will soon be at least de rigueur for companies if not outright required.

The Sustainability Accounting Standards Board (SASB) has been a leader in encouraging both publicly traded and privately held organizations to better disclose their use of raw materials, natural resources, and other inputs in an effort to improve transparency and better represent risk (H. Phadke, interim head of standards-setting organization, SASB, pers. comm., November 12, 2015). SASB is working to encourage companies to disclose more information about energy use, energy management, and the degree to which operations rely on the local grid. SASB develops standards and guidance on a per-sector basis, targeting industries such as health care, transportation, and aerospace.

Increasingly shareholders and other stakeholders are paying attention to questions of energy resources, reliability, and resiliency. Better information about risks related to energy resources helps investors and others make better decisions about how to allocate capital. Efforts to improve transparency via improvements in financial disclosures are one way to increase demand for this kind of data and information. These efforts could stimulate demand for better metrics around resiliency and reliability.

Efforts to Rate Utilities on Their Quality

One of the major challenges facing facilities, insurance companies, and other stakeholders that would benefit from more-accurate evaluations of the value of CHP is that the risks associated with relying on the local grid are not well known. If utilities report any reliability data they typically do so on an average basis, and as mentioned earlier this muddles the picture and obfuscates poor power quality or reliability experienced in certain pockets of the system.

While we now rate refrigerators, cars, and even buildings on their energy efficiency and performance, we do not have a rating system for our electric utilities to help consumers better understand how their utilities compare to others based on efficiency level, emissions intensity, reliability, and other metrics. As consumers seek out more-reliable and resilient power systems and information on alternatives to relying on the incumbent grid, data on local utility performance are increasingly in demand. Fortunately several existing processes and efforts are already improving data collection and reporting around utility-system performance in the United States.

One program working to meet the demand for better comparison data is the Performance Excellence in Electricity Renewal (PEER) effort, which is administered by Green Business Certification Inc. (GBCI), the entity behind the administration of LEED certification for buildings. The PEER standard considers a variety of characteristics when rating and certifying utility systems. These include reliability and resiliency, energy efficiency and environmental impact, the operational effectiveness of the organization, and customer contribution and access to emerging technologies and opportunities (GBCI 2015). PEER aims to certify large utility systems as well as microgrid and district energy systems at the municipal and campus scale.

Confidence in CHP System Performance

Data on how CHP systems and CHP-based microgrids perform in situ are scarce. Such data could include the frequency with which CHP systems unexpectedly go offline and the reliability performance of CHP when weather events and other events are negatively impacting the grid. While many anecdotes about system resiliency were collected after Hurricane Katrina and Superstorm Sandy, there is no available database of the performance of CHP and microgrid systems. Further, there is no repository of information available for developers or investors who wish to see how different CHP systems and system configurations operate on a day-to-day basis. To address this the New York State Energy Research and Development Authority (NYSERDA) and the US Department of Energy (DOE) have developed programs that vet different CHP developers using a variety of CHP equipment for system performance. NYSERDA has also established the most extensive database of operations data collected from real systems operating in New York State. The DOE program expects to help customers better understand how certain systems will operate, and will support system configurations by developers that agree to adhere to a multiyear warranty on their systems' performance. These efforts are helping and will continue to help the CHP market mature and will likely yield significant new data on how these systems perform.

One sign that the market has begun to mature and that CHP performance is generally viewed as reliable is the establishment of insurance products that underwrite the performance of CHP systems. Companies such as Energi and Hartford Steam Boiler (a subsidiary of the reinsurance giant Munich Re) are writing policies guaranteeing certain levels of performance from CHP systems. This activity is relatively new and is another indication that as market players better understand the risk profile of CHP systems, CHP systems will appear to be attractive and dependable assets (R. B. Jones, senior vice president of research and engineering, Hartford Steam Boiler, pers. comm., October 5, 2015; C. Lohmann, vice president of alternative energy, Energi, pers. comm., August 26, 2015).

The DOE has also supported efforts to define resiliency characteristics and deploy CHP and microgrids as a strategy to increase the resiliency of the US energy system. Sandia National Laboratories, the National Renewable Energy Laboratory, and the DOE in general are working on modeling the operation and performance of various CHP and microgrid designs and measuring the performance metrics of in-place microgrids to better understand how they function and how they can strengthen the existing grid.

As microgrid and CHP programs continue to move these markets from niche plays toward wider adoption, more data will help more sectors become comfortable with the benefits of CHP versus the existing grid.

A New Path Forward

Significant challenges remain in encouraging market players to better value the resiliency benefits of CHP and appropriately assess the risk associated with relying solely on the grid. The above-mentioned activities present new opportunities for moving this conversation forward.

Coalescing around a Value of Resilience

Today CHP and microgrid developers, city leaders, state policymakers, utility executives, and those working independently to measure, collect, and analyze data on utility, CHP, and microgrid performance are all facing the same question: how do we adequately value the resiliency benefits of these new types of energy infrastructure, and how do we adequately assess the risk associated with our critical facilities, schools, residential complexes, manufacturing facilities, and so forth relying solely on our increasingly vulnerable grid? Based on the interviews conducted for this paper it is clear that these questions are vexing to a broad group of stakeholders with considerable financial interest in finding answers.

Therefore we suggest that a coalition of interested parties be formed to share information about data availability and discuss data gaps. This coalition should include

- CHP and microgrid developers, which can share real-world data on system performance and their various approaches to helping customers think about the resiliency, reliability, and power-quality benefits of their systems
- Representatives from the microgrid industry, who in particular have recently expressed a desire to share more data among companies in order to better understand how their particular family of solutions is working in real life
- Insurance companies offering business damage and liability insurance products, which can share information about their different exposures, the value they see in mitigating various types of risks, and the type of data their industry needs in order to better underwrite particular risks
- Insurance companies that offer insurance products guaranteeing the performance of various energy systems, which can indicate the kinds of data they rely on to underwrite various types of systems and system configurations
- Utilities, which can share information about their system performance and the performance of microgrids that are in synchronous interconnection with their distribution systems
- State utility regulators, which can discuss whether resiliency, reliability, and power-quality metrics have a place in existing cost-benefit analyses and what data they might need around CHP and microgrid performance in order to alter their cost-benefit analyses
- Advocates for enhanced transparency for shareholders and for improved disclosures, such as SASB and the SEC's Office of the Investor Advocate, which can help establish guidelines and protocols on disclosing information related to the energy-related risk exposure of highly energy-dependent companies

The goal of this gathering would be to identify current practices in valuing and measuring risk-reduction benefits and to assess whether enough data exist to consider the development of standardized approaches to measuring these benefits. It is too early to determine whether some of the previously discussed approaches to valuation are best practices because the actual performance of these systems has yet to be fully evaluated. Despite this the coalition could work together to catalog these approaches, identify where data gaps exist, and determine whether certain stakeholders or types of stakeholders might be well suited to help build up such data. Existing metrics such as SAIFI and SAIDI could be assessed for their usefulness in these efforts.

This proposed coalition may be well suited as an extension of existing and planned PEER activities, or it may take another form, aided by existing DOE activities or those at the national laboratories. It may be that such a coalition will need to operate as a series of smaller gatherings and that certain companies will need to contribute either anonymously or in smaller groups in order to protect proprietary information or trade secrets.

Integrating Resiliency into Energy Planning

In parallel with the above-described activities designed to encourage a coalescing around metrics and valuation, energy systems around the country could do more to deploy capital toward more-resilient assets and away from less efficient ones. Typical IRP activities at the utility level do not assess whether resiliency, reliability, and power quality could be better achieved with alternative assets such as CHP and CHP-based microgrids. Since the resiliency-boosting aspects of distributed generation are not calculated, decision making at the utility level fails to assess such benefits. Two states are undertaking new planning efforts at the utility level that may address this long-standing oversight.

In California a switch from IRPs to distributed resource plans (DRPs) is a major effort to begin accounting for the locational resiliency and reliability benefits of distributed resources. California's investor-owned utilities have all developed DRPs that begin to determine which types of distributed resources make the most sense for all consumers, considering the degree to which certain feeders, substations, and other infrastructure elements are already operating at or near their maximum loads or ages. In New York the Reforming the Energy Vision effort explicitly begins to propose metrics for assessing the resiliency and reliability impacts of various energy-infrastructure assets. In this way utilities are beginning to ascertain whether resources such as CHP and CHP-based microgrids could be the most cost-effective way to meet future energy needs and boost system resiliency.

Many other states are considering future changes in their utility planning processes. California and New York offer examples of how to begin to develop metrics in the resiliency and reliability space. Critically, both states encouraged incumbent utilities to share data related to known vulnerabilities, in order to better assess a variety of potential location-specific solutions.

Challenges along This Path

Despite the overt resiliency goals of certain states affected by Superstorm Sandy and other states that have identified resiliency as a near-term policy priority, programs to encourage the deployment of CHP and microgrids, and the companies that are proposing new projects as a part of these programs, have not coalesced around a set of resiliency metrics. Resiliency has only recently emerged as a major market driver, and it is likely that the market would coalesce around standard metrics over time. However we do not have time. By misallocating capital into less resilient options when cost-effective, more resilient options exist based on proven technology, we are setting ourselves up for far worse financial pain later.

In order to adequately promote the deployment of resilient infrastructure, policy goals must be aligned with stated resiliency goals. Energy efficiency programs, emissions reduction policies, and cost-effectiveness requirements can all impact the types of energy infrastructure selected. In some cases it may make sense to lose some overall energy efficiency if a system can offer more-reliable power. It may be cheaper in the near term to deploy diesel generators to offer backup capabilities, but those diesel generators are ultimately less reliable and also contribute much more to local air pollution. In order to build a just, clean, and resilient energy infrastructure, these considerations must be taken in concert. At present, they are handled in a piecemeal fashion.

Additionally, the fuel resources that CHP systems and CHP-based microgrids will rely on will often be the same fuel resources that other types of infrastructure will depend on during times of catastrophe and crisis. This was most recently experienced during the polar vortex–induced cold wave of 2013–14, during which constraints on the natural gas distribution system were experienced as both electric generators and direct-use gas customers leaned heavily on the natural gas system to stay warm in frigid temperatures. These types of cross-industry and cross-geography challenges must be considered from a broader societal perspective. Individual utilities, industries, and even state agencies cannot adequately consider appropriate solutions. Region-wide efforts will be required to assess whether certain types of energy infrastructure make more or less sense given known data on fuel availability. These types of efforts do not currently exist, but a coalition of regional emergency-management agencies as well as the affected regional electric-reliability councils might be the appropriate way in which to begin this discussion.

Changing the existing approach to utility planning to better include assessments of the resiliency impacts of various investments will require immense political effort. However the examples in California and New York show that such changes are not impossible. Other states do not need to start from scratch and could begin to determine whether the metrics and valuation approaches used in the California DRP and New York Prize cost-benefit analyses are useful starting points for their own utilities.

Finally, convincing individual companies to better disclose their risks, and encouraging insurance companies and shareholders to better assess these risks, will likely meet with significant resistance. US companies subject to SEC regulations are already required to disclose in their annual reports information that is material to their business. A cursory search of the annual reports of American companies with significant exposure to grid uncertainty reveals that this risk is disclosed in a single sentence at most, referring generically to risks of power outages or power failures. The reports do not quantify these risks or explore them further. They do not disclose the use of CHP or microgrids, even among companies that rely on them significantly, such as Bristol-Myers Squibb, which invested in a major CHP and microgrid upgrade at one of its New Jersey plants following Superstorm Sandy (Pathakji 2016).

Conclusion

Increased deployment of CHP and microgrids will yield significant benefits to the people, businesses, and organizations that need resilient, reliable, and high-quality energy systems. These benefits come in the form of increased system resiliency, improved energy reliability, and improved facility-level power quality. Only very recently have these types of energy systems been prioritized for their resiliency benefits, and even then a full accounting of these benefits does not typically occur. This has led to the undervaluation of the benefits of these systems, and insufficient exploration of the risks of relying on business-as-usual energy infrastructure.

A number of different efforts are under way to increase the efficient allocation of capital and to better understand the performance metrics of CHP systems and the existing grid. These efforts offer a significant opportunity to engage a wide variety of stakeholders in this issue and to explore whether some common standards and data-collection efforts could be mutually beneficial. Utilities are beginning to conduct their own assessments of how such distributed systems could benefit their system users. This is a clear sign that utility resistance to CHP and microgrids is ebbing in states where utilities see a business opportunity in these resources. This is a very good sign for advocates of increased use of CHP and microgrids, as utilities are the actors best positioned to assess the resiliency and reliability impacts relative to their existing infrastructure, which will help move more projects forward.

This paper recommends the following two near-term actions for encouraging greater valuation of the risks associated with different types of infrastructure and the benefits of various types of distributed resources such as CHP and microgrids:

- Assess whether the existing cost-benefit tests employed by utilities and state regulatory agencies to determine appropriate utility investments could be enhanced to include greater and more nuanced analyses of the resiliency, reliability, and power-quality costs and benefits of CHP and CHP-based microgrids
- Build a group of stakeholders interested in valuing these benefits to determine whether existing approaches to valuation have certain common metrics and approaches that could be described and shared with a broader group of stakeholders, and whether data gaps exist that all stakeholders would benefit from filling. This stakeholder group could help compare proposed costs and benefits with what has actually been experienced in real projects, in order to build the data bank of true measures of premium reliability, resiliency, and power quality offered by these systems.

Engaging such a disparate group of stakeholders to continue to work toward agreed-upon approaches to valuation will be no small task. No single entity will be able to guide this conversation, but it is beginning to happen naturally, albeit in a piecemeal, disorganized way. The information need is great, and the demand for this information will only grow. When we fully account for the premium resiliency benefits of CHP, we will make better decisions about how to invest in our energy future.

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