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Energy Resiliency Panel

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QUANTIFYING THE RESILIENCE VALUE OF DISTRIBUTED ENERGY RESOURCES

I. INTRODUCTION

Extreme weather events, [1] which are occurring with increasing frequency as a result of climate change, [2] threaten the reliability and resilience of the nation's electricity grid. Increased flooding due to intense rainfall, hurricane damage fueled in part by a warmer atmosphere and warmer, higher seas, and widespread wildfires caused by extended drought conditions constitute potential hazards for utility infrastructure and delivery of ***16** essential electricity service. [3] As a possible adaptation strategy, increased deployment of distributed energy resources (DERs), which are small-scale generating resources located near--and connected to--a load being served with or without grid interconnection, [4] can improve the resilience of the electric system in the face of the increasing frequency of extreme weather events, by avoiding some of the systemic vulnerabilities of a centralized large grid. [5]

The experience of Hurricane Sandy (ultimately downgraded to "Superstorm" Sandy by the time it hit the coasts of New York and New Jersey in late October 2012) provides a case study of the resilience benefits of DERs, and the lessons that can be learned as utilities plan for increasingly frequent extreme weather events of the future. Superstorm Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season, resulting in 286 deaths and $68 billion in damages. [6] The storm's diameter extended almost 1,000 miles, and produced a storm surge of 14 feet at the Battery in lower Manhattan that was at least three feet higher than prior reported storm tides. [7] Approximately 8.5 million utility customers along the eastern U.S. lost power during Sandy. [8] Apart from the sheer magnitude of the disaster in terms of fatalities and destruction, Superstorm Sandy provided a "wake up call" for energy providers, and electric utilities in particular, on the need to adopt a different set of long-term planning tools to improve the resilience of the electric system to cope with the anticipated extreme weather events of the future.

One such tool is an expanded role for DERs and microgrids. If the electrical grid is impaired, DERs can be configured to "island" from the grid, thereby ensuring an uninterrupted supply ***17** of power to utility customers within a "microgrid."[9] That was the experience from Superstorm Sandy, where the use of microgrids and DERs enabled power to be provided to pockets of consumers in the face of widespread outages of central power plants and the associated transmission and distribution (T&D) systems. While extended power outages affected the region for days, many commercial and industrial facilities and educational institutions in the area (including Princeton University's campus in New Jersey and New York University's campus in lower Manhattan) were able to continue operating uninterrupted, due to on-site DG facilities, primarily cogeneration or combined heat and power (CHP) facilities.[10] DG resources offer the opportunity to improve the resilience of the electrical grid, mitigating the impacts of an emergency by keeping critical facilities running without any interruption in service.[11]

At the same time, it is difficult to quantify the resilience value of DERs and microgrids. To what extent is the grid more resilient due to the presence of DERs? What are the tools available to place a value on this increased resilience? Is it possible to place a value on the continued availability of critical facilities during an extended grid outage? As states move away from compensating DERs through net metering--based on the serving utility's retail rate toward a system based on paying DERs according to their actual contributions to the grid--it becomes increasingly important to try to place a value on the resilience ***18** benefits that DERs provide to the grid, to ensure that DER owners and operators receive accurate price signals to stimulate an economically efficient level of investment.

This article describes the experience of Superstorm Sandy and the resilience benefits that were provided by DERs and mircrogrids during that particular extreme weather event. The article then discusses recent developments in the approaches for compensating DERs, which is driving the need to quantify the resilience benefits of DERs. Next, the article will review recent efforts to place a value on the resilience benefits of DERs, followed by some concluding observations.

II. SUPERSTORM SANDY AND THE SUCCESSES OF DERS

A. The Impact of Superstorm Sandy on Utility Systems in the Northeast

Superstorm Sandy was the worst natural disaster to strike Con Edison's customers in the history of that utility, causing five times as many outages as the next-largest storm, Hurricane Irene.[12] In Sandy's immediate aftermath, 1,115,000 of Con Edison's 3.3 million customers were without power.[13] Con Edison (and its mutual aid crews) ultimately replaced 140 miles of electric cable and responded to damages at 30,000 different locations, and used a six-month supply of utility poles and transformers in a single week.[14] "Within 12 days, the company had restored service to 98 percent of the customers affected by the storm."[15]

In New Jersey, Superstorm Sandy was the largest and worst storm in the history of PSE&G, affecting approximately 2 million of its customers.[16] The impact of Superstorm Sandy involved more than twice the number of customers than were affected by Hurricane Irene, with over 90 percent of PSE&G's customer ***19** base losing power.[17] Ninety-six electric substations, or 39 percent of its substations were affected, and 51 of 154 PSE&G transmission lines, or 33 percent of lines, totaling 1,517 miles in length, were interrupted.[18] In PSE&G's service territory, 355 of its sub transmission lines, totaling 2,499 miles in length, were interrupted, 320 miles of conductor were replaced from Newark to Pittsburgh, 2,427 utility poles were replaced and/or damaged, 1,022 transformers were damaged, and 1,282 overhead and underground distribution circuits were damaged.[19] PSE&G estimated the cost associated with the restoration of its distribution and transmission system following the impact of Superstorm Sandy and the subsequent Nor'easter was approximately $250-$300 million.[20]

B. The Performance of DG Resources during Superstorm Sandy

Following Superstorm Sandy, the consulting firm ICF International prepared a report highlighting the role of DG resources, and CHP facilities in particular, in improving the resiliency of critical infrastructure facilities during the extended power outages caused by Superstorm Sandy.[21] "Critical infrastructure" facilities were defined to include "those assets, systems and networks that, if incapacitated, would have a substantial negative impact on national or regional security, economic operations, or public health and safety."[22] The *ICF Report* includes fourteen "case studies" where CHP facilities improved system resiliency through "mitigating the impacts of an emergency by keeping critical facilities running without any interruption in electric or thermal service. The report noted that depending upon how the CHP system is configured, it can continue to operate even if the electricity grid is impaired, thereby "ensuring an uninterrupted supply of power and heating or cooling to the host facility."[23]

Included in the case studies were four microgrids operated by educational institutions, where the campuses essentially ***20** disconnected from the grid and relied on self-generated power and heat. The Washington Square Campus of New York University was served during Superstorm Sandy by a 14.4 MW combined cycle CHP system installed in 2010.[24] The electricity generated supplied twenty-two campus buildings, while the steam is used to produce hot water for thirty-seven campus buildings and meets 100 percent of their space heating, space cooling, and hot water needs.[25] NYU's core campus maintained both power and heat during Superstorm Sandy; the University's CHP system went into island mode when the local grid went down, isolating itself from Con Edison's network.[26] The system provided uninterrupted electricity, heating, and cooling to the campus, and also enabled NYU and New York City officials to set up a command post on the campus as well as serve area residents forced to evacuate their homes in the wake of the storm.[27]

Princeton University in Princeton, NJ has a district energy facility consisting of a 15 MW gas turbine CHP system that produces electricity, steam, and chilled water for the campus.[28] During Superstorm Sandy, the University was able to continue running normally due to the CHP plant.[29] Princeton disconnected from the grid and used its district energy CHP system to power the campus, and the plant produced 100 percent of campus energy needs from Monday evening to Wednesday evening when the University was able to receive power from the grid again.[30] The CHP system was also able to provide uninterrupted steam and chilled water service.[31]

Two other college campuses had similar experiences. The College of New Jersey in Ewing, NJ, with its 5.2 MW gas turbine, also went into "island mode" during the storm, severing the connection between the campus and the electric grid so that the campus could continue to operate despite grid disruptions.[32] The campus stayed in island mode for about a week, because of severe utility infrastructure problems.[33] Salem Community College in Carney's Point, NJ, disconnected its 300 kW microturbine facility from the grid on Sunday morning, October 28, and it operated continuously until the morning of November 1, allowing ***21** the American Red Cross to open a disaster relief shelter in the DuPont Field House in Davidow Hall at 6:00 pm Sunday evening in preparation for the storm.[34]

Several hospitals equipped with on-site DG resources also functioned normally during Superstorm Sandy and its aftermath. South Oaks Hospital in Amityville, NY, isolated itself from the Long Island Power Authority (LIPA) grid on the evening of October 28 and remained disconnected from the grid for approximately fifteen days.[35] It was able to provide critical services for two weeks relying solely on its 1.25 MW reciprocating engine CHP system.[36] The area surrounding Greenwich Hospital in Greenwich, Connecticut, lost power due to Superstorm Sandy for approximately seven days but, due to its 2.5 MW reciprocating engine CHP system, Greenwich Hospital was able to continue normal operations throughout the storm.[37] The Christian Health Care Center (CHCC) in Wyckoff, NJ is equipped with a 260 kW microturbine and three emergency backup generators.[38] During Superstorm Sandy, the CHCC ran smoothly, with only a momentary loss of power, and ran independently of the grid for ninety-seven hours, meeting all of its residents' power, heat, and hot water needs.[39]

With the benefit of on-site DG resources, a housing development in The Bronx, NY was also able to maintain heat and power for its 60,000 plus residents, notwithstanding the heavy impacts suffered in the surrounding area, with trees blown over and extended power outages.[40] Co-op City, one of the largest cooperative housing developments in the country, is spread out over 330 acres in the Bronx, and includes 14,000 apartments, thirty-five high-rises, seven clusters of townhouses, eight parking garages, three shopping centers, one high school, two middle schools, and three grade schools.[41] It is served by a 40 MW natural gas-fired combined cycle CHP plant installed in 2011, which provides about 95 percent of the electric and thermal needs of the community.[42]

***22** On Long Island, a district energy CHP system providing thermal energy to Nassau University Medical Center and Nassau Community College was able to continue operating throughout the storm and its aftermath, without any operational issues.[43] The 57 MW system, operated by Nassau Energy Corporation in Garden City, NY, as also able to continue supplying power to the Long Island Power Authority.[44]

Another form of critical infrastructure--data centers providing hundreds of companies with office telecommunications support--benefitted from on-site DG resources during Superstorm Sandy. The Public Interest Data Center at 50 West 17th Street in Manhattan, with its 65 kW microturbine-based CHP system, was able to remain fully operational even though power to the building and surrounding area was out for over two days.[45] Finally, a major manufacturing facility was able to continue operating, and became a "center of refuge" for the surrounding area when its facilities were opened up to provide showers and cell phone charging, and the cafeteria offered meals and a source of clean water.[46] The Sikorsky Aircraft Corporation in Stratford, Connecticut, is equipped with a 10.7 MW gas turbine that supplies 84 percent of the two million square foot facility's power needs and a CHP system that provides 85 percent of the facility's steam heating needs.[47] The facility's CHP system did not experience any disruptions during Superstorm Sandy, and 9,000 people were able to come to work the day following the storm.[48]

III. THE EVOLVING APPROACHES FOR COMPENSATING DERS

A. Moving Away from Compensation Based on the Retail Rate

The vast majority of states in the U.S. have net metering in place, which generally requires utilities to purchase the output of customer-sited DERs. According to the DSIRE website, forty-four states plus the District of Columbia have mandatory net metering rules in place.[49] Net metering historically used the retail rate of the serving utility as the basis for compensating ***23** DER output.[50] In other words, the output of a DER would simply offset purchases that the customer would otherwise make from the grid, and the serving utility would effectively pay the equivalent of its retail rate for any net deliveries from the DER. While not necessarily a price that precisely reflected the value of the contributions of a DER to the electrical grid, using the retail rate was understandable and fairly easy to administer.

In more recent years, solar photovoltaic ("PV") installations began to achieve significant penetration in solar-favorable states such as Arizona, Nevada and Utah, and the costs of solar PV installations continued to decline through increased panel efficiency and reductions in "soft costs" associated with installations. In response, policymakers began to evaluate cross-subsidization issues (i.e., whether continuing to pay the retail rate for DER output resulted in generating customers being subsidized by non-generating customers). Several states commenced proceedings to revisit net metering rates, with an eye toward setting a rate for net deliveries to the grid reflecting the actual value these resources contributed to the grid.

One such state, Minnesota, passed legislation in 2013 requiring a determination of the value of distributed solar PV installations, or a "value of solar" rate.[51] The process required by the legislation produced an extensive analysis quantifying the benefits produced by interconnecting distributed solar PV facilities to the utility grid.[52] The 2013 legislation required a number of benefits from distributed PV to be quantified, including the value of fuel costs, generation capacity, transmission capacity, transmission and distribution line losses, and environmental value.[53] The goal of the process was to produce a tariff for buyback rates that the utility would pay for solar-generated power, with tariff rates that would "quantify the value of distributed PV electricity."[54] If the rates are set correctly, "the utility and its ratepayers would be indifferent to whether the electricity is supplied from customer-owned PV or from comparable ***24** conventional means."[55] Under the methodology filed with the Minnesota PUC in January 2014, a value was placed on the fuels cost avoided by the utility, based on the PV output displacing natural gas-fired units during PV operating hours.[56] Similarly, the PV unit would allow the utility to avoid generation capacity cost--the capital cost of generation the utility would be built to meet peak load--as well as avoided transmission capacity and distribution capacity costs--the capital cost of transmission and distribution facilities that will not have to be built. [57] The methodology also allowed for "adders" for location-specific avoided costs, to allow higher rates to be paid in areas wither capacity is most needed. [58] Investor-owned utilities were authorized to apply to the Minnesota Public Utility Commission for a "value of solar" tariff as an alternative to net metering. [59]

In what was described as a "groundbreaking methodology" at the time, Minnesota added a "'climate factor' to utility rates based on potential dollar damage to society from future storms and flooding caused by the impact of rising global temperatures." [60] The "avoided environmental cost" is calculated based on the federal social costs of carbon dioxide (CO_2) emissions and on the Minnesota PUC-established externality costs for non-CO_2 emissions (including particulate matter (PM_{10}), carbon monoxide (CO), lead (Pb), and nitrogen oxide (NO_X). [61] In the sample calculation of the "Value of Solar" tariff, 13.5 cents per KWh is paid for the output of a solar PV installation. [62] Nearly half of that amount, or 6.6 cents/KWh, represents the avoided fuel cost, while 3.1 cents/KWh represents the avoided environmental cost. [63]

B. New York's "Value Stack" Approach

The New York Public Service Commission ("NYPSC") has attracted considerable attention with its "value stack" approach to compensating DERs. As part of its "Reforming the Energy Vision", or "REV," proceeding initiated in April 2014, the NYPSC in March 2017 commenced a "value of distributed energy ***25** resources" proceeding to determine the value of contributions provided by DERs to the grid, as a successor to the traditional net metering tariff based on retail rates. In its VDER TRANSITION ORDER, the NYPSC directed that compensation for eligible DERs transition from net energy metering to the value stack, which is a "compensation structure for ... [DERs] based on the benefits they create and the costs they impose." [64] DERs subject to the value stack receive compensation for the energy they inject into the grid for a set of values calculated based on the utility costs they offset, as follows:

- Energy Value, based on the energy commodity purchase offset by each kWh injected, generally measured by reference to the location-based marginal price ("LBMP") as determined by the New York Independent System Operator;

- Capacity Value, based on the purchase of installed capacity that is offset by the injections from the DER;

- Environmental Value, based on the higher of (1) the procurement price for a renewable energy certificate (REC), or (2) the social cost of carbon;

- Demand Reduction Value, based on the distribution costs offset by injections, averaged across the utility's service territory; and

- Locational System Relief Value, which is available only in locations that the utility has identified as having needs that can be addressed by DERs and based on the higher, specific distribution costs offset by injections in that area. [65]

The VDER docket since March 2017 has been focused on developing values for each of these components, to be incorporated into the successor net metering tariff to become effective as of January 1, 2020. Without exploring the details of those deliberations and decisions of the NYPSC, the essential point of the discussion is the increased emphasis on determining the dollar value of the benefits that DERs contribute to the grid. In a sense, if the value cannot be quantified, then it may not be compensated under either New York's value stack approach or the "value of solar" approach followed by Minnesota and other states. In the case of resilience benefits, the next section describes ***26** some of the efforts that have been made to quantify the benefits that DERs provide to the grid in the form of increased resilience.

It is particularly urgent for CHP resources that a dollar value be placed on the resilience benefits they provide to the grid. As noted in Section II.B. above, CHP facilities--and microgrids reliant upon CHP facilities--performed particularly well in "keeping the lights on" in the aftermath of Superstorm Sandy. Because these CHP facilities were fueled with either diesel fuel or natural gas, however, they will not fare well under the benefit-cost analysis ("BCA") employed by the NYPSC for valuing DERs. Under the NYPSC's Order Establishing the Benefit Cost Analysis Framework, the Commission determined that the impact of carbon dioxide (CO_2) emissions from DERs need to be reflected in the BCA framework.[66] According to the NYPSC, "[a] bridge to the future that recognizes the cost of carbon is needed," and the Commission cited the social cost of carbon as determined by the Environmental Protection Agency ("EPA") as the starting point.[67] Given that a price is already placed on carbon in New York through the emissions trading program operated by the Northeast Regional Greenhouse Gas Initiative, or "RGGI," the NYPSC determined that the value used in the BCA analysis would be the difference between the social cost of carbon as set by EPA and the price prevailing for RGGI carbon allowances.[68]

Because CHP resources will be "burdened" with this cost of carbon under typical cost/benefit analyses, policymakers are unlikely to provide incentives for CHP installations unless the resilience value of these resources--as demonstrated at least qualitatively, if not quantitatively, in the aftermath of Superstorm Sandy--can offset in part the negative attributes of burning a fossil fuel to produce the valued reliability. As battery storage technology improves, microgrids in the future may cease to be reliant on CHP; a solar array coupled with battery storage may enable a microgrid to operate independently from the grid. Currently, however, 82 percent of installed capacity for microgrids is driven by fossil fuels (60 percent of which is diesel, and 40 percent of which is natural gas),[69] and 64 percent of all CHP capacity is fueled by natural gas.[70] For CHP-based microgrids, ***27** their economic viability under common cost/benefit analyses will largely depend upon quantifying the economic value to the grid of resilience benefits which, as discussed in the following section, is a challenging endeavor.

IV. QUANTIFYING THE RESILIENCE BENEFITS OF DERS

A. Defining "Resilience"

The concept of resilience is increasingly being mentioned in the context of infrastructure and essential services in the wake of extreme weather events. In the *NYS 2100 Commission Report*, for example, resilience is defined as "the ability of a system to withstand shocks and stresses while still maintaining its essential functions."[71] The *Report* also mentions a second concept associated with resilience, as noted above: "resilient systems are also better able to repair and recover afterwards."[72] In contrast to resilient systems, those that are more vulnerable were described in the *Report* as "those that are brittle, at stretched capacity, or with very low diversity."[73]

With respect to the resilience of electric utility systems, a 2002 report of the National Research Council identified the vulnerabilities of the electric system to intentional disruptions, and noted the potential role of DERs in achieving "an intelligent, adaptive power grid":

> The trend over time has been to build large, remote generating plants, which require large, complex transmission systems. Today there is a growing interest in distributed generation--generators of a more modest size in close proximity to load centers. This trend may lead to a more flexible grid in which islanding to maintain key loads are [sic] easier to achieve. Improved security from distributed generation should be credited when planning the future of the grid.[74]

The decision of the New York PSC in the Con Edison case defined resiliency as "encompass[ing] more than hardening existing utility infrastructure against the impact of severe ***28** storms."[75] Adopting the definition from the *NYS 2100 Report*, the *Con Edison Order* defined resilience as "the ability of a system to withstand shocks while still maintaining its essential functions."[76] When the Department of Energy and the President's Council on Economic Advisors examined the economic benefits of grid resiliency, they defined a more resilient grid as "one that is better able to sustain and recover from adverse events like severe weather."[77] Their report noted that the cost of weather induced outages range from twenty-five to seventy billion dollars annually, with these costs taking various forms "including lost output and wages, spoiled inventory, delayed production, inconvenience and damage to the electric grid."[78] The report recommended continued investment in grid modernization and resilience in order to mitigate these costs over time, and thereby save "the economy billions of dollars and reducing the hardship experienced by millions of Americans when extreme weather strikes."[79]

The Energy Policy Act of 2005 required DOE to conduct a study of the benefits of DG and the rate-related issues that impede their expansion;[80] DOE's February 2007 study identifies many of these benefits.[81] The *DOE Study* identified the potential role of DG resources in improving resilience, "through its reliance on larger numbers of smaller and more geographically disperse power plants, rather than large, central station power plants and bulk-power transmission facilities."[82] While acknowledging that the greater number of smaller-scale power plants in a DG-based system would increase the number of targets vulnerable in an attack, it also "reduce[s] the number of customers who might potentially be affected."[83] The *DOE Study* also noted the reduced vulnerability when utility customers are able to "island" themselves in microgrid arrangements, which are particularly important in the case of "critical infrastructure facilities such as fire and safety buildings, telecommunications systems, hospitals, ***29** and natural gas and oil delivery stations."[84] The *DOE Study* described DG as a "viable means" for "improving the resilience of electrical infrastructure," and cited the "actual cases in which DG continued to provide power to critical facilities during times of large-scale power disruptions and outages."[85] According to the conclusions of the *DOE Study*, "[a] resilient grid can avert many types of losses, be they economic, material, or information, or losses of human life, health, safety, and communications."[86]

Most recently, the Federal Energy Regulatory Commission ("FERC") had an opportunity to consider the issue of resilience in the context of the bulk power system. In September 2017, DOE offered a proposed rule pursuant to section 403 of the Federal Power Act under which nuclear and coal plants with a ninety-day fuel supply on-site would be recognized as "reliability and resilience resources." Although FERC rejected the proposed rule, it commenced a separate proceeding to consider resilience. In doing so, it defined resilience as: "The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[87]

The National Association of Regulatory Utility Commissioners ("NARUC") issued a report in April 2019 on the resilience value of DERs, and adopted the following definition of resilience: "Robustness and recovery characteristics of utility infrastructure and operations, which avoid or minimize interruptions of service during an extraordinary and hazardous event."[88]

B. Efforts to Quantify the Resilience Benefits of DERs

The *NARUC Report* referenced above, which was devoted to the question of placing a value on the resilience provided by DERs, found that although regulators have identified resilience as an important benefit provided by DERs, no specific value of resilience was determined in the regulatory proceedings examined ***30** in the study.[89] Rather, the proceedings--two in Maryland and one in Illinois--included qualitative arguments for and against resilience investments, but did not quantify or monetize resilience.[90]

The *NARUC Report* also examined four case studies in which a value of resilience was incorporated into decision-making.[91] According to the *Report*, placing a value on avoided power interruptions is currently the "standard proxy" for quantifying energy resilience.[92] Based on the case studies, the *Report* identified four different specific methods used to analyze the resilience value of DER:

> • Contingent valuation: This is a "stated preference" method that uses surveys or interviews to directly ask customers about their intended (or actual) behavior. In this case, utility customers would be asked to give a hypothetical willingness-to-pay for better service or a willingness-to-accept a payment for less reliable service.[93]
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> • Defensive behavior: This is a "revealed preference"' approach that considers the amount that customers have paid to avoid the negative consequences of a power interruption, such as the costs of purchasing and maintaining a back-up diesel generator.[94]
>
> • Damage cost: This "revealed preference" approach calculates the actual costs that may be experienced by different groups (in this case, customers) during a power interruption. For example, the Federal Emergency Management Agency ***31** ("FEMA") examines the damage costs associated with increased injuries and lives lost from degraded critical services during power interruptions.[95]
>
> • Input-output modeling: This is an "economy-wide" approach that examines "the effects of power interruptions on regional economies using indicators such as economic output and employment."[96]

The *NARUC Report* evaluated these different methods according to usefulness to regulators, using four criteria: ease of use, scope of outputs, geographic scalability, and power interruption duration analysis capability.[97] The Report concluded that none of the methods reviewed met all four criteria for regulator usefulness and usability, and thus that no single method captured all regulatory concerns regarding the resilience value of DERs.[98]

The Clean Energy Group prepared an analysis of energy storage that also touched on the resilience value of customer-sited resources (in this case, battery storage).[99] Its report identified seven non-energy benefits of battery storage, including avoided power outages, comprising two elements: "[e]nergy system reliability benefit (the system-wide benefit of fewer grid outages)" and "[n]on-energy reliability benefits to consumers (customer's value of backup power)."[100] The report put a value of $172/kWh for residential customers and $15.64/kWh for commercial customers for "all of the costs that come with outages for both families and businesses."[101] A "key [take-away] from [the] report ... [is that these] non-energy benefits ... have significant value and should be included in cost/benefit analyses" when developing incentives for energy storage.[102] Failing to do so means that "the measure being considered will be under-valued, and ... may not pass the cost-effectiveness screen."[103]

*32 V. OBSERVATIONS AND CONCLUSIONS

It is inevitable that compensating DERs will eventually evolve from the simple and elegant use of retail rates under traditional net metering to a more rigorous analysis that examines the value of the benefits that DERs actually contribute to the electrical grid. The declining costs of solar PV and the general maturing of the DER market give rise to the issue of whether traditional net metering based on retail rates is simply too generous for DERs, and thus results in cost shifts to non-participating customers. In this "reset" of net metering rates, the emphasis is on increased precision in compensating DERs according to the value that they actually confer upon the grid. Whether it is the "value of solar" approach pioneered in Minnesota and followed in other states or the "value stack" method being implemented in New York, the task is identifying the various means by which DERs confer benefits upon the grid, and attempting to put a dollar value on the elements of those contributions.

The energy value and the capacity value of DERs are fairly easy to quantify by reference to the prices determined in competitive wholesale markets. To some extent, the avoidance of T&D infrastructure costs similarly is not too difficult to identify. Environmental benefits, for their part, can be roughly valued according to the social cost of carbon, or other values placed on carbon and other pollutants through market-based mechanisms. DERs that are located in areas where load relief is particularly valuable can be compensated for that contribution as well, as is done in New York's locational system relief value ("LSRV") component. In the case of resilience benefits provided by DERs, however, the effort to quantify the value conferred upon the grid is much more difficult. The above-referenced *CEG Study* highlights the challenges that regulators have faced in trying to monetize the seemingly obvious qualitative benefits that DERs provide.

As illustrated in the *CEG Study*, the drive to quantify arises in two different contexts. First, when regulators are considering whether to allow rate recovery of proposed programs--such as microgrid projects that provide resilience benefits--the benefits must exceed the costs before ratepayers can be expected to bear the costs, and those benefits must be broad-based rather than limited to the participants in a particular microgrid if the general body of ratepayers is expected to cover the costs in rates. Second, policymakers are routinely designing incentives to encourage investment in resources that achieve various clean energy ***33** objectives. The development of those incentives depends upon a rigorous cost/benefit analysis that requires the various costs and benefits to be quantified to ensure that the benefits exceed the costs. As noted in the *CEG Study*, the failure to quantify and include resilience benefits in those analyses will result in DERs (or energy storage, in the case of the *CEG Study*) being undervalued compared to other measures under consideration, and thus the price signal designed by regulators in their incentive programs will produce an economically inefficient level of investment in DERs.

Much more work must be done to more accurately define and quantify the resilience benefits of DERs. The *NARUC Report* identifies the preliminary efforts thus far and provides a roadmap for additional analytical tools that need to be developed. As more states move down the path of compensating DERs according to the value of their actual contributions to the grid, more resources can be expected to be devoted to quantifying the various components of DER contributions, including resilience.

Footnotes

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[1] The National Climate Assessment's discussion of "extreme weather events" includes heat waves, drought, heavy downpours, floods, hurricanes, and increased frequency and intensity of other storms. *Extreme Weather*, NATIONAL CLIMATE ASSESSMENT, https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather#intro-section-2 (last visited Sept. 22, 2019).

[2] According to the Intergovernmental Panel on Climate Change ("IPCC"), "[a] changing climate leads to changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events." WORKING GROUPS I AND II OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* 7 (Field et al. eds., 2012), https://wg1.ipcc.ch/srex/downloads/SREX-All_FINAL.pdf.

[3] NYS 2100 COMMISSION, RECOMMENDATIONS TO IMPROVE THE STRENGTH AND RESILIENCE OF THE EMPIRE STATE'S INFRASTRUCTURE 182, http://www.governor.ny.gov/assets/documents/NYS2100.pdf [hereinafter NYS 2100 COMMISSION REPORT] (defining Distributed Generation (DG) as "[s]mall electrical power generators installed in homes, businesses, and office buildings, that can supply power to a location when grid power is not available.").

[4] *Id.* at 97-98.

[5] Joel B. Eisen, *Distributed Energy Resources, "Virtual Power Plants," and the Smart Grid*, 7 ENVT'L & ENERGY L. & POL'Y J. 191, 193 (2012) ("Given the urgency to address climate change, [distributed energy resources] have become especially important as part of a portfolio of solutions to reduce fossil fuel use (and resulting GHG emissions) in the electricity sector of the economy and adapt to the changing climate.").

[6] Ejaz Kahn, *10 Most Destructive Hurricanes in U.S. History*, WONDERSLIST, http://www.wonderslist.com/10-destructive-hurricanes-u-s-history/ (last visited Sept. 26, 2019).

[7] *Consolidated Edison Company of New York, Inc., Case 13-E-0030 Before the N.Y. Pub. Serv. Comm'n* at 14-15, http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={A3EFED44-5E61-42B6-9348-7AB59BAA8CB5} (testimony of Electric Infrastructure and Operations Panel).

[8] *Id.* at 15.

[9] Microgrids are small-scale distribution systems that link and coordinate multiple DG resources into a network serving some or all of the energy needs of users located in close proximity and can be "islanded" to operate independently from the utility grid. NYS 2100 COMMISSION REPORT, *supra* note 3, at 95 n.b ("Microgrids refers to clusters of homes and buildings that share a local electric power generation and/or energy storage device while disconnected from the utility grid.").

[10] A CHP system is a highly efficient form of DG, typically designed to power a single large building, campus or group of facilities. CHP systems consist of an on-site electrical generator (primarily fueled with natural gas) that achieve high levels of efficiency through capturing heat, a byproduct of electricity generation that would otherwise be wasted. The captured heat can be used to provide steam or hot water to the facility for space heating, cooling or other processes. "Capturing and using the waste heat allows CHP systems to reach fuel efficiencies of up to 80%, compared with about 45% for conventional separate heat and power." ANNE HAMPSON ET AL., ICF INT'L, COMBINED HEAT AND POWER: ENABLING RESILIENT ENERGY INFRASTRUCTURE FOR CRITICAL FACILITIES 4 (Mar. 2013) [hereinafter ICFREPORT], http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf. CHP systems typically use the utility grid as a backup source to meet peak electricity needs, and to provide power when the CHP system is down for maintenance or during an emergency outage. *Id.* Because the supply of natural gas is generally not dependent upon electricity from the grid, a CHP system can continue to operate when the electricity grid is impaired, thereby ensuring an uninterrupted supply of electricity to the host facility. *Id.*

[11] Eisen, *supra* note 5, at 193 (noting that distributed energy resources "help the electric grid by increasing grid reliability and resilience, making the grid less vulnerable to prolonged power failures.").

[12] *Superstorm Sandy*, *2013 State of the Company*, CON EDISON (2013), http://www.conedison.com/ehs/2012-sustainability-report/engaging-stakeholders/reliability/superstorm-sandy/index.html#gsc.tab=0.

[13] *Consolidated Edison Company of New York, Inc., Case 13-E-0030 Before the N.Y. Pub. Serv. Comm'n* at 15, http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={A3EFED44-5E61-42B6-9348-7AB59BAA8CB5} (testimony of Electric Infrastructure and Operations Panel).

[14] *See Superstorm Sandy*, *supra* note 12.

[15] *Id.*

[16] Petition of PSE&G, Dockets EO13021055 and GO13020156, New Jersey Board of Public Utilities, at 2, http://www.pseg.com/family/pseandg/tariffs/reg_filings/pdf/EnergyStrong.pdf.

[17] *Id.*

[18] PSE&G OUTLOOK, SPECIAL EDITION: SUPERSTORM SANDY (Dec. 2012), at 2, http://www.pseg.com/info/retiree/pdf/Outlook_1212_Sandy.pdf.

[19] *Id.*

[20] PSE&G, PSEG ESTIMATES THE UTILITY'S COST OF SUPERSTORM SANDY RESTORATION, (Dec. 4, 2012), http://www.pseg.com/info/media/newsreleases/2012/2012-12-04.jsp#.Uo0LMKMo670.

[21] *See* ICF REPORT, *supra* note 10.

[22] *See* ICF REPORT, *supra* note 10, at 2, n.1 and accompanying text.

[23] *Id.*

[24] *Id.* at 29.

[25] *Id.*

[26] *Id.*

[27] *See* ICF REPORT, *supra* note 10, at 29.

[28] *Id.* at 16.

[29] *Id.*

[30] *Id.*

[31] *Id.*

[32] *Id.* at 18.

[33] *See* ICF REPORT, *supra* note 10, at 18.

[34] *Id.* at 19.

[35] *Id.* at 13.

[36] *Id.*

[37] *Id.* at 14.

[38] *See* ICF REPORT, *supra* note 10, at 15.

[39] *Id.*

[40] *Id.* at 21.

[41] *Id.*

[42] *Id.*

[43] *See* ICF REPORT, *supra* note 10, at 25.

[44] *Id.*

[45] *Id.* at 20.

[46] *Id.* at 31.

[47] *Id.*

[48] *Id.*

[49] DSIRE, *Net Metering Policies*, http://www.dsireusa.org/resources/detailed-summary-maps/net-metering-policies-2/.

[50] *See Solar Energy and Net Metering*, EDISON ELEC. INST., https://www.eei.org/issuesandpolicy/generation/NetMetering/Documents/Straight%20Talk%C20About%C20Net%20Metering.pdf (last visited Oct. 20, 2019).

[51] The legislation passed by Minnesota in 2013 allows investor-owned utilities in the state to apply to the Public Utility Commission (PUC) for a Value of Solar (VOS) tariff as an alternative to the net metering provisions that would otherwise apply to purchases from the output of solar installations. MN Laws 2013, Chap. 85 HF 729, Art. 9, Sec. 10.

[52] CLEAN POWER RESEARCH, *Minnesota Value of Solar: Methodology*, Jan. 31, 2014, https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7bEE336D18-74C3-4534-AC9F-0BA56F788EC4%7d&documentTitle=20141-96033-02 [hereinafter MN VALUE OF SOLAR], at ii.

[53] *Id.*

[54] *Id.* at 1.

[55] *Id.*

[56] *Id.* at 4, 5.

[57] *Id.* at 4.

[58] *Id.* at 33.

[59] DSIRE, *Minnesota Value of Solar Tariff*, https://programs.dsireusa.org/system/program/detail/5666.

[60] Peter Behr, *Minn. Tries to Put a Climate Value on Rooftop Solar*, E&E NEWS, Jan. 2, 2014, http://www.eenews.net/stories/1059992297.

[61] MN VALUE OF SOLAR, supra note 52, at 39.

[62] *Id.* at 42.

[63] *Id.*

[64] Order on Net Energy Metering Transition, Phase One of Value of Distributed Energy Resources, and Related Matters, N.Y. Pub. Serv. Comm'n, No. 15-E-0751 (Mar. 9, 2017) at 9.

[65] *Id.* at 15-16.

[66] Order Establishing the Benefit Cost Analysis Framework, N.Y. Pub. Serv. Comm'n, No. 14-M-0101 (Jan. 21, 2016), at 18.

[67] *Id.*

[68] *Id.*

69 Adam Hirsch, Yael Parag, Josep Guerrero, *Microgrids: A Review of Technologies, Key Drivers, and Outstanding Issues*, RENEWABLE AND SUSTAINABLE ENERGY REVIEWS 90, 2018, at 402-411.

70 DOE, *Energy Efficiency and Renewable Energy*: *Combined Heat and Power Technology Fact Sheet Series*, https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/CHP%20Overview-120817_compliant_0.pdf (last visited Oct. 20, 2019).

71 NYS 2100 COMMISSION REPORT, *supra* note 3, at 24.

72 *Id.*

73 *Id.* The NYS 2100 COMMISSION REPORT identified several features that are common to most resilient systems: "having spare or latent capacity (redundancy); ensuring flexibility and responsiveness; managing for safe failure (building resistance to domino effects); and having the capacity to recover quickly and evolve over time." *Id.*

74 NATIONAL RESEARCH COUNCIL, *Making the Nation Safer--the Role of Science and Technology in Countering Terrorism*, THE NATIONAL ACADEMIES PRESS (2002).

75 Order Approving Electric, Gas and Steam Rate Plans in Accord with Joint Proposal, N.Y. Pub. Serv. Comm'n, No. 13-E-0030 (January 21, 2016) at 63, n.47.

76 *Id.*

77 *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, http://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf., at 5.

78 *Id.* at 3.

79 *Id.*

80 Energy Policy Act of 2005, Pub. L. No. 109-58, § 1817, 119 Stat. 594, 1130-31 (2005).

81 U.S. DEP'T OF ENERGY, THE POTENTIAL BENEFITS OF DISTRIBUTED GENERATION AND RATE-RELATED ISSUES THAT MAY IMPEDE THEIR EXPANSION, https://www.ferc.gov/legal/fed-sta/exp-study.pdf (2005) [hereinafter DOE STUDY].

82 *Id.* at 7-3.

83 *Id.*

84 *Id.*

85 *Id.* at 7-12.

86 *Id.*

87 Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures, 162 FERC ¶ 61, 012 (Jan. 8. 2018), https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf at 13.

88 CONVERGE STRATEGIES, LLC, THE VALUE OF RESILIENCE FOR DISTRIBUTED ENERGY RESOURCE: AN OVERVIEW OF CURRENT ANALYTICAL PRACTICES 7 (2019), https://pubs.naruc.org/pub/531AD059-9CC0-BAF6-127B-99BCB5F02198 [hereinafter NARUC REPORT].

89 *Id.* at 4.

90 In Baltimore Gas & Electric Company ("BGE"), Case No. 9416, the Maryland Public Service Commission considered a proposal for two community microgrid pilots; resilience was repeatedly identified as a benefit of the proposed

microgrids, but PSC staff challenged many of the resilience benefits that BGE claimed would be provided to surrounding communities. NARUC REPORT, *supra* note 88, at 11. In Commonwealth Edison ("ComEd"), Docket 17-0331, the Illinois Commerce Commission ("ICC") considered a microgrid project that ComEd claimed would serve as a "resilient oasis" for the surrounding community in the event of a power interruption. The ICC approved the proposal without requiring a quantitative cost-benefit analysis. *Id.* at 12-13. In Potomac Electric Power Company ("PEPCO"), Case No. 9361, the Maryland Public Service Commission considered a proposal for two community microgrids in which PEPCO claimed that resilience would have been the primary benefit. PEPCO "use[d] [an] [Interruption Cost Estimate ("ICE")] [c]alculator to estimate two benefits for customers connected to the microgrid - 'outage avoidance benefits to microgrid participants' ($7.6 million) and 'resiliency savings' ($8.3 million)." But the Maryland PSC rejected the proposal in part because of PEPCO's failure to quantify the community resilience benefits (i.e., the thousands of customers who may indirectly benefit from the microgrids). *Id.* at 13-15.

[91] NARUC REPORT, *supra* note 88, at 4.

[92] *Id.* at 4.

[93] *Id.* at 17.

[94] *Id.*

[95] *Id.*

[96] *Id.* at 18.

[97] NARUC REPORT, *supra* note 88, at 4.

[98] *Id.*

[99] Todd Olinsky-Paul, *Energy Storage: The New Efficiency*, CLEAN ENERGY GROUP (Apr. 2019), https://www.cleanegroup.org/wp-content/uploads/energy-storage-the-new-efficiency.pdf [hereinafter CEG STUDY].

[100] *Id.* at 11.

[101] *Id.* at 12.

[102] *Id.* at 24.

[103] *Id.* at 19.

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