THE ROLE OF DISTRIBUTED ENERGY RESOURCES IN NEW JERSEY'S CLEAN ENERGY TRANSITION

GRIDWORKS

GridLAB

Center for Renewables Integration

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INTRODUCTION

Electricity grids across the nation are undergoing a rapid transition. To date the principal contributor to this transition is the increased deployment of utility-scale renewable energy resources, driven in part by declining costs of these resources relative to conventional, fossil-fired resources. A second key factor contributing to the current grid transition is increased adoption of distributed energy resources (DER) by customers, including distributed generation such as rooftop or community solar, storage, smart inverters, energy efficiency, demand response, electric vehicles, and microgrids. This trend is driven by customers who see value in DER, which provide them with choice in their energy source, the ability to proactively manage their energy use, and to better achieve resilience in the case of a power outage. Effective integration of renewable resources into electricity supplies and grids is the central challenge of our industry, both from a technical and from an economic point of view.

In New Jersey, the main transition contributor is the adoption of rooftop solar PV by over 100,000 residential customers. This transition and its challenges will accelerate through the 2019 Energy Master Plan as the administration seeks to further address climate change, a key priority for Governor Murphy.[1] Led by an Executive Order from Governor Murphy, the 2019 Energy Master Plan aims to achieve 100% clean energy for New Jersey by 2050. Given that climate change is a key priority for the Murphy administration, Governor Murphy announced the 2019 plan "is intended to set forth a strategic vision for the production, distribution, consumption, and conservation of energy in the State of New Jersey." A draft of the Energy Master Plan suggests this vision will include a wide range of policy and market action, including:

- Complete electrification of the transportation sector;
- Accelerated deployment of renewable energy, including a 50% Renewable Portfolio Standard and a 3,500 MW target for new offshore wind by 2030, and new opportunities for distributed energy resources;
- Expanded investment in energy efficiency and building electrification;

1 https://nj.gov/emp/

CONTENTS

THIS PAPER OFFERS A FRAMEWORK TO BROADLY UNDERSTAND DER AND THE VALUE THEY CAN PROVIDE TO THE ELECTRICITY GRID. WE USE CALL OUT BOXES LIKE THIS ONE TO HIGHLIGHT INSIGHTS AND RECOMMENDATIONS TAILORED TO NEW JERSEY FOR ITS CONSIDERATION IN FINALIZING THE 2019 ENERGY MASTER PLAN.

- Modernizing the electric grid;
- Extending the economic and environmental benefits of the clean energy transition to all New Jersey citizens, with an emphasis on reaching underserved communities.[2]

This paper amplifies to the draft Energy Master Plan's vision for DER in New Jersey's clean energy transition.

Many view the trends of increased reliance on renewable energy resources and customer-sited DER adoption as separate and distinct. But a handful of utilities and policy-makers are finding a better way forward, recognizing that DER can provide key grid services, including flexibility, that will complement, not frustrate, the deployment of large-scale renewables. These regulators, utilities and market operators are showing how to strategically pivot away from legacy systems to enable a more efficient, environmentally benign energy sector. These examples show how New Jersey can leverage the unique capabilities of DER.

In this paper, we define and identify the capabilities of DER and connect those capabilities to potential services DER may provide to the electricity grid, a utility and its customers. Building on existing literature and case studies, we further consider how DERs provide utilities and grid operators new flexibility in meeting grid needs. Next, we identify four case studies wherein utilities are embracing the capabilities of DER.

2 Energy Master Plan (Draft). June 2019.

Based on these case studies, best practices from across the country, and interviews with subject matter experts, we conclude DER can play a valuable role in realizing the goal of a 100% clean energy for New Jersey, complementing large-scale renewable energy resources and providing new services to distribution companies and customers.[3] We conclude by offering the following recommendations on how the unique capabilities of DER could be reflected in New Jersey's 2019 Energy Master Plan.

- **Integrate DER:** Give both distribution companies and DER providers the responsibility to integrate distributed resources through interconnection reform, valued based compensation mechanisms, targeted incentives to extend the environmental and economic benefits of DER to all New Jersey's citizens, and advanced inverter functionality. These efforts should be led by the New Jersey Board of Public Utilities (BPU) working with relevant distribution companies, and conducted in consultation with contributing and impacted stakeholders.
- **Embrace Electrification of Buildings and Transportation:** Strategic electrification of buildings and transportation can reduce emissions, improve air quality, make energy more affordable for customers, and increase

3 The authors wish to thank the following organizations and reviewers for their input: Borrego Solar, Coalition for Community Solar Access, Energy Storage Association, Environmental Defense Fund, IGS Solar, Momentum Solar, New Jersey Conservation Foundation, New Jersey Environmental Justice Alliance, New Jersey Solar Energy Coalition, PJM, Scott Weiner, Steve Gabel, Clearway Energy Group, Sunrun, ReThink Energy NJ, Sustainable New Jersey, Vote Solar.

customer satisfaction. Done right, it can accomplish all this without increasing costs to customers.

- **Maintain Equity Lens in Planning:** To reach Governor Murphy's goal of empowering underserved communities through the Energy Master Plan, this Holistic Grid Planning must be inclusive and maintain an economic equity lens to fully ensure the outcomes benefit all of New Jersey's communities.
- **Holistic Grid Planning:** Conduct Holistic Grid Planning, assessing portfolios of bulk renewable and distributed energy resources capable of meeting New Jersey's goal of 100% carbon free energy by 2050. This planning should be led by the New Jersey Board of Public Utilities working with relevant state agencies, distribution companies, and conducted in consultation with contributing and impacted stakeholders. A focus on reaching and including New Jersey's underserved communities should be prioritized.

DEFINITION AND CAPABILITIES

Distributed Energy Resources is a term applied to a wide variety of technologies and consumer products, including distributed generation (DG), smart inverters, distributed battery energy storage, energy efficiency (EE), demand response (DR) and electric vehicles (EVs). (In New Jersey Distributed Energy Resources (DER) is synonymous with "distributed generation." In this paper we distinguish between the two, broadening DER to encompass a range of technologies and interventions which impact the grid on the customer side of the substation.) These resources can be stand alone or combined; each has distinct strengths and capabilities. Some of the most popular DER in use today include:

CUSTOMER-SITED AND COMMUNITY DISTRIBUTED GENERATION (DG): DG refers to small-scale power resources that generate energy. DG Systems are decentralized and typically connected to the distribution grid, compared to traditional centralized large-scale infrastructure which is connected to the transmission system. DG encompasses many forms of generation including, but not limited to, solar photovoltaics (PV), small wind systems, cogeneration/CHP systems, and fuel cells.

The most prominent and growing technology in recent years, buoyed by falling technology costs and favorable policies, is distributed solar PV. This includes both customer-sited solar located on home and business rooftops, as well as community solar, in which a larger, community-scale solar system serves hundreds of homes and businesses in the surrounding communities. The prevailing motivation for customer investments in both customer-sited and community DG is bill management. These solutions offer customers the opportunity to reduce and manage their utility cost, a capability of particular value to low- and moderate-income customers. As many customers are unable to site solar on their roof, the ability for homes and businesses to participate in off-site solar systems via community solar or virtual net metering is critical in order to expand access to solar for all customers.

Beyond bill management, DG's ability to generate close to the end use of the electricity can reduce demand for costly, large-scale utility infrastructure, such as high-voltage transmission lines, as well as defer or displace the need for distribution infrastructure. DG also reduces line losses experienced due to the transmission of power across large distances.

DG is also seen by many customers as a resilience solution, continuing to operate during grid outages and a better

alternative to a diesel generator. In the wake of Superstorm Sandy, many homeowners in New Jersey learned that first generation solar systems don't operate when there is a wide-scale outage, but smart inverters cost effectively allow for continued operation, and increasingly adding energy storage to solar allows access to power after sunset.

Finally, adoption of DG, and in particular solar PV, often catalyzes greater customer engagement. Customers who choose to install DER gain greater insight into their energy usage and often go on to install other DER technologies or utilize energy efficiency programs. Customers who adopt DER can be engaged on an ongoing basis in a manner that has the potential to provide additional benefits for the grid.

BATTERY STORAGE: Distributed energy storage systems can store and discharge energy, allowing batteries to act as both a generator and a source of load. Batteries can be integrated as standalone systems, used in support of other distributed resources (e.g., solar plus storage), and are becoming widely deployed in electric vehicles. Battery storage can be adopted by a customer and place "behind the meter" or co-located with generation and utility substations.

Energy storage can provide additional capabilities above and beyond distributed generation. First, batteries can provide dispatchability because charging behavior and battery output can be controlled. This capability allows batteries to shift energy generation by discharging at times of high demand or peak load. When energy prices vary temporally, batteries can be programmed to respond to price signals in order to both meet grid needs and reduce customer bills. Batteries can be programmed to charge when excess power is available and discharge at times of peak demand. Batteries can also respond instantaneously to changing load conditions, enabling battery systems to serve as a demand response resource to meet load.

Batteries can also provide important voltage regulation and frequency regulation services to improve power quality on existing grid infrastructure. In contrast to traditional utility infrastructure (e.g., transformers, regulators, etc.), storage systems can be paired with smart inverters, described in further detail below, to control the battery's energy output autonomously in response to changing conditions on the grid. Battery storage can be programmed to ramp up or down rapidly in response to voltage and frequency conditions on the grid, which can help to stabilize and manage the grid.

SMART INVERTERS: Inverters are devices that convert direct current produced by a generator to alternating current used by the grid. In the past, inverters used by DG and battery systems were designed to switch off when the system experienced a grid disturbance, such as the sudden loss of a large generating resource. With more DER on the system, this can amount to a large loss of generating capacity at once, further disturbing grid conditions.

ENERGY STORAGE CAN PROVIDE SIGNIFICANT ECONOMIC AND SOCIAL BENEFITS TO THE STATE OF NEW JERSEY

To begin gaining these benefits, the state has adopted a storage deployment goal of 600 MW by 2021 and 2000 MW by 2030. Should New Jersey go further? A recent study of widespread energy storage deployment in Massachusetts found potential benefits to ratepayers of $2.3 billion over 10 years, mainly in the form of reduced system and local peak demands.[5] Whether such value may also be obtained in New Jersey should be assessed.

"Smart" inverters are now deployed with advanced functionalities which are capable of intelligently managing the output of the DG system, which can mitigate the impact of distributed generation on the grid. In fact, smart inverters can contribute to resolving grid constraints by providing voltage support, frequency regulation, and ramp rate control. These capabilities support the grid by allowing distributed generation to help stabilize voltage and frequency on the grid, and to "ride through" a minor voltage or frequency disturbance and remain online rather than tripping offline.[5]

ENERGY EFFICIENCY refers to customer-sited technologies and behaviors that reduce a consumer's end-use energy consumption. Energy efficiency can target residential, commercial, and industrial customers, and is most often focused on building efficiencies, such as lighting or insulation improvements, mechanical improvements of heating, cooling, appliance, and industrial systems, or passive measures that monitor and control energy consumption.

Energy efficiency primarily provides load and demand reductions by enabling and encouraging consumers to use less energy. Customers invest in energy efficiency measures, often supported by utility incentives or rebates, thus altering energy consumption patterns. Energy efficiency can provide value in many ways; we highlight two here. First, energy efficiency can be targeted at specific parts of the distribution network which face congestion or capacity constraints and encourage specific types of energy efficiency in response. Second, energy efficiency measures can be broadly deployed to reduce system peaks and avoid or defer future need for additional generating capacity.[6] Efficiency is also being used to reduce demand at specific

4 *State of Charge: Massachusetts Energy Storage Initiative Study,* Massachusetts Department of Energy Resources. 2016 September. (https://www.mass.gov/files/documents/2016/09/oy/state-of-charge-report.pdf).

5 Mow, Benjamin. *Smart Grid, Smart Inverters for a Smart Energy Future*, National Renewable Energy Laboratory. 2017 December.

6 *2017 Utility Demand Response Market Snapshot*, Smart Electric Power Alliance. 2017 October.

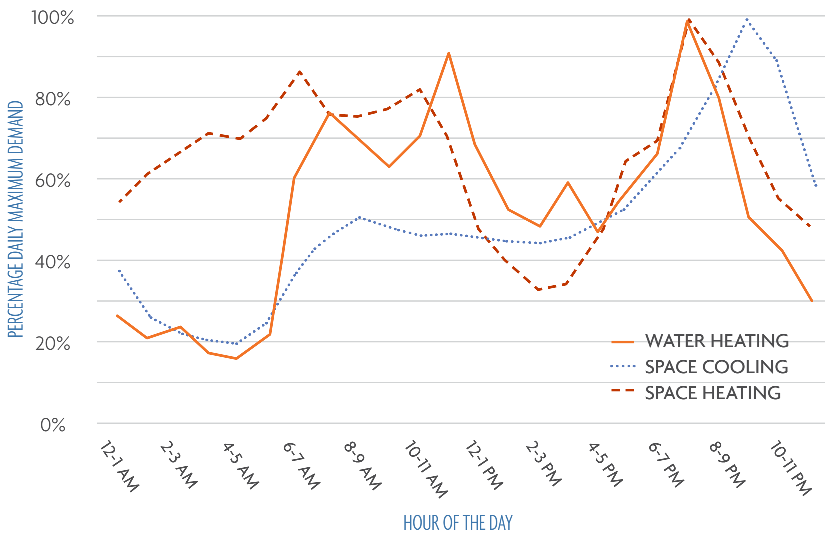


FIGURE 1. TARGETING ENERGY EFFICIENCY FOR PARTICULAR LOAD REDUCTION (ACEEE)

Energy efficiency can be targeted to achieve load reduction during times of peak demand. This chart illustrates example load profiles for three common energy end-uses. Incentives for efficient space cooling could be used to reduce evening peak energy usage, whereas incentives for more efficient space heating contribute to morning and evening peak reduction.

Image Courtesy of ACEEE

times, or even to shift demand. The chart above illustrates different energy profiles for various common energy end-uses. By targeting a specific energy end-use, utilities can choose to deploy efficiency technologies that will achieve demand reduction during a specific time period.[7] For example, incentivizing energy efficient space heaters would reduce the evening peak illustrated in Figure 1.

Beneficial building electrification similarly seeks to encourage customer adoption of technologies which lower cost and reduce emissions. However, unlike energy efficiency, electrification implies fuel-switching, from a fossil-fuel such as natural gas to electricity. Leading electrification measures include conversation of space and water heating, clothes drying, and stoves.[8] When aligned with increased reliance on renewable generators, this switch can offer substantial public value.[9]

NEW JERSEY AND PJM

As a part of the PJM Interconnection, New Jersey's power supplies are determined through a fuel-neutral market mechanism. Achieving Governor Murphy's goal of 100% clean energy for New Jersey by 2050 within this paradigm will require market changes that allow renewable energy resources to displace conventional generation. For New Jersey, the full benefits of electrification depend on successfully achieving the draft Energy Master Plan's goal to "maximize the development of offshore wind and in-state renewable energy generation (including community solar) and the interconnection of carbon-neutral distributed energy resources."[10]

DEMAND RESPONSE is defined as a coordinated increase or decrease in electric load in response to specific system conditions or market incentives.[11] Demand response can be controlled by a customer, a third party, directly by the utility, or by a transmission operators such as PJM. Demand response capabilities allow a utility to curtail or shift load in response to a scarcity of power supplies or other various grid conditions, including changes in generating capacity, peak load scenarios, ramping requirements, transmission or distribution constraints, or voltage irregularities. Demand response can be sourced from residential, commercial and industrial customers, each with unique capabilities.

Demand response can be used to shape and shift load. Demand response programs can reshape customer loads over time through rate structures or energy efficiency measures that encourage better utilization of grid resources.[12] Similarly, demand response programs can shift periods of high energy demand to periods of low demand.[13] For example, demand response programs can be used to encourage electric vehicle charging or heavy appliance operation during times when power supplies are abundant. Demand response can also be used to shed load during peak load events, for example, by incentivizing consumers to turn down air conditioning units during system peaks.[14] Finally, demand response can be used to provide ancillary grid services, for example rapidly smoothing load or regulating voltage in response to sudden grid disturbances.

ELECTRIC VEHICLES primarily provide mobility, and consumers rarely (if ever) purchase them for the additional grid services they can provide. However, intelligent EV charging enables load shaping and shifting in response

7 *Beyond the Meter, Distributed Energy Resources Capabilities Guide*, Smart Electric Power Alliance. 2017 June. (http://www.ourenergypolicy.org/wp-content/uploads/2017/09/SEPA_AEE_RMI__BTM-Recommended.pdf)

8 New Jersey's "COOLAdvantage" Program offers customers rebates on electric heat pumps at http://www.njcleanenergy.com/residential/programs/cooladvantage/heat-pumps.

9 Regulatory Assistance Project. *Beneficial Electrification: Ensuring Electrification in the Public Interest*. 2018 January.

10 Energy Master Plan (Draft). Page 10. June 2019.

11 *2017 Utility Demand Response Market Snapshot*, Smart Electric Power Alliance. 2017 October.

12 *2015 California Demand Response Potential Study*, Lawrence Berkeley National Laboratory. 2016 November. (http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=644245154).

13 *Final Report of the California Public Utilities Commission's Load Shift Working Group. 2019 January. (https://gridworks.org/wp-content/uploads/2019/02/LoadShiftWorkingGroup_report-1.pdf)*

14 Currently New Jersey Electric Distribution Companies offer customers Demand Response programs aimed at peak load management, discussed in detail at https://www.nj.gov/bpu/about/divisions/energy/demandresponse.html.

to grid conditions. Such "smart charging" is expected to provide significant flexibility in the near term as EV deployment grows. Grid operators can effectively utilize an aggregated network of EVs and EV chargers to respond to certain grid events, using both real-time and day-ahead pricing and demand signals. For example, grid operators can shape demand by encouraging charging at certain hours of the day, particularly when ample solar or wind resources are available. Similarly, operators can shed load by turning off or throttling EV chargers at peak demand hours.

The electrification of medium and heavy duty vehicles (MHDV), particularly fleets such as delivery trucks and municipal busses, is driven in large part by falling battery costs and the low lifetime operating costs of electrified vehicles. MHDV charging is often concentrated on a few peak hours or can be incentivized to charge at concentrated periods and locations beneficial to the grid. For example, electrified busses can be encouraged, through appropriate price signals, to charge at off-peak hours at a central depot, thus minimizing impacts to the grid.

In the medium- to long-term, vehicle-to-grid services could provide capabilities similar to energy storage by not only shifting charging, but allowing EVs to generate power to the grid at key times to alleviate grid stress. EVs are a particularly effective customer engagement tool that provide an added demand response resource and aggregated energy storage technology.

GOOD ON THEIR OWN, BETTER TOGETHER

In addition to the individual capabilities of each DER, distributed energy resources can be combined to maximize their value to the grid and the adopting customer. For example, a customer-sited solar and storage installation, paired with an electric vehicle and regulated by a smart inverter, can generate power when needed, store and discharge that power in response to grid conditions, energize the transportation needs of the customer, and contribute to the grid operator's regulation of voltage at the point of interconnection. In this way, individual distributed energy resources complement one another to provide greater service to the adopting customer while also contributing to grid needs.

Microgrids provide another example of how DER can be combined to meet other needs. Microgrids are "interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid."[15]

15 https://building-microgrid.lbl.gov/microgrid-definitions

COMBINING DER AT A SINGLE CUSTOMER SITE (GE)

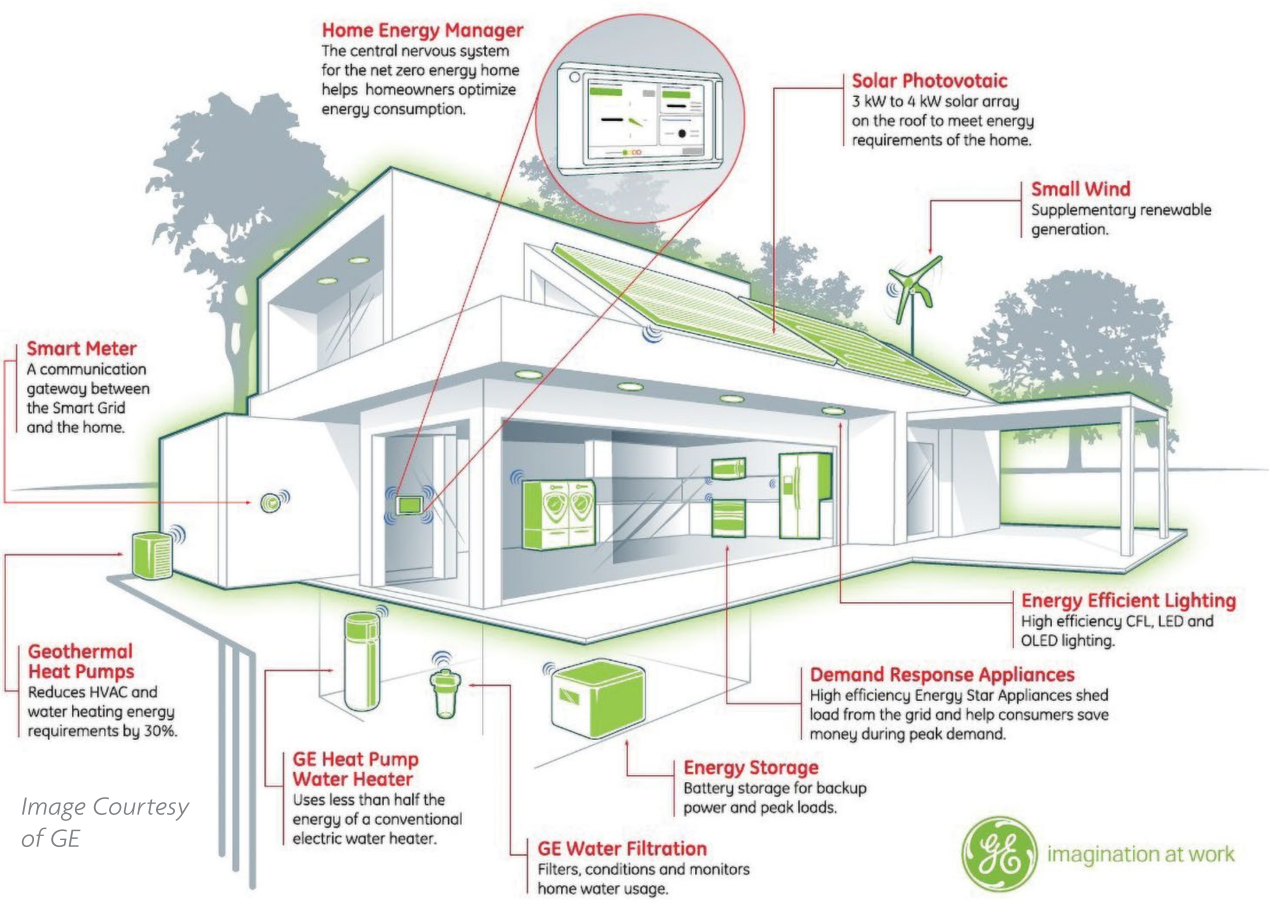


Image Courtesy of GE

As discussed further below, a microgrid's ability to connect and disconnect from the grid allow it to operate in both grid-connected or island-mode, providing added resilience in emergency conditions, including extreme weather events such as hurricanes and wildfires.

DER can also be deployed in portfolios where large aggregations of DER are coordinated to meet grid needs. In such cases, the DER adopted by customers — in some cases hundreds of thousands of customers — are brought together by utilities and third parties. (Such aggregations are sometimes referred to as Virtual Power Plants.) Aggregating resources in this way provides new opportunities. First, drawing on the relative strengths of different technologies, these portfolios offer services to the grid which exceed services that each technology can offer on a standalone basis. Additionally, a portfolio approach allows for risk management strategies that are not possible for single DER resources. As is the case with an investment portfolio, risk can be managed through diversification. For example, to meet new capacity needs, a utility can combine energy efficiency, demand response, and distributed storage, engaging a range of residential, commercial and industrial customers. Aggregated, the technologies and customers can contribute to a whole which is greater than the sum of the parts.

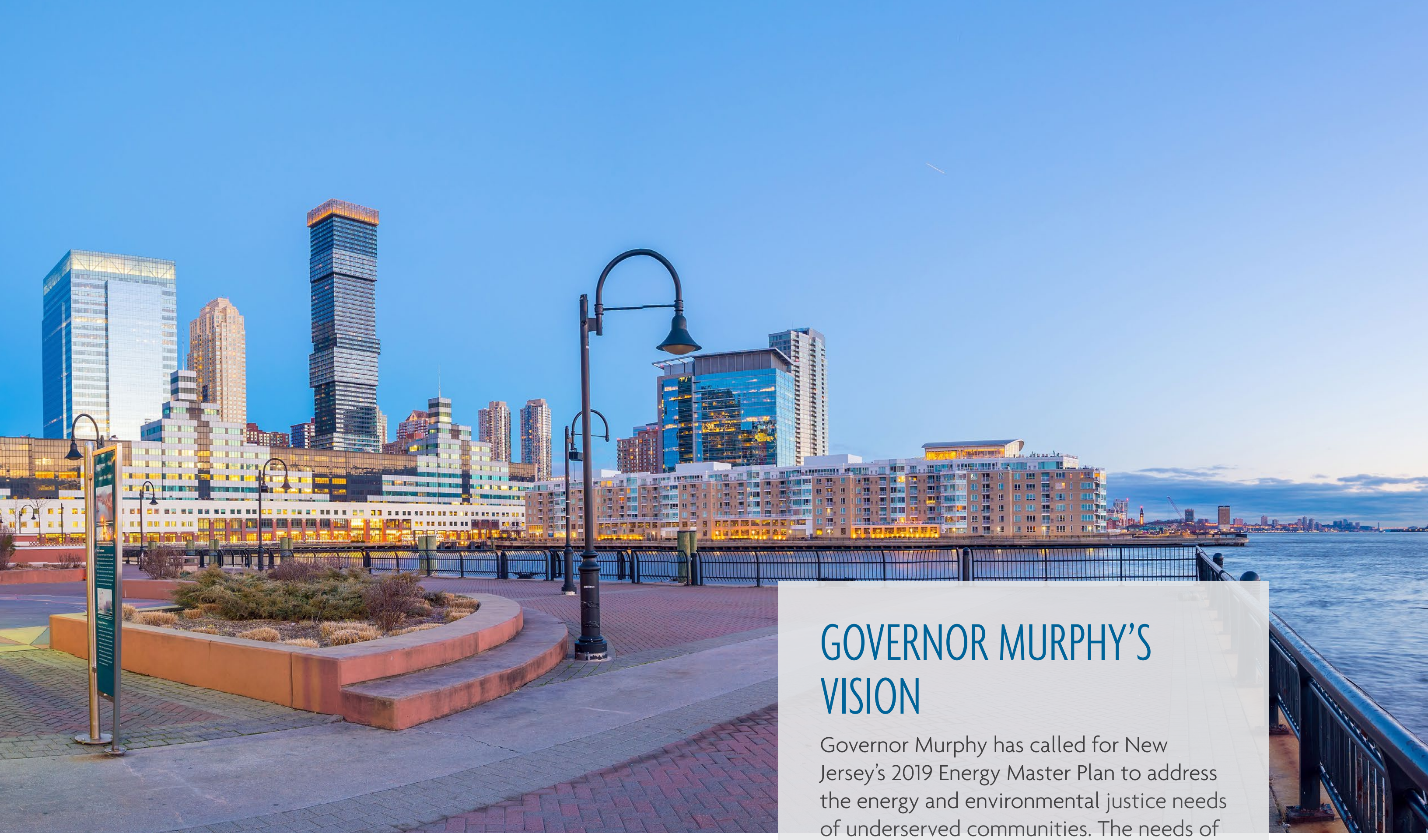
DER SERVICES

DER are capable of providing a wide range of services to the grid whether they are used as individual resources (like DG or EE), combinations (such as solar and storage), or aggregated into portfolios of diverse technologies and customers. The following section identifies services DER can provide and describes how the capabilities of DER match both traditional and new grid needs.

AVOIDED TRANSMISSION AND DISTRIBUTION SYSTEM INVESTMENTS

DER can avoid or defer investments in the transmission and distribution system. They accomplish this in at least two ways: by reducing dispersed demands on the grid, as might be the case with an energy efficiency program that reduces future growth in peak demand, or by serving as a non-wires solution.

A non-wires solution is a "electricity grid investment or project that uses non-traditional solutions to transmission and distribution (T&D) problems, such as distributed generation, energy storage, energy efficiency, demand response, or grid software and controls, to defer or replace the need for specific equipment upgrades, such as T&D lines or transformers, by reducing load at a substation or



circuit level."[16] Each path may lead to avoided upgrades to transformers, conductors, capacitors, and in select cases, substations.

Determining "avoided T&D" value requires quantification of the costs that would otherwise be incurred by utilities and ratepayers with traditional "wires" infrastructure. The cost of a business-as-usual (traditional utility infrastructure) approach must be quantified with sufficient transparency and locational granularity to allow consideration of DER as non-wires alternatives. This includes cost information as well as sufficient information about the type of infrastructure or upgrade needed (e.g., how often upgrades are needed, or by what magnitude voltage is considered out of range). Locational granularity is particularly important to accurately understand avoided distribution costs, as the ability of DER to avoid traditional upgrades is dependent on local infrastructure needs. Once quantified, DER can be sourced to avoid or defer expected T&D costs.

DER is largely valuable for meeting local distribution needs, but it also has an impact on transmission costs and needs, particularly as high DER adoption levels change load shapes and reduce the need for additional transmission infrastructure. At the transmission level, it is highly important to consider DER in aggregate. It is also important to consider additional factors, including aligning load forecasting and planning efforts between the distribution

16 *Non-Wires Alternatives*, Navigant Research. 2017.

GOVERNOR MURPHY'S VISION

Governor Murphy has called for New Jersey's 2019 Energy Master Plan to address the energy and environmental justice needs of underserved communities. The needs of these communities include:

Reduced Energy Burden: decrease the share of household income that goes to paying for energy bills which is disproportionately high in New Jersey's underserved communities;

Increased Equity: mitigate or remove the negative impacts on health and economy resulting from the disproportionate siting of energy infrastructure in low income communities and communities of color (environmental justice), while increasing the share of incentives reaching lower income customers (energy justice);

Expanded Economic Development: extend the opportunity to grow jobs and wealth in communities which have fallen behind financially.

DER can address each of these needs if deployed strategically. Strategic deployment begins with open, inclusive planning processes that assess and address the barriers to better serving all communities. On a foundation of open planning, DER can address these concerns of underserved communities while delivering grid services that decarbonize the grid.

RESILIENCE FOR NEW JERSEY

In 2012 New Jersey was overwhelmed by Hurricane Sandy. Extensive wind and water damage resulting from the storm left more than 2.5 million customers (over 75%) without service,[19] prompting a renewed commitment to resilient power systems. In 2017, the BPU allotted over $2 million to study the feasibility of 13 town center microgrids, which are designed to keep crucial public services operating during an outage. Results of those studies are forthcoming, with further engineering design to follow.[20]

FIGURE 2. PEAK POWER OUTAGES BY SELECT STATE AND STORM

Source: OE/ISER Emergency Situation Reports

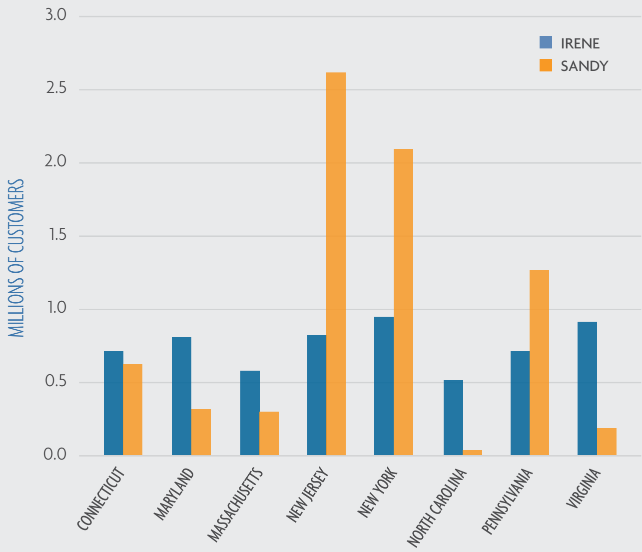
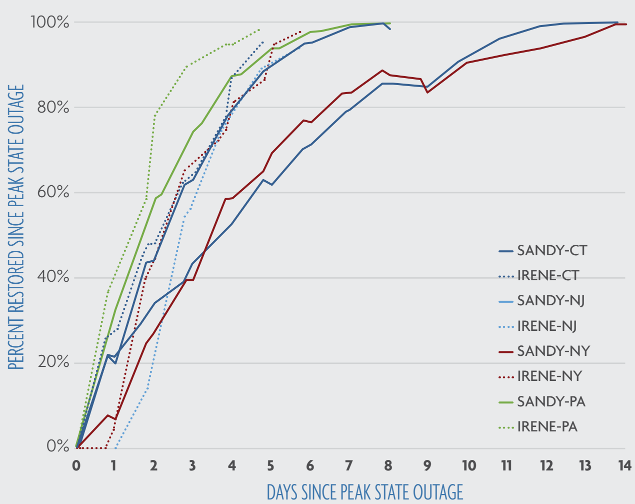


FIGURE 3. COMPARISONS OF POWER OUTAGE RESTORATION PERCENTAGES BY STORM

Source: OE/ISER Emergency Situation Reports



As Figure 2 and 3 illustrate, recent superstorms Irene and Sandy have impacted New Jersey customers particularly hard. In both cases, New Jersey had some of the highest number of effected customers and slowest power restoration times of impacted states.

and transmission sides of operations. For example, in 2018 the California ISO approved a Transmission Plan which recommended the modification or cancellation of 18 transmission projects. The modifications are largely due to increasing levels of DER, including energy efficiency and distributed solar, which will help utilities avoid an estimated $2.6 billion in future costs.[17]

Building on the concept of non-wires alternatives, non-pipeline alternatives adopt the same framework, targeting electric distributed energy resources for the displacement of new transmission or distribution infrastructure for the conveyance of natural gas. Like non-wire alternatives, non-pipeline alternatives give utilities the opportunity to avoid major new capital expenditures in favor of distributed energy resource deployment.

Examples of non-wire and non-pipeline alternatives being implemented in New York are featured as case studies below.

AVOIDED GENERATION

DER can avoid new generation investments by providing both energy and capacity. Distributed generation can meet local load needs, while load-modifying DER (EE, storage, DR, and EVs) can shift load to avoid system peaks at specific times of the day and reduce the need for additional capacity investments. The NYISO estimates that energy efficiency and other DER are expected to reduce annual energy usage by just under 20,000 GWh in 2028.[18] Together, a coordinated portfolio of DER can avoid the need for high-polluting peaker plants. Furthermore, DER can reduce transmission congestion issues and line losses, representing the avoided cost of delivering energy, if appropriate price signals are present.

As avoided generation, DER can provide both energy and capacity value. In order for DER to provide capacity value, certain performance requirements may be needed. DER are demonstrating their capabilities to meet those performance requirements, as evidenced by the case studies cited in the next section.

RESILIENCE

DER can support electricity system resilience, which we define as the ability of that system to recover from disruptive events. Employing the ability of DER to produce, store and manage energy supplies and load at a local level, customers and grid operators gain new tools to withstand the unexpected.

17 California ISO; *2017-2018 Transmission Plan*. March 2018. (http://www.caiso.com/Documents/BoardApproved-2017-2018_Transmission_Plan.pdf).

18 New York Independent System Operator; *2018 Power Trends.* 2018.

19 US DOE. "Comparing the Impacts of Northeast Hurricanes on Energy Infrastructure" 2013 April.

20 https://www.state.nj.us/bpu/commercial/microgrid.html

HOW DER PROVIDE FLEXIBILITY

Storage is changing the DER landscape, when deployed on its own or when coupled with other DER. For example, companies are deploying customer-sited storage for demand charge management, while simultaneously participating in demand response programs. Time of use rates have incentivized some customers to couple storage with rooftop solar, which makes the solar more valuable to the grid by extending generation into peak times and "firming" the solar. Storage primarily provides flexibility by providing ramp, but it can also absorb excess generation (reducing curtailment) and help to maintain frequency.

Smart inverters will increase flexibility through their ability to ride through fault conditions, communicate with grid operators, and manage voltage. On a system-wide basis, smart inverters allow for frequency response and enable communication to allow for response to grid needs. Crucially, smart inverters can manage and maintain voltage on their local circuit. Leading states, including California, Hawaii, Illinois and Minnesota are deploying smart inverters today, and the new IEEE smart inverter standard will mandate that smart inverters have these capabilities and go into wider adoption in 2020.

Finally, working with stakeholders, utilities and grid operators are developing rules to allow DER to participate in wholesale markets. Although there are barriers, DER participation in wholesale markets unlocks additional flexibility from customer sited storage, distributed generation, demand response, and flexible loads like electric vehicles. Allowing for DER participation in the larger system addresses many of the concerns grid operators have with DER today, and "unlocks" the flexibility that DER can provide the wider grid. This includes enabling flexible loads to absorb excess generation, reducing ramps, and providing incentives and signals for DER to respond to grid needs. These developments are occurring in both deregulated markets and in vertically integrated utilities.

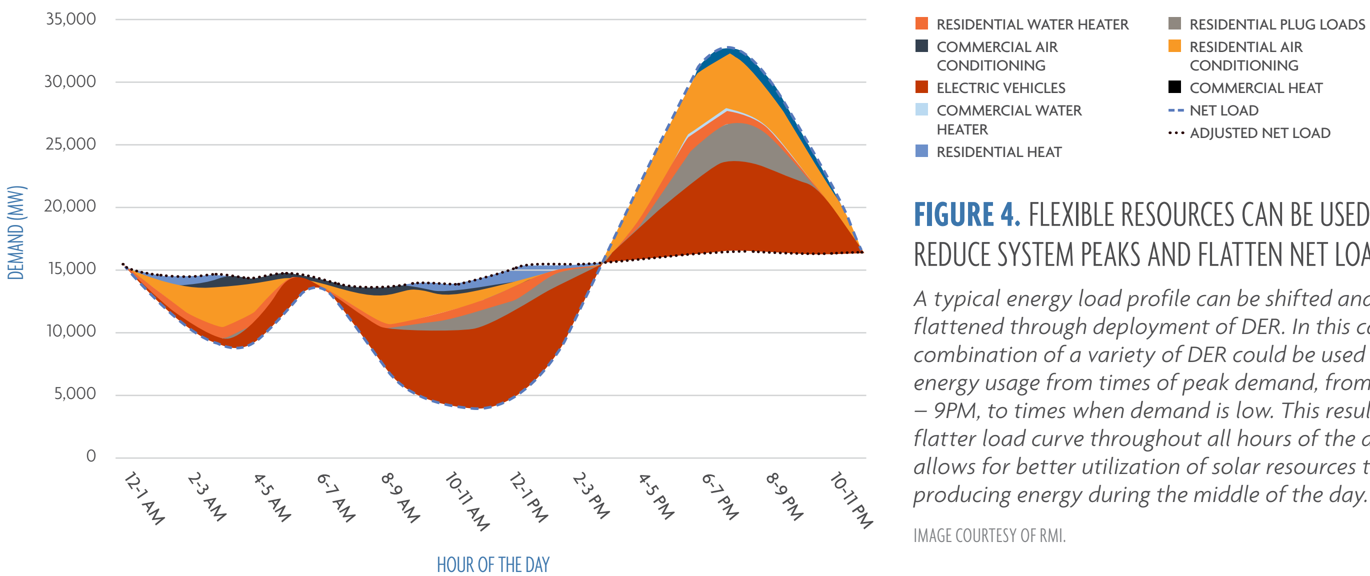


FIGURE 4. FLEXIBLE RESOURCES CAN BE USED TO REDUCE SYSTEM PEAKS AND FLATTEN NET LOAD.

A typical energy load profile can be shifted and flattened through deployment of DER. In this case, a combination of a variety of DER could be used to shift energy usage from times of peak demand, from 5PM – 9PM, to times when demand is low. This results in a flatter load curve throughout all hours of the day, and allows for better utilization of solar resources that are producing energy during the middle of the day.

IMAGE COURTESY OF RMI.

FLEXIBILITY

While the deployment of DER is changing the distribution grid, the wider grid is going through its own transformation. Increased deployment of renewables and retirement of traditional thermal units has increased the need for flexibility. DER are emerging as a way to provide this flexibility. At both the distribution and wholesale level, DER are increasingly relied upon to serve the grid's need for flexibility.[21]

The flexibility the grid requires can be described as

- **Frequency** the grid needs to keep generation and load in balance at all times
- **Overgeneration** the grid needs to be able to absorb or shift excess generation
- **Ramp** the ability to respond rapidly and over sustained periods to changes in load or generation
- **Voltage** maintain voltage within acceptable limits. While the other flexibility needs are required at a larger system level, voltage is a local requirement and must be managed at a circuit level.

21 Dyson, M., Lovins, A.; *The Grid Needs a Symphony, Not a Shouting Match*, The Rocky Mountain Institute. 2017 June. (https://rmi.org/news/grid-needs-symphony-not-shouting-match/).

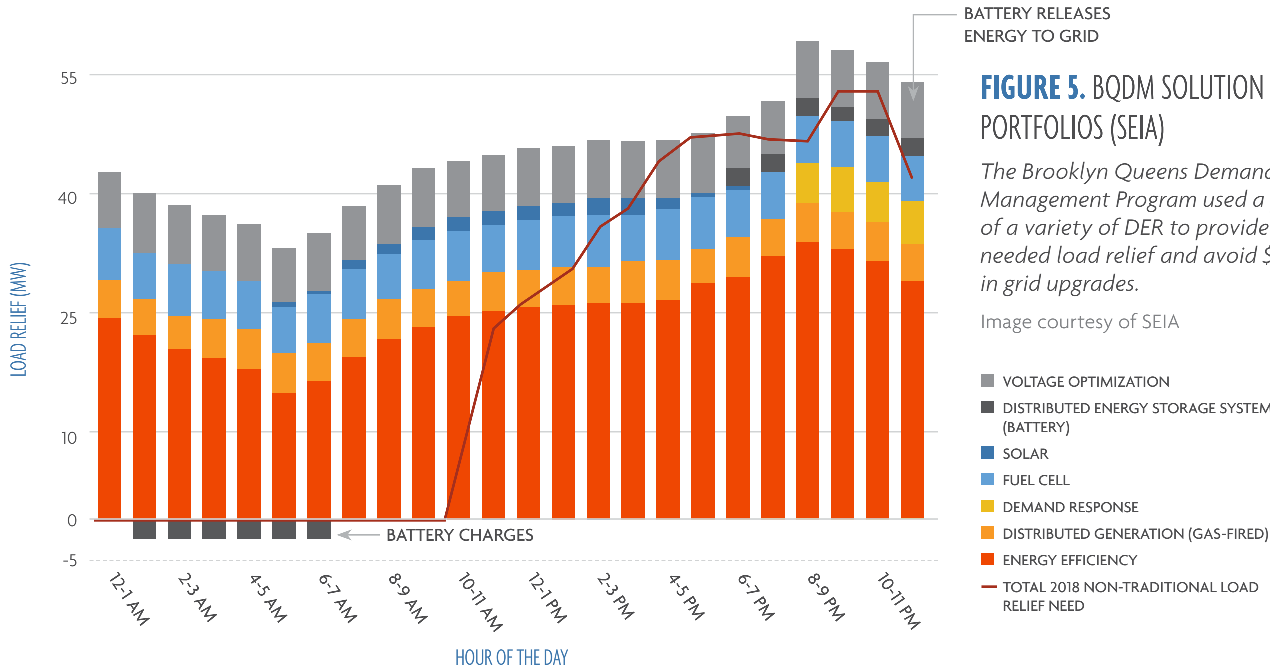


FIGURE 5. BQDM SOLUTION PORTFOLIOS (SEIA)

The Brooklyn Queens Demand Management Program used a portfolio of a variety of DER to provide significant needed load relief and avoid $1.2 million in grid upgrades.

Image courtesy of SEIA

Both overgeneration and ramp are challenges commonly associated with the "duck curve," in which power supplies seasonally swing from surplus to scarcity between a mid-day trough and evening peak.

The majority of New Jersey's DER currently deployed are rooftop solar, which generates on an as-available basis (i.e., when the sun shines). In this context, DER are currently viewed as "negative load" by most system operators and therefore considered inflexible resources. Demand response has been one of the few DER applications considered to provide system flexibility.

Today some utilities are beginning to use DER as a solution to these grid needs, calling for new recognition of DER value. We believe that DER contribution to system flexibility has been undervalued, and new technologies and rate structures will increase the value of DER on the system and improve grid flexibility. These technologies are led by storage, but include solar with smart inverters, targeted energy efficiency, sophisticated demand response, and flexible loads like electric vehicle chargers.

For example, Rocky Mountain Institute recently completed a study on how flexibility provided by DER not only better matches demand to variable supply, but can lead to a system with lower overall costs and carbon emissions. This overall system is better, and increasingly cheaper, than the traditional approach of using only gas-fired generation to balance renewables and meet peak load. As the table above details, the adjusted net load is considerably smoother with the utilization of flexible resources.[22] Flexibility in this case reduces ramps, reduces curtailment (lost excess generation), and increases the value of renewable energy on the system.

22 *Demand Flexibility: The Key to Enabling A Low-Cost, Low-Carbon Grid*, The Rocky Mountain Institute. 2018 February. (https://www.rmi.org/wp-content/uploads/2018/02/Insight_Brief_Demand_Flexibility_2018.pdf).

CASE STUDIES: EMBRACING DER SERVICES

The services DER can provide in supporting today's grid transition are being realized by utilities now, as the following four case studies demonstrate.

CASE STUDY: CONSOLIDATED EDISON DEPLOYS DER TO MEET GRID NEEDS

Consolidated Edison's Brooklyn-Queens Demand Management Project (BQDM) and New York's VDER

ConEd in New York was one of the first utility projects to proactively source local DER and develop creative solutions to defer traditional utility investment to manage load growth. Following an increased focus on climate resilience due to Superstorm Sandy, plus a projected 69 MW overload, ConEd was forced to consider $1.2 billion of grid upgrades, including a new substation, in order to mitigate the overload. Instead, ConEd pursued a mix of traditional grid upgrades and distributed solutions that in total cost one-fifth of the traditional "wires" solution. The solution included a portfolio of DER such as distributed generation, energy efficiency, demand response, and battery storage.

The development of BQDM resulted in three successful lessons learned. First, that utilities can successfully and proactively engage in conversation on non-wires solutions within their traditional distribution planning process. Second, in aggregate, DER technologies spread across diverse customers can add up to address big grid needs. Third, models for compensating utilities based on their successful integration of DER have been tested, shifting their focus from traditional business models wherein compensation is linked to capital deployment, to performance based earnings opportunities.

VALUE-BASED COMPENSATION AND DER SOURCING MECHANISMS

In order to facilitate enhanced adoption of DER, distribution utilities and the BPU can enact various compensation and sourcing mechanisms that incentivize DER adoption. Examples of these mechanisms, including tariffs and "Bring Your Own Device" programs, are explained below.

Bid Based: Bid based solicitations for distributed energy resources such as auctions or solicitations. These solutions create competition among providers to provide the lowest price, but can entail higher participation costs.

Rebate Incentive Program: A rebate incentive program provides customers with a rebate or discount for purchasing and installing a customer-sited DER, such as solar, storage, or fuel cells. The programs are simple in that customers can install DER at a reduced price, while also receiving the various benefits that DER traditionally provide.

Tariff Based: A tariff program designates a particular service, such as peak demand reduction, and the price to be paid for that service. Customers are then given the opportunity to opt-in to the program, utilizing distributed energy resources to capture the value of the tariff and provide the grid service.

Bring Your Own Device: Bring Your Own Device (BYOD) is a customer-focused program that allows utility customers to purchase their own DER such as smart thermostats or energy storage systems, which are then enrolled in utility demand response programs. The utility is able to utilize the customer-sited DER as a grid asset, discharging a battery or turning down a thermostat during peak times, for example. Grid benefits are on top of the value these devices provide to the participating customer.

The right sourcing mechanism may depend on the size of the need to be met, the maturity of the market, and readiness of customers to engage.

In addition to the BQDM project, New York has moved forward with locationally differentiated DER compensation.[23] While the assessment of this locational value need not be overly precise, a thoughtfully crafted DER tariff can send the proper market signals to encourage DER at the right time and place, deferring the need for traditional grid upgrades.

CASE STUDY: PG&E SOLVING TRANSMISSION RELIABILITY ISSUES WITH DER

Pacific Gas & Electric's Oakland Clean Energy Initiative Project

The retirement of a 40-year old peaking plant in Oakland, California posed risks to local transmission reliability. To replace the plant, which operated under a Reliability Must-Run contract, the California grid operator (CAISO) and local utility (PG&E) evaluated whether a portfolio of DER could replace traditional investment options, such as building new gas turbines or transmission lines. The resulting proposal, approved by CAISO, allows PG&E to procure 20-45 MW of clean energy and DER. The proposed resource portfolio includes demand response, battery storage, a mix of local generation and energy efficiency upgrades, and some grid transformer upgrades for an anticipated cost of $102 million—a significantly lower cost than the traditional wires upgrade of $537 million for a 230kv transmission upgrade. This innovative solution is a key example of DER serving transmission reliability needs.

The project also advances environmental justice. Located in an underserved community of color, the plant being displaced contributes to local air pollution; Its removal means cleaner air for all.

CASE STUDY: ISO-NE CAPACITY PROCUREMENTS FROM DER

Sunrun's 20 MW Aggregated Solar Plus Storage Capacity Market Bid

In early 2019, the New England Independent System Operator (ISO-NE) announced that Sunrun, the residential solar and battery storage provider, was awarded a capacity contract for

23 *Order Regarding Value Stock Compensation*, New York Public Service Commission. Pg. 7. 2019 April. (https://assets.documentcloud.org/documents/5975095/06B07A5A-893A-48CB-BB0E-E8B3ABF4A7C6.pdf).

20 MW. The bid represents the first time a capacity market has accepted an aggregated solar plus storage project.

ISO-NE has a mandatory capacity market, known as the Forward Capacity Market. Sunrun participated in this market as a demand response resource, not as a generator. ISO-NE allows two types of demand resources to participate; *active* demand resources are activated and dispatched by the ISO, and include typical demand response technologies to respond to grid signals. *Passive* demand resources are designed to reduce demand across multiple hours, do not require active telemetry, and are not required to participate in energy markets. Sunrun bid its capacity as a passive demand resource, and serves seasonal peak load periods. In the summer, Sunrun solar plus storage systems must provide capacity from 1-5 p.m. in June, July, and August. In winter, that peak shrinks to providing capacity to two hours, between 5-7 p.m. in December and January. The key differentiating factor between ISO-NE's passive demand resource program and similar constructs in other ISOs is that ISO-NE allows for direct metering of the resources, which includes exports in the capacity that can be provided to the market. This is important, as other programs often use baselines to limit the capacity a BTM resource can provide to only what onsite load reduction can take place.

The solar plus storage system provides customer bill management, allowing Sunrun to optimize the value of the behind-the-meter DER to ensure customers receive the best economic value based on the available rate structures. Capacity revenue helps to offset the cost of purchasing the system for Sunrun customers. For the 2018 capacity market auction, the system would receive $3.80/kW-month, suggesting a typical 5kW of capacity across those hours from a residential system would receive $225 per year in capacity payments.

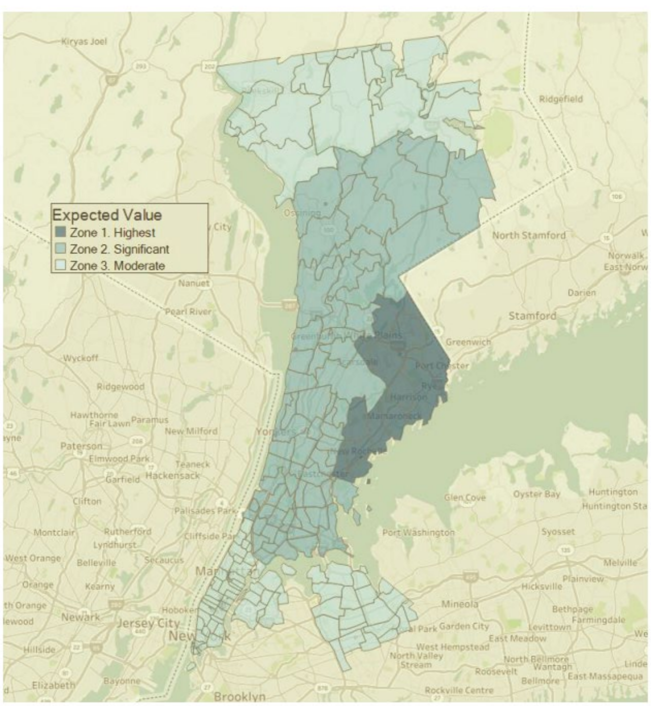


FIGURE 6. *Approximate Boundaries of Con Edison's Natural Gas Service Territory and the Zones Most Affected by Gas Supply Constraints*[24]

The aggregated solar plus storage bid is an innovative example of DER providing both grid services and customer benefits. ISO-NE has developed a market structure that allows the DER to provide capacity value to the grid without complex barriers. At the same time, the customer benefits from the energy value of DER, including a clean, resilient power supply.

CASE STUDY: NEW YORK'S NON-PIPELINE SOLUTIONS

In New York, Consolidated Edison has experienced significant growth in demand for natural gas. Meanwhile, the state's energy policy calls for reduced reliance on fossil fuels, and the utility faces substantial opposition to the types of traditional infrastructure construction it would traditionally deploy to meet growth in demand. Facing this challenge, the New York Public Service Commission recently approved funding for a Con Ed proposal to use approval of non-pipeline solutions focused on reducing demand through energy efficiency measures for its gas customers and supporting beneficial electrification through the deployment of heat pump technology.[24]

Con Edison proposed to implement a multi-pronged program to address its forecasted growing shortfall of peak day pipeline capacity, including non-pipeline solutions. The portfolio, which is currently being rolled out to customers, includes incentives to encourage customer adoption of air-source electric heat pumps, geothermal heat-pumps, all-electric retrofits, as well as traditional energy efficiency measures to reduce natural gas consumption.[26] These measures manifest NYSERDA's industry leading "Renewable Heating and Cooling Policy Framework for New York."[27] The New York Public Service Commission found the proposed $305 million project budget cost effective.

This reliance on distributed energy resources to meet the need for new heating capacity shows promise. Successful implementation could further the applications and value of DER beyond the electric grid into other fuel, essential to reaching deep decarbonization scenarios being pushed by states like New Jersey.

24 New York Public Service Commission, Case 17-G-0606.

25 *Non-Pipeline Solutions Request for Proposals.* Consolidated Edison. (https://www.coned.com/-/media/files/coned/documents/business-partners/business-opportunities/non-pipes/non-pipeline-solutions-rfp.pdf (accessed June 2019)

26 https://www.coned.com/en/business-partners/business-opportunities/non-pipeline-solutions

27 *Renewable Heating and Cooling Policy Framework for New York*. NYSERDA. February 2017.

RECOMMENDATIONS

New Jersey can follow the subsequent best practices and innovations from across the country to establish the role of DER in its clean energy transition.

1) Integrate DER: Ongoing cost reductions and technological improvements guarantee — sooner or later — New Jersey customers will embrace distributed energy resources at scale.[28] The question facing New Jersey is whether its energy system will learn to integrate these resources or simply tolerate them. The former takes more foresight, but saves money; the latter is easier today, but more expensive and challenging in the long run. We recommend the former, giving New Jersey's distribution companies and DER vendors the responsibility and tools to integrate. Key components of this responsibility:

- **Interconnection:** Interconnection policies for DER should be reviewed, reformed and iteratively refined through collaborative forums and working groups. The interconnection process remains one of the key bottlenecks to New Jersey's clean energy future. Understanding and illuminating the challenges of both distribution companies and interconnecting DER providers sets the stage for many key market and technical factors that follow.
- **Value of DER:** Elected officials, distribution companies regulators, and policy makers should consider the value of DER as demonstrated in this paper in order to capture their benefits for the grid. Compensation mechanisms for DER should reflect this value.
- **Targeted Incentives:** In order to extend the environmental and economic benefits of DER to all New Jersey's citizens, targeted incentives would help further the Energy Master Plan's goal to "support local, clean power generation in low-and moderate-income and environmental justice communities."[29]
- **Smart Inverters:** Regulators should start planning now for the adoption of smart inverters, which provide a host of additional services to support the grid, as highlighted above. Not only do smart inverters provide a number of ancillary grid services, such as voltage support or soft-start capabilities, but they similarly help avoid costly T&D investments. Thoughtful adoption of smart inverters will inevitably lead to a more flexible, resilient electric grid.

2) Embrace Electrification of Buildings and Transportation: Strategic electrification of buildings and transportation can reduce emissions and improve air quality, if implemented in concert with a shift to renewable energy through Holistic Grid Planning. The 2019 New Jersey EMP should demand just that. Done right, electrification of buildings and transportation can also make energy more affordable for customers, and increase customer satisfaction. Three key components of this recommendation include:

- **Non-Pipeline Alternatives:** Target DER deployment to avoid the construction of new natural gas pipelines. This could be pursued through three steps. First, execute a moratorium on new gas pipelines while the state considers its options. Second, as ConEdison did in their Brooklyn-Queens Demand Management Projects, require the evaluation of whether targeted DER could defer or displace the need for new pipelines by replacing traditional natural gas end uses like hot water or space heating with electric heat pumps providing clean heat from renewable energy. Third, where pipelines can be displaced or deferred, DER should be allowed to compete to meet identified system needs.
- **Electric Mobility:** Consistent with principles of smart growth, invest in EV charging infrastructure with incentives targeting light-, medium-, and heavy-duty EV. Require that all new charging infrastructure be capable of communicating with grid operators, enabling the resource to be managed as penetration levels warrant. Prioritize developing regulatory solutions that encourage and allow aggregated fleets of EVs to provide grid services such as load shifting.
- **Smart-Charging:** Electrified buildings and EV infrastructure should be made ready for smart charging. Smart charging aligns the use of an electric load with time periods of low emissions, low prices and favorable grid conditions. With smart charging, a suite of price, emission, and dispatch signals can be used to communicate power and grid conditions to the customer or their device. In turn, the customer can provide an automated or behavioral response shifting load to a more favorable time. Smart charging may not be needed on day one of New Jersey's clean energy transition, but planting seeds now provides customers and technology vendors who serve them a signal to invest. New Jersey's building codes will need to be adapted to enable smart charging. Future changes to building codes should begin these changes.

3) Maintain Equity Lens in Planning: To reach Governor Murphy's goal of empowering underserved communities through the Energy Master Plan, this Holistic Grid Planning must be inclusive and maintain an economic equity lens to fully ensure the outcomes benefit all of New Jersey's communities.

4) Holistic Grid Planning: Conduct Holistic Grid Planning, assessing portfolios of bulk renewable and distributed energy resources capable of meeting New Jersey's goal of 100% carbon free energy by 2050. Building on industry best practices for Integrated Resource Planning, Holistic Grid Planning includes transparency in assessing the needs and capabilities of New Jersey's distribution system, a threshold step to realizing the full value of DER.

- This planning should be led by the New Jersey Board of Public Utilities working with relevant state agencies, distribution companies, and conducted in consultation with contributing and impacted stakeholders. It will take time to do correctly, but will serve as the foundation for achieving New Jersey's clean energy transition at the lowest long run cost. While this planning unfolds, invest in the preceding no-regrets seeding solutions.

28 *Electric Vehicle Outlook 2018*, Bloomberg New Energy Finance. 2018 May. (https://about.bnef.com/electric-vehicle-outlook/).

29 Energy Master Plan (Draft), page 7. June 2019

CONCLUSION

DER offer a means to leverage private investment to the benefit of the grid while satisfying the desire among some customers to choose the source of their power, to proactively manage their energy, and to better deal with the increasing extreme weather events. Not all customers wish to make such a choice, but the number is growing due in large part to decreasing costs and increasing availability of DER. This trend is likely to accelerate as EVs become more mainstream, and as the cost of solar, battery storage, and smart energy management devices continues to fall.

As shown through the case studies highlighted in this paper, utilities and their regulators are increasingly recognizing the capabilities of DER to address challenges emerging from the grid transition. DER are demonstrating their capability to provide services to reduce peak demand, avoid transmission and distribution investments, and provide voltage and frequency support. DER also provide an important new service, flexibility. In so doing, they provide enhanced value to utilities and their customers. This progress invites policymakers in New Jersey to think of DER as a complement to the grid transition, rather than a frustration. Once the full capabilities of DER are recognized, policymakers can value the resource accordingly, and consider approaches to incentivizing DER to unlock that value.

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