AGGREGATING THE WAY TO A BETTER FUTURE: HOW DISTRIBUTED POWER PLANTS AND MICROGRIDS HELP MEET THE NEEDS OF THE TWENTY-FIRST CENTURY POWER GRID*

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The U.S. electricity sector is confronting rapid load growth, increasingly extreme weather, and mounting affordability pressures after decades of relative stability. At the same time, distributed energy resources ("DERs")—including rooftop solar, battery storage, electric vehicles, and smart thermostats—are reshaping the grid. This Article argues that aggregations of DERs in the form of distributed power plants ("DPPs") and microgrids are essential tools for managing this transition.

DPPs aggregate customer-sited resources to provide grid services such as peak reduction, capacity support, and demand flexibility, lowering system costs and improving reliability. Microgrids, by contrast, prioritize local resiliency by enabling communities and critical facilities to operate independently during outages while also delivering benefits under normal grid conditions. Drawing on recent federal guidance and state-level developments, with particular attention to North Carolina, this Article examines the benefits DPPs and microgrids can provide and evaluates their regulatory treatment.

Realizing the full potential of DPPs and microgrids requires reforms to expand equitable DER access, streamline enrollment and interconnection, standardize operations and data access, integrate these resources into utility planning and wholesale markets, and properly value resiliency. As regulators seek to balance capacity, affordability, reliability, and decarbonization, DPPs and microgrids should be viewed as foundational components of the twenty-first century power grid.

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INTRODUCTION

Perhaps more than any other industry, the U.S. energy industry finds itself at an inflection point, working to reconcile multiple factors pulling in, at times, competing directions. While the challenges of load growth, extreme weather, and technological change are each distinct in origin, the interrelated nature of the energy system means that approaches to addressing any one must also necessarily inform the strategies to addressing the others. In certain circumstances, one challenge may even present part of the solution for another. Such is the case with distributed power plants ("DPPs") and microgrids, which are emblematic of the technological change fundamentally altering the energy system as it functioned for nearly a century. At the same time, DPPs and microgrids also offer options to address concerns around the impacts of impending load growth and increasingly extreme weather.

After nearly twenty years of limited-to-no load growth through most of the country, many parts of the United States are now experiencing large increases in projected energy demand,[1] including North Carolina.[2] One of the primary reasons for this period of mostly level energy usage was the increasing use of energy efficiency ("EE")[3] and demand-side management ("DSM")[4] programs.[5] Three of the primary factors contributing to increasing energy demand are data center development, the reshoring of manufacturing, and the electrification of buildings and transportation.[6] These three factors are

1. *See* T. BRUCE TSUCHIDA, LONG LAM, PETER FOX-PENNER, AKHILESH RAMAKRISHNAN, SYLVIA TANG, ADAM BIGELOW & ETHAN SNYDER, BRATTLE, ELECTRICITY DEMAND GROWTH AND FORECASTING IN A TIME OF CHANGE 1 (2024) [hereinafter BRATTLE REPORT], https://www.brattle.com/wp-content/uploads/2024/05/Electricity-Demand-Growth-and-Forecasting-in-a-Time-of-Change-1.pdf [https://perma.cc/PV5Y-NCSC]; JOHN D. WILSON, SOPHIE MEYER, ZACH ZIMMERMAN & ROB GRAMLICH, GRID STRATEGIES, POWER DEMAND FORECASTS REVISED UP FOR THIRD YEAR RUNNING, LED BY DATA CENTERS 5 (2025), https://gridstrategiesllc.com/wp-content/uploads/Grid-Strategies-National-Load-Growth-Report-2025.pdf [https://perma.cc/K4EU-7X6G].

2. *See* Order Initiating Proceeding and Requesting Comments at 1, Docket No. E-100, Sub 208 (N.C. Utils. Comm'n June 6, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=e11bad51-1ebd-4237-acf7-358c292be069 [https://perma.cc/Y3K9-SG5S (staff-uploaded archive)]. Duke Energy set new summer and winter energy usage records in 2025. *Duke Energy Serves Customers, Sets Preliminary Electric Use Record in the Carolinas During Week of Sustained Cold Temperatures*, DUKE ENERGY (Jan. 23, 2025), https://news.duke-energy.com/releases/duke-energy-serves-customers-sets-preliminary-electric-use-record-in-the-carolinas-during-week-of-sustained-cold-temperatures [https://perma.cc/KH9P-TZTV] [hereinafter *Duke Energy Serves*] (stating that Duke Energy set a new winter usage record of 37,387 MWh); *Duke Energy Thanks Customers for Help Managing the Power Grid Through Hot Temperatures*, DUKE ENERGY (June 26, 2025), https://news.duke-energy.com/releases/duke-energy-thanks-customers-for-help-managing-the-power-grid-through-hot-temperatures [https://perma.cc/7WCS-2KPY] [hereinafter *Duke Energy Thanks*] (stating that Duke Energy set a new summer usage record of 35,269 MWh).

3. "Energy efficiency means adapting technology to meet consumer needs while using less energy." *Energy Efficiency*, CAL. ENERGY COMM'N, https://www.energy.ca.gov/programs-and-topics/topics/energy-efficiency [https://perma.cc/RV3E-EGR6].

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> Utilities implement demand-side management programs to help customers save energy. Energy efficiency programs, by far the largest demand-side management effort, offer customers incentives to increase efficiency and, therefore, decrease overall electricity demand. Demand response programs, another type of demand-side management, are implemented to decrease customer demand during times of very high system demand or emergencies.

Demand-Side Management Programs Save Energy and Reduce Peak Demand, U.S. ENERGY INFO. ADMIN. (Mar. 29, 2019), https://www.eia.gov/todayinenergy/detail.php?id=38872 [https://perma.cc/NR77-FT7V].

5. *See* BRATTLE REPORT, *supra* note 1, at 5.

6. "The United States is experiencing a surge in electricity demand, driven in part by a confluence of unprecedented electrification, artificial intelligence–driven data center expansion, and a resurgence in industrial reshoring or manufacturing." Thomas L. Keefe, Kate Hardin & Jaya Nagdeo, *2025 Power and Utilities Industry Outlook*, DELOITTE (Dec. 9, 2024), https://www.deloitte.com/us/en/insights/industry/power-and-utilities/power-and-utilities-industry-outlook.html [https://perma.cc/6AM6-ENN5]; *see also* TYLER H. NORRIS, TIM PROFETA, DALIA PATINO-ECHEVERRI & ADAM COWIE-HASKELL, NICHOLAS INST. FOR ENERGY, ENV'T & SUSTAINABILITY, RETHINKING LOAD GROWTH 1 (2025) [hereinafter RETHINKING LOAD GROWTH],

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influencing grids across the country, though the impact varies by region.[7] In North Carolina, the electrification of buildings and transportation infrastructure is an important factor,[8] and data center development remains a much-discussed concern, as with much of the rest of the United States.[9] As of July 2025, of the 101 prospective new projects with at least fifty megawatts of projected demand in North Carolina,[10] a significant portion are in the manufacturing sector.[11] Concerns around integrating so many new large energy users within such a small timeframe led the North Carolina Utilities Commission ("NCUC") to open up a special docket to consider the implications,[12] with many parties participating and sponsoring expert

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https://nicholasinstitute.duke.edu/sites/default/files/publications/rethinking-load-growth.pdf [https://perma.cc/9V5U-UZHU]; *see, e.g.*, Duke Energy Carolinas, LLC and Duke Energy Progress, LLC Responses to Commission's Questions on Large Loads at 1, Docket No. E-100, Sub 208 (N.C. Utils. Comm'n July 24, 2025) [hereinafter Questions on Large Loads], https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=a125fc82-ee3a-40c7-b899-323b46d77217 [https://perma.cc/SH4U-3DBZ (staff-uploaded archive)]; BRATTLE REPORT, *supra* note 1, at 3–4.

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> The combined speed and magnitude of the new growth drivers point towards a sustained period of very high electric demand growth for many parts of the country. However, it is likely that growth will vary substantially across regions and smaller areas (even within a given utility's footprint), highlighting the importance of forecasting specific to each area's circumstances.

BRATTLE REPORT, *supra* note 1, at 2.

8. "[T]he Grid Edge and Customer Programs Panel cited certain challenges . . . noting that 'favorable economic development, residential population growth[,] and the increasing adoption of [EVs] are driving dramatic load growth in the Carolinas . . . .'" Order Accepting Stipulation, Granting Partial Waiver of Commission Rule R8-60A(d)(4), and Providing Further Direction for Future Planning at 71, Docket No. E-100, Sub 190 (N.C. Utils. Comm'n Nov. 1, 2024) [hereinafter Order Accepting Stipulation], https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=cfc6d586-12e4-447f-a552-757d6e73c30e [https://perma.cc/2H9X-RHW9 (staff-uploaded archive)].

9. *See, e.g.*, Comments of the Data Center Coalition at 2–3, Docket No. E-100, Sub 208 (N.C. Utils. Comm'n Aug. 28, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=dd84210e-f69c-4345-9162-3b06cfb82077 [https://perma.cc/2R2K-PTRE (staff-uploaded archive)].

10. *See* Questions on Large Loads, *supra* note 6, at 1.

11. From January to July 2025,

> companies have announced economic development projects producing more than 25,000 jobs and $19 billion in investments, the bulk of which is for new manufacturing facilities. The scale of these investments is driving unprecedented demand for electricity—according to Duke Energy's most recent load forecast, nearly 6,000 MW of additional capacity will need to be added to the grid over the next 10 years to support these and other economic development projects.

Consumer Statement of Position at 1–2, Docket No. E-100, Sub 208 (N.C. Utils. Comm'n Aug. 22, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=18998f13-d885-447b-9527-46e7b3b4b473 [https://perma.cc/93WC-RVNV (staff-uploaded archive)] (statement by Jennifer Mundt, N.C. Department of Commerce).

12. Order Initiating Proceeding and Requesting Comments, *supra* note 2, at 5.

witnesses.[13] The impacts of load growth on the electricity sector are still unfolding, though they are certain to be profound.

Another challenge proving increasingly disruptive to utilities is extreme weather. In 2023, the United States saw a record twenty-eight billion-dollar storms, causing ninety-five billion dollars in damage. "These extreme weather events are responsible for 75–80% of U.S. power outages for households and businesses."[14] Extreme weather caused almost fifty percent of power outages in the United States in the first half of 2025.[15] Wildfires are another massive source of risk from the natural world for utilities.[16] The destabilization of weather patterns is leading to more significant and longer-lasting temperature extremes, whether they be heat domes[17] or polar vortexes.[18] And hurricanes, such as Hurricane Helene, show the ferocity and tragedy that a warmer, wetter world

13. Order Providing Information Regarding Technical Conference at 1–3, Docket No. E-100, Sub 208 (N.C. Utils. Comm'n Sep. 16, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=16e44f09-71a2-4060-90d5-8a0470d906b7 [https://perma.cc/RUA2-N5ND (staff-uploaded archive)]; *see Docket No. E-100, Sub 208*, N.C. UTILS. COMM'N, https://starw1.ncuc.gov/NCUC/PSC/DocketDetails.aspx?DocketId=a4f6ec9e-696f-4d03-9339-1ebe7cbb645b [https://perma.cc/5K2F-AAZ2 (staff-uploaded archive)].

14. SONALI RAZDAN, JENNIFER DOWNING & LOUISE WHITE, U.S. DEP'T OF ENERGY, PATHWAYS TO COMMERCIAL LIFTOFF: VIRTUAL POWER PLANTS 2025 UPDATE, at 3 (2025), https://www.smartenergydecisions.com/wp-content/uploads/2025/04/liftoff_doe_virtualpowerplants2025update.pdf [https://perma.cc/S4BD-LUVY].

15. MARK SPALINGER, J.D. POWER, DISASTERS BECOME A FACT OF LIFE FOR MANY U.S. ELECTRIC UTILITY CUSTOMERS (2025), https://www.jdpower.com/business/resources/disasters-become-fact-life-many-us-electric-utility-customers [https://perma.cc/KPE9-J9X9 (staff-uploaded archive)].

16. *See* ERIC MACOMBER, I. AVERY BICK, MICHAEL WARA & MICHAEL MASTANDREA, STANFORD WOODS INST. FOR THE ENV'T, WILDFIRE: AN UPDATED LOOK AT UTILITY RISK AND MITIGATION 3–4 (2025), https://purl.stanford.edu/nj087tm1688 [https://perma.cc/599X-52GM].

17. Meghan Bartels, *Scorching Heat Dome Grips Eastern U.S., with No Relief in Sight*, SCI. AM. (July 25, 2025), https://www.scientificamerican.com/article/heat-dome-temperatures-may-break-records-in-eastern-u-s/ [https://perma.cc/T3CT-VHVN]; *see Duke Energy Thanks*, *supra* note 2; Brian Martucci, *Virtual Power Plants Helped Save the Grid During Heat Dome*, UTIL. DIVE (July 16, 2025), https://www.utilitydive.com/news/virtual-power-plants-helped-save-the-grid-during-heat-dome/753247/ [https://perma.cc/WZS2-CE3F].

18. *See* Gareth Vipers, Joseph De Avila & Alyssa Lukpat, *Deadly Winter Storm Disrupts Air Travel, Leaves Hundreds of Thousands Without Power*, WALL ST. J. (Jan. 26, 2026), https://www.wsj.com/us-news/climate-environment/deadly-winter-storm-disrupts-air-travel-leaves-thousands-without-power-8786db2d?reflink=desktopwebshare_permalink [https://perma.cc/34V6-JCW8 (dark archive)]; *see* News Release, Fed. Energy Regul. Comm'n, FERC, NERC Release Final Report on Lessons from Winter Storm Elliott (Nov. 7, 2023), https://www.ferc.gov/news-events/news/ferc-nerc-release-final-report-lessons-winter-storm-elliott [https://perma.cc/D4N2-MZZV]; *The Great Texas Freeze: February 11–20, 2021*, NAT'L CTRS. FOR ENV'T INFO. (Feb. 24, 2023), https://www.ncei.noaa.gov/news/great-texas-freeze-february-2021 [https://perma.cc/J4ZB-788Y].

can bring.[19] For utilities, "major storm costs are escalating and not sustainable."[20] Taken together, utilities must prepare for and manage the risks created by a changing climate.

Well before utilities started to experience load growth and the effects of climate change started to become pronounced, a massive technological shift started to change the way utilities manage the grid. The traditional model is for a utility to invest in both large, centralized generation resources and the necessary infrastructure to supply the energy generated to match customers' demand. The rise of distributed energy resources ("DERs")—such as rooftop solar, battery storage, smart thermostats, high-efficiency heat pumps, electric vehicles, and others—represents a fundamental shift in the way customers interact with the grid. The deployment of Advanced Metering Infrastructure ("AMI")[21] allows for both increased EE savings through the better identification of sources of waste and for the more efficient management of DERs and utilization of DSM resources.[22] The cost of many of these behind-the-meter[23] technologies has dropped significantly.[24] Lower costs have led to

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> Hurricane Helene has left significant, long-term impacts on western North Carolina. In addition to the devastating loss of life, the storm destroyed thousands of homes and damaged tens of thousands more. Millions of North Carolinians lost access to critical services like water and sewer, electricity, telecommunications, and healthcare facilities. Thousands of miles of roads and bridges were damaged, cutting communities off and limiting egress for residents and entrance by essential response and recovery teams.

OFF. OF STATE MGMT. & BUDGET, HURRICANE HELENE RECOVERY: REVISED DAMAGE AND NEEDS ASSESSMENT 5 (2024), https://www.osbm.nc.gov/hurricane-helene-dna/open [https://perma.cc/EGJ6-YZKE].

20. *Green Mountain Power Launches First in Nation 2030 Zero Outages Initiative*, GREEN MOUNTAIN POWER (Oct. 10, 2023), https://greenmountainpower.com/news/green-mountain-power-launches-first-in-nation-2030-zero-outages-initiative/ [https://perma.cc/2SEH-GWUU].

21. "Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers." U.S. DEP'T OF ENERGY, ADVANCED METERING INFRASTRUCTURE AND CUSTOMER SYSTEMS 4 (2016), https://www.energy.gov/sites/prod/files/2016/12/f34/AMI%20Summary%20Report_09-26-16.pdf [https://perma.cc/3PTK-8ZSJ].

22. *See* STEVEN ROGERS, MIKE DANZIGER, MICHAEL CLEVELAND, MIKE PIECHOWSKI & SESHADRI NADENDLA, DELOITTE, ENABLING THE CLEAN ENERGY TRANSITION WITH NEXT-GEN ADVANCED METERING INFRASTRUCTURE 8 fig. 1 (2022), https://www.deloitte.com/us/en/Industries/energy/articles/next-gen-advanced-metering-infrastructure.html [https://perma.cc/X5DJ-MZTT].

23. "Behind-the-meter (BTM) refers to the energy systems located on the customer's side of the utility meter. These systems—solar panels, batteries, or efficient appliances—mainly power the building, reduce grid use, lower bills, and can sell excess energy for income or credits." *Behind the Meter vs. Front of the Meter—What's the Difference?*, POWER-SONIC, https://www.power-sonic.com/behind-the-meter-vs-front-of-the-meter/ [https://perma.cc/N5HK-AQQC].

24. Alex Behrens, *Solar Prices Hit All-Time Lows in 2024—Is That About To Change?*, ENERGYSAGE (May 22, 2025), https://www.energysage.com/news/solar-prices-hit-all-time-lows-in-

rapidly increasing deployment,[25] though more can be done to expand equitable access to these technologies.[26] In isolation, many of these resources are likely sources of strain on the grid, whether simply by increasing demand on aging distribution infrastructure or by requiring higher levels of management than previously necessary to ensure reliability. However, the aggregation of DERs can allow many individual DERs that might otherwise be a cost to the system to become a key grid asset.[27] In this way, the rise of artificial intelligence, the primary contributor in the growth of data center development,[28] can also help to contribute to grid reliability through the more efficient management of DERs.[29]

As regulators grapple with each of these sources of change, there are three imperatives that must be balanced: meeting the capacity needs of the grid (Is there enough energy to go around at all times?), ensuring rates do not rise more than necessary (Is the utility following the least cost path to providing service?), and being prepared for and minimizing supply disruptions when they occur (How storm- or fire-ready is the grid's infrastructure?). In many states, there is also a carbon-reduction mandate to balance alongside capacity needs, affordability, and reliability.[30] Regulators' ability to balance these core needs in

2024/ [https://perma.cc/B726-U53U] (solar panel prices); Oktavia Catsaros, *Lithium-Ion Battery Pack Prices See Largest Drop Since 2017, Falling to $115 per Kilowatt-Hour: BloombergNEF*, BLOOMBERGNEF (Dec. 10, 2024), https://about.bnef.com/insights/commodities/lithium-ion-battery-pack-prices-see-largest-drop-since-2017-falling-to-115-per-kilowatt-hour-bloombergnef/ [https://perma.cc/CB46-8AQV] (battery pack prices); *Electric Vehicle Battery Prices Are Expected to Fall Almost 50% by 2026*, GOLDMAN SACHS (Oct. 7, 2024), https://www.goldmansachs.com/insights/articles/electric-vehicle-battery-prices-are-expected-to-fall-almost-50-percent-by-2025 [https://perma.cc/4Q6J-KH5C] (electric vehicle prices).

25. "Across the U.S., DER capacity doubled over the last five years and is expected to nearly double again in the next five years, growing by 217 GW across DER types." RAZDAN ET AL., *supra* note 14, at 19.

26. *See id.* at 16–18.

27. *See* Jim Thomson, Christian Grant, Craig Rizzo, Kate Hardin & Carolyn Amon, *Households Transforming the Grid: Distributed Energy Resources Are Key to Affordable Clean Power*, DELOITTE (June 12, 2024), https://www.deloitte.com/us/en/insights/industry/power-and-utilities/der-grid-modernization.html [https://perma.cc/B7HV-SJM6]; INT'L ENERGY AGENCY, UNLOCKING THE POTENTIAL OF DISTRIBUTED ENERGY RESOURCES 23–26 (2022) [hereinafter UNLOCKING THE POTENTIAL], https://iea.blob.core.windows.net/assets/3520710c-c828-4001-911c-ae78b645ce67/UnlockingthePotentialofDERs_Powersystemopportunitiesandbestpractices.pdf [https://perma.cc/DWG7-862U].

28. Rebecca Leppert, *What We Know About Energy Use at U.S. Data Centers amid the AI Boom*, PEW RSCH. CTR. (Oct. 24, 2025), https://www.pewresearch.org/short-reads/2025/10/24/what-we-know-about-energy-use-at-us-data-centers-amid-the-ai-boom/ [https://perma.cc/5C52-PCK2].

29. KEITH J. BENES, JOSHUA E. PORTERFIELD & CHARLES YANG, U.S. DEP'T OF ENERGY, AI FOR ENERGY: OPPORTUNITIES FOR A MODERN GRID AND CLEAN ENERGY ECONOMY 4–8 (2024), https://www.energy.gov/sites/default/files/2024-04/AI%20EO%20Report%20Section%205.2g%28i%29_043024.pdf [https://perma.cc/RA82-R6Z7].

30. *See* Act of October 13, 2021, ch. 165, § 1, 2021 N.C. Sess. Laws 738, 739–40 (codified as amended at N.C. GEN. STAT. § 62-110.9).

the face of the significant disruptions previously discussed will be the key question for the U.S. utility industry for many years to come.

In the face of such complexity, both as to the existing grid and the challenges that face it, taking a multi-faceted approach is the only way to manage at-times competing risks. "The immensity of the challenge underscores the importance of deploying every available tool, especially those that can more swiftly, affordably, and sustainably . . ."[31] address the challenges facing the system. Two emerging tools for this transitory period are DPPs and microgrids. Both DPPs and microgrids are aggregations of DERs utilized for distinct purposes. There are some examples of the successful deployment and utilization of these technologies, though they are only at the very beginning of achieving what could be possible and concentrated efforts are needed to achieve scale. The rest of this paper will discuss DPPs and microgrids in more detail, explain some of the benefits that they can provide, highlight some prominent examples of their deployment, and describe what is needed to allow these technologies to realize their potential.

I. DISTRIBUTED POWER PLANTS AND MICROGRIDS DON'T ALWAYS HAVE STRAIGHTFORWARD DEFINITIONS, BUT STATES ARE SHOWING THEIR BENEFITS

As still-emerging technologies, both DPPs and microgrids are often subject to a wide range of definitions and may mean different things in different places and contexts. Taken at their most expansive, both technologies have actually been around for a long time.[32] However, advances in technologies have made DERs more accessible than ever before while fundamentally enhancing their capabilities to deliver benefits to both customers and the grid. It is helpful to begin any discussion of DPPs and microgrids by establishing clear definitions. This Part will discuss DPPs and microgrids separately, providing definitions for these resources and discussing the benefits they provide to the grid and those who use them.

A. *Distributed Power Plants*

The concepts of demand response and DSM programs have a long history, gaining emphasis with the energy crisis in the 1970s and efforts to reduce dependence on foreign sources of fuel.[33] "Demand response refers to balancing the demand on power grids by encouraging customers to shift electricity

31. RETHINKING LOAD GROWTH, *supra* note 6, at 1.

32. DPPs were simply considered a form of demand response, while microgrids are comprised of those at the edge of the grid who have chosen to self-supply energy.

33. Lindsey Paulk, *The Evolution and Impact of Demand Response Programs*, ENERGY TOOLBASE: BLOG (June 18, 2024), https://www.energytoolbase.com/blog/energy-storage/the-evolution-and-impact-of-demand-response-programs/ [https://perma.cc/89FA-6TMA].

demand to times when electricity is more plentiful or other demand is lower, typically through prices or monetary incentives."[34] As underlying technologies have advanced and new ones developed, so have the types of demand response programs and their ability to be integrated into DPPs.[35] Recognizing the disparate use of terminology, the U.S. Department of Energy ("DOE") provides this helpful clarity on DPPs from its Pathways to Commercial Liftoff Report:

> [Virtual Power Plants] are aggregations of DERs that can balance electricity demand and supply and provide utility-scale and utility-grade grid services. This report uses the term 'Virtual Power Plants' (VPPs) given it is the predominant term used in the industry, though it recognizes that other organizations use varying terms to describe similar grid assets. The National Association of Regulatory Utility Commissioners (NARUC) uses aggregated DERs (ADERs) to describe groups of DERs capable of providing one or more services to the electric grid through dispatch or control. Electric Power Research Institute (EPRI) uses the term distributed energy resource aggregations (DERAs). Other industry actors use the term distributed power plants (DPPs). This report's definition of Virtual Power Plants includes grid assets that meet the definition of all these terms, including traditional demand response (DR).[36]

While the term VPP currently predominates, this Article uses the term DPP as it more accurately describes these technologies and their implications for the grid. There is nothing virtual about them.

There are now more types of DERs than ever before, with varied capabilities.[37] Some technologies, such as EVs and batteries, are dispatchable, allowing them to be applied to grid reliability concerns.[38] Other technologies, such as rooftop solar systems, bring variable generation capabilities that can help provide energy to the grid, though that variability must be forecast in advance.[39] Other technologies which help to reduce energy usage overall can become grid assets when upgraded with smart controls.[40] While many technologies are still being developed and deployed, DPPs are here and already

34. *Demand Response*, IEA, https://www.iea.org/energy-system/energy-efficiency-and-demand/demand-response [https://perma.cc/JJ36-BG4N].

35. Paulk, *supra* note 33; *see also* ENERGYHUB, BUILDING TRUSTWORTHY VIRTUAL POWER PLANTS: THE VPP MATURITY MODEL 1-2 (2025), https://415845.fs1.hubspotusercontent-na1.net/hubfs/415845/White%20papers%20(2023)/EH_White%20paper-Building%20trustworthy%20VPPs_FINAL_12.16.25.pdf [https://perma.cc/9BJ2-T9SE].

36. RAZDAN ET AL., *supra* note 14, at 1.

37. UNLOCKING THE POTENTIAL, *supra* note 27, at 14–17.

38. *Id.*

39. *Id.*

40. *Id.*

providing meaningful benefits.[41] Wood Mackenzie estimates that U.S. DPP capacity reached 37.5 gigawatts in 2025, representing a 13.7% growth year-over-year.[42]

There are three primary ways that DPPs provide benefits to both the grid and the customers that own them, which also align with the key consideration regulators must balance—as discussed above. First, DPPs can help to meet grid capacity needs during times of peak system demand. Second, DPPs can help to lower the cost of managing the energy transition for ratepayers. And third, DPPs provide reliability benefits from the grid level down to the individual customer and in between. While each of these benefits is distinct and quantifiable, the benefits are also inexorably linked when viewed from a grid-services level—that is because they are tied to utilities' efforts to meet peak demand.

When it comes to the range of benefits DPPs can provide, it is important to understand how peak demand drives system costs and how demand flexibility can benefit consumers and the grid. Peak demand is simply the period(s) of time when consumers within a certain balancing authority[43] consume the most energy. For instance, in North Carolina, while the broadest periods of high energy usage usually occur in the summer, the highest periods of overall energy demand occur on winter mornings during polar vortex events.[44] Utilities plan for, and build their grids around, serving peak demand—making it a significant,

41. Ben Hertz-Shargel, *Virtual Power Plant Growth Is Getting Very Real*, WOOD MACKENZIE (Sep. 17, 2025), https://www.woodmac.com/news/opinion/virtual-power-plant-growth-is-getting-very-real/ [https://perma.cc/GB7C-YTSE]; KEVIN BREHM & MARY TOBIN, VIRTUAL POWER PLANT FLIPBOOK (2024), https://rmi.org/wp-content/uploads/dlm_uploads/2024/07/VP3_flipbook_v1_3.pdf [https://perma.cc/343M-4253]; BRATTLE, ASSESSING VPP PERFORMANCE: IMPACTS OF A TEST EVENT IN CALIFORNIA (2025) [hereinafter BRATTLE, ASSESSING], https://www.brattle.com/wp-content/uploads/2025/08/Assessing-VPP-Performance-Impacts-of-a-Test-Event-in-California-1.pdf [https://perma.cc/ZC5F-CE2P]; *see* RAZDAN ET AL., *supra* note 14, at 6–14.

42. WOOD MACKENZIE, 2025 NORTH AMERICA VIRTUAL POWER PLANT MARKET REPORT 3 (2025) [hereinafter WOOD MACKENZIE, 2025 NORTH AMERICA REPORT], https://go.woodmac.com/l/131501/2025-09-17/34swj9/131501/1758304954Qf9LT4ze/2025_VPP_market_report.pdf [https://perma.cc/L4M3-RMRH (staff-uploaded archive)].

43. A balancing authority

> manages the operation of the electric system within a specific geographic area. There are more than 60 balancing authorities in the U.S., and they are typically either utilities, Power Marketing Administrations (PMAs), or a group of utilities that have formed regional entities called regional transmission organizations (RTOs) and independent system operators (ISOs).

U.S. DEP'T OF ENERGY, OFF. OF CYBERSECURITY, ENERGY SEC. & EMERGENCY RESPONSE, ENERGY SECURITY AND RESILIENCE LEARNING SERIES: THE ROLE OF A BALANCING AUTHORITY 1 (2023), https://www.energy.gov/sites/default/files/2023-08/Balancing%20Authority%20Backgrounder_2022-Formatted_041723_508.pdf [https://perma.cc/DXZ6-DJ7B].

44. N.C. UTILS. COMM'N, ANNUAL REPORT REGARDING LONG RANGE NEEDS FOR EXPANSION OF ELECTRIC GENERATION FACILITIES FOR SERVICE IN NORTH CAROLINA 10 tbl. 3 (2024), https://www.ncuc.gov/reports/longrange24.pdf [https://perma.cc/J5J2-8RPH].

if not the largest, source of cost. The U.S. standard for system reliability is measured by "loss of load expectation" ("LOLE"), and while there is some variation in application, utilities are expected to plan a system that allows for no more than one grid failure event in ten years.[45] Increasing energy demand and extreme weather events make it even more expensive to maintain this standard.[46] Utilities must maintain sufficient generation capacity to meet reliability standards during periods of peak demand,[47] while trying to keep prices affordable for customers.

One way to help lower the costs of meeting peak demand, especially in the face of increasing load, is by utilizing customer demand flexibility to displace demand from peak periods to times where there is latent capacity on the grid. "Flexibility, in this context, refers to the ability of end-use customers to temporarily reduce their electricity consumption from the grid during periods of system stress by using on-site generators, shifting workload to other facilities, or reducing operations."[48] DPPs play a key role in allowing customers to displace their demand from peak periods and to compensate them for that.

> By strategically timing or curtailing demand, these flexible loads can minimize their impact on peak periods. In doing so, they help existing customers by improving the overall utilization rate [of existing infrastructure]—thereby lowering the per-unit cost of electricity—and reduce the likelihood that expensive new peaking plants or network expansions may be needed.[49]

To meet the LOLE standard, utilities must build a significant amount of infrastructure that sits idle most of the time. As demand rises, the types of resources that utilities use to meet the LOLE standard during peak periods will be a significant driver of system costs in the future. When demand is displaced from the peak to other periods, some of that infrastructure is then utilized more often, increasing its overall utilization rate. As ratepayers must cover the cost

45. *See* Johannes P. Pfeifenberger, Kathleen Spees, Kevin Carden & Nick Wintermantel, *Resource Adequacy Requirements: Reliability and Economic Implications*, BRATTLE GRP. (Sep. 2013), https://www.ferc.gov/sites/default/files/2020-05/02-07-14-consultant-report.pdf [https://perma.cc/MK2N-GRTV].

46. *Duke Energy Serves*, *supra* note 2; *Duke Energy Thanks*, *supra* note 2.

47. News Release, *supra* note 18. They do so by maintaining a reserve margin of generation resources above what is necessary on paper to meet their projected peak demand, as this provides back-up resources when infrastructure inevitably fails during extreme weather. In North Carolina, Duke Energy's approved reserve margin is twenty-two percent. *See* Order Accepting Stipulation, *supra* note 8, at 49.

48. RETHINKING LOAD GROWTH, *supra* note 6, at 2.

49. *Id.* at 7.

of that infrastructure one way or another,[50] increasing the utilization rate of existing infrastructure lowers the cost per unit of energy that customers pay.[51]

As new load is added to the system, both the new demand and the resources added to serve that demand impact the per-unit cost. When considering the cost to ratepayers, the key question is whether the new resources being added to the grid cost more or less than the existing resources serving the current needs of customers. As with much of the economy, the energy industry is experiencing both inflation[52] and supply chain disruptions[53] that are driving the cost of building new things higher. Rather than requiring further investment from the utility, DPPs usually leverage both existing infrastructure and private investment[54] in their deployment, lowering costs and allowing them to be implemented faster than traditional resources.[55] DPPs also do not rely on resources that require fuel, reducing ratepayers' exposure to often volatile fuel costs.[56]

Some utilities are already using DPPs and demand flexibility to help significantly with meeting peak demand.[57] Figure 1 shows Portland General

50. Because it is being utilized to meet peak demand, the infrastructure still meets the "used and useful" standard and so the utility may still recover the cost of it.

51. *See Presentation Materials from Devi Glick*, N.C. SUSTAINABLE ENERGY ASS'N (Oct. 14, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=eca6f13c-44f2-48f1-853c-1574c235bb6f [https://perma.cc/7AKV-FC9D].

52. *See Retail Electricity Prices Closely Tracked Inflation over the Last 10 Years*, U.S. ENERGY INFO. ADMIN. (Sep. 11, 2024), https://www.eia.gov/todayinenergy/detail.php?id=63064 [https://perma.cc/G5J9-GA5B]; *U.S. Electricity Prices Continue Steady Increase*, U.S. ENERGY INFO. ADMIN. (May 14, 2025), https://www.eia.gov/todayinenergy/detail.php?id=65284 [https://perma.cc/2CBR-ZKWV]; Scott Horsley, *Electricity Prices Are Climbing More than Twice as Fast as Inflation*, NPR (Aug. 16, 2025), https://www.npr.org/2025/08/16/nx-s1-5502671/electricity-bill-high-inflation-ai [https://perma.cc/972A-F39D].

53. "The energy sector depends on a steady flow of critical components, raw materials, and infrastructure to maintain reliable power generation and distribution. Supply chain disruptions can create significant project delays and operational inefficiencies, affecting both traditional and renewable energy sources." *Supply Chain Industry Challenges in Energy, Refining, and Chemical Manufacturing*, NEXUS, https://nexusegroup.com/news/supply-chain-industry-challenges [https://perma.cc/CBF6-R34Z]; *see also How Do Supply Chain Disruptions Affect Energy Prices?*, MONTEL (June 5, 2025), https://montel.energy/resources/blog/how-do-supply-chain-disruptions-affect-energy-prices [https://perma.cc/KQK4-HXP8].

54. In the form of customers buying behind-the-meter DERs.

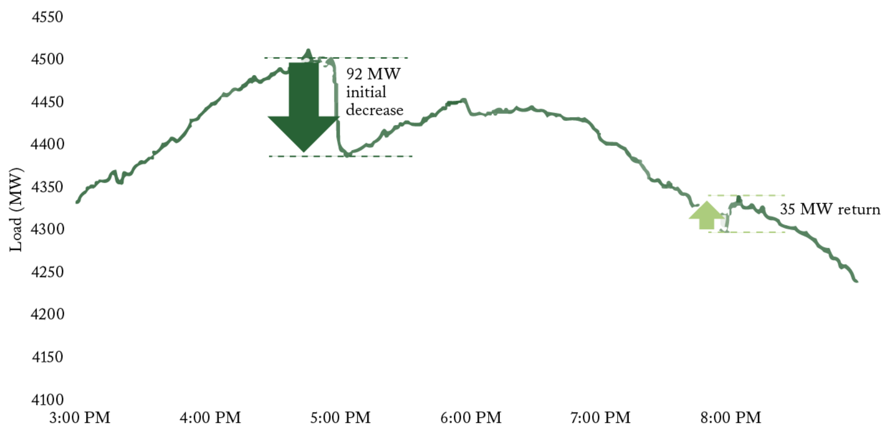
55. RAZDAN ET AL., *supra* note 14, at 11–14.

56. Even when DPPs do utilize resources that rely on fuel, such as behind-the-meter diesel generators, the costs of that fuel flow to the individual customer operating that resource and not to the general rate base, as with the costs of fuel for utility-operated resources. *See* Direct Testimony of Albert Lin on Behalf of NCSEA, Docket No. E-7, Sub 1313 (N.C. Utils. Comm'n May 13, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=0a338e68-d7a5-481d-85b7-6cb3dedfeb96 [https://perma.cc/YR4R-5ZLW].

57. Portland General Electric ("PGE") is using a DPP to reduce summer peak demand with marked increases in contributions to peak demand from 2023 to 2025. In 2023, PGE achieved 92 MW of demand reduction at the peak, with a stated goal of increasing the capacity of its DPP from serving

Electric's ("PGE") demand curve for August 14, 2023. It shows how PGE deployed its DPP to significantly lower demand at around five p.m., just as the curve approached its peak. DPPs often utilize resources that represent a deferral of demand, rather than only a reduction. The "return" seen at eight p.m. shows where customer demand rebounded after the PGE no longer called on customers' DERs to participate in its DPP.

Figure 1: Bulk System Impact from Portland General Electric's Peak Shaving Program (August 14, 2023)[58]



There are many DERs that can contribute to DPPs. While PGE and California's DPPs rely primarily on rooftop solar and behind-the-meter battery storage, other technologies are also being scaled to make an impact—such as smart thermostats.[59] Programs utilizing smart thermostats help shift the energy

~2% of current peak demand to ~25%. RAZDAN ET AL., *supra* note 14, at 10–11. Showing this growth, PGE was able to deploy its DPP on consecutive days in July 2025 to achieve back-to-back peak load reductions of over 100 MW. *PGE Customer Actions Resulted in the Largest Electricity Demand-Shift in Company History During Multi-Day Heat Wave*, PGE (July 11, 2024), https://portlandgeneral.com/news/2024-07-customer-actions-resulted-in-largest-electricity-demand-shift [https://perma.cc/V7GZ-UQNW\]. Not to be outdone, California tested its DPP around the same time and achieved 535 MW of average output. BRATTLE, ASSESSING, *supra* note 41. For comparison, Duke Energy recently received approval to build two new natural gas combustion turbine units (which are mostly used to meet peak demand, providing a good comparison point as an alternative resource to DPPs) that are 425 MW each. Order Granting Certificate of Public Convenience and Necessity at 9, Docket No. E-7, Sub 1297 (N.C. Utils. Comm'n Dec. 2, 2024), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=d7e15bec-c4a7-4437-bcb2-94984ebc8d35 [https://perma.cc/WRV6-P6XD].

58. Figure adapted from RAZDAN ET AL., *supra* note 14, at 11 fig. 1.

59. Arizona Public Service ("APS") started its Cool Rewards program in 2018, which utilizes smart thermostats to displace energy used for heating and cooling during peak demand. *See APS Virtual Power Plant Benefits Customers, Smart Grid & Environment*, APS (Nov. 8, 2021), https://www.aps.com/en/About/Our-Company/Newsroom/Articles/APS-Virtual-power-plant-benefits-customers-smart-grid-environment [https://perma.cc/YX7Y-4WVF]. Between 2020 and 2023, APS was able to scale the

needed for heating and cooling away from peak demand "to cheaper and cleaner times."[60]

DPPs can also provide a cost-effective solution to meeting peak demand, as shown by recent studies.[61] One such analysis by Rewiring America found that incentivizing heat pump and solar paired with storage deployment can enable utilities to meet the demand needs from new data centers, while providing more reliability and decreasing costs for existing ratepayers.[62] Figure 2 demonstrates how DPPs can stack different types of benefits, including capacity needs (as represented by "Energy"), avoided system upgrades ("Distribution and Transmission"), and emissions reductions.

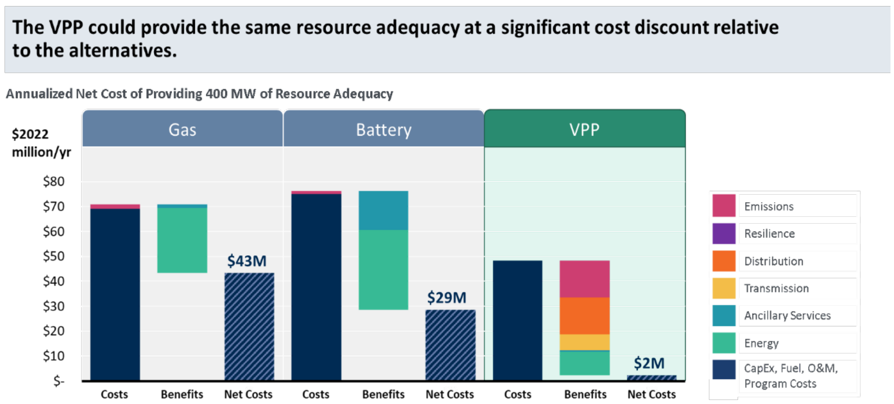
Cool Rewards program by over 340%, *see* BREHM & TOBIN, *supra* note 41, at 9, now connecting over 90,000 thermostats representing a capacity of 160 MW, *Our Virtual Power Plant*, APS, https://www.aps.com/en/About/Sustainability-and-Innovation/Technology-and-Innovation/Virtual_Power_Plant [https://perma.cc/YAS3-FJQ9]. Meanwhile in Texas, NRG Energy and Renew Home partnered in 2024 with the goal of "distribut[ing] hundreds of thousands of VPP-enabled smart thermostats by 2035 and creat[ing] a nearly 1 GW AI-powered VPP . . . to improve the Texas grid's resiliency and help households manage and lower their energy costs." *NRG, Renew Home and Google Cloud Announce Partnership*, RENEW HOME (Nov. 7, 2024), https://www.renewhome.com/press/press-release/nrg-renew-home-google-cloud-announce-plan-to-develop-1gw-virtual-power-plant-in-texas [https://perma.cc/48XK-ZXLS].

60. *For Your Home*, RENEW HOME, https://www.renewhome.com/for-your-home [https://perma.cc/8JPE-F4AR].

61. A 2023 study performed by Brattle found that among numerous options to provide 400 MW of resource adequacy, "a 60 GW VPP deployment could meet future resource adequacy needs at a net cost that is $15 billion to $35 billion lower than the cost of the alternative options over the ensuing decade." RYAN HLEDIK & KATE PETERS, REAL RELIABILITY: THE VALUE OF VIRTUAL POWER 5 (2023), https://www.brattle.com/insights-events/publications/real-reliability-the-value-of-virtual-power/ [https://perma.cc/H3PZ-8GVE]. Similarly, RMI conducted a case study examining different resource portfolios used to meet the projected needs of the grid in 2035. It found that utilizing DPPs would realize $1 billion in annual benefits and save households $140 per year. JACOB BECKER, KEVIN BREHM, JESSE COHEN, TYLER FITCH & LAUREN SHWISBERG, RMI, POWER SHIFT: HOW VIRTUAL POWER PLANTS UNLOCK CLEANER, MORE AFFORDABLE ELECTRICITY SYSTEMS 20 (2024), https://rmi.org/wp-content/uploads/dlm_uploads/2024/09/power_shift_report.pdf [https://perma.cc/62CE-BYB9]. Looking at California's existing DPP, a recent report found that it will bring $206 million in savings just between 2025 and 2028. Robert Walton, *California's Virtual Power Plant Could Save $206M by 2028: Brattle*, UTIL. DIVE (Aug. 20, 2025), https://www.utilitydive.com/news/californias-virtual-power-plant-could-save-206m-by-2028-brattle/758145/ [https://perma.cc/4A4M-GTVB].

62. *Household Upgrades Could Offset All New Projected Data Center Demand*, REWIRING AM., https://www.rewiringamerica.org/research/homegrown-energy-report-ai-data-center-demand [https://perma.cc/YW4E-Q86K].

Figure 2: Annualized Net Cost of Providing 400 MW of Resource Adequacy[63]



DPPs also provide reliability benefits beyond the grid level, helping with the regional balancing of resources while also providing energy security at the individual customer level.[64] As utilities work to serve peak demand, they must also consider the practical constraints of the grid, or put another way, the operational limitations of existing grid infrastructure. One example of this is when a large amount of utility-scale generation resources are built a significant distance from the customers using the energy generated, congesting both distribution and transmission infrastructure.[65] DPPs can help to ease that congestion and reduce curtailment of renewable resources that might be needed to maintain system reliability.[66]

The charging of EVs represents both the need for, and the potential of, DPPs.[67] Some estimates show that, by 2030, EVs could represent the largest

63. HLEDIK & PETERS, *supra* note 61, at 24.

64. *See* NAT'L ASS'N OF REGUL. UTIL. COMM'RS, REGULATORS' FINANCIAL TOOLBOX: BEHIND-THE-METER (BTM) ENERGY STORAGE 3–4 (2023), https://pubs.naruc.org/pub/6233DBE2-B58B-52FF-925E-250DD26DECF9 [https://perma.cc/36J6-PFVU].

65. *See, e.g.*, Order Adopting Initial Carbon Plan and Providing Direction for Future Planning at 113–19, Docket No. E-100, Sub 179 (N.C. Utils. Comm'n Dec. 30, 2022), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=7b947adf-b340-4c20-9368-9780dd88107a [https://perma.cc/W3D7-MEBS (staff-uploaded archive)].

66. *See* KEVIN BREHM, MARK DYSON, AVERY MCEVOY & CONNOR USRY, RMI, VIRTUAL POWER PLANTS, REAL BENEFITS 16 (2023), https://rmi.org/wp-content/uploads/dlm_uploads/2023/01/virtual_power_plants_real_benefits.pdf [https://perma.cc/39ZW-DGGM].

67. *A Comprehensive Guide to Electric Vehicle Managed Charging*, SMART ELEC. POWER ALL., https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/ [https://perma.cc/GJ8X-T9B3 (staff-uploaded archive)]; Muhammad Bashar Anwar, Matteo Muratori, Paige Jadun, Elaine Hale, Brian Bush, Paul Denholm, Ookie Ma & Kara Podkaminer, *Assessing the Value of Electric Vehicle Managed Charging: A Review of Methodologies and Results*, 15 ENERGY

single source of load growth since air conditioners in the 1950s.[68] This additional load could put a significant strain on existing grid resources and necessitate expensive grid upgrades. However, when managed, EV charging can quickly go from being a source of cost on the grid to an essential resource.[69] A recent study found that "[m]anaged charging programs can turn flexible electric vehicle loads into a grid resource capable of generating $30 billion in annual utility savings . . . ."[70] The value of managed charging programs comes from multiple sources. First, managed charging programs can help shift EV charging from times of peak demand, while still ensuring the EV is charged in the morning—particularly in the summer when residential charging is most likely to align with existing peak demand without intervention.[71] Second, the timing of EV charging can be aligned with the timing of intermittent renewable energy generation—whether from solar midday or wind, which is usually strongest at night—to ensure optimal use and limit curtailment of those resources. Third, managed charging can help to reduce the cost of distribution system upgrades needed to serve new EV-driven load.[72] While many utilities are still experimenting with managed charging in pilot programs,[73] other utilities such as Xcel Energy have forged ahead with full-scale programs.[74] The first two types of benefits described above can be seen in Figure 3, with EV charging being used to match solar resources' peak output midday and wind in the very early

& ENV'T SCI. 466, 466 (2022), https://www.energy.gov/eere/analysis/assessing-value-electric-vehicle-managed-charging-review-methodologies-and-results [https://perma.cc/CU9Y-NYWA (staff-uploaded, dark archive)].

68. *A Comprehensive Guide to Electric Vehicle Managed Charging*, *supra* note 67.

69. A recent Brattle report estimated "that the value of active managed charging that optimizes distribution system loading can be as high as $400 per EV per year." AKHILESH RAMAKRISHNAN, J. MICHAEL HAGERTY, ETHAN SNYDER, SANEM SERGICI & RYAN HLEDIK, BRATTLE, DEMONSTRATING THE FULL VALUE OF MANAGED ELECTRIC VEHICLE CHARGING 9 (2026) [hereinafter MANAGED ELECTRIC VEHICLE CHARGING], https://www.brattle.com/wp-content/uploads/2026/01/Demonstrating-the-Full-Value-of-Managed-Electric-Vehicle-Charging-1.pdf [https://perma.cc/RQT7-7R3Y].

70. Robert Walton, *Managed EV Charging Could Generate $30B in Annual Savings by 2035: Report*, UTIL. DIVE (Aug. 27, 2025), https://www.utilitydive.com/news/managed-ev-charging-could-generate-30b-in-annual-savings-by-2035-report/758242/ [https://perma.cc/2YL6-939B].

71. People are most likely to plug in their EV to recharge as they return home from work. Nick Pesta, *EV Charging—The Importance of Affordable, Convenient Access* (Apr. 3, 2026), https://rmi.org/ev-charging-the-importance-of-affordable-convenient-access/ [https://perma.cc/7SRF-8BCA].

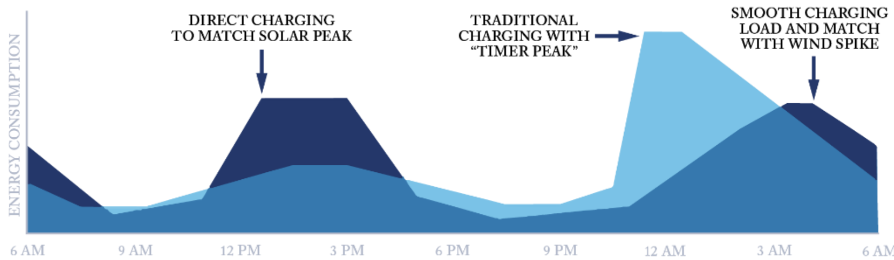
72. Managed charging programs are estimated to reduce distribution grid costs by roughly $200 per year per EV. MANAGED ELECTRIC VEHICLE CHARGING, *supra* note 69, at 10.

73. *See* Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's First Consolidated Quarterly Report on Electric Transportation Programs and Motion to Modify Reporting Timeline—Redacted at 47–48, Docket No. E-100, Sub 203 (N.C. Utils. Comm'n Aug. 1, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=62cc681a-0815-4c05-b89e-ae1fa95d536d [https://perma.cc/3QM3-HYEV (staff-uploaded archive)].

74. *See Electric Vehicle Charging Programs and Rebates*, XCEL ENERGY, https://ev.xcelenergy.com/ev-charging-programs [https://perma.cc/4CQN-HZ6H].

hours, and a timed EV charging peak occurring at night after peak demand has passed.[75]

Figure 3: Opportunities for EV Managed Charging to Meet Grid Needs (Illustrative)[76]



DPPs can also provide benefits at the customer level; in fact, "[t]he primary beneficiaries of DERs are the customers that own them."[77] Extreme weather is causing more energy supply disruptions than ever before.[78] Customers equipped with the right DERs, such as rooftop solar and battery storage, can self-supply their needs in order to limit their disruptions.[79]

Duke Energy's Residential PowerPair Pilot Program provides one example of how a utility-run program can both achieve demand reduction benefits for the grid while providing customers with individual resiliency

75. *A Comprehensive Guide to Electric Vehicle Managed Charging*, *supra* note 67, at 15.

76. Figure adapted from *id.*; Ramez Naam, *How To Decarbonize America—and the World*, TECHCRUNCH (Feb. 15, 2019, at 06:30 PT), https://techcrunch.com/2019/02/15/how-to-decarbonize-america-and-the-world/ [https://perma.cc/RPL4-3AXR].

77. KIM, *supra* note 27, at 7.

78. *See supra* Part I (discussing the disruptive effects of extreme weather on utilities).

79. *See* John Deem, *Power of "Basic": Low-Cost Solar System Kept Power on for Savannah Couple After Helene*, SAVANNAH NOW (Oct. 15, 2024, at 05:10 ET), https://www.savannahnow.com/story/news/environment/2024/10/15/low-cost-solar-system-kept-power-on-for-savannah-couple-after-helene/75632908007/?gnt-cfr=1&gca-cat=p&gca-uir=true&gca-epti=z114801d00----v114801d--48--b--48--&gca-ft=141&gca-ds=sophi [https://perma.cc/B865-VJBF]; Jeff St. John, *Hurricane Helene Underscores Need for More Solar-Battery Microgrids*, CANARY MEDIA (Oct. 18, 2024), https://www.canarymedia.com/articles/distributed-energy-resources/hurricane-helene-underscores-need-for-more-solar-battery-microgrids [https://perma.cc/47BJ-C7TU] [hereinafter St. John, *Hurricane Helene Underscores Need for More Solar-Battery Microgrids*]. "We also anticipate that solar plus storage will have a huge resilience benefit, especially in the face of a growing intensity of natural disasters hurricanes, heat waves, and cold snaps. Winter Storm Elliot clearly showed how incentivizing distributed solar plus storage could improve outcomes for ratepayers." Joint Initial Comments of Southern Alliance for Clean Energy, Vote Solar, and North Carolina Sustainable Energy Association at 4, Docket Nos. E-2, Sub 927; E-2, Sub 1287; E-7, Sub 1032; E-7, Sub 1261 (N.C. Utils. Comm'n Aug. 25, 2023), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=85f00533-9b07-49d4-a657-e1fdcedf9e54 [https://perma.cc/X9G9-K23W (staff-uploaded archive)].

benefits.[80] Though limited in size and still in the implementation process, PowerPair is already contributing to grid reliability needs.[81] PowerPair also contributed to a significant increase both in the overall number of rooftop solar systems being installed in North Carolina and in the attachment rate of battery storage to rooftop solar systems.[82] From a reliability and resiliency standpoint, the attachment rate of battery storage is essential as rooftop solar systems without batteries cannot operate during grid blackouts, thereby providing no benefit to customers during those critical periods.[83] By incentivizing customer adoption of these technologies, Duke Energy is both helping to maintain the reliability of the grid while enabling customers to become more resilient to service disruptions. Though Duke Energy declined to expand the PowerPair program to include a cohort focused on medical device-dependent customers,[84] this at-risk population would benefit greatly from increased access to solar and storage.[85] Duke Energy recently filed a similar program proposal for nonresidential customers that is under consideration by the North Carolina Utilities Commission.[86]

80. Ethan Blumenthal, *PowerPair Program Approved By NC Utilities Commission*, N.C. SUSTAINABLE ENERGY ASS'N (Apr. 24, 2024), https://www.energync.org/blog/powerpair-program-approved-by-nc-utilities-commission/ [https://perma.cc/CP7D-R8VA] [hereinafter Blumenthal, *PowerPair*]; *Solar + Battery Incentives*, DUKE ENERGY, https://www.duke-energy.com/Home/Products/PowerPair [https://perma.cc/6ZGG-V82D (staff-uploaded archive)]; Stacey Washington, *Resilience and Reliability: Solar + Storage in the Southeast*, S. ALL. FOR CLEAN ENERGY (Sep. 19, 2025), https://cleanenergy.org/news/resilience-and-reliability-solar-storage-in-the-southeast/ [https://perma.cc/HJ2S-8WYT].

81. Duke Energy Carolinas, LLC and Duke Energy Progress, LLC's Initial Joint Annual Status Report at 8–9, North Carolina Utilities Commission Docket Nos. E-2, Sub 927; E-2, Sub 1287; E-7, Sub 1032; E-7, Sub 1261 (May 12, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=b67bf07d-b3d7-4db1-9893-d8348de83979 [https://perma.cc/65J3-Q8H6 (staff-uploaded archive)].

82. Direct Testimony and Exhibits of Jake Duncan on Behalf of the Southern Alliance for Clean Energy at 17–19, Docket No. E-100, Sub 207 (N.C. Utils. Comm'n Mar. 30, 2026), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=f8c16cbb-1194-4450-a0d2-1b0753ed6227 [https://perma.cc/6UBG-DKWJ].

83. Zachary Turner, *Solar Energy Helped Keep the Lights on After Helene, but Not How You Might Think*, WFAE (Oct. 22, 2024, at 07:32 ET), https://www.wfae.org/energy-environment/2024-10-22/solar-energy-helped-keep-the-lights-on-after-helene-but-not-how-you-might-think?utm_medium=email [https://perma.cc/2CBR-NMSV].

84. Duke Energy Carolinas, LLC, and Duke Energy Progress, LLC's Update on the Addition of Another Cohort for PowerPair—Errata at 2, Docket Nos. E-2, Sub 927; E-2, Sub 1287; E-7, Sub 1032; E-7, Sub 1261 (N.C. Utils. Comm'n July 10, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=097b044e-f484-414f-871c-c05ef4b86394 [https://perma.cc/7TE3-YNP7 (staff-uploaded archive)].

85. *See* Washington, *supra* note 80; Deem, *supra* note 79.

86. Duke Energy Progress, LLC's Application for Approval of Its Non-Residential Storage Demand Response Program at 1, Docket No. E-2, Sub 931 (N.C. Utils. Comm'n Sep. 15, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=fad2bee2-507f-4293-b779-20357656f177 [https://perma.cc/X3CV-8GH9 (staff-uploaded archive)]; Duke Energy Carolinas, LLC's Application for Approval of Its Non-Residential Storage Demand Response Program at 1, Docket No. E-7, Sub 1032 (N.C. Utils. Comm'n Sep. 15, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=121f4277-0143-4678-bd7d-ce18ac52e1b4 [https://perma.cc/3TT6-CFYJ (staff-uploaded archive)].

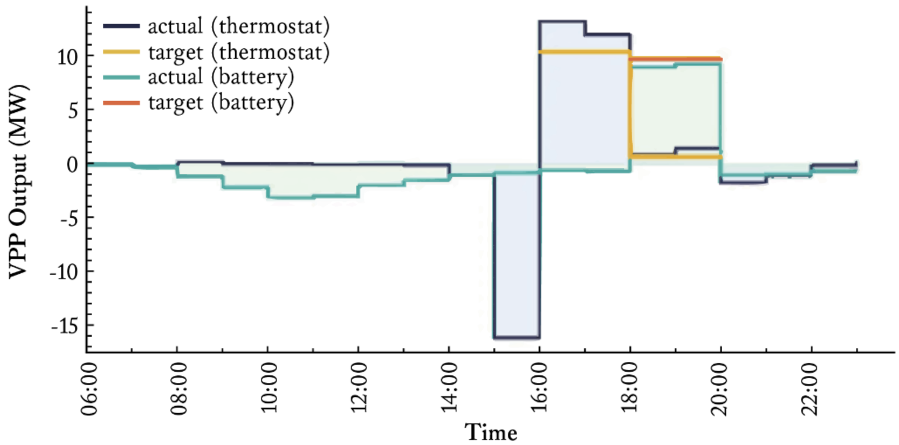
The PowerPair program follows in the footsteps of programs operated by Green Mountain Power[87] and National Grid. National Grid's ConnectedSolutions program provides an example of how different DERs can be linked within a DPP to provide benefits and how DPPs can be deployed in a rapid manner.[88] The program utilizes a third party to aggregate the impacts of multiple technologies from multiple vendors. Figure 4 shows how certain technologies can be used together, with smart thermostats providing the initial two hours of peak demand reduction (from four to six p.m.) followed by the utilization of battery storage (from six to ten p.m.).[89] The negative DPP output from three to four p.m. reflects the utilization of smart thermostats to pre-cool customers' premises in advance of their use to reduce cooling-related load to match overall system peak demand, while from eight a.m. to two p.m., the light green line tracks battery systems charging.

87. "Green Mountain Power launched a utility-owned and operated battery VPP that offers backup power for participants, peaking capacity, emissions reduction, and transmission benefits for the grid, and lower costs for all customers." KIM, *supra* note 27, at 32. The program has two primary elements. There is a Bring-Your-Own Device component that offers an up-front incentive similar to the PowerPair program discussed above; there is also an energy storage system leasing option, where the utility maintains ownership but allows customers greater access to storage without as steep an up-front investment. STEPHANIE BIELER, CARA GOLDENBERG, AVERY MCEVOY, KATERINA STEPHAN & ALEX WALMSLEY, NAT'L ASSOC. OF REGUL. UTIL. COMM'RS, AGGREGATED DISTRIBUTED ENERGY RESOURCES IN 2024: THE FUNDAMENTALS 63 (2024), https://connectedcommunities.lbl.gov/sites/default/files/2024-07/NARUC_ADER_Fundamentals_Interactive.pdf [https://perma.cc/L3YW-XPAW]. As of April 2024, the two programs have collectively more than 3,000 participants that can achieve over 30 MW in capacity. *Id.* "Both programs also provide participating customers with backup power during outages in Vermont due to extreme weather." *Id.* Building on the success of these programs, GMP launched a 2030 Zero Outages Initiative that seeks to eliminate outages for customers by 2030 through grid hardening, grid modernization, and battery storage deployment. *Green Mountain Power Launches First in Nation 2030 Zero Outages Initiative*, GREEN MOUNTAIN POWER (Oct. 10, 2023), https://greenmountainpower.com/news/green-mountain-power-launches-first-in-nation-2030-zero-outages-initiative/ [https://perma.cc/B6ZK-JBHV].

88. The ConnectedSolutions program was developed and launched within four months. KIM, *supra* note 27, at 66–69.

89. *Id.* at 69.

Figure 4: Target Versus Actual VPP Output Utilizing Batteries and Smart Thermostats[90]



As DPPs become more sophisticated, more technologies can be linked to amplify the benefits that can be provided[91]—though significant barriers remain.[92]

B. *Microgrids*

Microgrids, like DPPs, utilize aggregated DERs to provide benefits greater than any individual technology or device could provide. However, whereas DPPs look to DER aggregation primarily to provide benefits to the grid,[93] microgrids combine DERs with the primary goal of being self-sufficient from the grid. "A microgrid is a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to operate in grid-connected or

90. Figure adapted from Jeff St. John, *Fine-Tuning How Homes Can Help the Grid as 'Virtual Power Plants*,' CANARY MEDIA (Nov. 26, 2024), https://www.canarymedia.com/articles/virtual-power-plants/fine-tuning-how-homes-can-help-the-grid-as-virtual-power-plants [https://perma.cc/326D-9QYC].

91. EnergyHub recently published a framework for evaluating DPPs at various "maturity" levels, moving from basic DR at Level 0 to a "grid-adaptive VPP" at Level 4. *See* ENERGYHUB, *supra* note 35, at 8. The amount of technologies and the sophistication of their use, as well as the benefits achieved, increase with each level of maturity. *Id.*

92. *See generally* ANGELA LONG, RYAN LONG & NATALIE FRICK, INSIGHTS INTO SCALING VIRTUAL POWER PLANTS (2025), https://eta-publications.lbl.gov/sites/default/files/2025-01/insights_into_scaling_vpps_01_15_2025_vcopyedited.pdf [https://perma.cc/94K8-5KSR] (discussing challenges to implementing successful DPPs).

93. Which is why, at their core, each DPP program is about compensating customers for the grid-level benefits they are providing in order to incentivize their participation and/or adoption of that technology.

island mode."[94] This definition, like with DPPs, is intentionally broad because of the range of on-the-ground applications. Microgrids can be scaled to power whole communities or even entire islands,[95] or they can refer to a set of DERs at a single location. Though reliability and resiliency are the primary benefits microgrids provide, in certain cases, they can also be the most affordable option.

The relative affordability of microgrids generally turns on two key factors: geography and the existing infrastructure around a particular community. Communities that are "islanded," or sufficiently isolated such that there are limited infrastructure options that can be used to serve them, can greatly benefit from microgrids. While there is certainly still the resiliency benefit, the cost of building, maintaining, and repairing critical infrastructure can make microgrids the more affordable option in such locations.[96] The risk of wildfires is another important consideration driving remote microgrid adoption, mostly in the western United States.[97]

An example of a microgrid meeting a community's need comes from Hot Springs, North Carolina. Though the North Carolina Utilities Commission could not say for certain that constructing a microgrid in Hot Springs would be the least-cost option, it did find that it would be in the public interest overall and allow for valuable data collection for the future.[98] Hot Springs is a small town of around 600 people in the mountains of Western North Carolina. Located about forty miles from Asheville, it is served by a single ten-mile transmission line that traverses extremely rough terrain and is subject to frequent outages.[99] Rather than build a second transmission line, the North Carolina Utilities Commission approved Duke Energy's plan "for construction of an approximately 3-MW direct current, 2-MW alternating current solar photovoltaic electric generation facility and associated equipment for the Hot

94. *Microgrids*, NAT'L LAB'Y ROCKIES, https://www.nrel.gov/grid/microgrids [https://perma.cc/83Z9-4QF9].

95. *See id.* (discussing microgrid project on Guam); St. John, *Hurricane Helene Underscores Need for More Solar-Battery Microgrids*, *supra* note 79; *Success Story: Ocracoke Microgrid*, N.C. RESILIENCE EXCHANGE (Mar. 1, 2024), https://www.resilienceexchange.nc.gov/identify-actions/success-stories/ocracoke-island-electric-cooperatives-microgrid [https://perma.cc/2P5P-8C7D].

96. *See* Jeff St. John, *Can Utilities Replace Power Lines with Solar and Batteries in Remote Areas?*, CANARY MEDIA (Sep. 8, 2025), https://www.canarymedia.com/articles/solar/california-utility-clean-energy-microgrids-wildfires [https://perma.cc/73HH-TJMF] [hereinafter St. John, *Can Utilities Replace Power Lines*]; *see also* Duke Energy Progress, LLC's Hot Springs 15-Month Report at 12, Docket No. E-2, Sub 1185 (N.C. Utils. Comm'n Oct. 29, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=accedf0f-7d26-4643-8ba6-e4c57c46f5d1 [https://perma.cc/4SBN-XY5A (staff-uploaded archive)].

97. St. John, *Can Utilities Replace Power Lines*, *supra* note 96.

98. Order Granting Certificate of Public Convenience and Necessity with Conditions at 10, Docket No. E-2, Sub 1185 (N.C. Utils. Comm'n May 10, 2019), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=751a240b-9a68-4970-89cc-b9c85f289607 [https://perma.cc/R39X-S4PU (staff-uploaded archive)].

99. St. John, *Hurricane Helene Underscores Need for More Solar-Battery Microgrids*, *supra* note 79.

Springs Microgrid Project."[100] Over the first two years of operation, the microgrid acted almost entirely in parallel with the grid, only islanding four times.[101] However, as with most resiliency-based investments, the true value of the Hot Springs microgrid would not be realized until it was needed most.

The impacts of Hurricane Helene on Western North Carolina are very difficult to overstate; it was a historic event that impacted nearly every community in that region.[102] Twenty-plus foot walls of water carved gashes through ancient mountainsides, quiet creeks became raging torrents, and innumerable homes, valuables, and over 100 lives were lost.[103] In a state all too familiar with the impacts of hurricanes on the coast,[104] nothing could have prepared North Carolina for the devastation that Helene would bring. Infrastructure of every kind was severely impacted—from roads, to water supplies, to communications networks, to energy distribution and transmission infrastructure.[105] Because of energy's centrality to providing other services,[106] restoring energy services became a key focus.

100. *See* Order Granting Certificate of Public Convenience and Necessity with Conditions, *supra* note 98, app. A.

101. Duke Energy Progress, LLC's Hot Springs 15-Month Report—Redacted at 5, Docket No. E-2, Sub 1185 (N.C. Utils. Comm'n Oct. 31, 2024), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=2b0375d3-e15c-43aa-b51c-aed761a0d648 [https://perma.cc/PD5R-MZ2H (staff-uploaded archive)].

102. *See* Joey Marshall, Chase Sawyer, Heather King, Bethany DeSalvo & Walter Peacock, *Hurricane Helene's Impact on the Socially Vulnerable in North Carolina*, U.S. CENSUS BUREAU (Oct. 11, 2024), https://www.census.gov/library/stories/2024/10/hurricane-helene.html [https://perma.cc/AM3R-9JD8].

103. "Hurricane Helene was a geomorphic event that triggered hundreds of landslides, reshaped landscapes and carved new river channels." *Hurricane Helene: One Year Later*, NATURE CONSERVANCY (Sep. 26, 2025), https://www.nature.org/en-us/about-us/where-we-work/united-states/north-carolina/stories-in-north-carolina/hurricane-helene-impacts/ [https://perma.cc/M7XL-TLU3]; "Helene's impacts—particularly flooding and landslides—have made it one of the deadliest US storms of the 21st century, with more than 100 confirmed deaths in North Carolina alone." OFF. OF STATE MGMT. & BUDGET, *supra* note 19, at 5.

104. While Hurricane Floyd in 1999 was describe a 100-year flood event, many communities experienced similar or higher levels of flooding from both Hurricane Matthew in 2016 and Hurricane Florence in 2018. *See* Corey Davis, *Floyd's Flooding Overwhelmed Eastern North Carolina*, N.C. STATE CLIMATE OFF. (Sep. 16, 2019), https://climate.ncsu.edu/blog/2019/09/floyds-flooding-overwhelmed-eastern-north-carolina/ [https://perma.cc/UTT7-CAL3]. The impacts of these storms exceed the regulatory framework in place to keep communities safe, with forty-three percent of all buildings flooded between 1992 and 2020 located outside of regulatory floodplains. Helena M. Garcia, Antonia Sebastian, Kieran P. Fitzmauric, Miyuki Hino, Elyssa L. Collins & Gregory W. Characklis, *Reconstructing Repetitive Flood Exposure Across 78 Events from 1996 to 2020 in North Carolina, USA*, at 1, *in* 13 EARTHS FUTURE art. e2025EF006026 (2025), https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2025EF006026 [https://perma.cc/7F9Q-SX2U (staff-uploaded archive)].

105. OFF. OF STATE MGMT. & BUDGET, *supra* note 19, at 5.

106. Communications infrastructure requires electricity to operate and, in most cases, so does water infrastructure (both drinking water and wastewater).

> In the wake of Hurricane Helene, creation of reliable energy systems was both an urgent necessity and long-term challenge. In the immediate aftermath of the storm, [DERs] proved vital in delivering lifesaving power to remote, storm-ravaged areas in the western mountains of North Carolina, where downed lines were difficult to access and repair. Thanks to organizations such as the Footprint Project, a solar microgrid at a fire station was used to run refrigerators, freezers, and communications; an atmospheric water generator was set up to keep relief teams hydrated without relying on single-use bottled water; and portable power stations were established to help residents in need of emergency medical care.[107]

During the aftermath of Helene, Hot Springs' microgrid provided a lifeline for many.[108] Near Hot Springs, an essential substation serving the town was washed away by the French Broad River.[109] Though it took some time to get the microgrid operational due to flooding, the Hot Springs microgrid provided power from October 2, 2024, to October 8, 2024, until regular service could be restored[110]—running continuously for 143.5 hours.[111] The microgrid was able to power essential locations such as the fire station, the gas station, the Dollar General, and a diner in town.[112] In a remote region, the operation of the Hot Springs microgrid stands in stark contrast to surrounding communities that remained without power for much longer.[113] Similarly, Warren Wilson College in Swannanoa, North Carolina, was able to utilize its microgrid to power refrigeration to prevent food spoilage, provide laundry for students and the community, and charge a wide range of EVs from tractors to golf carts to cars.[114]

107. Maureen Quinlan, *Opinion: Distributed Energy Sources Provided Reliable, Vital Power During Helene*, CITIZEN TIMES (Sep. 20, 2025, at 17:00 ET), https://www.citizen-times.com/story/opinion/2025/09/20/opinion-distributed-energy-sources-proved-vital-during-helene/86198813007/ [https://perma.cc/QSS7-N68G (staff-uploaded archive)].

108. JARED LEADER, SMART ELEC. POWER ALL., HURRICANE HELENE: HOT SPRINGS MICROGRID 7 (2025), https://s3.us-east-1.amazonaws.com/fonteva-customer-media/00Do0000000Yi66EAC/lTIGvfWO_SEPA_Duke_Energy_Hot_Springs_Microgrid_Case_Study_2025_Final_pdf [https://perma.cc/GJ8X-JVK8].

109. CLEANENERGYGROUP, RESILIENT POWER FOR NORTH CAROLINA: SOLAR+STORAGE EFFORTS IN THE WAKE OF HURRICANE HELENE 7–8 (2025), https://www.cleanegroup.org/wp-content/uploads/CEG-Helene-SS-Webinar-6-25-25-all-slides.pdf [https://perma.cc/QV4B-VBBC].

110. *In re* Duke Energy Progress, LLC's Hot Springs 15-Month Report—Redacted at 5–6, Docket No. E-2, Sub 1185 (N.C. Utils. Comm'n Oct. 29, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=accedf0f-7d26-4643-8ba6-e4c57c46f5d1 [https://perma.cc/5AP2-U4P9 (staff-uploaded archive)].

111. LEADER, *supra* note 108, at 3.

112. CLEANENERGYGROUP, *supra* note 109, at 11.

113. *See* Brad Plumer, *Why Restoring Power After Helene Is Complicated*, N.Y. TIMES (Oct. 1, 2024), https://www.nytimes.com/2024/10/01/climate/helene-hurricane-power-carolinas.html [https://perma.cc/AUW2-C459 (staff-uploaded, dark archive)].

114. WARREN WILSON COLLEGE, *Resilience in the Storm: Clean Energy at Warren Wilson College*, at 03:15 (YouTube, Sep. 10, 2025), https://www.youtube.com/watch?v=Wrhhgp0v0o8 [https://perma.cc/M2RL-U8D2].

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Another organization that utilized microgrids to provide invaluable services to those in need after Helene was the Footprint Project.[115] The Footprint Project's mission is to provide cleaner energy for communities in crisis.[116] Based out of New Orleans, the organization has deployed around the United States and even internationally to help communities in need.[117] By utilizing portable solar panels and battery storage, the Footprint Project deployed microgrids to over sixty-five sites across 1,200 square miles.[118] These microgrids were paired with refrigeration units to keep medicine from spoiling, atmospheric water generators to provide clean drinking water, and/or satellite-enabled telecommunications equipment to allow for internet access.[119] The map[120] below shows both the extent of the damage across Western North Carolina as well as the breadth of the Footprint Project's work following the storm.

115. Turner, *supra* note 83.

116. FOOTPRINT PROJECT, https://www.footprintproject.org/ [https://perma.cc/N57N-J75B].

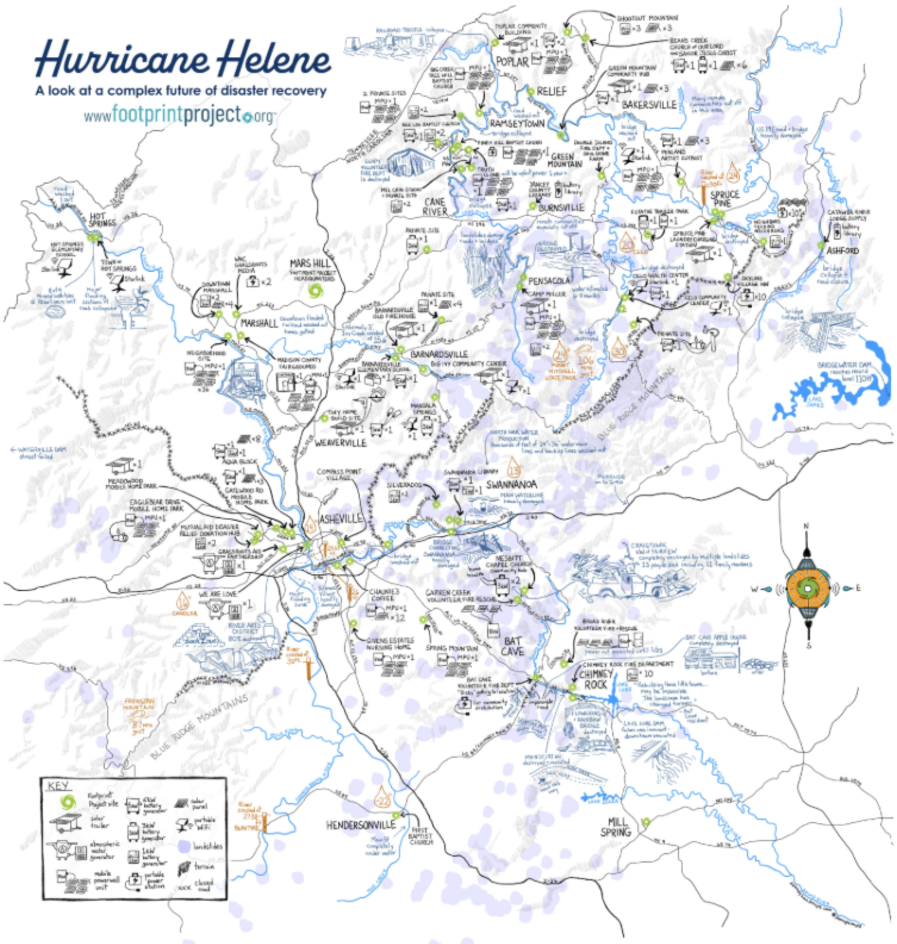
117. *See Our Programs*, FOOTPRINT PROJECT, https://www.footprintproject.org/programs [https://perma.cc/6HPD-ULAG].

118. Jen Urso, *Mapping Hurricane Helene*, STEADYHANDMAPS (Feb. 21, 2025), https://steadyhandmaps.com/2025/02/21/hurricane-helene-map/ [https://perma.cc/NNL6-5VVN].

119. Lisa Cohn, *After Hurricane Helene, Pop-up Microgrids Powered Medical Clinics, Water Generators, Communications Equipment and Other Critical Resources*, MICROGRID KNOWLEDGE (Oct. 21, 2024), https://www.microgridknowledge.com/microgrids/critical-services/article/55236920/after-hurricane-helene-pop-up-microgrids-powered-medical-clinics-water-generators-communications-equipment-and-other-critical-resources [https://perma.cc/4QS8-VVT5].

120. FootprintProject, 2024 Impact Summary 11 (Jamie Sweezy, GoogleDrive), https://drive.google.com/file/d/16rLYGR07y1_Eytup_stRtXyVh3VSZs5T/view [https://perma.cc/6WEB-64GD] (staff-uploaded archive)] (last modified May 30, 2025).

Figure 5: Footprint Project Microgrid Deployments in the Wake of Hurricane Helene[121]



Many of these microgrids remain operational, helping to provide longer-term resiliency in the region.[122] As discussed in more detail below, the North Carolina Department of Environmental Quality recently granted five million dollars to the Footprint Project, along with organizational partners the North

121. Catherine Kozak, *Microgrid Project To Provide Renewable Power After Disasters*, COASTAL REV. (Aug. 19, 2025), https://coastalreview.org/2025/08/microgrid-project-to-provide-renewable-power-after-disasters/ [https://perma.cc/4WR9-VH2D].

122. Quinlan, *supra* note 107.

Carolina Sustainable Energy Association and Land of Sky Regional Council, to build upon this work in both Western and Eastern North Carolina.[123]

There are also private developers turning microgrids into a selling point. Babcock Ranch[124] and Hunters Point,[125] both located in Florida, are entire communities with DERs and microgrids built into their master plan. Each of them has been tested by extreme weather and came out the other side "relatively unscathed."[126] Similarly, BlockEnergy also works at the community level, partnering with developers or utilities to develop residential front-of-the meter microgrids.[127] While BlockEnergy has also developed a microgrid-based community in Florida that withstood Hurricane Ian,[128] it has also worked on an affordable housing development outside of Washington, D.C.,[129] and with the U.S. Air Force.[130]

Another model for microgrids to provide reliability benefits is community resiliency hubs. These can be done in a variety of ways, though generally speaking, community resiliency hubs are located at communal gathering spaces that already provide aid to vulnerable populations and consist of at least sufficient rooftop solar and battery storage to cover aid operations that would happen in a time of crisis.[131] "Community Resilience Hubs equip local communities with solar energy and backup energy storage, ensuring critical services—such as powering medical devices, enabling emergency communications, and phone charging—remain readily available during power

123. Amanda Murphy, *North Carolina Launches Clean Energy Microgrid Initiative to Boost Disaster Resilience*, N.C. DEP'T ENV'T QUALITY (Aug. 12, 2025), https://www.deq.nc.gov/news/press-releases/2025/08/12/north-carolina-launches-clean-energy-microgrid-initiative-boost-disaster-resilience [https://perma.cc/2NFM-QTA8].

124. Lucy Sherriff, *Babcock Ranch: Florida's First Hurricane-Proof Town*, BBC (Sep. 4, 2023), https://www.bbc.com/future/article/20230904-babcock-ranch-floridas-first-hurricane-proof-town [https://perma.cc/93V4-W4RE (staff-uploaded archive)].

125. Rachel Ramirez, *As Parts of Florida Went Dark from Helene and Milton, the Lights Stayed on in This Net-Zero, Storm-Proof Community*, CNN (Oct. 12, 2024, at 22:58 ET), https://www.cnn.com/2024/10/12/climate/hurricane-milton-helene-florida-homes/index.html [https://perma.cc/7A5H-CQMH] (staff-uploaded archive)].

126. Sherriff, *supra* note 124; Ramirez, *supra* note 125.

127. BLOCKENERGY, https://blockenergy.com/ [https://perma.cc/WK9L-SHRH].

128. *Lights Stay on in BlockEnergy Community During Hurricane Ian*, BLOCKENERGY (June 16, 2023), https://blockenergy.com/lights-stay-on-in-blockenergy-community-during-hurricane-ian/ [https://perma.cc/47Y2-FJWV].

129. GUIDEHOUSE INSIGHTS, HOW UTILITIES CAN ENHANCE OUR DER ENERGY FUTURE 7 (2022), https://blockenergy.wpengine.com/wp-content/uploads/Guidehouse-Insights-White-Paper-Emera-Technologies_Final.pdf [https://perma.cc/583F-DCZF].

130. Dan Ton, *Kirtland Air Force Base DC Microgrid Is Fully Operational*, DEP'T ENERGY: BLOG (July 29, 2020), https://www.energy.gov/oe/articles/kirtland-air-force-base-dc-microgrid-fully-operational [https://perma.cc/57UM-83RU]; *Kirtland Resiliency Project Unveiled—The Future of Utility-Distributed Power*, BLOCKENERGY (Sep. 1, 2020), https://blockenergy.com/kirtland-resiliency-project-unveiled-the-future-of-utility-distributed-power/ [https://perma.cc/6JGV-K5W3].

131. *See* St. John, *Hurricane Helene Underscores Need for More Solar-Battery Microgrids*, *supra* note 79.

outages."[132] Two organizations are working to build out this model. The Footprint Project, while working to deploy microgrids in impacted communities after natural disasters, also helped to launch the Community Lighthouse program with the organization Together New Orleans.[133] The initial pilot phase of building sixteen "lighthouses" is underway, with the goal of having eighty-six in total, where "every New Orleans resident will live within a 15-minute walk of one."[134] Groundswell, a nonprofit organization focused on building community-based energy,[135] is working to develop similar community resilience hubs, though across their larger footprint.[136] Moving forward, community resiliency hubs are a model that could be very impactful for at-risk communities.

II. MOVING FORWARD WITH DPPS AND MICROGRIDS: CHALLENGES AND OPPORTUNITIES

The deployment of both DPPs and microgrids is growing,[137] though significant barriers to their widespread adoption remain. Before going further into the challenges and opportunities for the accelerated development of these technologies, there are some important distinctions between programs and the states deploying them. These distinctions boil down to three categories: ownership, operation, and regulation.

Ownership is one clear dividing line between many DPP and microgrid programs. Many, if not most, private companies deploying the DERs that underpin DPPs and microgrids prefer to have direct access to customers rather than going through utility-run programs or allowing utilities to deploy DERs

132. *Community Resilience Hubs*, GROUNDSWELL, https://groundswell.org/community-resilience-hubs/ [https://perma.cc/HVP4-YYH7].

133. *Community Lighthouse*, TOGETHER NEW ORLEANS, https://www.togethernola.org/community-lighthouse [https://perma.cc/8VDD-XRVY]; Olivia Lewis, *As Hurricane Season Approaches, New Orleans Activates as Hub for Grassroots Resilient Energy*, DIRECTRELIEF (Apr. 29, 2025, at 03:31 ET), https://www.directrelief.org/2025/04/a-hurricane-season-approaches-new-orleans-activates-as-hub-for-grassroots-resilient-energy/ [https://perma.cc/WRG4-YBX4].

134. *Community Lighthouse*, *supra* note 133.

135. EPA, GROUNDSWELL SHAREPOWER™: COMMUNITY SOLAR SUBSCRIPTION SERVICE 1 (2024), https://www.epa.gov/system/files/documents/2024-01/groundswell-sharepower-community-profile_2024-01-26_508.pdf [https://perma.cc/9NBD-24YJ].

136. *Community Resilience Hubs*, *supra* note 132. Groundswell currently has projects in five states in their pipeline. *Id.*

137. Juliana Ennes, *Microgrids Spread Across US as Big Tech, Utilities Shore Up Power Supplies*, REUTERS, https://www.reuters.com/business/energy/microgrids-spread-across-us-big-tech-utilities-shore-up-power-supplies--reeii-2025-11-03/ [https://perma.cc/72U8-DBQ7] (last updated Nov. 3, 2025).

themselves.[138] However, others in the industry prefer to work directly with utilities.[139] This can be seen directly in the juxtaposition of how Groundswell and the Footprint Project develop microgrids as compared to BlockEnergy.[140] One developing model underscores the differences in perspectives between ownership approaches—Sparkfund's Distributed Capacity Procurement ("DCP") model.[141]

> A survey of key players revealed that while hardwire providers are understandably enthusiastic about utilities as a new sales channel, the majority of other VPP companies do not support utilities rate basing DER. This approach could limit private capital and aggregator access to the DER market, unlike the third-party VPP procurement model []. There is far more enthusiasm for utilities integrating DER into system planning and operations, specifying where such resources are needed, but letting the market supply them, via customer programs and competitive solicitations.[142]

However, as discussed further below, while individual market actors may prefer a particular ownership model, states' regulation of utilities can supersede those preferences in a way that can impact market depth[143] and the availability of certain opportunities.[144]

138. Hertz-Shargel, *supra* note 41; *Virtual Power Plant Capacity Expands 13.7% Year-over-Year to Reach 37.5 GW, According to Wood Mackenzie*, WOOD MACKENZIE (Sep. 17, 2025), https://www.woodmac.com/press-releases/virtual-power-plant-capacity-expands-13.7-year-over-year-to-reach-37.5-gw/ [https://perma.cc/3E5V-T3CD] [hereinafter *Virtual Power Plant Capacity Expands*].

139. *See supra* note 127 and accompanying text. For instance, as this author has worked to progress smart meter and meter collar/meter socket adapter technologies in North Carolina, a split in industry business models has come to light with some preferring to work with, and sell to, Duke Energy, while others would prefer a utility program that allows the customers to drive adoption.

140. *See supra* text accompanying notes 105–17.

141. *See generally Distributed Capacity Procurement*, SPARKFUND, https://sparkfund.com/dcp [https://perma.cc/42GJ-QXRK] (describing the DCP model as "Sparkfund's flagship solution to unlocking the full value of the grid"); SMART ELEC. POWER ALL., DISTRIBUTED CAPACITY PROCUREMENT (July 2025), https://sepapower.org/wp-content/uploads/2025/07/SEPA305-Distributed-Capacity-Procurement.pdf [https://perma.cc/AJ59-4K3S] (exploring the key benefits and challenges of the DCP model).

142. Hertz-Shargel, *supra* note 41.

143. *See supra* text accompanying note 131. Companies can and will choose to locate in states that offer opportunities that match their business model and will choose to avoid states that do not. *See Regulated States Landing Page*, POWER FOR TOMORROW, https://www.powerfortomorrow.org/regulated-states-landing-page [https://perma.cc/F4WP-45UT].

144. One example of this concerns financing options for DERs. H.B. 589 (2017) in North Carolina allowed third-party leasing for the first time, though with limited financial partners, relatively few projects have been completed. Act of July 27, 2017, ch. 62, 2017 N.C. Sess. Laws 192 (codified as amended at N.C. GEN. STAT. § 62-110.8). However, other financing companies recently moving into North Carolina, and the creation of the Clean Energy Fund of the Carolinas, has opening more opportunities. *See About CEF Carolinas*, CLEAN ENERGY FUND OF CAROLINAS, https://cefcarolinas.org/about-nccef/ [https://perma.cc/MC7D-L3QS]. *See generally* Order Granting

Another important distinction between different DPP and microgrid programs and projects comes down to the entity controlling their operation. While there are numerous models, generally, operation of these resources comes down to the utility,[145] a third-party aggregator,[146] the DER vendor,[147] or the end-use customer themselves.[148] While each option has its benefits and detractions, these differences can confuse customers and ultimately impede the growth of these resources through the lack of standardization.[149] Even if standardization across the country is not realistic, the scale of DPPs and ability to link multiple DERs to maximize achievable benefits necessitates a certain degree of standardization within each service territory.[150]

Finally, the ability of DPPs and microgrids to be successfully developed and expanded at least in part depends on the underlying energy regulation within that region. There have been many efforts to examine the relative benefits of traditional, vertically integrated energy regulation as compared to the various forms of de- and re-regulated markets that have developed over the last quarter century around the country.[151] While this Article does not venture into the benefits to and detractions from these regulatory choices, it is clear that the method of regulation can play a big role in the types of DERs deployment that occur on the ground and the opportunities to grow them moving forward. For instance, one of the biggest differences between vertically integrated states and those participating in Regional Transmission Organizations/Independent

Certificate of Authority to Engage in Business as an Electric Generator Lessor, Docket No. EGL-24, Sub 0 (N.C. Utils. Comm'n Aug. 11, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=03d8d936-fc58-4b19-abf3-8fae9819159c [https://perma.cc/X7LH-PS7K] (granting GoodLeap, LLC's application for a certificate of authority to engage in business as an electric generator lessor).

145. See *supra* notes 89–91 and accompanying text.

146. See *supra* notes 79–83 and accompanying text.

147. See HLEDIK & PETERS, *supra* note 61.

148. For example, most participation options in Duke Energy's proposed PowerShare program updates require the customer to either reduce their own usage or deploy behind-the-meter DERs themselves. Duke Energy Progress, LLC's Application for Approval of Enhancements to PowerShare® Nonresidential Load Curtailment Program at 2, Docket No. E-2, Sub 931 (N.C. Utils. Comm'n Sep. 15, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=da4d66d3-906f-43bd-96e1-9f78e762c3e9 [https://perma.cc/U66J-K7ME (staff-uploaded archive)]; Duke Energy Carolinas, LLC's Application for Approval of Enhancements to PowerShare® Nonresidential Load Curtailment Program at 1–3, Docket No. E-7, Sub 1032 (N.C. Utils. Comm'n Sep. 15, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=121f4277-0143-4678-bd7d-ce18ac52e1b4 [https://perma.cc/MMZ5-AE44 (staff-uploaded archive)].

149. *See* PATHWAYS TO COMMERCIAL LIFTOFF, *supra* note 14, at 23–31; LONG ET AL., *supra* note 92, at 12; VIRTUAL POWER PLANT FLIPBOOK, *supra* note 41, at 42.

150. That may mean either a geographic area under one regulatory authority or, as is the case in vertically integrated energy markets, within an individual utility's exclusive service territory.

151. *See* Jonas J. Monast, *Electricity Competition and the Public Good: Rethinking Markets and Monopolies*, 90 U. COLO. L. REV. 667, 669 (2019).

System Operators is the operation of wholesale markets.[152] However, while many analyses identify allowing DPPs access to capacity markets as a key source of value to enable their growth,[153] the uneven implementation of FERC Order 2222[154] raises the possibility that it may be easier to incorporate DPPs into capacity planning in vertically integrated markets instead—at least in the short term.

Keeping these distinctions in mind, much work has been done to identify the challenges and opportunities to expand DPPs and microgrids. Some states have moved forward with legislation seeking to advance DPPs and microgrids, though it is too early to tell how successful such efforts will ultimately be.

A. *Distributed Power Plants*

As seen in Wood Mackenzie's 2025 DPP Scorecard,[155] DPPs are both growing in scale and becoming more mature.[156] The figure below shows significant year-over-year growth of DPPs from 2024 to 2025 across several key metrics, such as a 13.7% increase in overall capacity, 38% more unique off-takers (meaning those utilizing the energy, either utilities or large load customers), 35% more programs funded and operating, and 33% more companies active in this space. The rising share of participation in wholesale markets, both overall and for capacity purposes, as well as the continued growth of storage systems and EVs relative to smart thermostats (thermostats were one of the first demand

152. *See Electric Power Markets*, FED. ENERGY REGUL. COMM'N (Mar. 27, 2025), https://www.ferc.gov/electric-power-markets [https://perma.cc/TNR5-LGQR (staff-uploaded archive)].

153. PATHWAYS TO COMMERCIAL LIFTOFF, *supra* note 14, at 40–45; UNLOCKING THE POTENTIAL, *supra* note 27, at 10.

154. FERC issued Order 2222 in 2020 to address the ability of aggregations of DERs to participate in markets operated by Regional Transmission Organizations and Independent System Operators. *See* FED. ENERGY REGUL. COMM'N, ORDER NO. 2222, PARTICIPATION OF DISTRIBUTED ENERGY RESOURCE AGGREGATIONS IN MARKETS OPERATED BY REGIONAL TRANSMISSION ORGANIZATIONS AND INDEPENDENT SYSTEM OPERATORS (2020), https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf [https://perma.cc/W8LF-RBUS]. While the goal of this order was to provide standardized access to wholesale markets for these resources, its implementation has thus far varied widely region to region and continues to face significant challenges. *See* Roberto Rodriguez Labastida & Adam Stein, *FERC Order 2222: Implementation Is Progressing, but More Work Is Needed from Stakeholders*, GUIDEHOUSE RSCH. (May 9, 2025), https://www.guidehouseresearch.com/reportaction/SI-FERC-25/Marketing [https://perma.cc/H9EC-MBUP]; *see also* Robert Walton, *Uneven Pace of FERC Order 2222 Implementation Continues as Grid Operators Face Challenged*, UTIL. DIVE (Oct. 12, 2023), https://www.utilitydive.com/news/grid-operators-face-technology-finance-and-policy-challenges-FERC-2222/696392/ [https://perma.cc/45A3-Y8FJ]; Ruben Bäumer, *Solving FERC Order No. 2222 Challenges by Taking a Look at European Energy Markets*, CENTRICA BUS. SOLS., https://www.centricabusinesssolutions.com/us/blogpost/solving-ferc-order-no-2222-challenges-taking-look-european-energy-markets [https://perma.cc/583B-6RAP].

155. *See infra* Figure 6. As discussed in the definitions section, many, including Wood Mackenzie, use the term Virtual Power Plant rather than Distribute Power Plant. *See supra* note 36 and accompanying text.

156. *Virtual Power Plant Capacity Expands*, *supra* note 138.

response-capable behind-the-meter technologies with widespread customer adoption), also show a market that is maturing and deepening.

Figure 6: Wood Mackenzie's 2025 DPP Scorecard[157]

VPP scorecard		2024	2025	Growth
Scale	Active company deployments	1459	**1940**	**33%**
	Programs monetized	321	**433**	**35%**
	Unique offtakers	139	**192**	**38%**
	VPP capacity	33 GW	**37.5 GW**	**13.7%**
Maturity	Residential share of wholesale market capacity	8.8%	**10.2%**	16%
	Economic participation in markets	16.4%	**17.4%**	6%
	Storage and EV penetration relative to thermostats	56%	**61%**	9%

Wood Mackenzie Source: Wood Mackenzie

When it comes to advancing DPPs, the DOE has helpfully identified five "imperatives" to enable their expansion: expanding DER adoption with equitable benefits, simplifying DPP enrollment processes, increasing standardization in DPP operations, integrating DPPs into utility planning processes and incentives, and integrating into wholesale markets.[158] Though there are differences in characterization and opinion, these imperatives are similar to those identified in other analyses.[159]

1. Expanding DER Adoption with Equitable Benefits

The first step towards successful DPP expansion comes from the technologies that underpin them—customer adoption of DERs is essential.[160] While adoption rates have been increasing—particularly for certain types of DERs such as smart thermostats, heat pumps, battery storage, and EVs—they still only represent a fraction of their overall potential. Some current barriers

157. Figure adapted from WOOD MACKENZIE, 2025 NORTH AMERICA REPORT, *supra* note 42, at 10.

158. RAZDAN ET AL., *supra* note 14, at 15.

159. *See generally* BREHM & TOBIN, *supra* note 41 (identifying similar imperatives); KIM, *supra* note 27 (same).

160. *See* RAZDAN ET AL., *supra* note 14, at 16–18.

"include high upfront costs with limited low-cost financing options, split incentives between property owners and tenants, and knowledge gaps on available programs and incentives . . . ."[161] However, "[u]pfront incentives that stack across . . . programs, inclusive utility investments, and partnerships with community-based organizations are strategies helping communities today participate in reliability, affordability, and resilience benefits from DERs and VPPs."[162]

For the future expansion of DPPs, it is critical that customers are able to realize the full suite of benefits that DER adoption can bring both to them and to the grid.[163] There are many disparate value streams that DERs can offer, particularly when aggregated into DPPs. Capturing these values so that customers with DERs can be compensated for providing them is one key way to lower the costs of DER ownership.[164] This includes expanding compensation for the temporal and locational benefits DPPs can provide.[165] Inclusive utility

161. *Id.* at 16.

162. *Id.*

163. *Id.* at 17; KIM, *supra* note 27, at 91–114.

164. *See* Blumenthal, *PowerPair*, *supra* note 80; *Solar + Battery Incentives*, *supra* note 80; GRIDSCAPE, CASE STUDY: SAN DIEGO 5, https://grid-scape.com/wp-content/uploads/2022/09/2.-2022-San-Diego-Case-Study.pdf [https://perma.cc/XRQ5-ELUQ]; RAZDAN ET AL., *supra* note 14, at 18, app. 82. For one model advancing compensation for the full range of values that DPPs can provide, see RAZDAN ET AL., *supra* note 14, app. at 82–84 (describing New York's Value of Distributed Energy Resources' Value Stack). For another model, see *Clean Peak Energy Standard Guidelines, Distribution Circuit Multiplier*, COMMONWEALTH OF MASS., https://www.mass.gov/info-details/clean-peak-energy-standard-guidelines#distribution-circuit-multiplier [https://perma.cc/NA47-UK3J].

165. KIM, *supra* note 27, at 91–99.

financing,[166] pay-as-you-save financing,[167] and property-assessed capital expenditure financing[168] are all potential ways to expand DER access.[169]

2. Simplifying DPP Enrollment Processes

DOE's second imperative, simplifying enrollment in DPPs, speaks to an underlying reality regarding DERs—"Without enrolling available DERs into VPPs, their rapid adoption could strain existing, aging distribution systems that are already near maximum capacity during peak events."[170] Thus, improving customer participation on DPPs is not only about achieving the significant potential benefits that they can provide, but also about avoiding what could be a significant source of system cost.[171] Similarly, placing the customer's experience at the center of program design is essential to ensuring the programs will be functional. Programs should seek to balance the interests of customers and the grid—"[w]hether through incentives or rates, rebates or discounts, programs should be designed with an eye to scaling participation and optimizing

166. *Introduction to Inclusive Utility Investments*, CLEAN ENERGY WORKS: ENERGY EFFICIENCY (Jan. 1, 2023), https://www.cleanenergyworks.org/2023/01/01/introduction-to-inclusive-utility-investments/ [https://perma.cc/F4DH-JZHZ]; *Upgrade to $ave Program*, ROANOKE COOP.: CLEAN ENERGY SOLS., https://www.roanokecooperative.com/clean-energy-solutions/upgrade-to-ave-program/ [https://perma.cc/9A88-RM3S]; Consolidated Annual Report at 2–3, Docket Nos. E-2, Sub 1309; E-7, Sub 1279 (N.C. Utils. Comm'n Sep. 22, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=da8bf253-7e5b-4fec-abfa-818bb9d8d661 [https://perma.cc/F8E3-4DYF].

167. *Pay as You Save (PAYS)*, EETILITY, https://www.eetility.com/pays [https://perma.cc/FT4Y-MAC7]. The solar and energy loan fund uses the PAYS model with a lot of success. SOLAR ENERGY LOAN FUND, https://solarenergyloanfund.org/ [https://perma.cc/9SFD-NADT].

168. Because this form of financing results in a lean being put on the property, raising equity concerns for homeowners, this form of financing is best reserved for commercial properties, as North Carolina approved of in 2024. *CFPB Finalizes Rule To Protect Homeowners on Solar Panel Loans and Other Home Improvement Loans Paid back Through Property Taxes*, CONSUMER FIN. PROT. BUREAU: NEWSROOM (Dec. 17, 2024), https://www.consumerfinance.gov/about-us/newsroom/cfpb-finalizes-rule-to-protect-homeowners-on-solar-panel-loans-and-other-home-improvement-loans-paid-back-through-property-taxes/ [https://perma.cc/47FR-TWAZ]; ECON. DEV. P'SHIP OF N.C., NORTH CAROLINA C-PACE PROGRAM GUIDELINES AND TOOLKIT (2025), https://edpnc.com/wp-content/uploads/2025/04/North-Carolina-CPACE-Program-Guidelines-and-Toolkit.pdf [https://perma.cc/T92D-BZXR].

169. Some other financing options include third party leasing, as discussed above, and innovative public-private partnerships. *Connecticut Green Bank and GoodLeap Partner to Create an AI-Powered Virtual Power Plant Initiative to Unlock Savings for Homeowners and Enhance Grid Reliability*, PR NEWSWIRE: NEWS (Aug. 13, 2025, at 02:12 ET), https://www.prnewswire.com/news-releases/connecticut-green-bank-and-goodleap-partner-to-create-an-ai-powered-virtual-power-plant-initiative-to-unlock-savings-for-homeowners-and-enhance-grid-reliability-302529313.html [https://perma.cc/9GFX-5PJU].

170. RAZDAN ET AL., *supra* note 14, at 20.

171. CAL. PUB. UTILS. COMM'N, CONSIDERATION OF DISTRIBUTION COSTS AND BENEFITS OF DERS IN IRP (May 30, 2018), https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpucwebsite/content/utilitiesindustries/energy/energyprograms/electpowerprocurementgeneration/irp/2018/consideration-of-locational-value-in-irp-5-30-18-irp-mag.pdf [https://perma.cc/35QM-KN6L].

benefits for the grid and all participating customers, including residential and lower-income customers."[172]

3. Increasing Standardization in DPP Operations

The third imperative, standardization of operations, is essential to both streamlining early DPP adoption as well as allowing for their expansion by realizing additional value streams.[173] The DOE, working with industry actors, has helped to standardize a large number of technical aspects of DPPs, including communications interfaces, grid services definitions, contract terms between utilities, third-party platform operators, and customers, meter data format and access, cybersecurity, and others.[174] Standardizing communications protocols, participation requirements, and technology requirements is key to providing vendors and customers with the necessary clarity to invest in DERs.[175] Standardization is also key to enabling open access to DPPs in order to integrate multiple DERs, vendors, and programs into a unified solution.[176]

One area where standardization is particularly important is with access to data. Data underpins how DERs can be used to achieve EE and DSM savings, from identifying waste to allowing for the optimal timing of operations. However, customer and third-party access to different types of data varies significantly across the country.[177] Another important aspect of data, as discussed above, is determining the locational and temporal value of assets. The interaction between the transmission and distribution parts of the grid, and the levels of congestion at various locations of each, is information essential to valuing the benefits that DPPs can provide and compensating customers accordingly.[178] From the utilities' perspective, data is also essential in helping

172. *Let's Stop Worrying over Load Growth and Get Serious About Solutions*, ENERGY INNOVATION, https://energyinnovation.org/expert-voice/lets-stop-worrying-over-load-growth-and-get-serious-about-solutions/ [https://perma.cc/J25Y-Q53Y] [hereinafter *Let's Stop Worrying*].

173. RAZDAN ET AL., *supra* note 14, at 23. Standardization of processes is essential for DPPs to progress to more advanced levels within EnergyHub's DPP maturity model. *See* ENERGYHUB, *supra* note 35, at 6.

174. RAZDAN ET AL., *supra* note 14, at 24–27.

175. LONG ET AL., *supra* note 83, at 2, 19–22, 25–26.

176. BREHM & TOBIN, *supra* note 41, at 64–66; *see also supra* notes 87–92 and accompanying text.

177. *Green Button Explorer*, MISSION DATA, https://explorer.missiondata.io/ [https://perma.cc/4YXU-2VKD]; *Reports*, MISSION DATA, https://www.missiondata.io/reports [https://perma.cc/K6BL-L2AU]. For instance, the North Carolina Utilities Commission recently concluded a very long examination of its data access rules, updating them such that customers have better access to their own data and, upon implementation, can share that data with third parties such as DPP aggregators. Order Adopting Rule Revisions to Commission Rule R8-51 at 10–12, Docket No. E-100, Sub 161 (N.C. Utils. Comm'n July 16, 2025), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=b18eb0c3-6968-47d0-adbf-9f1b6ea8f680 [https://perma.cc/SAL2-6NWF (staff-uploaded archive)]. This will allow customers to make better use of the AMI already in place for most. *Smart Meter*, DUKE ENERGY, https://www.duke-energy.com/our-company/about-us/smart-grid/smart-meter [https://perma.cc/AMH8-LW5S (staff-uploaded archive)].

178. *Let's Stop Worrying*, *supra* note 172.

to provide visibility into the DERs already on their system.[179] Standardization of data access and technology/communications protocols also points to another consideration key to the equitable deployment of DPPs: many areas of the United States lack sufficient internet access.[180] The use of cellular networks can sometimes be used to overcome this issue, though it represents a significant barrier, particularly in rural spaces.

Finally, when pursuing standardization, it is important to keep in mind that "[t]he 'right' configuration of VPP hardware and software will be determined by the desired performance attributes of the VPP, which are a function of the needs and priorities of the utility."[181] Delivering bulk system peaking capacity is the most common capability of DPPs initially, with increasing complexity and benefits being added over time.[182]

4. Integrating DPPs into Utility Planning Processes and Incentives

The DOE's fourth imperative focuses squarely on utilities, aligning planning and incentives to maximize DPPs' impacts. The DOE has identified twenty-two policy actions currently being adopted within the United States, from which state regulators and policymakers can choose.[183] One example is utilizing performance-based ratemaking ("PBR") and performance incentive mechanisms ("PIMs") to incentivize utilities to pursue DPPs.[184] In North Carolina, PBR was authorized for electric public utilities in 2021[185] and first implemented in 2023.[186] One of the PIMs approved concerned improving

179. *Id.*; KIM, *supra* note 27, at 54–62; ENERGYHUB, *supra* note 35, at 15.

180. RAZDAN ET AL., *supra* note 14, at 49; Kelly Wert, *Every State Identifies Broadband Affordability as Primary Barrier to Closing Digital Divide*, PEW CHARITABLE TRS. (Oct. 4, 2024), https://www.pew.org/en/research-and-analysis/articles/2024/10/04/every-state-identifies-broadband-affordability-as-primary-barrier-to-closing-digital-divide [https://perma.cc/D5SS-EU5L]; Heather King, Michael Martin, Suzanne McArdle, Rafi Goldberg & Bethany DeSalvo, *Mapping Digital Equity in Every State*, U.S. CENSUS BUREAU (May 13, 2022), https://www.census.gov/library/stories/2022/05/mapping-digital-equity-in-every-state.html [https://perma.cc/ZA3R-2KBC].

181. RAZDAN ET AL., *supra* note 14, at 28.

182. "The progression from basic to more sophisticated utility-led VPP configurations can be assessed along at least seven performance attributes." *Id.* Those attributes are grid services, frequency of dispatch, locational visibility, locational control, scale, operational integration, and decarbonization potential. *Id.* at 29–30.

183. *Id.* at 79–82.

184. *Id.* at 79; *Let's Stop Worrying*, *supra* note 172.

185. Act of Oct. 13, 2021, ch. 62, 2021 N.C. Sess. Laws 165 (codified as amended at N.C. GEN. STAT. §§ 62-3, 110.8, 133.16).

186. Order Approving Revenue Requirement, Rate Schedules and Notice to Customers of Change in Rates at app. A, Docket No. E-2, Sub 1300 (N.C. Utils. Comm'n Sep. 21, 2023), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=c40db203-b597-4cc2-8b7e-2c592317efd4 [https://perma.cc/2JV6-NE58 (staff-uploaded archive)]; Order Accepting Stipulations, Granting Partial Rate Increase, Requiring Public Notice, and Modifying Lincoln CT CPCN Conditions at 15, Docket Nos. E-7, Sub 1134; E-7, Sub 1276 (N.C. Utils. Comm'n Dec. 15, 2023),

interconnection rates for DERs such as rooftop solar and battery storage. Similarly, a new incentive was recently added to Duke Energy's North Carolina EE/DSM Cost Recovery Mechanism.[187] While the Mechanism is designed to incentivize the utility to achieve load reductions, particularly during peak demand, other value streams were not incentivized and so not pursued. That is precisely why the Active Load Management incentive was introduced and approved. North Carolina has also made progress on incorporating DERs into utility planning, such as publishing a grid hosting capacity map;[188] however, much more can be done regarding distribution system planning and allowing DERs to participate meaningfully in capacity planning.[189]

5. Integrating DPPs into Wholesale Markets

The fifth and final imperative, integrating DPPs with wholesale markets, is closely related to both the first imperative's discussion of capturing all value streams and the third imperative concerning standardization. In states that participate in wholesale markets, capturing the true capacity benefit DPPs present requires their participation in capacity markets and day-ahead markets. Because these resources are operationally distinct from centralized sources of energy generation, standardized communication and participation protocols are essential to ensuring they can provide the benefits they offer to the market.[190]

6. State-Level Support for DPP Deployment

Multiple states have recently taken steps to bolster DPPs through the legislative process and executive action. Maryland passed the DRIVE Act in 2024.[191] This act requires utilities to expedite bidirectional EV charging programs and capabilities, to establish a DPP program with compensation provided to participating customers, and to pursue greater use of time-of-use rate schedules that incentivize customers to shift their usage away from peak

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https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=7ef152c5-3a07-49fc-8099-b865f2317676 [https://perma.cc/LSA5-3R5T (staff-uploaded archive)].

187. Order Approving Revisions to Demand-Side Management and Energy Efficiency Cost Recovery Mechanisms at 3, Docket Nos. E-2, Sub 931; E-7, Sub 1032 (N.C. Utils. Comm'n May 22, 2024), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=5aaea5ce-6458-41fe-ab2d-14d86881092d [https://perma.cc/JN42-YYYL (staff-uploaded archive)].

188. *Generation Hosting Capacity (3-phase)*, DUKE ENERGY: MAPS, https://dukeenergy.maps.arcgis.com/apps/webappviewer/index.html?id=ac03ae612bc94c38bfc2a283cabc262a [https://perma.cc/ZLM6-MH3B].

189. Joint Post Hearing Brief of the Southern Alliance for Clean Energy, Natural Resources Defense Council, Sierra Club and North Carolina Sustainable Energy Association at 73–76, Docket No. E-100, Sub 190 (N.C. Utils. Comm'n Sep. 3, 2024), https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=708ef872-581c-4ecc-a192-55d463fde350 [https://perma.cc/899A-U3VU].

190. RAZDAN ET AL., *supra* note 14, app. at 91–95.

191. DRIVE Act, ch. 476, 2024 Md. Laws 1 (codified at MD. CODE ANN., Pub. Utils. §§ 1-101, 7-1001–1007).

periods. Colorado's Modernize Energy Distribution Systems Act, also passed in 2024, requires Xcel Energy to file an application with the Colorado Public Utilities Commission to form a DPP by February 2025, along with emphasizing the importance of distribution system capabilities for DER integration.[192] It also created performance incentives for Xcel tied to meeting interconnection timelines for new renewables,[193] similar to the PIM for Duke Energy discussed above. To implement this statute, Xcel introduced its Renewable Battery Connect program, which, much like Duke Energy's PowerPair program, utilizes behind-the-meter batteries to help with system peak demand reduction.[194] Illinois recently passed the Clean and Reliable Grid Affordability Act in 2025.[195] It strengthens integrated resource planning, provides for more energy efficiency programs and incentives for battery storage, as well as establishing a DPP program (among many other things).[196] While they are still being implemented, these statutes demonstrate how legislators can, and are, getting more hands-on when it comes to the electricity system. Governor Sherrill in New Jersey made energy policy a cornerstone of her 2025 campaign, following through with a series of Executive Orders issued within her first month in office.[197] Specifically, Executive Order 2 directs the Board of Public Utilities to, "within 180 days, commence the development of a "virtual power plant" program. . . ."[198]

B. *Microgrids*

There has recently been an increasing emphasis on developing microgrids,[199] though significant barriers remain to their widespread adoption.

192. Modernize Energy Distribution Systems Act, ch. 232, 2024 Colo. Sess. Laws 1437 (codified as amended at COLO. REV. STAT. § 40-2-132.5).

193. COLO. REV. STAT. § 40-2-132.5(5)(e).

194. *Renewable Battery Connect*, XCEL ENERGY (Oct. 9, 2025), https://co.my.xcelenergy.com/s/renewable/battery-connect [https://perma.cc/WU6W-XNCE].

195. Clean and Reliable Grid Affordability Act, Pub. Act 104-0458, 2025 Ill. Laws (to be codified in scattered sections of ILL. COMP. STAT.); *see* Press Release, Howard Learner, CEO & Executive Director, Env't L. & Pol'y Ctr., Illinois Passes Clean Energy Law to Lower Costs and Strengthen Grid (Oct. 30, 2025), https://elpc.org/news/illinois-passes-clean-energy-law-to-lower-costs-and-strengthen-grid/ [https://perma.cc/F6TW-R4EH].

196. Clean and Reliable Grid Affordability Act, *supra* note 195.

197. *See* Robert Walton, *New Jersey Governor Orders State To Accelerate Solar, Storage and Virtual Power Plants*, UTIL. DIVE (Jan. 21, 2026), https://www.utilitydive.com/news/new-jersey-gov-sherrill-orders-electric-bill-credits-development-of-vpp-p/810085/ [https://perma.cc/QKZ8-76KX].

198. N.J. Exec. Order No. 2 (Jan. 20, 2026), https://www.nj.gov/infobank/eo/057sherrill/pdf/EO-2.pdf [https://perma.cc/NL93-AE9X].

199. "U.S. microgrid capacity could hit 10 GW by the end of 2025, according to the Department of Energy (DOE). There was 4.4 GW of microgrid capacity installed at the end of 2022 across 692 sites, data from the Center for Climate and Energy Solutions (C2ES) show." Juliana Ennes, *Microgrids Spread Across U.S. as Big Tech, Utilities Shore Up Power Supplies*, REUTERS (Nov. 3, 2025, at 12:02 ET), https://www.reuters.com/business/energy/microgrids-spread-across-us-big-tech-utilities-shore-up-power-supplies--reeii-2025-11-03/ [https://perma.cc/72U8-DBQ7]; *see also* Kelsey Jones, Will

As the entities charged with maintaining the grid, utilities retain a lot of control to either enable or prohibit projects from moving forward.[200] So long as a microgrid remains at least partially connected to the larger grid, utility rate schedules, tariff and rider options, and interconnection procedures must be followed.[201] Legislators and regulators play a big role in the development of utility-scale microgrids. However, as more models are developed, the private market is likely to take an increasing role beyond disaster response and residential community development.[202]

Much like DPPs, one of the most significant barriers regards capturing the full benefit that such systems provide. In particular, while the cost of maintaining system reliability can be approximated by using utilities' reserve capacities, as determined using LOLE, and the resources used to meet those reserve capacities, regional and customer reliability lacks a clear proxy that can provide a monetary value.[203] For instance, in 2022, U.S. electricity customers averaged five and a half hours of service interruptions.[204] There are two primary metrics used to capture and evaluate this data: The System Average Interruption Duration Index ("SAIDI") measures the total duration (in hours) an average customer experiences non-momentary power interruptions in a one-year period, while the System Average Interruption Frequency Index ("SAIFI") measures the frequency of interruptions in number of occurrences.[205] Though SAIDI and SAIFI are essential metrics to understanding utility performance, unlike LOLE, they don't provide a minimum standard that

McCurry & Kiera Zitelman, *Core Sector: Energy Resources and the Environment*, NAT'L ASSOC. OF REGUL. UTIL. COMM'RS, https://www.naruc.org/core-sectors/energy-resources-and-the-environment/microgrids/state-microgrid-policy-programmatic-and-regulatory-framework/ [https://perma.cc/R4EF-9E62].

200. One particular way that utilities control the ability of DER-focused projects to move forward is through their interconnection processes. *See, e.g.*, AM. CLEAN POWER, INTERCONNECTION 101 1 (2023), https://cleanpower.org/resources/interconnection/ [https://perma.cc/W56N-4EFX].

201. *See, e.g.*, N.H. REV. STAT. ANN. § 374:3-c.

202. For example, the Central Pines Regional Council of North Carolina (representing Chatham, Durham, Johnston, Lee, Moore, Orange, and Wake counties) recently issued a request for proposals to conduct Regional Resilience Hub Energy Feasibility Assessments. *Requests for Proposals/Qualifications*, CENT. PINES REG'L COUNCIL, https://www.centralpinesnc.gov/requests-proposalsqualifications [https://perma.cc/9QTY-NYY6].

203. While metrics such as the value of lost load can be applied, they are still being studied to provide predictive value and are inherently retrospective for the time being. *See* Taeyoung Jin, *A Meta-Analysis of Outage Cost for Value-Based Reliability Planning*, 62 ENERGY STRATEGY REVS. 1, 1 (Nov. 2025), https://www.sciencedirect.com/science/article/pii/S2211467X25003384 [https://perma.cc/9ZFZ-KPS7 (staff-uploaded archive)]; *see also* K.G. Willis & G.D. Garrod, *Electricity Supply Reliability*, 25 ENERGY POL'Y 97, 98 (1997), https://www.sciencedirect.com/science/article/abs/pii/S0301421596001231 [https://perma.cc/D6Q6-MQ35 (staff-uploaded archive)].

204. Alex Gorski, *U.S. Electricity Customers Averaged Five and One-Half Hours of Power Interruptions in 2022*, U.S. ENERGY INFO. ADMIN. (Jan. 25, 2024), https://www.eia.gov/todayinenergy/detail.php?id=61303 [https://perma.cc/8XA7-H42N].

205. *Id.*

utilities must meet. By enforcing a standard, it is possible to derive a cost in meeting that standard, allowing value to be assigned to the resources that enable the utility to achieve that standard. In the context of DPPs, assigning such value is critical to developing incentives designed to achieve it. For microgrids, recognizing their resiliency and reliability benefits in monetary terms would allow them to be evaluated against other infrastructure options more fairly, which can make all the difference when regulators apply the principle of least cost as they must.[206]

Another key question regarding microgrids deployed as disaster recovery is what happens after the storm. "[M]ore than 60 operational DER projects support communities across Western North Carolina, proving that these weren't one-time fixes—they are the building blocks of long-term resilience."[207] However, microgrids deployed after Helene, as with essentially all infrastructure deployed during disaster recovery efforts, did not have to go through the normal inspection and interconnection processes as would have been required otherwise. That raises the thorny question of if such resources, now in place and providing meaningful community benefits, must now be removed and reinstalled through normal processes. While this seems counterproductive to helping communities recover, the lack of clear legal guidelines makes this a dense grey area that could lead to vulnerable communities losing DER assets already in place.

North Carolina provides a good example of state efforts to support the deployment of microgrids, particularly through the North Carolina Department of Environmental Quality ("DEQ"). In 2025, DEQ started utilizing funds from two federal sources to advance microgrids. As part of the Climate Pollution Reduction Grant program, DEQ identified microgrids as a key infrastructure solution for North Carolina in its North Carolina Comprehensive Climate Action Plan.[208] DEQ is also using the federal Infrastructure Investment & Jobs Act to provide a grant to build "[u]p to 24 stationary microgrids . . . across six Helene-affected counties, with two mobile 'Beehive' microgrid hubs serving the entire state—one in Western [NC] and one in Eastern [NC]."[209] One of the main beneficiaries of this grant is the Footprint Project,[210] allowing them to build upon their existing work in Western North Carolina, as discussed above. While such an initiative represents progress for microgrids generally, it also introduces a first-of-its-kind concept called "beehive microgrids." Beehives are

206. St. John, *Hurricane Helene Underscores Need for More Solar-Battery Microgrids*, *supra* note 79.

207. Quinlan, *supra* note 107.

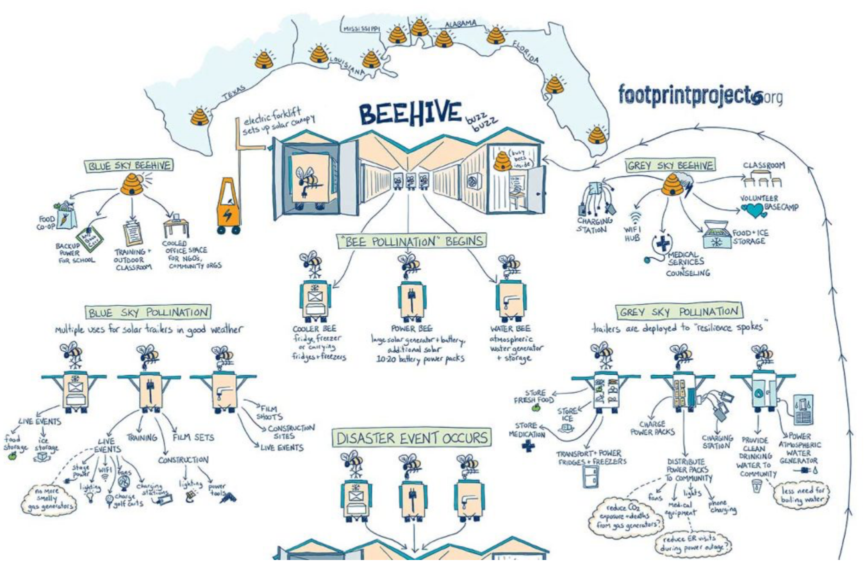
208. N.C. DEP'T ENV'T QUALITY, NORTH CAROLINA COMPREHENSIVE CLIMATE ACTION PLAN 78 (2025), https://www.deq.nc.gov/state-energy-office/2025-nc-ccap-draft/open [https://perma.cc/B5F5-EMKP].

209. Murphy, *supra* note 123.

210. Additional beneficiaries include the North Carolina Sustainable Energy Association, the Land of Sky Regional Council, and a network for regional partners. *Id.*

community hubs with significant microgrid capabilities, usually using rooftop solar and battery storage among other DERs. Within each beehive, there are many "bees," essentially each a trailer equipped with solar and batteries with the capability of being deployed in the community as a standalone microgrid. As with after Helene, these "bees" can be equipped with other equipment to provide refrigeration, internet access, clean water, reusable battery packs for vulnerable communities, or some combination of the above. "Beehive Microgrid Hubs will act as mobile, no-cost lending libraries, making solar and battery equipment accessible to community organizations across the state for both emergency use and ongoing preparedness."[211] While the ultimate value of this concept is in the wake of extreme weather, it can also operate under "blue sky" or "grey sky" conditions, channeling benefits back into the larger grid. While still in the implementation phase, this new design of modular microgrids attached to the grid but deployable over large geographic areas when needed is certainly one to watch. This concept can be seen in more detail in Figure 7.

Figure 7: Beehive Microgrid Conceptual Configuration[212]



Recent legislative efforts demonstrate how legislators are becoming more interested in bolstering microgrids. Oregon shows how microgrid deployment can be supported through legislation, passing two pieces of legislation in 2025. House Bill 2066 requires the Oregon Public Utilities Commission to create a roadmap and regulatory framework for building, owning, and valuing

211. *Id.*
212. Urso, *supra* note 118.

microgrids.[213] A key aspect of this process would allow for the private development of microgrids, helping to overcome utility reticence and the regulations they are bound by (such as least cost).[214] Similarly, though more broad in scope, House Bill 2065 addresses bottlenecks in energy planning processes by allowing communities to work directly with certified third parties to conduct grid interconnection studies.[215] The goal of this is to reduce project delays and increase the number of projects that get built.[216] Recent legislation in New Hampshire provides a clear path for "off grid energy providers," allowing for private microgrid development; however, these microgrids must be completely disconnected from the grid to qualify.[217] It remains to be seen how effective the provisions prove, though the effort to displace the utility from conducting interconnection studies and allowing for private ownership of community microgrids are significant policy developments.

CONCLUSION

While progress is being made in deploying DPPs and microgrids around the country, the path forward is not linear. For instance, in a surprise move, California declined to continue funding for two grid reliability programs, including its DPP, in September 2025.[218] While this is a disappointing development, the continued and accelerating growth of these resources across the country and throughout the world is a reason for optimism. Much work remains to be done to ensure these resources can provide the full range of potential benefits they offer, but there is clear forward momentum.

The challenge facing both regulators and utilities over the coming decades is steep. Ensuring that access to energy remains affordable and reliable in the face of load growth and increasingly extreme weather will be a key theme of the twenty-first century power industry. Doing this will require a multi-faceted approach and a close examination of all available resources. DPPs and microgrids have already shown that they can provide valuable services to the grid while making a meaningful difference in the lives of many; deploying in new markets and achieving scale where they already are is the next step. The challenges facing the U.S. energy industry are great and will require continued innovation. DPPs and microgrids are two essential tools to meeting these challenges.

213. H.B. 2066, Legis. Assemb. Reg. Sess. (Or. 2025).

214. *Id.*

215. H.B. 2065, Legis. Assemb. Reg. Sess. (Or. 2025).

216. *Id.*

217. N.H. REV. STAT. ANN. § 374:3-c.

218. Meris Lutz, *California Zeroes Out Funding for World's 'Largest Virtual Power Plant,'* UTIL. DIVE (Sep. 16, 2025), https://www.utilitydive.com/news/california-zeroes-out-funding-for-largest-virtual-power-plant/760274/ [https://perma.cc/9A8W-MGYR].