UPDATE: NC CLEAN PATH 2025

nc2025 CleanPath

achieving an economical clean energy future

Prepared for NC WARN

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BILL POWERS, P.E., BIOGRAPHY

Mr. Powers is a registered professional mechanical engineer in California with over 30 years of experience in energy and environmental engineering. He has written numerous articles on the strategic cost and reliability advantages of local solar power over large-scale, remote, transmission-dependent renewable resources, and he frequently appears as an expert witness on alternatives to conventional power generation infrastructure. Mr. Powers is the author of the 2012 strategic energy plan, *Bay Area Smart Energy 2020*, for the San Francisco Bay region. The plan relies on rooftop and parking lot solar power, combined with accelerated energy efficiency

denied a new peaking gas turbine power plant while determining that urban solar power could potentially serve as a cost-effective alternative to the proposed gas plant.

Mr. Powers began his career converting Navy and Marine Corps shore installation power plants from oil-firing to domestic waste, including wood waste, municipal solid waste and coal, in response to concerns over the availability of imported oil following the Arab oil embargo. He has permitted numerous peaking gas turbine, microturbine and internal combustion engine power plants. His home currently serves as urban off-grid test bed, including rooftop solar, battery storage, backup generation and an electric vehicle, to demonstrate the cost-effectiveness and reliability of this power delivery approach. Mr. Powers has a B.S. in mechanical engineering from Duke University and an M.P.H. in environmental sciences from the University of North Carolina at Chapel Hill.

NC WARN

NC WARN is a 30 year-old, member-based nonprofit tackling the climate crisis – and other hazards posed by electricity generation – by watch-dogging Duke Energy practices and building people power for a swift North Carolina transition to clean, renewable and affordable power generation and increased energy efficiency.

In partnership with other organizations, and using sound scientific research, NC WARN informs and involves the public in key decisions regarding their health and economic well-being. Dedicated to climate and environmental justice, NC WARN seeks to address the needs of all of the public by intentionally including those often excluded from participation because of racism, sexism, classism and other forms of oppression.

NC WARN commissioned the 2017 report *North Carolina Clean Path 2025*, and this update, in order to present a positive alternative to Duke Energy's long-term plan. See how NC WARN is working to implement *NC Clean Path 2025* at www.ncwarn.org/cp25/.

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Storage Breakthroughs Make the Clean Path Transition Even More Practical

Dramatic advances and rapidly declining prices in battery storage technologies are game changers in the global electricity business in 2018. There are no technical or economic reasons that North Carolina cannot retire all coal- and gas-fired power generation even more rapidly than was projected in 2017's *North Carolina Clean Path 2025*.

NC Clean Path 2025 Overview

NC Clean Path 2025 laid out a strategy for North Carolina to rapidly replace coal and gas-fired electricity – in a way that helps all customers – by focusing on local solar paired with battery storage, along with proven energy-saving and energy-balancing programs. Batteries in homes and businesses can serve as a "virtual power plant" by allowing the utility to draw upon the stored energy during periods of high system-wide demand. This suite of proven, less expensive measures eliminates the justification for building a new generation of natural gas-fired power plants. It provides for replacement of all coal and gas used for electricity with clean energy by 2030, getting halfway there by 2025.

Industry Being Upended as Solar with Storage Outperforms Gas

The National Renewable Energy Laboratory (NREL) reported a decline in cost of approximately 10 percent for rooftop solar systems of 100 kilowatt (kW) capacity and less, including residential systems of 10 kW and less, from the first quarter of 2017 to the first quarter of 2018. Global solar panel prices and costs are expected to continue to decline over the next few years.

Solar power combined with battery storage is now beating new natural gas-fired power plants on cost-effectiveness and reliability. Battery storage can do what gas turbines cannot – store and discharge renewable energy. Gas turbine manufacturing departments at General Electric and Siemens, among the biggest gas turbine suppliers in the world are in a tailspin, and many U.S. utilities and governments are aggressively shifting to renewables with storage.

Examples of this trend from 2018 include:

- Arizona Public Service chose a solar-powered battery after the 50 megawatts (MW) of storage beat out natural gas turbines on cost for electricity.
- In California, three gas-fired power plants were cancelled in favor of battery storage.
- Sterling Municipal Light Department in Massachusetts became the first municipal utility to deploy large-scale battery storage in a microgrid configuration that saved $400,000 in its first year of operation and can provide 12 days of backup power to the police station and dispatch center.

- Green Mountain Power in Vermont saved $500,000 in July 2018 by dispatching 500 Tesla Powerwall™ batteries as a virtual power plant.
- The Kauai electric cooperative in Hawaii met 23 percent of its annual demand from solar power in 2017, and in 2019 a solar with storage project – with a kilowatt-hour (kWh) price that's lower than North Carolina's average residential price of electricity – will increase Kauai's renewable energy to 70 percent.
- Minster, Ohio has a solar with battery storage system producing a contracted price of $0.095 per kWh, matching the municipal utility's average retail rate.
- New York State plans to add nearly 3,000 MW of battery storage, which will bring the state to 50 percent renewable energy generation by 2030.

Other utilities and state and local governments – including some in North Carolina – are moving assertively ahead with innovative storage and microgrid projects.

Dramatic Breakthroughs in Battery Storage

While lithium battery costs continue to fall as predicted in *NC Clean Path 2025*, a breakthrough in 2018 is commercially available zinc-air rechargeable batteries. This technology has been tested and proven over the last several years and appears likely to drive down battery storage costs even further and faster than anticipated even a few months ago.

Zinc-air battery. Source: NantEnergy, https://nantenergy.com/news/

The dramatic reduction in cost is likely to assure that storage becomes a standard component of residential and commercial solar installations over the next several years, with the storage component used daily to reduce energy bills.

Battery storage capacity in the U.S. is expected to grow by a factor of 10 over the next five years, from a 400 MW per year market to a 4,000 MW per year market. The reported cost of the zinc-air battery is potentially low enough to transform the electric grid into a round-the-clock carbon-free system.

Duke Energy Defies Market Trends – A Risky Position

Duke Energy has actually proven the reliability of rechargeable zinc-air battery storage but plans only pilot storage projects as other utilities move forward assertively. In its 2018 strategic plan, Duke Energy projects growing its electricity supply from renewables to only 8 percent by 2033.

In some of the states that are leading in the deployment of large-scale battery storage, specifically California and Arizona, it is now unlikely that any more gas-fired generation will be built. By contrast,

in its latest 15-year strategic plan, Duke Energy proposes to build the equivalent of two-dozen large, gas-fired power plants in the Carolinas alone, nearly 10,000 MW in total. The justification for part of this build-out is the unsubstantiated position that the utility must build gas-fired turbines to back up solar power, ignoring the accelerating market shift from gas to battery storage.

While Duke Energy is protected to a large degree from market competition, it is not insulated from what Amory Lovins calls "grid defection," the loss of customers to technologies such as solar with storage. The groundswell of interest, and commitments, by Duke Energy's customers in North Carolina to add battery storage may force Duke to shift emphasis and add much larger quantities of battery storage to the grid in the near-term future or be shut out of a major market that others will soon capitalize on.

NC Rural Coops and Municipal Utilities Set for Storage – With or Without Solar

Several of North Carolina's rural cooperatives and municipal utilities are moving ahead with solar plus storage programs, and there is strong interest among other such utilities. They understand how falling battery storage prices offer an opportunity – with or without solar generation – to cut deeply into the demand charges that represent roughly half of their wholesale payments to Duke Energy.

Under a federal provision, municipal utilities such as Apex, NC are allowed to install significant amounts of town-owned solar generation and sell it onto the grid.

More NC Opportunities for Virtual Power Plants

Municipal utilities and rural cooperatives, along with cities and university campuses served by Duke Energy, present different types of opportunities for implementing *NC Clean Path 2025.* There are no restrictions on creating virtual power plants by aggregating hundreds or thousands of individual home and commercial solar panels co-located with battery storage systems. University campuses, such as Duke University, are good candidates to develop up to 80 MW of solar with battery storage on campus under a federal law intended to promote independent power production. Cities such as Durham and Apex may also be able to take advantage of this option to develop large amounts of solar and battery storage capacity without conflicting with existing power supply agreements with Duke Energy.

Electric Cars Complement Home Solar with Storage

The commercialization of relatively low-cost electric vehicles (EVs), like the Chevy Bolt, with long-range capability, from 250 to 300 miles, allows the EV to serve as an energy-balancing resource for a home equipped with solar and battery storage.

The momentum behind solar with battery storage, from residential to utility-scale, is strong and growing in North Carolina. Customers want this technology. Duke Energy may be forced to shift from a business strategy of framing battery storage as a perpetual pilot project to deploying it as a mainstream option, or risk losing the battery storage market to customers taking their energy destiny into their own hands.

I. INTRODUCTION

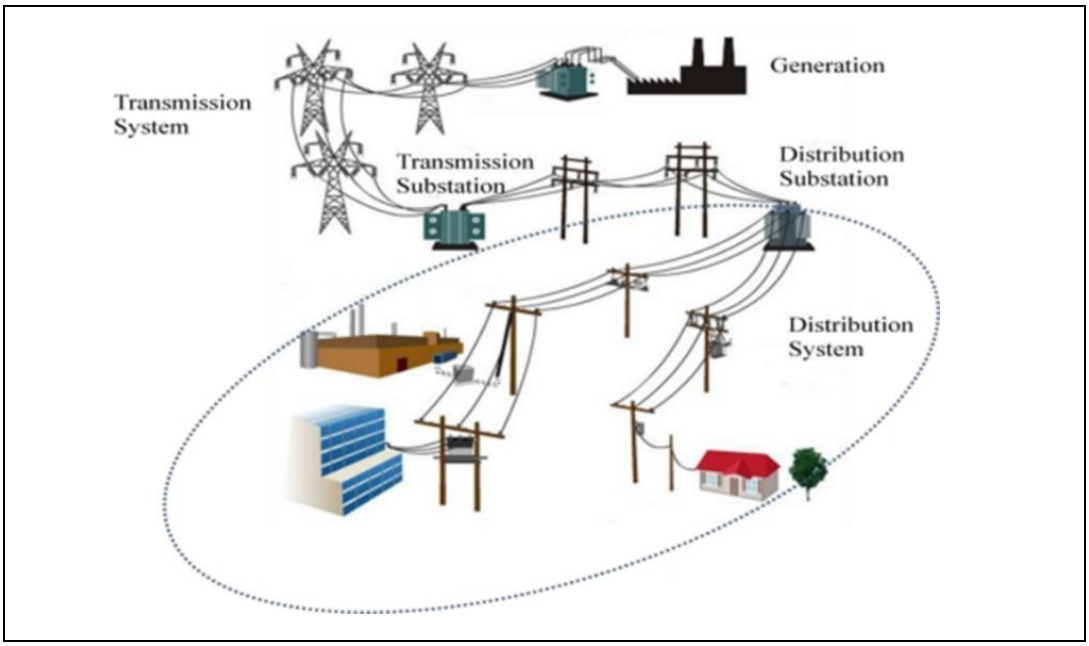
The strategic focus of *North Carolina Clean Path 2025*, a plan published in August 2017, is rapid expansion of local solar and energy storage on homes, buildings, parking lots and vacant urban land. Over time this becomes the primary source of power. Under this plan, 25 percent of homes and commercial buildings will meet 100 percent of demand with solar and batteries by 2025 – rising to 50 percent of homes by 2030. This local, clean power supply displaces existing coal- and natural gas-fired power. Power generated for North Carolina by coal- and gas-fired plants is reduced over 50 percent by 2025, with a net elimination of power from coal- and gas-plants by 2030.

The existing high-voltage transmission grid and existing gas-fired power plants become backup systems that will be maintained but not expanded. The existing distribution grid at the neighborhood level can already accommodate large flows of local solar power at little or no additional cost for upgrades, especially when battery storage is paired with solar power

Maximum demand response, for example shifting winter electric water heating load and cycling electric space heating load, will be achieved through "opt-out" programs. Energy efficiency measures will be maximized in the same manner. All customers will benefit due to on-bill financing of efficiency, solar and storage, and reduced bills due to the end of costly fossil-fueled power plant construction. There will be no cross-subsidies. *NC Clean Path 2025* will pay for itself and maintain stable rates.

The focus of *NC Clean Path 2025* is on generating solar power with battery storage at homes and commercial buildings at the distribution grid level, the area within the circle in Figure 1.

Figure 1. *NC Clean Path 2025* is focused on solar power and battery storage at the local level, near where the power is used.



C Clean Path 2025 has been used as a framework for grassroots action across the state. NC WARN has built teams of volunteer activists in seven counties that have been working to implement renewable energy policies, demand solar options from their cities and towns, help local governments include the cost of solar and storage solutions into municipal budgets and generally raise the awareness of how viable clean energy options are at the local level.

II. INDUSTRY "UPENDED" AS SOLAR WITH STORAGE OUTPERFORMS GAS

Solar projects matched with battery storage are now beating new peaking gas turbines on cost-effectiveness and reliability. Several 2018 examples of this trend include:

- Arizona Public Service signed a 15-year agreement for peaking power from a solar-powered battery – the 50 MW of storage beat out other forms of peaking generation on cost,[1] including natural gas combustion turbines.
- In California, three gas-fired power plants were cancelled in favor of battery storage, a landmark in the shift to a clean energy future.[2]
- Gas turbine manufacturing departments at General Electric and Siemens, among the biggest gas turbine suppliers in the world, are struggling.[3] [4] [5]
- The U.S. is expected to add 35 gigawatts (35,000 MW) of storage in the next eight years and generate $4 billion in annual savings.[6]
- New York State plans to add nearly 3,000 MW of battery storage, and be at 50 percent renewable energy generation, by 2030.[7]

III. BATTERY STORAGE: DRAMATIC BREAKTHROUGHS IN COST AND TECHNOLOGY

The dramatic reduction in the cost of storage is likely to assure that storage becomes a standard component of residential and commercial solar installations over the next several years. Behind-the-meter storage owned by residential and commercial customers accounted for two-thirds of battery

[1] "Energy storage projects to replace three natural gas power plants in California," *IEEE Spectrum*, July 17, 2018.
[2] Ibid.
[3] Jack Hough, "How Batteries Will Change the Power Business," *Barron's*, June 9, 2018, https://www.barrons.com/articles/how-batteries-will-change-the-power-business-1528509035.
[4] Andrew Bary, "General Electric's Dim Prospects," *Barron's*, February 17, 2018, https://www.barrons.com/articles/general-electrics-dim-prospects-1518842677.
[5] Aparna Narayanan, "GE Rival Siemens Is Having the Same Problems in this Hard-Hit Business," *Investor's Business Daily*, June 13, 2018. https://www.investors.com/news/ge-rival-siemens-may-sell-gas-turbines-unit/.
[6] See note 3 above.
[7] Iulia Gheorghiu, "New York unveils roadmap to 1.5 GW storage by 2025," *Utility Dive*, June 21, 2018, https://www.utilitydive.com/news/new-york-unveils-roadmap-to-15-gw-storage-by-2025/526292/.

capacity installed in 2017.[8] Installed battery capacity in the U.S. is projected to increase from about 400 MW per year in 2018 to about 4,000 MW per year in 2023.[9]

A. Zinc-Air Batteries Could Outpace Lithium

In September 2018, *The New York Times* broke the story that zinc-air batteries are commercially proven and can beat lithium batteries on price. Zinc-air battery systems are moving rapidly into the U.S. marketplace with major corporate backing. This comes after the zinc-air battery has been proven in 1,000 cell towers around the world over the last several years and in more than 100 village-level microgrids in developing countries.[10]

This puts the zinc-air technology in direct competition with lithium batteries and is reportedly already priced at $100 per kWh in 2018.[11]

This battery – the same basic technology used in many hearing aids – has the potential to produce energy storage at a cost below that of lithium batteries. While zinc-air batteries use relatively common zinc as the core component, lithium batteries rely on the relatively rare metals of lithium and cobalt. The zinc-air battery does not pose the fire hazards of lithium batteries or need external cooling systems to prevent overheating.

B. Continuing Decline in Lithium Battery Cost

The cost of a lithium battery has declined from about $1,000 per kWh in 2010 to about $270 per kWh in 2016[12] to approximately $200 per kWh in 2018,[13] following the trajectory shown in Figure 2. Lithium storage is projected to cost $70 per kWh by 2030,[14] a price point that may be reached more rapidly given competition from the zinc-air battery.

Tesla's response to the stated $100 per kWh cost of rechargeable zinc-air batteries is that Tesla may get the cost of lithium battery cells down to $100 per kWh this year. A $100 per kWh battery storage

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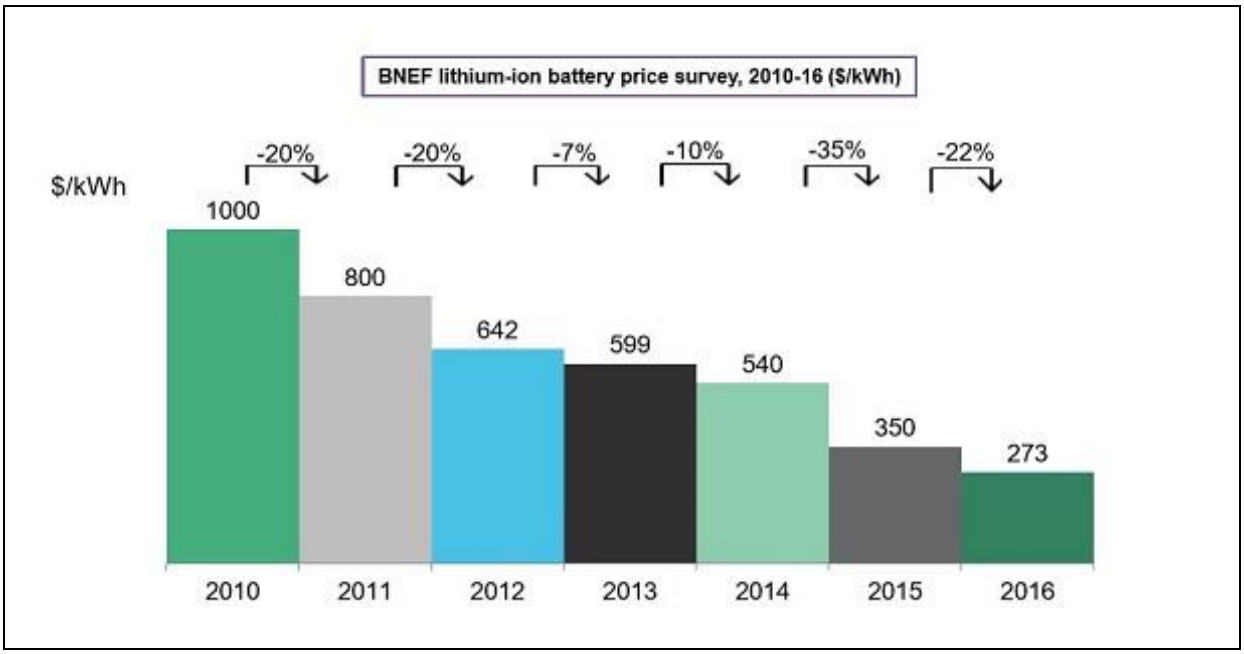
[8] GTM Research, *U.S. Energy Storage Monitor: Q3 2018 Executive Summary*, September 2018, p. 4. "BTM deployments accounted for almost two-thirds of MWh deployments in Q2 2018."
[9] Ibid, p. 10.
[10] NantEnergy website, accessed October 21, 2018: https://nantenergy.com/technology/.
[11] Ivan Penn, "Cheaper Battery Storage is Unveiled as a Step to a Carbon-Free Grid," *New York Times*, September 26, 2018, https://www.nytimes.com/2018/09/26/business/energy-environment/zinc-battery-solar-power.html.
[12] Bloomberg New Energy Finance, "Lithium-ion Battery Costs and Market," PowerPoint, July 5, 2017, p. 2, and Bloomberg New Energy Finance, "How Big Will the Battery Boom Get? Try $548 Billion," June 19, 2018. "Battery prices are expected to fall to $70 a kilowatt-hour by 2030."
[13] Peter Maloney, "Not so fast: Battery prices will continue to decrease, but at a slower pace, GTM says,: *Utility Dive*, March 13, 2018, https://www.utilitydive.com/news/not-so-fast-battery-prices-will-continue-to-decrease-but-at-a-slower-pace/518776/.
[14] A typical home solar system of 8,000-watt capacity would have a gross cost of about $20,000 before tax credits. A battery storage system large enough to power the home largely on solar and battery power would need a capacity in the range of 20 to 25 kWh. At $70 per kWh, the battery cost would be in the range of $1,400 to $1,750, or less than 10 percent of the cost of the solar system. This battery cost would increase the cost of production from the solar with battery system by less than $0.01/kWh. However, this cost would be completely offset by the ability of the homeowner to shift demand for grid power to low-cost, late evening periods (under a time-of-use tariff).

cost is potentially low enough to transform the electric grid into a round-the-clock carbon-free system.[15]

Figure 2. Lithium Battery Cost Decline, 2010-2016[16] [17]



C. Implications of Low-Cost Batteries – With or Without Solar

Both zinc-air and lithium batteries are "hands-off" storage systems with guarantees of 10 years or more. It is reasonable to assume that many or most new customer-owned solar installations going forward, and many existing solar-only customer-owned installations, will include battery storage by 2025.

It is also reasonable to assume that some customers will add battery storage without solar due to tree shading, poor roof orientation, or a congested, complex roof that impedes rooftop solar. Under *NC Clean Path 2025*, those customers might choose to participate in community solar programs. Commercial and residential customers can already generate net savings by adding storage in order to shave peak demand under mandatory time-of-use (TOU) rates,[18] reducing their net costs while assuring onsite backup power. The predominant form of battery storage installed in the U.S. in 2018 is behind-the-meter – owned by residential and commercial customers.[19]

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[15] See note 11 above.
[16] Bloomberg New Energy Finance, "Lithium-ion Battery Costs and Market," PowerPoint, July 5, 2017, p. 2.
[17] Bloomberg New Energy Finance, "How Big Will the Battery Boom Get? Try $548 Billion," June 19, 2018. "Battery prices are expected to fall to $70 a kilowatt-hour by 2030."
[18] Bill Powers, *North Carolina Clean Path 2025: Achieving an Economical Clean Energy Future*, August 2017, p. 50.
[19] GTM Research, *U.S. Energy Storage Monitor: Q3 2018 Executive Summary*, September 2018, p. 4. "BTM deployments accounted for almost two-thirds of MWh deployments in Q2 2018."

This is consistent with longstanding projections that distributed generation, rather than central power plants, is the future of the electric power grid.

Duke Energy, despite an overwhelming emphasis on adding gas-fired generation in its September 2018 IRP, acknowledged in 2017 the major role batteries will play going forward, stating:[20]

"There's going to be a lot of excitement around batteries in the next five years … I would say that the country will get blanketed with projects … It's a big opportunity for all of us to deliver what customers want."

D. Electric Vehicles Complement Home Energy Storage

The commercialization in 2017 of relatively low-cost electric vehicles (EVs), like the Chevy Bolt, with long-range capability from 250-300 miles, allows the EV to serve as an effective demand response resource for a home equipped with solar and battery storage.[21] Assuming typical daily EV usage of about 50 miles, a residential solar and battery storage system designed to meet the home electric load and EV demand can dedicate the entire capacity of the solar and battery storage system for the house electric demand much of the time during winter months, charging the EV only every several days.

IV. DUKE ENERGY: BUSINESS-AS-USUAL DESPITE STORAGE SUCCESSES

Dramatic advances in battery technology and the declining cost of renewable energy are the game changers in the electricity business in 2018. Duke Energy corroborated the reliability of the low-cost rechargeable zinc-air battery technology at a cell tower in the Great Smoky Mountains National Park and will also construct a state-of-the-art solar battery microgrid project in Hot Springs, North Carolina, as described below in detail. However, in its 2018 strategic plan, Duke Energy approaches battery storage as essentially a pilot technology even as other utilities recognize the technology is "ready for prime time."

Duke Energy anticipates adding about 300 MW of battery storage over the next 15 years in the Carolinas. This pales in comparison to the nearly 10,000 MW of new gas-fired generation Duke proposes to build in the same time period – and is dwarfed by the storage being added by other U.S. utilities and states. For example, California alone is expected to add nearly 3,000 MW of battery storage in residential and commercial buildings by 2026.[22]

In its 2018 strategic plan, Duke Energy projects growing its electricity supply from renewables to only 8 percent by 2033.[23] This is at a time when some U.S. cities and utilities, for example Salt Lake City,

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[20] Jeff McMahon, "In 5 Years, Batteries Will Blanket The U.S., Duke Executive Says," *Forbes*, October 22, 2017, https://www.forbes.com/sites/jeffmcmahon/2017/10/22/in-5-years-batteries-will-blanket-the-u-s-duke-executive-says/.
[21] Chevy Bolt: $36,600 MSRP, 250+ mile range.
[22] Peter Maloney, "Energy storage gets a boost as California legislature extends SGIP,: *Utility Dive*, August 31, 2018, https://www.utilitydive.com/news/energy-storage-gets-a-boost-as-california-legislature-extends-sgip/531350/.
[23] John Downey, "Duke Energy accounts for large boost in solar power in its latest long-range plan," *Charlotte Business Journal*, September 5, 2018, https://www.bizjournals.com/charlotte/news/2018/09/05/duke-energy-long-term-plan-solar-

San Diego and Kauai Electric, are targeting 100 percent renewable energy by 2033. Duke also plans to back up all new renewable power with gas-fired plants. This presumption is obsolete. Battery storage can do what gas turbines cannot – store and discharge renewable energy. Battery storage projects are beating gas-fired generation on cost and reliability, as noted above. In addition, as explained in *NC Clean Path 2025*, Duke Energy already operates 2,140 MW of readily dispatchable, pumped hydroelectric storage, which is capable of storing solar power for nighttime use and helping solve the intermittency challenge posed by renewables.[24]

In June 2018 the North Carolina Utilities Commission (NCUC) denied Duke Energy's application for authorization to add $13 billion in transmission and distribution (T&D) grid upgrades to its North Carolina system over the next decade.[25] That denial followed the legislature's 2017 refusal to go along with the "grid modernization" plan that has been widely criticized by the business community, consumer watchdogs and other constituents, and which has gained little or no support from stakeholders. This opens an opportunity for a reworking of Duke Energy's strategic plan to include a far larger role for battery storage. However, it is likely that Duke will again seek legislative approval in 2018 for the grid program.

Implementing battery storage at the point where power is used will increase reliability for all North Carolina communities, as noted in *NC Clean Path 2025*.[26] It is a more economical and effective solution than Duke Energy's proposal to 1) build redundant backup transmission lines to meet vulnerable communities' reliability needs and 2) address transmission congestion caused by solar farms being built in remote parts of the state by building more transmission lines.

A. Exceptions to Duke Energy's Business-As-Usual Plans

1. Great Smoky Mountains National Park Cell Tower Project

One exception to Duke Energy's business-as-usual strategic plan is the solar with zinc-air battery storage project, located on the Mount Sterling cell tower in the Great Smoky Mountains, which began operation in mid-2017. This project, although of modest scale with a 10 kW solar array and 95 kWh of battery storage, is important for its role in demonstrating the reliability of the rechargeable zinc-air battery technology in the U.S. The success of the zinc-air battery in the cell tower allowed Duke to discontinue use of the existing distribution line that had served the tower. This resulted in 13 acres of land, previously used for the power line serving the cell tower, to be returned to the National Park Service.

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power.html. "Although the Duke utilities expect to add almost 4,300 megawatts of solar capacity in the Carolinas in the next 15 years, solar power will not make up a significantly larger percentage of the company's energy mix by 2033. … By 2033, it will account for 8%."

[24] Bill Powers, *North Carolina Clean Path 2025: Achieving an Economical Clean Energy Future*, August 2017. p. 19.

[25] *Order Accepting Stipulation Deciding Contested Issues, and Requiring Revenue Reduction*, https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=80a5a760-f3e8-4c9a-a7a6-282d791f3f23, pp. 42-44, 127-150.

[26] Bill Powers, *North Carolina Clean Path 2025: Achieving an Economical Clean Energy Future*, August 2017.p. 5, p. 31 and p. 38.

Figure 3. Duke Energy cell tower installation on Mt. Sterling[27]

Duke Energy Mt. Sterling cell tower microgrid:

- 10 kW solar array
- 95 kWh zinc-air battery storage system

2. *Hot Springs, North Carolina Microgrid Project*

Hot Springs is a remote town of 500 people in the Appalachian Mountains served by a single distribution line that is subject to frequent outages. Duke Energy plans to install approximately 3 MW of solar power and 4 megawatt-hours (MWh) of lithium battery storage and configure circuits to allow Hot Springs to isolate from the grid as needed, known as "islanding," when grid power is unavailable. The project is projected by Duke Energy to be online by 2020.[28]

Using the same approach, storage could be added to the nearly 5,000 MW of solar farms in eastern North Carolina to smooth out generation and enable local communities to be islanded during grid outages to increase local reliability. This would reduce or eliminate Duke Energy's justification to 1) add new transmission capacity to address grid congestion and 2) double up on transmission lines to increase the reliability of parts of the grid that serve vulnerable communities.

V. UPDATES ON SUCCESSFUL SOLAR + BATTERY PROJECTS DESCRIBED IN CLEAN PATH 2025

Several operational utility solar and battery programs, including Green Mountain Power, Minster Municipal and Kauai Island Electric Cooperative, are addressed in *NC Clean Path 2025*. This section looks at the advances made in these utility programs in the year since *NC Clean Path 2025* was published in August 2017.

[27] Ibid.

[28] Duke Energy Progress, Application for Certificate of Public Convenience and Necessity - Hot Springs Microgrid Solar and Battery Storage Facility, Docket No. E-2, Sub 1185, October 8, 2018, p. 7.

A. Green Mountain Power (VT)

Green Mountain Power (GMP), an investor-owned utility in Vermont, began offering retail customers 14 kWh battery storage units for $15 per month in 2017.[29] The project at full build-out will consist of 2,000 residential units. GMP will aggregate the output of these battery storage systems to serve as a virtual peaking power plant.

GMP saved $500,000 during a July 2018 heat wave by dispatching 500 of these Tesla Powerwall™ batteries as a virtual peaker plant.[30] Tesla introduced a software update in 2018 that allows the Powerwall™ to be optimized for charging and discharging on time-of-use rates in order to best benefit the customer.

B. Minster Municipal Utility (OH)

Minster is a small Ohio town of about 3,000 people that receives its electric power primarily from American Municipal Power, the wholesale power provider for municipal utilities in Ohio.[31]

The first Minster solar with battery storage system, a 4.2 MW solar array and a 3 MWh battery storage system with 7 MW of peak output, came online in April 2016 under a power purchase agreement (PPA) with Half Moon Ventures.[32] The PPA sets the price for solar electricity at $0.07 per kWh. The all-in PPA price with storage is $0.095 per kWh. This matches the Minster utility's average retail rate.

This system provides Minster with multiple revenue streams, including integration of frequency and voltage regulation, demand response and transmission services.[33] Minster has cut its peak capacity and demand charges by approximately $150,000 per year.[34] The town also avoided a $350,000 cost to buy capacitors, that otherwise would have been needed to improve power quality, by installing the battery system.[35]

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[29] The customer owns the Powerwall™ after 10 years of payments. The customer also has the option to make a one-time $1,500 payment to purchase the unit.

[30] Robert Walton, "Tesla batteries save $500K for Green Mountain Power through hot-weather peak shaving," *Utility Dive*, July 23, 2018, https://www.utilitydive.com/news/tesla-batteries-save-500k-for-green-mountain-power-through-hot-weather-pea/528419/. Tesla is in the process of completing the 2,000-unit Powerwall™ deployment.

[31] K. Kaufmann, "Solar-powered yogurt and pop tops: How solar+storage helps a rural village to thrive," Smart Electric Power Alliance, January 11, 2018, https://sepapower.org/knowledge/solar-powered-yogurt-pop-tops-solarstorage-helps-rural-village-thrive/. "After partnering with American Municipal Power — the town's electricity provider — on other generation projects, '[Minster was] looking to find another cost-effective (resource) that would enable us to diversify our portfolio . . . shave our peak demand, and reduce our costs,' [Minster Village Administrator Don] Harrod recalled."

[32] Ibid.

[33] NREL Blog, "Community Energy Storage: A New Revenue Stream for Utilities and Communities?," September 24, 2018, https://www.nrel.gov/state-local-tribal/blog/posts/community-energy-storage-a-new-revenue-stream-for-utilities-and-communities.html.

[34] K. Kaufmann, "Solar-powered yogurt and pop tops: How solar+storage helps a rural village to thrive," Smart Electric Power Alliance, January 11, 2018.

[35] Ibid.

Minster is in the process of adding another 4.2 MW of solar and 7 MW of storage – Phase 2 – to the existing installation. The solar price under the Phase 2 contract will be about $0.05 per kWh.[36]

Finally, Minster also has in its project pipeline a Phase 3 that would add 19 MW of battery storage. The goal of Phase 3 is to create a local microgrid to ensure power and improve reliability for critical facilities and local businesses in the event of a grid outage.[37]

C. Kauai Island Utility Cooperative (HI)

Kauai Island Utility Cooperative (KIUC), a public utility with 30,000 customers and peak load and annual energy demand of 78 MW and 430 million MWh,[38] respectively, has taken the lead in the U.S. in the transition from a fossil fuel-based grid to a solar with battery storage model. To date, the cooperative has concentrated on utility-scale solar with battery projects in the 6 MW to 12 MW capacity range. At the end of 2017, KIUC had 40 MW of operational utility-scale solar and 22 MW of operational customer behind-the-meter solar.[39] KIUC has the highest concentration of solar and battery storage – meeting 23 percent of its annual electricity demand from solar power in 2017 – of any utility in the country.[40]

A 20 MW solar project with 70 MWh of battery storage will come online in 2019, increasing the cooperative's renewable energy content to about 70 percent.[41] This project is being built under a PPA between KIUC and AES. The PPA contract price is $0.1083 per kWh,[42] a price between the average retail price of residential electricity ($0.1103 per kWh) and commercial electricity ($0.0863 per kWh) in North Carolina in 2016.[43] [44]

This project will be on land leased from the U.S. Navy and will be capable of functioning as an "islanded" microgrid serving the Navy facility if grid power is unavailable from KIUC.[45]

A substantial percentage of Kauai solar power is generated from customer net-metered systems. This has resulted in some curtailment of the island's utility-scale renewable energy projects at times of peak solar output. The cooperative established a residential solar with battery storage tariff in late 2017, the *Smart Export* tariff, intended to shift behind-the-meter customer solar output to time

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[36] Ibid.
[37] Ibid.
[38] KIUC peak load and annual energy demand of 78 MW and 430 million MWh are similar to the peak load and annual energy demand of Duke University, 76 MW and ~450 million MWh (2012), respectively.
[39] Christian Roselund, "Kaua'i to near 70% renewables with massive solar + storage project," *PV Magazine*, June 25, 2018, https://pv-magazine-usa.com/2018/06/25/kauai-to-near-70-renewables-with-massive-solar-storage-project/.
[40] Ibid.
[41] Ibid.
[42] Ibid.
[43] U.S. EIA, *State Electricity Profiles – North Carolina*, January 25, 2018, Table 8. Retail sales, revenue and average retail price by sector, https://www.eia.gov/electricity/state/northcarolina/.
[44] Kauai has about 15 percent more solar insolation on an annual basis than North Carolina (Raleigh). https://pvwatts.nrel.gov/pvwatts.php.
[45] Ibid.

periods in which the cooperative could absorb the customer solar power without curtailing utility-scale solar projects.[46]

D. Ocracoke Island Microgrid (NC)

The Ocracoke Island microgrid was briefly referenced in *NC Clean Path 2025*.[47] Tidelands EMC operates the Ocracoke Island microgrid, which consists of a 500 kW, 1 MWh Tesla battery, 15 kW of rooftop solar, a 3.2 kW diesel generator and demand response controllers for climate and water heater control in members' homes. Tidelands EMC is upgrading the control system for the microgrid to allow "islanding" of the microgrid from the Tidelands EMC grid as necessary. The upgrade will be complete in the December 2018/January 2019 timeframe.[48]

Tidelands EMC uses the Tesla battery bank frequently, on the order of 200 days per year. A priority use is to discharge the battery bank during high-demand hours on peak days to reduce capacity charges. The Tesla battery bank is also used to assist the cold start-up of the diesel generator.[49]

E. Brunswick Rural Cooperative (NC)

Rural cooperative and municipal utility wholesale power agreements generally allow for these electricity providers to supply up to 5 percent of their total power needs with generation units up to 500 kW capacity each. As a result of this authority, and battery storage costs continuing to decline rapidly, a major growth area will be battery storage with capacity less than 500 kW installed at rural cooperative and municipal utility distribution substations.

This strategy has been pioneered in North Carolina at the Brunswick Electric Membership Cooperative, located in the extreme southeast of North Carolina with about 90,000 members.

Brunswick EMC, under a power purchase agreement with Cypress Creek Renewables, brought twelve 500 kW solar with 500 kW battery storage systems online at substations in March 2018.[50]

In 2017 Brunswick EMC initiated a net-metered tariff – whereby member customers are paid $0.0932 per kWh for any excess solar generation produced – which is very popular with members and is approaching 1 MW of installed capacity. [51]

Finally, Brunswick EMC is in the first stages of developing a residential microgrid, consisting of about 30 homes, with each residence equipped with solar and battery storage.[52] [53]

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[46] "KIUC Files Proposal to Manage Distributed Energy Resources (DER) with the PUC Additional Future Rate Changes Likely," KIUC press release, August 14, 2017.
[47] Bill Powers, *North Carolina Clean Path 2025: Achieving an Economical Clean Energy Future*, August 2017. p. 21.
[48] Telephone communication between B. Powers, Powers Engineering, and H. Smith, Tidelands EMC, October 23, 2018.
[49] Ibid.
[50] "Lockheed Martin Delivers Energy Storage Systems to Cypress Creek Renewables for Solar-Plus-Storage Projects," *PR Newswire*, March 26, 2018.
[51] Telephone communication between B. Powers, Powers Engineering, and N. Nance, Brunswick EMC, October 21, 2018.
[52] Ibid.

VI. AMBITIOUS SOLAR + BATTERY PROJECTS IN DEVELOPMENT OR UNDERWAY

A. Government of South Australia and Tesla: 50,000-Home, 250 MW Solar + Battery Project

This virtual power plant project consists of 50,000 grid-tied homes, primarily publicly-owned affordable housing units, and is twenty-five times the size of the GMP-Tesla virtual power plant project in Vermont. Each housing unit will be equipped with 5 kW of solar panels and a 13.5 kWh Tesla Powerwall™ battery storage unit.[54] The aggregated project will have a discharge capacity of 250 MW, with total storage capacity of 650 MWh. This is a follow-on project to Tesla's "built in 100 days" 100 MW, 129 MWh battery storage facility in Jamestown, Australia. The Jamestown project became operational in December 2017.[55]

Twenty projects of this 250 MW scale, or about three per year, would meet the *NC Clean Path 2025* target of 5,000 MW of distributed battery storage in North Carolina by 2025.

B. Sterling Municipal Light Department (MA) Battery Storage Project

Sterling Municipal Light Department in Massachusetts serves 3,700 residential, commercial, municipal and industrial customers. Sterling had the most solar watts per customer in the country in 2013, with PV power accounting for approximately 30 percent of the utility's peak load. The costs of capacity and transmission services purchased from the grid operator rose from $500,000 in 2010 to $1.2 million in 2017. The high solar penetration was also causing some power quality issues.[56]

To address these issues, a 2 MW, 3.9 MWh lithium battery storage system was installed in October 2016. The system is designed to "island" from the grid during a power outage. It is supported by 2 MW of existing solar generation. The substation where the battery storage is located, the 2 MW of solar and the police department are all on the same electrical feeder, which can be isolated to form an islanded microgrid in the event of a grid outage. This package can provide 12 days or more of backup power to the Sterling police station and dispatch center when it is operating as an islanded microgrid.

Battery storage was chosen over the gas turbine alternative initially considered. The project is expected to save at least $400,000 per year over the project's 10-year lifespan. This is a significant savings for the Sterling municipal utility, which has an annual budget of $8.2 million. The battery storage also allows Sterling to increase solar penetration while maintaining good power quality.

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[53] Also worthy of note is a new Randolph EMC (Asheboro, NC) residential battery tariff implemented in 2018 and designed to reward members for dispatching their batteries during peak demand periods.

[54] "Tesla's world's largest "virtual power plant" gets the green light in South Australia," www.teslarati.com, May 24, 2018, https://www.teslarati.com/tesla-virtual-power-plant-south-australia/.

[55] "Tesla Bet and Delivered 100-MW/129-MWh Energy Storage System Within 100 Days," *Power Magazine*, January 3, 2018, https://www.powermag.com/tesla-bet-and-delivered-100-mw129-mwh-energy-storage-system-within-100-days/.

[56] "Sterling Municipal Light Department - Energy Storage System," *Home Power*, August 2018, pp. 25-26.

C. Pacific Gas & Electric Virtual Power Plant (CA)

Pacific Gas & Electric will enter into a PPA contract for 10 MW of aggregated commercial battery storage to be online by 2020.[57] A similar 1 MW project is being developed under a power purchase agreement (PPA) between Hawaii Electric Company on Oahu and STEM, Inc.[58] These PPA projects are functionally equivalent to the GMP-Tesla virtual power plant project in Vermont. These projects may serve as good models for similar developments in the City of Durham and/or Duke University.

D. California SB 700 Behind-the-Meter Battery Storage Program Expansion

State senate bill SB 700 was signed into law by the California governor in late September 2018 and is expected to add up to 3,000 MW of behind-the-meter residential and commercial storage in California by 2026.[59]

E. Brooklyn Microgrid (NY)

The greater New York City area has become a focal point of local clean energy innovation to address grid fragility concerns in the wake of Hurricane Sandy in 2012. One example of this innovation is the Brooklyn Microgrid project, which uses a "blockchain" accounting system to allow individual customers to buy and sell solar power generated by participants in the microgrid. Blockchain is in essence a digital ledger that is kept on millions of computers at the same time. When changes are made, anyone with access to the ledger can verify the changes.[60]

The Brooklyn Microgrid project is located in Consolidated Edison (ConEd) service territory. ConEd is an investor-owned utility (IOU) similar to Duke Energy. ConEd earns a transaction fee as individual customers buy and sell self-generated solar power over ConEd wires.[61]

The blockchain approach to clean power generation has the potential to leapfrog the gatekeeper role currently filled by the IOU, while also providing the IOU with a financial reason to support expanded development of blockchain microgrids like the Brooklyn Microgrid.

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[57] PG&E, Advice 5322-E, *Energy Storage Contracts Resulting from PG&E's Local Sub-Area Request for Offers Per Resolution E-4909*, June 29, 2018, p. 9. "The project is a 10 MW, four-hour duration project. The mNOC AERS project will go through the appropriate interconnection process for behind-the-retail meter energy storage resources. Initial delivery date is October 1, 2019."

[58] Peter Maloney, "Stem, HECO launch 1 MW storage virtual power project on Oahu," *Utility Dive*, February 2, 2017, https://www.utilitydive.com/news/stem-heco-launch-1-mw-storage-virtual-power-project-on-oahu/435351/.

[59] Jeff St. John, "California Passes Bill to Extend $800M in Incentives for Behind-the-Meter Batteries," *GreenTech Media*, August 31, 2018, https://www.greentechmedia.com/articles/read/california-passes-bill-to-extend-incentives-for-behind-the-meter-batteries#gs.6cxCMs0.

[60] Brooklyn Microgrid website, https://www.brooklyn.energy/.

[61] Ibid.

VII. REGULATORY CHANGES THAT IMPACT IMPLEMENTATION OF NC CLEAN PATH 2025

A. House Bill 589

HB 589 ("Competitive Energy Solutions for NC") became law in July 2017. The intent of the law was to provide a comprehensive revision to North Carolina's renewable energy development. The law 1) adds some limited support for customer rooftop solar and community solar while at the same time instructing Duke Energy to propose revised compensation rates for rooftop solar, 2) reduces the compensation rate for large-scale solar, 3) reduces the year-to-year quantity of large-scale solar added to the grid and 4) restricts the ability of large-scale solar developers to add battery storage to solar projects. The main elements of HB 589 are described below.

Rooftop Solar Rebate: Duke Energy will pay a rebate of $0.50 per watt to businesses that install solar electric systems, $0.60 to residences and $0.75 to nonprofits. While this benefits customers who receive it, the program is capped at only 20 MW per year for 5 years.

Rooftop Solar and Net Metering: HB 589 instructs Duke Energy to propose revised net metering rules that would affect the economics of rooftop solar installations. Existing net metering customers are grandfathered until January 1, 2027. Duke Energy is expected to file its proposal in 2019. Net metering is a system by which customers with solar arrays offset grid power with onsite solar power that is compensated at the retail rate. Net metered rooftop solar is now cost-effective in North Carolina due to a steady decline in the cost of solar in recent years. Net metering is a popular program with customers that has come under attack by utilities around the country. Numerous state-level studies, as described in *NC Clean Path 2025*,[62] indicate that net metered electricity is actually as valuable – or more valuable – to the utility than the retail grid power this solar electricity offsets.

Rooftop Solar Leasing: The law allows Duke Energy or third parties to offer solar leasing, which can allow customers to avoid the upfront cost of solar, similar to a car lease. The customer would get the benefit of their rooftop solar while paying a monthly fee to the company that owns the panels. The program is capped at around 250 MW and expires in 5 years.

Third-Party Solar Sales: Under "third-party solar," the customer would purchase solar energy produced by panels on their roof and have the option to buy the panels at the end of the agreed term, but avoid paying for the system upfront. After a bipartisan legislative effort in 2015 to legalize third-party sales of solar electricity and NC WARN's "Solar Freedom" court challenge,[63] HB589 prohibited this arrangement, which has been integral to growth of rooftop solar in other states.

Community Solar: Community solar allows customers who cannot put solar panels on their homes (for example renters and homeowners with shady roofs) to purchase part of the output of a larger

[62] Bill Powers, *North Carolina Clean Path 2025: Achieving an Economical Clean Energy Future*, August 2017. p. 55.
[63] Solar Freedom Project, https://www.ncwarn.org/our-work/solar-freedom/.

community array and get credit for the solar production. HB589 requires Duke Energy to offer a limited 40 MW of community solar. In contrast, the leading community solar state in the nation, Minnesota, has installed approximately 400 MW of community solar.[64]

Large-Scale Solar: Prior to the passage of HB589, developers of all but the largest solar projects sold power to Duke Energy under a standard long-term contract with favorable terms. These contract terms were set at what is known as the utility's "avoided cost" to produce the same electricity. HB589 mandates that the contract terms of most projects over 100 kW must be negotiated individually.

The law directed Duke to establish competitive bidding for 2,660 MW of large-scale solar over 45 months. The cap and time period limit solar development compared to large-scale solar added in recent years. For example, approximately 1,200 MW of solar was installed in North Carolina in 2017,[65] or on average about 100 MW of solar per month. Many solar projects were stalled in 2018 by the change from a standard offer contract to a competitive bid, least-cost selection process overseen by Duke Energy.

Duke Energy awarded 680 MW of solar contracts in July 2018 in the first round of large-scale solar project bidding.[66] Independent solar developers contend that Duke Energy is attempting to extend its monopoly to projects combining battery storage with solar power.[67] These solar industry representatives indicate that onerous conditions imposed by the utility make it impossible for independent developers to offer economically competitive bids for projects that combine storage and solar.[68]

Despite solar industry protests, the NCUC authorized the first round of bidding to move forward and that changes be made to the second round of bids, for approximately 800 MW of capacity, in 2019. Duke Energy has indicated it will be difficult to develop guidelines that compensate independent developers for the value that storage can add to solar projects and to the power grid.[69]

Green Source Advantage: This program allows large energy users, including the University of North Carolina system and military installations, to contract for power from renewable energy projects to meet their sustainability goals. It is capped at 600 MW and expires in 5 years. Duke Energy's proposed program, awaiting approval by NCUC as of October 2018,[70] has been criticized by solar developers and

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[64] Tim Sylvia, "Minnesota community solar reaches 400 MW milestone," *PV Magazine*, August 28, 2018, https://pv-magazine-usa.com/2018/08/28/minnesota-community-solar-reaches-400-mw-milestone/. Minnesota, at 5.6 million people, has about half the 10.3 million population of North Carolina.
[65] "North Carolina Solar," Solar Electric Industry Association, https://www.seia.org/state-solar-policy/north-carolina-solar, accessed November 2, 2018.
[66] John Downey, "NC solar developers lose battery storage challenge to Duke Energy," *Charlotte Business Journal*, June 28, 2018, https://www.bizjournals.com/charlotte/news/2018/06/28/nc-solar-developers-lose-battery-storage-challenge.html.
[67] Ibid.
[68] Ibid.
[69] Ibid.
[70] NCUC webpage,https://www.ncuc.net/Hearings/e7sub1170hearing.html, accessed November 3, 2018.

potential participants as too costly.[71] It also requires participants to go through Duke Energy even when negotiating a contract with a private solar developer.

Wind Power: The law placed an 18-month moratorium on new wind power projects based on the premise that they could interfere with military operations. However, this justification for the ban falls flat as wind farms must already receive clearance from the Department of Defense as well as the Federal Aviation Administration.[72]

Energy Storage Study: North Carolina State University is conducting a study, mandated by HB589, to assess the value of energy storage and policies needed to accommodate it. The study is expected to be released in December 2018.

B. Duke Energy Voluntary Residential Time-of-Use Rates

Battery storage is likely to be more cost-effective for stand-alone solar with battery systems using voluntary residential time-of-use (TOU) rates, available as of August 1, 2018 from Duke Energy Carolinas (DEC) and as of January 1, 2016 from Duke Energy Progress (DEP), than those subject to conventional net metering.[73] The TOU rates allow customers to charge their batteries when the price of electricity is low and sell that power back to the grid (or use it in their home or business) when the price of electricity is high (see Figure 4).

Figure 4. Value of battery storage with TOU rates and as backup power[74]

[71] John Downey, "Critics propose compromise on Duke Energy's renewable power program," *Charlotte Business Journal*, October 25, 2018, https://www.bizjournals.com/charlotte/news/2018/10/25/duke-energy-opponents-reach-compromise-on-green.html.
[72] John Murawski, "Two proposed wind farms threatening to pull out of NC if moratorium becomes law," *News and Observer*, July 5, 2017, https://www.newsobserver.com/news/business/article159811154.html.
[73] Duke Energy Carolinas, Schedule RT (NC), Residential Service, Time-Of-Use, effective August 1, 2018, https://www.duke-energy.com/_/media/pdfs/for-your-home/rates/electric-nc/ncschedulert.pdf?la=en.
[74] SunRun, *3 Ways Solar Battery Storage Saves on Time-of-Use Rates*, June 15, 2018, https://www.sunrun.com/go-solar-center/solar-articles/3-ways-solar-battery-storage-saves-on-time-of-use-rates.

C. Challenge – Momentary Residential Battery Supply Bottleneck

Residential battery systems are also gaining popularity with Duke Energy customers.[75] The current limitation on deployments is the availability of Tesla Powerwall™ residential battery systems, with waiting periods of 4-6 months.[76] Surprisingly, other manufacturers of residential lithium battery systems, such as LG, Tabuchi, Sonnen and Pike Energy, have apparently not yet taken advantage of the Tesla Powerwall™ bottleneck to gain market share by offering competitive prices, relative to the Powerwall™, for their lithium battery products.

VIII. OPPORTUNITIES AND ACTIONS FOR NC CLEAN PATH 2025

Municipal utilities, rural cooperatives, cities and university campuses served by Duke Energy present different types of opportunities for implementing *NC Clean Path 2025*. These opportunities are described below.

A. Special Opportunities for Municipal Utilities and Rural Coops

Municipal utilities and rural cooperatives are under intense pressure to reduce rates or, at a minimum, not to take any action that will increase rates unless absolutely necessary. Therefore, any contracts entered into by the municipal utility or rural cooperative, including new generation or battery storage, that could be perceived as putting upward pressure on rates for nonessential reasons are potentially subject to criticism by customers.

However, adding battery storage provides a resource that can dispatch power at the right time to reduce the peak hourly demand as well as storing and dispatching renewable energy. About half of the cost of municipal utility and rural cooperative electricity supply is associated with demand charges (a charge based on the highest amount of electricity used at the peak hour of the month). The other half of the cost of power is associated with the actual electricity used by customers. For this reason – the need to predictably reduce monthly demand charges – there is strong interest in North Carolina municipal utilities and rural cooperatives in adding battery storage to bring down costs by reducing demand for grid electricity during peak times.

This demand charge is assessed to assure there are sufficient generation resources available to meet the peak hourly demand each month. Because the peak hourly demand in a given month may not coincide with high levels of solar output, adding solar alone does not result in a proportionate reduction in the monthly demand charge. Adding batteries, however, will allow the municipal utility or rural cooperative to balance out when energy is used from the grid.

As battery storage costs continue to decline rapidly, a major near-term growth area will be battery storage with capacity less than 500 kW (per substation) installed at municipal utility and rural

[75] Telephone communication between B. Powers, Powers Engineering, and B. Kingery, Southern Energy Management, October 16, 2018.
[76] Telephone communication between B. Powers, Powers Engineering, and S. Miller, Yes Solar Solutions, October 16, 2018.

cooperative distribution substations, up to the self-generation limits defined in the full requirements agreements (described below).

One area where municipal utilities and rural cooperatives are not restricted is retail net-metered solar and battery storage,[77] where individual retail residential and commercial customers opt to finance and install solar and battery storage on their own. Customers at this level also gain maximum protection in the event of grid outages (for example hurricanes, ice storms, utility equipment failure, scheduled distribution line maintenance) because the source of power – the battery system – is located where the power is used.

1. Rural Cooperatives

Ninety-five percent or more of rural cooperative electric power needs are typically provided under "full requirements agreements" by the statewide rural cooperative association, North Carolina Electric Membership Corporation (NCEMC), which in turn receives substantial amounts of power from Duke Energy under a separate full requirements agreement.[78] Individual rural cooperatives are limited to owning and/or contracting for individual generation units below 500 kW in capacity to fill the five percent of total electric power demand they can auto-supply under the terms of the full requirements agreement.

NCEMC is actively pursuing expanded deployment of battery storage at EMCs around the state. NCEMC has direct experience with battery storage and microgrid design through its role as owner of a 500 kW Tesla battery system at the Butler Farms microgrid in the territory of South River EMC.[79]

2. Municipal Utilities

There has been little development of battery storage systems to date at North Carolina municipal utilities; however, there is strong interest. Most municipal utilities in the state receive 100 percent of their wholesale power from their state associations, with the process administered by ElectriCities.[80] The eastern NC municipal utility association, North Carolina Eastern Municipal Power Agency (NCEMPA), in turn receives its wholesale power under a full requirements agreement with Duke Energy.

As with coops, about 50 percent of the cost of power for eastern NC municipal utilities is payment for capacity. The other 50 percent is for the actual power used.[81] "Capacity" means paying on the order of $20 per kW per month to assure there will be enough generation on hand to meet the monthly peak load.

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[77] There is currently no cap on net-metered solar installations in Duke Energy service territory either.
[78] The statewide associations also own and operate some generation assets, including nuclear (Catawba) and gas turbines. Bill Powers, *North Carolina Clean Path 2025: Achieving an Economical Clean Energy Future*, August 2017, pp. 19-21.
[79] South River EMC Butler Farms webpage, http://www.sremc.com/content/butler-microgrid, accessed November 4, 2018.
[80] ElectriCities webpage, https://www.electricities.com/.
[81] Telephone communication between A. Fusco, ElectriCities, and B. Powers, Powers Engineering, October 16, 2018.

Adding battery storage is very effective at reducing the peak load and can help the utility reduce the cost of capacity. Assuming a hypothetical municipal utility with a typical peak monthly demand of 10 MW, adding 5 MW of battery storage would reduce monthly capacity requirements by 5 MW. This would result in $100,000 per month in capacity payment savings [82] or an overall savings of about 25 percent of the utility's monthly cost of electricity.[83]

Solar power by itself can also help. However, solar output may not be coincident with the peak hour load in a month and therefore may not have much impact on reducing the monthly capacity payment.

The western NC municipal utility association, North Carolina Municipal Power Agency Number 1 (NCMPA1), has its own generation assets, including a portion of the Catawba Nuclear power plant. It also has some peaking gas turbines and tends to charge for capacity based on its market value instead of the fixed $20 per kW per month fee charged to eastern NC municipal utilities.[84]

There is strong interest at the municipal utility association level in developing a template for deploying similar solar and battery storage packages in the range of 500 kW each in municipal utilities around the state.

B. City of Durham

The City of Durham receives its grid power from Duke Energy under an existing franchise agreement that expires in 2020. However, the franchise agreement authorizes the City to generate its own power and mandates that Duke Energy deliver this power to Durham residents through its grid.[85]

The City formerly generated hydroelectric power for city residents in the 1930s and 1940s, before converting to Duke Energy service, and maintained the authority to generate power in its current franchise agreement with Duke Energy. A 3 MW landfill gas power project developed at the Durham landfill came online in 2008. The City receives a royalty from the power generation. The PPA contract is between the developer, Methane Power, and by City assignment, Duke Energy.[86]

The City can pursue new PPAs directed at deploying solar and battery storage in homes and businesses located in the City, just as PG&E entered into a PPA with its contractor in California to develop a virtual 10 MW power plant consisting of behind-the-meter battery storage in commercial office buildings.

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[82] 5 MW = 5,000 kW. 5,000 kW x $20/kW-month = $100,000/month. The battery system would typically be able to maintain rated capacity for 3 to 4 hours.

[83] Capacity payments are 50 percent of overall electricity cost and capacity payments are reduced 50 percent with the addition of the battery system. Therefore, overall electricity costs are reduced by: 0.50 × 0.50 = 0.25 (25 percent).

[84] See note 81.

[85] Durham-Duke Energy 2005 franchise agreement, addendum.

[86] Renewable Energy Power Purchase Agreement between Duke Energy Carolinas, LLC and MP Durham, LLC, July 11, 2008.

The City can also concurrently support and incentivize individual net-metered solar and battery projects. Net metering is on solid ground at this time in North Carolina and is not subject to any caps or limits for the time being.[87]

C. Duke University, Durham

The on-campus solar potential of Duke University, on rooftops and parking lots, is about 87 MW.[88] Of this total potential, on-campus parking lots represent about 36 MW while rooftops represent 51 MW. About 1 MW of Duke University's rooftop solar potential has been developed as of mid-2018. The University receives all of its grid power from Duke Energy and would need about 90 MW of solar to fully offset the fossil fuel component of the power it currently receives from Duke Energy.

Duke Energy has proposed to construct a controversial 21 MW combined heat and power (CHP) plant on the Duke University campus. The University has suspended its pursuit of that project at this time.

A cost-effective alternative would be a comprehensive solar and battery project on campus that fully develops the rooftop and parking lot solar resource with the object of largely substituting for the electric output of the proposed CHP plant.

The Duke University Facilities Engineering Department indicated in 2017 that the acceptable price ceiling for solar power on campus was $0.08 per kWh. The actual 2018 solar with battery storage price-point for large commercial systems is in the range of $0.05 to $0.06 per kWh.

Duke University meets the requirements under federal law to become an independent power producer, also known as a Public Utilities Regulatory Policy Act (PURPA) "Qualifying Facility" (QF). A QF may have a solar capacity of up to 80 MW, with multiple generation sources located within one mile of each other.[89] As noted, Duke University's rooftop and parking lot solar potential is about 80 MW. QF status would also assure that Duke University receives fair value for power or grid requirements it provides to Duke Energy and require that Duke Energy provide all backup power needed by Duke University at non-discriminatory rates.

Solar power can also be utilized by Duke University to meet its heating needs. Currently, the university generates steam at natural gas-fired central steam plants on the two campuses, West Campus and East Campus, to meet heating needs.[90] These steam plants have been in operation for

[87] Telephone communication between B. Powers, Powers Engineering, and S. Miller, Yes Solar Solutions, and B. Kingery, Southern Energy Management, October 16, 2018.
[88] Direct current (DC) MW.
[89] "A PURPA Roadmap for Microgrids," *George Washington Journal of Energy & Environmental Law*, April 12, 2018. The Public Utilities Regulatory Policy Act (PURPA) is a 1978 federal law intended to open up the provision of electric power to independent producers. Qualifying independent producers are those that produce heat and power concurrently or produce renewable energy. Renewable energy facilities are limited to a capacity of 80 MW. PURPA requires participating states to offer standard contracts to "Qualifying Facilities – QFs," at the incumbent utility's avoided cost of generation. PURPA has resulted in the development of thousands of MW of new generation around the nation since the 1980s.
[90] "Utility Services: Overview," Duke University Facilities Management, https://fmd.duke.edu/services/utilities/systems.php, accessed November 3, 2018.

almost 90 years, although they have undergone recent upgrades.[91] Conversion of the steam system to a hot water system would allow electric absorption chillers to serve as the heat source. This was done at Stanford University to allow solar power to serve as the source of electricity to drive absorption chillers, working in conjunction with heat recovery chillers, to produce both hot and chilled water.[92]

If insufficient solar capacity is available on campus parking lots and rooftops to meet the desired hot water supply, Duke University can potentially take advantage of Duke Energy's *Green Source Advantage* program to directly contract for solar capacity built off-campus through a PPA with a solar developer. Stanford contracted for off-campus solar to develop much of the solar power supply serving its campus.[93]

D. Town of Apex Municipal Utility – Evaluation of Opportunities

The NC Clean Energy Technology Center (Raleigh) conducted a detailed analysis in April 2018 of the opportunities available to Apex, a municipal utility and member of NCEMPA, to move forward on solar and battery storage projects.[94] The primary observations in the NC Clean Energy Technology Center report for Apex are summarized in this section and provide a useful roadmap for North Carolina municipal utilities in general.

Apex purchases electricity from NCEMPA under a full requirements power purchase agreement.[95] NCEMPA purchases the electricity that it sells to Apex and its other members from Duke Energy Progress.

In the case of Apex, the full requirements agreement means that NCEMPA and Duke Energy Progress meet the entire load of Apex, with some exceptions. These exceptions include: 1) customer-owned generation ≤ 95 kW located behind the customer's meter, 2) "qualified generation" > 95 kW (limited to about 2 MW total), 3) PURPA qualifying facilities < 500 kW[96] and 4) PURPA qualifying facilities ≥ 500 kW.[97]

As with other municipal utilities, Apex is allowed to own PURPA QFs that sell their generation onto the Apex grid. This is one approach that would enable Apex to install town-owned solar generation and sell it onto the grid, even at capacities of 95 kW or greater.[98]

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[91] Ibid.
[92] "Electric University," *EPRI Journal*, May 17, 2018, http://eprijournal.com/electric-university/.
[93] Ibid.
[94] E-mail communication, D. Sarkisian, NC Clean Energy Technology Center (CETC), and B. Powers, Powers Engineering, October 16, 2018. NC CETC conducts evaluations of community solar and battery storage at no charge for municipal utilities and electric cooperatives.
[95] NC Clean Energy Technology Center, *Analysis of power supply contracts and distributed energy policies for the Town of Apex*, April 10, 2018.
[96] See note 90 above. The Public Utilities Regulatory Policy Act (PURPA) is a 1978 federal law intended to open up the provision of electric power to independent producers. Renewable energy facilities are limited to a capacity of 80 MW.
[97] NC Clean Energy Technology Center, *Analysis of power supply contracts and distributed energy policies for the Town of Apex*, pp. 6-8.
[98] Ibid, p. 8.

The full requirements agreement does not prevent member municipal utilities from advancing funds, lending or extending credit for its own generation or customer generation. Apex would be allowed to finance the development of a PURPA QF if it chose to do so. Apex would also be permitted to finance smaller-scale distributed generation owned or operated by customers.

Energy storage could also be classified under the full requirements agreement as a demand response or demand-side management activity. Demand response measures are not restricted by the full requirements agreement. As a result, there would be no constraints on battery storage development if it is classified as demand response.

Energy storage systems with less than 95 kW of capacity are considered smaller-scale energy storage systems. These behind-the-retail-meter storage systems would be paired with residential- and small commercial-scale solar. These energy storage systems are unrestricted by the full requirements agreement.

Apex could offer a solar equipment leasing program for customers of the municipal utility. Apex could consider starting a Property Assessed Clean Energy (PACE) financing or revolving loan program.

Apex is in the process of implementing some of the recommendations in the NC Clean Energy Technology Center report. The town will install over a half million dollars of solar on high visibility buildings in the 2018-2019 fiscal year.[99] This follows the installation of a 24 kW system on the Public Works building. Developers are requested by the town council to install solar on 10 percent of new units in a subdivision. Commercial building developers are requested to install solar on 10 percent of the roof space. The town council is also in the initial stages of evaluating a municipal PACE financing arrangement for Apex customers. The PACE program would allow homeowners and business owners to install solar, storage and energy efficiency measures with no upfront expense. These upgrades would be paid for over time as supplemental payments included on the property tax bill.

IX. POLICY RECOMMENDATIONS

The NC Clean Path 2025 plan cannot be fully implemented in the timeframe needed to address the climate crisis without a number of revisions to current policies.

Duke Energy, municipal utilities and rural cooperatives must offer on-bill financing to residential and commercial customers for solar, battery storage and energy efficiency upgrades. On-bill financing allows customers to redirect utility payments that would otherwise be used to pay for grid power to instead pay for solar, battery storage and energy efficiency upgrades.

Duke Energy's inadequate community solar program must be expanded by the Utilities Commission. HB 589 requires Duke Energy to offer a limited 40 MW of community solar. The community solar program defined in HB 589 does not ensure community ownership, low-income accessibility or guaranteed savings. In contrast, the leading community solar state in the nation, Minnesota, with half

[99] E-mail communication between B. Jensen, Apex Town Council, and B. Powers, Powers Engineering, September 27, 2018.

the population of North Carolina, has already installed approximately 445 MW of community solar,[100] with another 800 MW in the project queue.[101] A critical component of the Minnesota program is that it does not cap the development of community solar projects.[102] The amount of community solar in North Carolina, including municipal utilities and rural cooperatives, may ultimately need to reach 1,000s of MW to achieve NC Clean Path 2025 goals, not 40 MW as provided for in HB 589.

Duke Energy is instructed in HB 589 to propose to the Utilities Commission revised net metering rules. It is expected that Duke Energy's proposed changes would make rooftop solar less economically viable for homeowners and businesses, despite ample evidence that net metering is a benefit to all ratepayers. It is critical that net metering be defended against efforts to undermine it.

Duke Energy's current focus on expanding the use of fracked gas in up to 20 planned gas-burning power plants in the Carolinas needs to be redirected to a focus on battery storage. Duke Energy itself has demonstrated that battery storage is a better fit for the needs of North Carolina than gas-fired power plants, both for making rapid advances in renewable energy and for energy security during hurricanes and ice storms. That reality needs to be reflected in Duke Energy's strategic planning.

North Carolina enacted legislation, HB 1389, in 2009 that authorizes cities and counties to establish revolving loan programs to finance renewable energy and residential and commercial energy efficiency projects.[103] However, no cities or counties have yet taken advantage of this authority.[104] They need to do so.

The North Carolina General Assembly lags behind other states by not yet passing enabling legislation for CCA (Community Choice Aggregation) or PACE (Property Assessed Clean Energy). These programs provide an alternative to investor-owned utility power supply on a city or county jurisdictional level in the case of CCA,[105] or an alternative "no money down" finance option for clean energy for individuals and businesses under PACE.

The North Carolina Utilities Commission must insist that Duke Energy explore all alternatives and propose lowest-cost supply, including battery storage, and not reflexively authorize Duke Energy to continue to build gas-fired power plants.

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[100] Institute for Local Self-Reliance, *Why Minnesota's Community Solar Program is the Best*, October 24, 2018: https://ilsr.org/minnesotas-community-solar-program/. Minnesota, at 5.6 million people, has about half the 10.3 million population of North Carolina.
[101] Ibid.
[102] Ibid.
[103] North Carolina Clean Energy Technology Center, *Analysis of power supply contracts and distributed energy policies for the Town of Apex*, April 10, 2018, p. 13.
[104] Ibid.
[105] For more detail on CCA, see: *North Carolina Clean Path 2025*, August 2017, p. 27.

X. CONCLUSION

The momentum behind solar with battery storage, from residential scale to utility-scale, is strong and growing in North Carolina. Customers want this technology. Duke Energy may be forced to shift from a business strategy of framing battery storage as a perpetual pilot project to a mainstream generation and demand response option, or risk losing the battery storage market to customers taking their energy destiny into their own hands.

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