Advancing Stationary Battery Storage in North Carolina

Where We Are, How We Got Here, and Where to Go From Here

Created: July 2021

NC SUSTAINABLE ENERGY ASSOCIATION

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About North Carolina Sustainable Energy Association

North Carolina Sustainable Energy Association (NCSEA) is the leading 501(c)(3) non-profit organization that drives public policy and market development for clean energy. Our mission is to drive policy and market development to create clean energy jobs, economic opportunities, and affordable energy that benefits all of North Carolina. NCSEA's work enables clean energy jobs, economic opportunities, and affordable energy options for North Carolinians. Learn more at www.energync.org.

Table of Contents

Executive Summary

Grid **resiliency*** is becoming a prominent concern as traditional fossil fuel plants come to the end of their operational life and severe weather events wreak large-scale power outages around the nation. With the ubiquity of renewable energy sources like solar and wind, a new niche opened up for technologies to remedy the intermittency of these clean energy sources. Stationary battery storage has emerged as an answer to the call for a cleaner, more sustainable, and resilient grid. Planting energy repositories on the grid and in homes not only dispurses energy geographically, it also distributes energy use temporally. Thus, batteries offer revolutionary flexibility in the delivery of electricity, holding energy when it's not being used and dispatching energy when and where it's most needed.

In the past several years, North Carolina has experienced unprecedented advancement in energy storage experimentation, research, deployment, and legislation. This report is divided into three sections and is intended to serve as a synopsis to track the progress of battery storage in North Carolina. Section one, "Where We Are," characterizes how batteries fit into the modern energy landscape and the many benefits it brings to the utility and customer. Section two, "How We Got Here," chronicles the last six years of energy storage pilot projects, policies, and technologies within the state since the nonprofit's latest energy storage publication. Section three, "Where to Go from Here," synthesizes a collection of recommendations for the state to best prepare for and harness the full potential of stationary battery storage in the coming years.

Ultimately, this report serves as an invitation for stakeholders and all North Carolinians to consider and take steps to achieve a 'batteries-included' electricity infrastructure. This paper represents only one of many publications advocating for the engagement, preparation, development, and legislation for healthier and more sustainable electrification.

* Bolded blue terms are defined in the glossary starting on page 37.

Introduction

Energy storage development is becoming increasingly pressing as North Carolina evolves into a state powered by more clean distributed energy sources. In the recent decade, energy storage has surfaced as the preeminent solution to retiring fossil fuel power plants and making intermittent renewable energy sources like solar and wind dependable, sustainable, and deployable at the utility scale. On top of energy storage technology adding value to renewable energy sources, its capacity to conduct **voltage support** and regulation makes it a favorable complement to conventional power plants as well. What's more, large-scale deployment of energy storage may be our only shot at circumventing large-scale power outages and making the U.S. electricity sector truly carbon-free by 2035.[1]

One of the leading competitors in the energy storage industry is stationary battery storage. This includes battery cells at utility substations with output capacities of up to hundreds of megawatts to the Tesla battery pack in your home with a capacity of a few kilowatts. Simply put, **stationary battery storage** units are immobile electrochemical cells that collect energy when supply is high and dispense energy when supply is low; like conventional lead-acid batteries, these cells store chemical energy, which is converted into electrical energy through a series of oxidation reactions. Other types of energy storage (i.e. flywheel, compressed air energy storage, pumped hydro, thermal storage) are also making a debut in the U.S. energy sector, but will not be discussed in this report. While the technology and market for stationary battery storage overlap with that of mobile battery storage (i.e. batteries in hybrid and electric vehicles), the two occupy very different niches in the energy sector.

In this report, I highlight the grid services stationary battery storage provides and summarize North Carolina's progress in deploying batteries in homes and on the grid. I first discuss how stationary battery storage fits into the bigger picture of the modern energy system; next, I outline the progress North Carolina made in the field of battery storage since the publication of our 2015 report, *Batteries ~~Not~~ Included*;[2] lastly, I provide recommendations for the state as we look to further deploy stationary battery storage.

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1 *FACT SHEET: The American Jobs Plan*. (2021, March 31). The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/

2 Ledford, P. (2015). *Batteries ~~Not~~ Included*. North Carolina Sustainable Energy Association. https://energync.org/wp-content/uploads/2017/03/Batteries_Not_Included.pdf

I. Where We Are

The Modern Landscape of Battery Storage

Fitting Stationary Battery Storage into the Picture

Today, environmentalists, city planners, and utilities are looking for a way to make electricity grids cleaner, cheaper, and more resilient. Firstly, battery storage acts as a critical counterpart to renewable energy sources, helping to make clean energy reliable. While renewable energy sources like solar and wind are becoming more and more cheap and widespread, these sources face a common problem: intermittency. Until renewable energy is able to provide uninterrupted, dispatchable energy, dirty energy sources will continue to dominate our grid supply. These weather-dependent renewables must be paired with energy storage in order to reliably power a city on a cloudy and windless day. Thus, stationary battery storage plays a crucial role in holding clean energy until it's needed during peak demand or when renewable sources stop spinning. On the other hand, battery storage also reduces the amount of energy produced by intermittent sources that is discarded (i.e. solar and wind **curtailment**). If demand is low on a very sunny and windy day, batteries harvests the surplus energy to be used later.

Moreover, deploying energy storage and other **distributed energy resources (DERs)** isn't just environmentally responsible but also financially attractive. A report published by Vibrant Clean Energy, LLC found that in efforts to decarbonize the electricity sector, developing a more resilient grid could save the U.S. half a trillion dollars through 2050 in cumulative energy spending.[3] In fact, widespread deployment of DERs paired with any energy scenario in the next few decades lowers the overall cost of the country's electrical system. Like any other investment, the relatively high upfront capital costs will pay for itself in future savings.

Thirdly, battery storage is also a key player in our movement toward microgrids and a more decentralized energy network. Not only are conventional power plants powered by nuclear and fossil fuels environmentally deplorable, the 2021 power outage in Texas served as a call for a more resilient grid design. Two ways to lower the risk of blackouts from grid accidents (ex. tree falls and line failures) and severe weather events are 1) decreasing the distance between energy generators and consumers and 2) relieving **grid congestion** during peak demand. Instead of relying on electricity delivered through long transmission lines, businesses and homeowners could draw clean energy right from their roof or down the street. On the other hand, during peak demand periods, instead of overwhelming the grid with dangerously high currents, users would share power through lower-voltage distribution lines.

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3 Clack, C. T. M., Choukulkar, A., Coté, B., & McKee, S. A. (2020). *Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid* [Technical]. Vibrant Clean Energy, LLC. https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf

In these cases, battery storage and other DERs are critical for making intermittent solar and wind reliable as we move toward a more decentralized energy system. (See Figure 1 and Table 1 for a schematic and comparison table for the benefits batteries bring to the grid.) As North Carolina cranks down on centralized nonrenewable energy sources, the state must also develop the infrastructure and policies to support a grid with distributed renewable energy sources.

As fossil fuel plants undergo decommissioning one-by-one, demand for distributed energy resources grows accordingly. However, the phasing out of traditional centralized energy does not mean eliminating centralized energy altogether. In the foreseeable future, as storage technology matures and DERs establish economies of scale, centralized and distributed systems will evolve together to make electricity grids cleaner, cheaper, and more resilient (see Figure 1). David Roberts, the author of clean energy blog *Volts*, claims that "DERs are not a boutique version of, or a distraction from, utility-scale renewables; they are a necessary complement, an enabler and accelerator."[4] In other words, centralized and distributed renewables and storage must join forces to achieve a truly carbon-free electricity sector.

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4 Roberts, D. (2021, May 28). *Rooftop solar and home batteries make a clean grid vastly more affordable*. Volts. https://www.volts.wtf/p/rooftop-solar-and-home-batteries

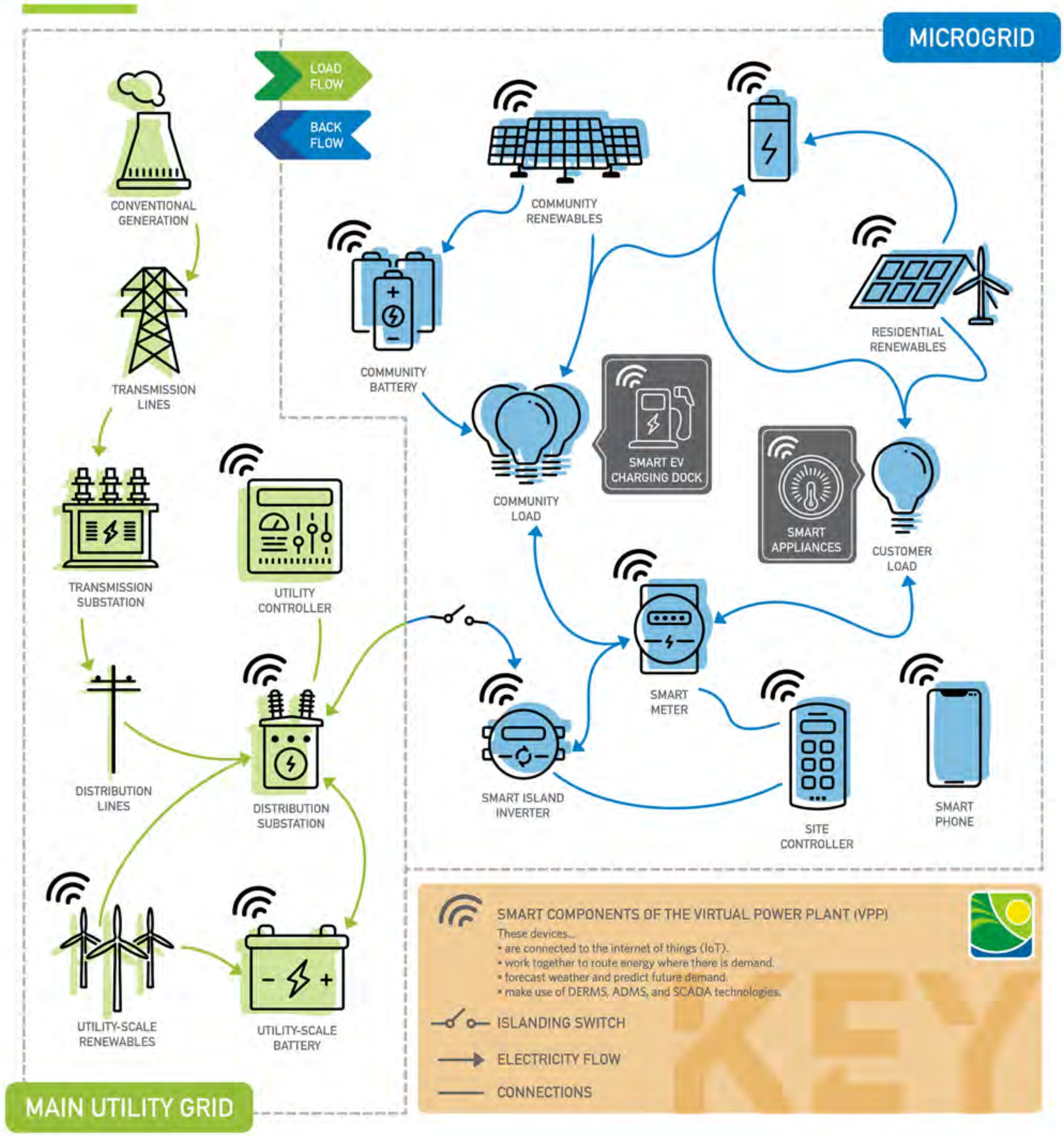


Figure 1. Centralized Plus Distributed Energy: How centralized and distributed energy storage (DERs) fit into today's electricity grid. The components of the **microgrid** are part of a **virtual power plant (VPP)**, which is a network of DERs that are remotely monitored, coordinated, and controlled by the internet.

CENTRALIZED VS. BATTERY-BACKED DISTRIBUTED ENERGY

	ATTRIBUTE	CENTRALIZED ENERGY	DISTRIBUTED ENERGY	WITH STORAGE
CHARACTERISTICS	SCHEMATIC			
CHARACTERISTICS	ENERGY SYSTEM MODEL	Top-down	Bottom-up	
CHARACTERISTICS	ENERGY FLOW	1-way	2-way	
CHARACTERISTICS	# OF ENERGY SOURCES	Few large power plants	Multiple small power producers	
CHARACTERISTICS	LOCATION	Offsite	Onsite	
CHARACTERISTICS	DISTANCE FROM END USER	Farther from end user	Closer to end user	
RELIABILITY	RISK OF POWER OUTAGE	High	Low	
RELIABILITY	GRID CONGESTION DURING PEAK DEMAND	High	Moderate	Low / avoided
RELIABILITY	RESILIENCY	Low	Moderate	High
RELIABILITY	INTERMITTENCY	Low	High	Low (See Figures 2b & 2c)
RELIABILITY	BACK-UP POWER	No	Sometimes	Yes
FUEL	MAIN FUEL	Fossil fuels	Renewable sources	
FUEL	GHG EMISSION	High	Low / zero	
CONSUMER	CONSUMER ROLE	Passive (consume electricity only)	Active participant (consume, produce, and sell electricity)	
CONSUMER	COST OF ENERGY	Set by energy supplier; sensitive to fluctuations in fuelprices and time-of-use	Installation and maintenance costs; free to operate; net metering offsets	Load shifting and shavings avoid peak demand charges (See Figure 2c)
CONSUMER	ENERGY EQUITY	Low	Moderate	High
UTILITY	COST OF ENERGY	High capital cost; high marginal cost	High capital cost; low marginal cost	High capital cost; low marginal cost; revenue from ancillary services and energy arbitrage
UTILITY	PEAKER PLANTS	Natural gas	Natural gas	Not needed
UTILITY	DEMAND VS. SUPPLY	Shift supply to meet demand	Can't shift demand or supply	Shift demand to meet supply (See Figure 2c)

Table 1. Centralized vs. Battery-Backed Distributed Energy: Attributes of centralized and distributed energy systems with added benefits of storage.

Benefits of Stationary Battery Storage

Utilities

On top of its benefits to the grid at large, stationary battery storage also offers perks to utilities and customers. For front-of-meter electricity providers, battery storage at utility substations ensures **resource adequacy** and offers **ancillary services** that stabilize the grid and increase system efficiency and reliability. These assets can be divided up into short term, mid term, and long term time frames.

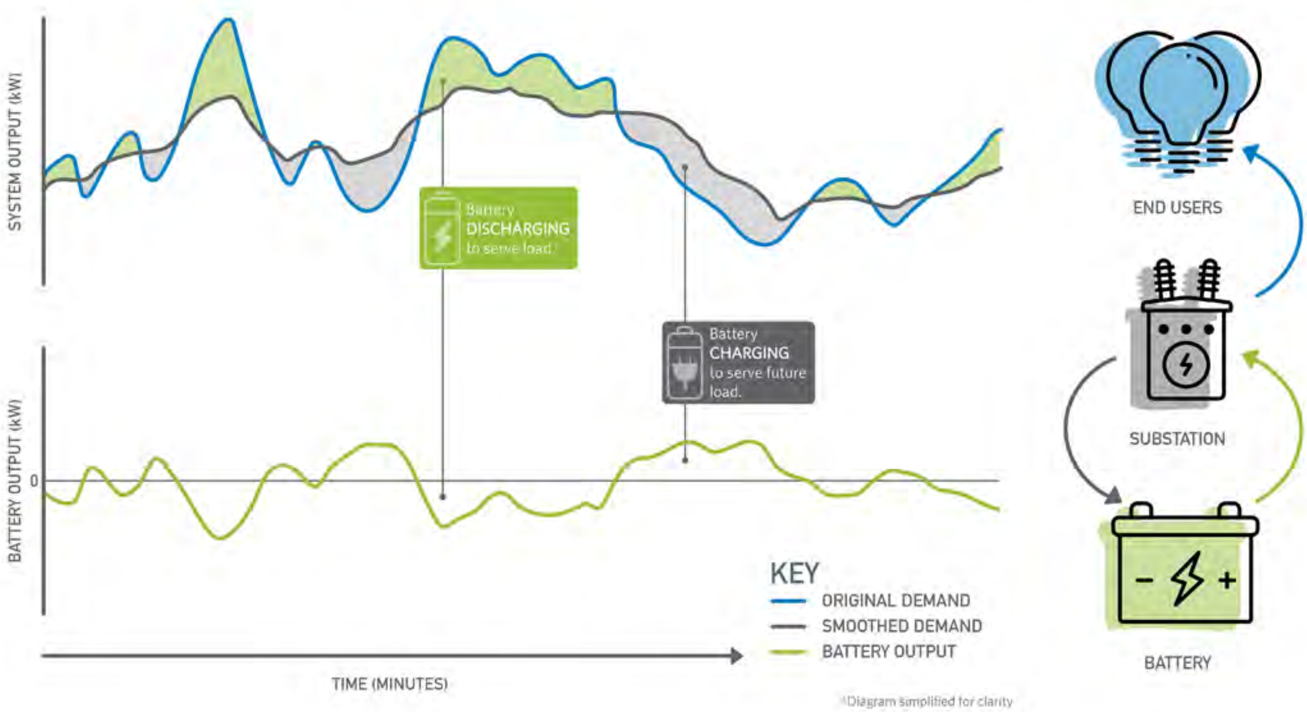
In the short term (in the matter of milliseconds to minutes), batteries offer utilities voltage and frequency regulation, support, and maintenance, improving outgoing power quality. Utility-scale batteries' ability to quickly discharge large volumes of electricity allows the substation to quickly recover from a power loss (i.e. **black start**), ramp up and down generation assets in milliseconds (i.e. **ramp control**), and smooth out consumer energy demand (i.e. **load smoothing**) (see Figure 2a).

Over the timespan of a few hours, batteries help utilities firm renewable energy generation (i.e **capacity firming**) (see Figure 2b). For example, when drawing energy from large-scale solar farms, utilities with batteries will be able to deliver a stable flow of electricity to its customers despite solar swings due to cloud cover. This ability to maintain voltage protects utility hardware and infrastructure from exhaustion and damage.

Finally, in the span of a day, batteries flatten a power generator's peak demand requirements (see Figure 2c). Instead of shifting supply to meet demand and relying on natural gas peaker plants, utilities are able to shift demand for energy to non-peak hours (i.e **load shifting**). This benefits the utility in several ways: 1) It allows utilities to profit from **energy arbitrage**, storing cheap energy during off-peak hours and selling at a higher price during peak periods. 2) It alleviates grid congestion during peak hours. 3) It allows generators to run more consistently at full capacity, cutting operating costs, excess capacity requirements, and energy curtailment of conventional power plants. Further financial savings come from **T&D upgrade deferrals**, whereby utilities are able to postpone or halt expensive transmission and distribution upgrades (as well as the construction of new peaker plants) to meet peak energy requirements.

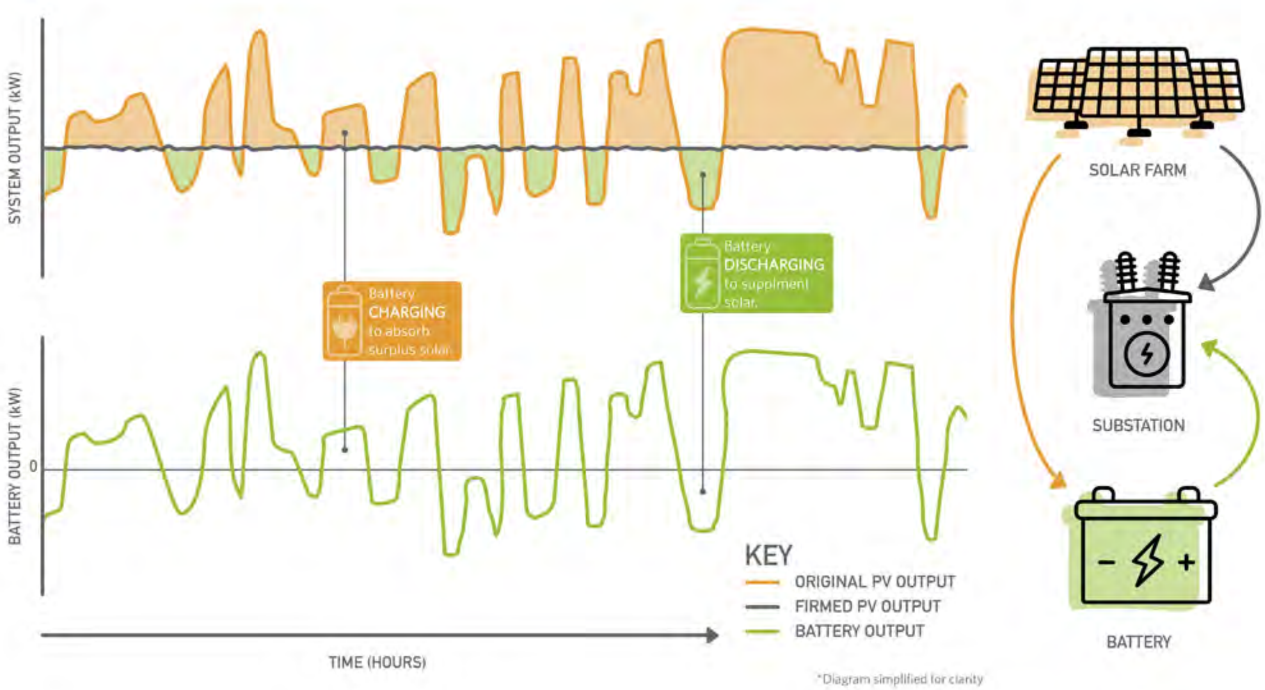
a. SHORT TERM STORAGE: LOAD SMOOTHING AND RAMP CONTROL

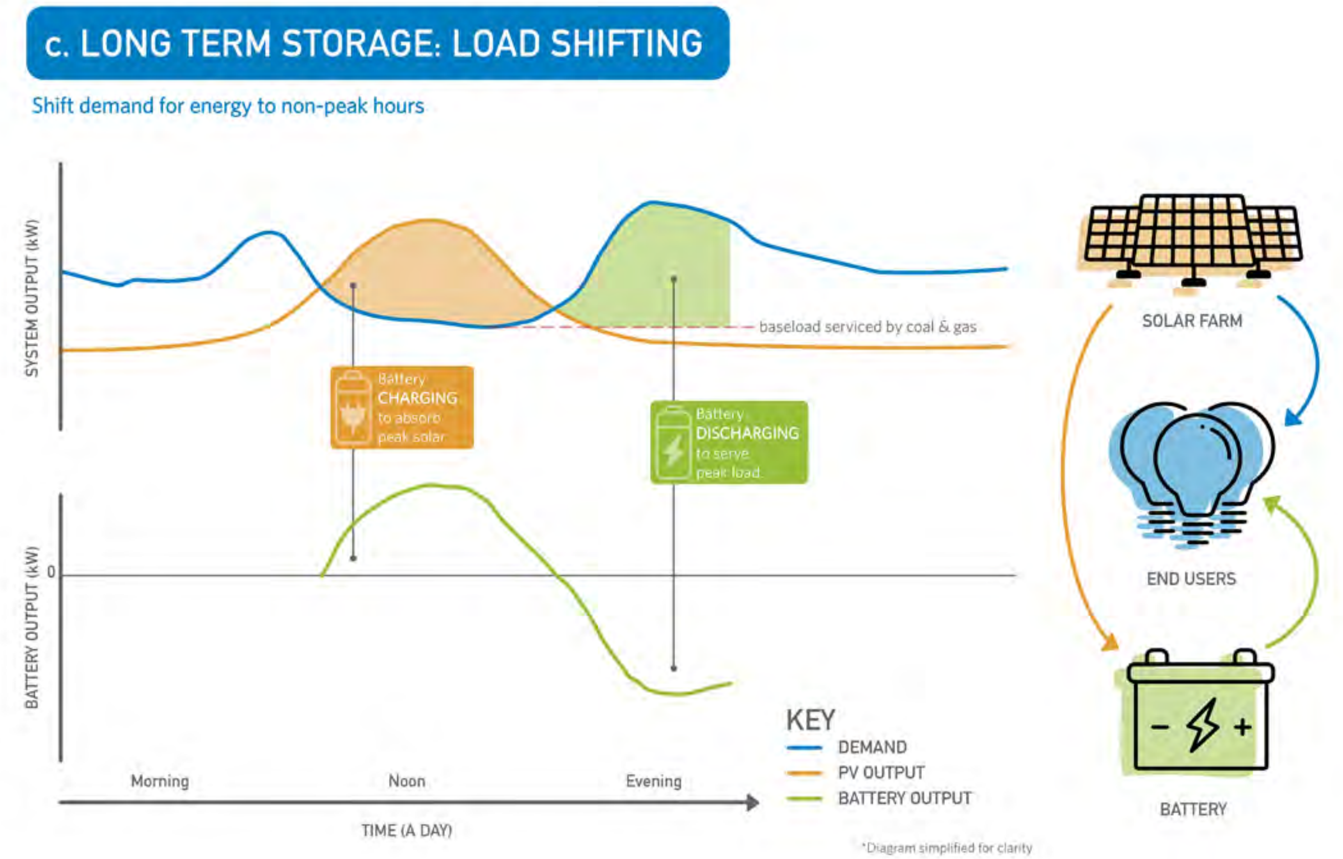
Smooth out variable electricity demand



b. MID TERM STORAGE: CAPACITY FIRMING

Stabilize intermittent power output from renewables





Figures 2a, 2b, and 2c. Short, Mid, and Long Term Benefits of Stationary Battery Storage.

Consumers

On top of its benefits to the grid at large, stationary battery storage also offers perks to utilities and For homeowners looking to install battery packs in their homes, small-scale energy storage also offers a slew of benefits (see Table 1). First and foremost, residential batteries offer **energy security**. Storing excess energy from the grid or rooftop solar panels provides around-the-clock power. This ability to rely on self-produced and self-stored power protects the user from grid-level power outages. Having back-up power is especially critical for data centers, emergency service buildings (i.e. hospitals, fire/police departments), and military bases where slight lags in power supply can be detrimental. Furthermore, being able to go "off-the-grid" on command also guards consumers from volatile price spikes in the energy market.

Similar to utilities, behind-the-meter storage units also benefit from energy arbitrage (see Figure 2c). The user's ability to extract and store power from the grid when it's cheap and supply power when it's expensive lowers the ratepayer's energy bill, avoid demand charges, and even provide a revenue stream in best-case scenarios.

Lastly, storage-backed distributed energy also cultivates a more equitable grid. On a grid with scattered generation sources, end users of electricity are no longer just recipients of energy but also active participants. Energy storage fights systemic inequities by fairly distributing the costs and benefits of the shift to cleaner energy and empowering communities with less reliable access to the utility grid.[5] Furthermore, investment in energy storage is also projected to bring an influx of clean energy jobs for disadvantaged districts.[6]

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5 Tarekegne, B., O'Neil, R., & Twitchell, J. (2021). Energy Storage as an Equity Asset. *Current Sustainable/Renewable Energy Reports*. https://doi.org/10.1007/s40518-021-00184-6

6 Clack, C. T. M., Choukulkar, A., Coté, B., & McKee, S. A. (2020). *Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid* (p. 14) [Technical]. Vibrant Clean Energy, LLC. https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf

Why Now?

The U.S. is at the cusp of an energy storage boom. A couple of years ago, the U.S. Energy Information Administration (EIA) predicted that U.S. utility-scale energy storage would exceed 2,500 MW by 2023, with a notable annual capacity addition uptick in 2021.[7] All the while, a U.K.-based energy consultancy group recently published a study estimating global energy storage capacity to grow 31% by 2030, totalling 741 GWh of cumulative capacity worldwide.[8] Furthermore, law firm K&L Gates, LLP noted in its 2018 publication that over 1 GW of advanced energy storage technologies have been contracted for or deployed in the United States.[9] Now is the prime time for North Carolina to join the movement and catch up with the other leading states in energy storage deployment.

North Carolina, along with the rest of the country, is experiencing a push away from traditional energy generation sources. With weather emergencies increasing in frequency and severity, creating a more resilient grid with battery facilities could significantly lower the $25-$70 billion the U.S. spends annually on weather-related power outages.[10] In response to environmental movements, volatile fuel prices, fuel shortages, and transmission and distribution (T&D) challenges on the grid, federal and state-level policy-makers are also pushing for legislation to prepare, facilitate, and accelerate development of energy storage (see Table 2).

Meanwhile, the state is also encountering a pull towards stationary battery storage to fill the demands of a growing renewable energy industry and environmentally-conscious consumers. According to NCSEA's 2018 Clean Energy Census, 65% of the surveyed residential solar PV consumers expressed interest in installing storage in their homes.[11] These pull factors along with the precipitous drop in battery technology have spurred competition in the energy market among tech companies and research institutes to make batteries cheaper, safer, and more efficient.

7 North Carolina Clean Energy Plan: *Transitioning to a 21st Century Electricity System* (p. 34). (2019). North Carolina Department of Environmental Quality. https://files.nc.gov/ncdeq/climate-change/clean-energy-plan/NC_Clean_Energy_Plan_OCT_2019_.pdf

8 *Global energy storage capacity to grow at CAGR of 31% to 2030*. (2020, September 30). Wood Mackenzie. https://www.woodmac.com/press-releases/global-energy-storage-capacity-to-grow-at-cagr-of-31-to-2030/

9 Energy Storage Handbook. (2018, May). *K&L Gates*, 2(1), 4. https://www.klgates.com/epubs/Energy-Storage-Handbook-Vol2/index.html

10 *Planning an Affordable, Resilient, and Sustainable Grid in North Carolina*. (2019). NC Clean Energy Technology Center. https://nccleantech.ncsu.edu/our-work/center-projects/planning-an-affordable-resilient-and-sustainable-grid-in-north-carolina/

11 Carey, J., Parker, D., & Jones, J. (2018). *2018 North Carolina Clean Energy Industry Census* (Clean Energy Industry Census, p. 19). North Carolina Sustainable Energy Association. https://energync.org/wp-content/uploads/2019/08/NCSEA_2018_NC_Clean_Energy_Industry_Census_Web.pdf

II. How We Got Here

The Recent Boom in Battery Storage Deployment, Technology, and Policy

Battery Storage Deployment

Since NCSEA's 2015 energy storage report, over a dozen stationary battery storage facilities have been approved, announced, and/or installed on the grid (Figure 3 highlights some of the key ones). Many of these new facilities are pilot projects designed to test the viability of future installations. These smaller-scale implementations help utilities and storage companies estimate capital, installation, and operation and maintenance (O&M) costs, identify installation and operational hurdles, and valuate the benefits of this budding industry.

The energy storage facilities installed on Ocracoke Island and in Hot Springs are prime examples of batteries providing energy resiliency in remote areas of the state. Ocracoke Island, located in North Carolina's Outer Banks, is the last island on the transmission line. Since the coast is prone to severe weather events, the microgrid's battery bank keeps the island electrified during power outages.[12] On the other hand, the Hot Spings microgrid – once completed – will service a remote mountain town right outside of Asheville. The project was a response to frequent incidents of power line accidents resulting from tree falls. Although the costly pilot project was initially contested by public staff, the **North Carolina Utilities Commission (NCUC)** eventually approved it, citing the potential financial returns that come with increased resiliency.[13]

Battery storage projects have also made an appearance in innovative green neighborhoods. For example, the Heron's Nest Environmental Village neighborhood microgrid won Smart Electric Power Alliance's (SEPA) "Grid Integration Power Player of the Year" award for demonstrating innovation and leadership in integrating DERs like storage into the grid.[14] A couple of months after that, North Carolina Electric Membership Corporation (NCEMC) and **Duke Energy** conducted a two part test at the site to demonstrate coordination between distribution and transmission operators. The parties found success in testing for both "Excess Energy Emergency" and "Emergency Demand Response" scenarios, showcasing the value of pilot projects as test subjects for future projects.[15]

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12 *Microgrid Guide: Ocracoke Island*. (2018, March). [Fact Sheet]. NC Electric Cooperatives. https://www.ncelectriccooperatives.com/wp-content/uploads/2018/03/FactSheets-2018-7-Ocracoke-Microgrid.pdf

13 Order Granting Certificate of Public Convenience and Necessity with Conditions, Docket No. E-2, Sub 1185 (2019, May 10). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=751a240b-9a68-4970-89cc-b9c85f289607

14 *2020 SEPA Power Players Award Winners*. (2020, July 23). Smart Electric Power Alliance. https://sepapower.org/knowledge/2020-sepa-power-players-award-winners/

15 *North Carolina Electric Membership Corporation/Duke Energy Distribution Operator Pilot Project*. (2020). North Carolina Electric Membership Corporation & Duke Energy. https://www.ncelectriccooperatives.com/wp-content/uploads/2021/02/NCEMC-Duke-Energy-DO-Pilot-Project-Final-Report.pdf

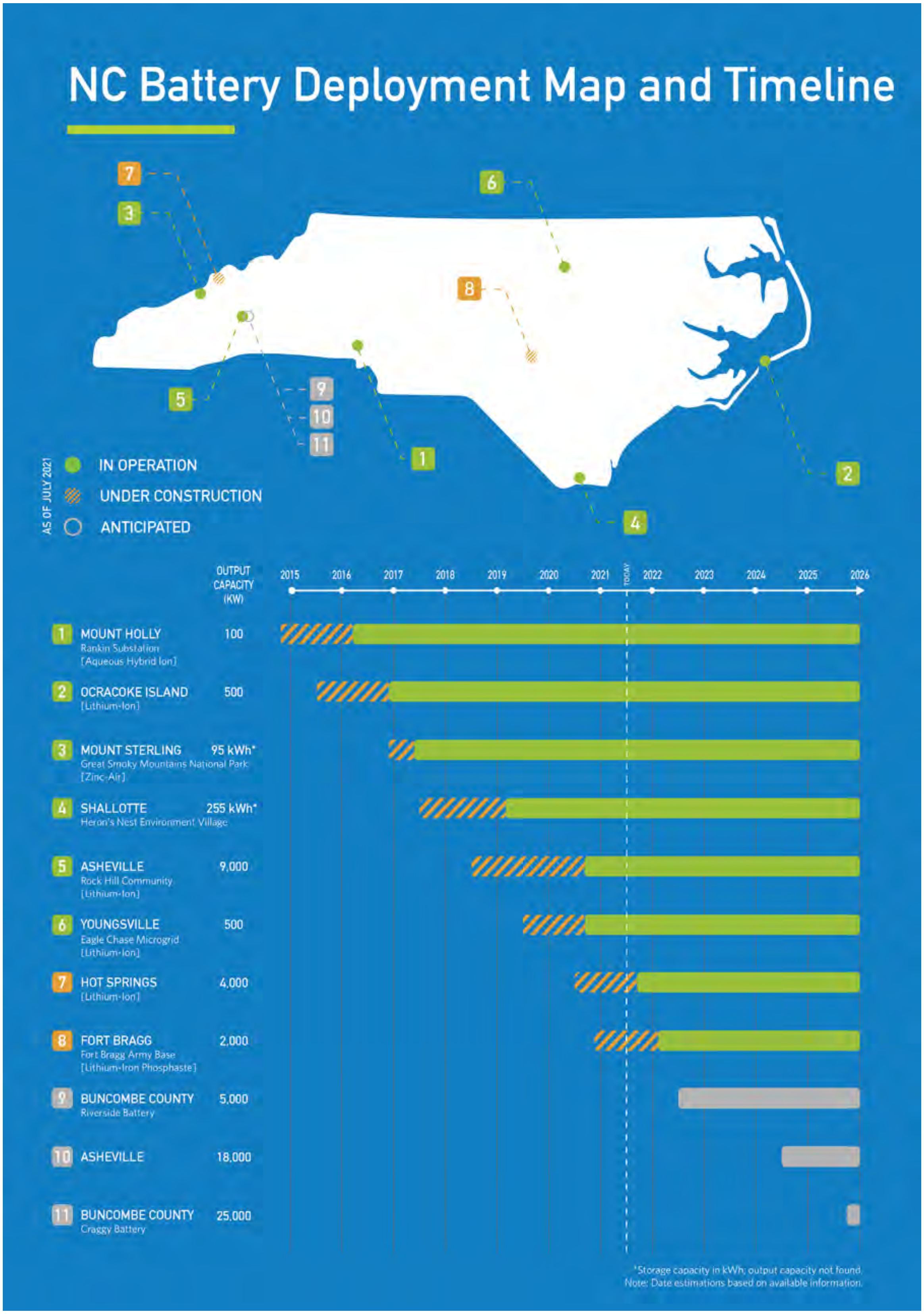

Figure 3: North Carolina Battery Storage Deployment Map and Timeline

Energy Storage Policies

The 2015 *Batteries ~~Not~~ Included* report put forth a number of recommendations for North Carolina, some of which have since been addressed. More generally, for units with multiple levels of ownership (federal vs. state; in-state vs. out-of-state), jurisdiction over energy storage regulations have been further clarified in many of the key policy items listed in Table 2. Secondly, the call to integrate energy storage into the planning process has also been addressed in Duke Energy's 2018 **Integrated Resource Plan (IRP)**, which recognized battery storage as a valuable component to the company's future resource portfolio and set a precedent for IRPs to come.[16] Thirdly, **interconnection standards** for residential batteries as well as new solar and storage installations have been clarified.[17] Finally, FERC Order 2222 opened markets for owners of distributed batteries by monetizing aggregate ancillary services to **Independent System Operator (ISO)** and **Regional Transmission Organization (RTO)** territories.[18, 19]

Table 2 highlights some of the key energy storage-related policies passed in the last six years. The "policy category" column indicates the function and magnitude of intervention of the respective policy. These categories and definitions were drawn from North Carolina State University's (NC State) *Energy Storage Options for North Carolina* report published in 2019.[20]

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16 *North Carolina Integrated Resource Plan* (NC IRP Biennial Report). (2018). Duke Energy Carolinas. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=aa9862b5-5e31-4b3f-bb26-c8a12c85c658

17 Order Approving Revised Interconnection Standard and Requiring Reports and Testimony, Docket No. E-100, Sub 101. (2019, June 14). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=aaf0d39e-44cb-466f-9d1e-ddafd93ab481

18 Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators, FERC Order No. 2222, 172 FERC ¶ 61,247, ¶ 2 (2020, September 17). https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf

19 FERC Orders only apply to North Carolina areas governed by PJM Interconnection (an RTO). This includes Dominion Energy North Carolina (DENC) and excludes Duke utilities.

20 NC State Energy Storage Team. (2018). *Energy Storage Options for North Carolina* (pp. 161–166). NC State. https://energy.ncsu.edu/storage/wp-content/uploads/sites/2/2019/02/NC-Storage-Study-FINAL.pdf

† Policy Categories (drawn from NC State University's *Energy Storage Options for North Carolina* report):

- Prepare: Addresses gaps and uncertainty in the deployment of energy storage.
- Facilitate: Increases value and decreases cost of energy storage.
- Accelerate: Increases the pace of energy storage deployment.

Name / Docket #	State / Federal	Status	Date Issued / Resolved	Summary	Policy Category †
*FERC Order 819: Third-Party Provision of Primary Frequency Response Service[21]	Federal	Final Rule	11/20/2015	Incorporated energy storage as a "Primary Frequency Response Service" in the energy market.	Prepare
Docket No. E-2 Sub 1089[22]	State	Approved	3/28/2016	Directed Duke Energy Progress to file annual reports tracking the progress of its Western Region storage facilities.	Prepare
S.L. #2017-192 (HB589): Competitive Energy Solutions for NC[23]	State	Law	7/27/2017	Charged the North Carolina Policy Collaboratory to write a report on energy storage technologies and the feasibility of implementing energy storage in NC.	Prepare
*FERC Order 841: Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators[24]	Federal	Final Rule	2/15/2018	Required RTOs and ISOs to revise rate designs to better incorporate energy storage into the energy market.	Facilitate

21 Third-Party Provision of Primary Frequency Response Service, FERC Order No. 819, 153 FERC ¶ 61,220, ¶ 1 (2015, November 20). https://www.ferc.gov/media/order-no-819

22 Order Granting Application In Part, With Conditions, And Denying Application In Part, Docket No. E-2, Sub 1089 (p. 44). (2016, March 28). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=50df4b08-ae5f-41c9-a1bd-8c26685673c2

23 Competitive Energy Solutions for NC, N.C. S.L. 2017-192. (2017). https://www.ncleg.gov/BillLookup/2017/h589

24 Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, FERC Order No. 841, 162 FERC ¶ 61,127, ¶ 1 (2018, February 15). https://www.ferc.gov/media/order-no-841

Name / Docket #	State / Federal	Status	Date Issued / Resolved	Summary	Policy Category †
IRS Private Letter Ruling 201809003[25]	Federal	Private Letter Ruling	3/2/2018	Established a tax credit for a residential solar system under IRC §25D(a)(1).	Facilitate
Executive Order No. 80: NC's Commitment to Address Climate Change and Transition to a Clean Energy Economy[26]	State	Passed	10/29/2018	Ordered the NC Department of Environmental Quality to submit a Clean Energy Plan that includes energy storage by 2019.	Faciliate
Docket No. E-2 Sub 1185[27]	State	Approved	5/10/2019	Approved DEP's Hot Spribgs Microgrid solar and battery storage facilities as a pilot project.	Accelerate
Docket No. E-100 Sub 101[28]	State	Approved	5/15/2019	Clarified interconnection rules for energy storage and made provisions for adding energy storage at existing solar PV sites.	Prepare
**Docket No. E-100 Sub 157[29]	State	Approved	8/27/2019	Required Duke Energy to consider energy storage in its 2020 IRP and examine storage integration at existing DER sites.	Prepare

25 Internal Revenue Service. (2018, March 2). *Request for rulings under IRC § 25D* [Private Letter Ruling]. https://www.irs.gov/pub/irs-wd/201809003.pdf

26 North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy, Exec. Order No. 80, (Roy Cooper), (2014). https://files.nc.gov/ncdeq/climate-change/EO80--NC-s-Commitment-to-Address-Climate-Change---Transition-to-a-Clean-Energy-Economy.pdf

27 Order Granting Certificate of Public Convenience and Necessity with Conditions, Docket No. E-2, Sub 1185 (p. 17). (2019, May 10). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=751a240b-9a68-4970-89cc-b9c85f289607

28 Order Approving Revised Interconnection Standard and Requiring Reports and Testimony, Docket No. E-100, Sub 101. (2019, June 14). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=aaf0d39e-44cb-466f-9d1e-ddafd93ab481

29 Order Accepting Integrated Resource Plans And Reps Compliance Plans, Scheduling Oral Argument, And Requiring Additional Analyses, Docket No. E-100, Sub 157 (Appendix A, p. 4). (2019, August 27). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=143d85de-b1e7-4622-b612-5a8c77e909d4

Name / Docket #	State / Federal	Status	Date Issued / Resolved	Summary	Policy Category †
Docket No. E-100 Sub 164[30]	State	Approved	9/4/2019	Initiated investigation of energy storage in NC through a series of educational presentations. (See S.L. #2017-192 (HB589))	Prepare
***Docket No. E-100 Sub 158[31]	State	Approved	4/15/2020	Charged Duke Energy to establish rules for integrating energy storage with existing solar qualifying facilities.	Prepare
*FERC Order 2222: Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators[32]	Federal	Final Rule	9/17/2020	Allowed participation of DER aggregations (ex. energy storage) in all wholesale electric markets operated by RTOs and ISOs.	Facilitate

*FERC Orders only apply to NC areas governed by **PJM Interconnection** (an RTO). This includes **Dominion Energy North Carolina (DENC)** and excludes Duke utilities.
**Docket for 2018 biennial integrated resource plans; ongoing 2020 IRP proceedings found under Docket No. E-100 Sub 165.
***Docket for NCUC biennial avoided cost proceedings; ongoing 2020 avoided cost proceedings found under Docket No. E-100 Sub 167.

Table 2: Key State and Federal Energy Storage-Related Policies Since 2015

30 Order Initiating Investigation, Docket No. E-100, Sub 164. (2019, September 4). North Carolina Utilities Commission. https://www.transmissionhub.com/wp-content/uploads/2019/09/NCorderStorageSep42019.pdf

31 Order Establishing Standard Rates And Contract Terms For Qualifying Facilities, Docket No. E-100, Sub 158. (2020, April 15). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=eff66bdb-e96f-417f-a526-e88dc8d3a6d9

32 Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators, FERC Order No. 2222, 172 FERC ¶ 61,247, ¶ 2 (2020, September 17). https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf

Research and Development

Investigations and Stakeholder Engagement

In the past six years, countless reports have been written on battery storage, which has helped to augment the knowledge base on the topic and provide a roadmap for the adaptation of storage technologies in the state. Most notably, NC State published its North Carolina energy storage report in late 2018, pursuant Part XII Section 12 of **House Bill 589**.[33, 34] The report evaluated North Carolina in terms of the value and feasibility of implementing energy storage in the long run. A year later, the **North Carolina Department of Environmental Quality (NC DEQ)** published a Clean Energy Plan (CEP) that included provisions for energy storage, pursuant Governor Cooper's **Executive Order #80**.[35] The report called for modernizing the grid with battery storage and presented clean energy policy and action recommendations for the state to reach carbon neutrality by 2050.[36]

Many of the reports were accompanied by stakeholder workshops to discuss the storage-related challenges and create models for the deployment of storage. For example, NCSEA held three Energy Storage Working Group meetings in 2016 with utilities, clean energy companies, public staff, and experts from around the country to learn about energy storage implementations in similarly-situated states and identify deployment barriers in North Carolina.[37] In 2019, the **U.S. Department of Energy (DOE)** awarded $300,000 to fund a joint two-year project spearheaded by the DEQ, University of North Carolina at Charlotte, NC State, and the NC Clean Energy Technology Center (NCCETC). The "Planning an Affordable, Resilient, and Sustainable Grid in North Carolina" (PARSG) project set out to examine storm-related impacts in North Carolina and investigate the cost-effectiveness of investing in grid resiliency.[38] Later that year, NCUC opened Docket No. E-100 Sub 164 that initiated

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33 NC State Energy Storage Team. (2018). *Energy Storage Options for North Carolina*. NC State. https://energy.ncsu.edu/storage/wp-content/uploads/sites/2/2019/02/NC-Storage-Study-FINAL.pdf

34 Competitive Energy Solutions for NC, N.C. S.L. 2017-192. (2017). https://www.ncleg.gov/BillLookup/2017/h589

35 North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy, Exec. Order No. 80, (Roy Cooper), (2014). https://files.nc.gov/ncdeq/climate-change/EO80--NC-s-Commitment-to-Address-Climate-Change---Transition-to-a-Clean-Energy-Economy.pdf

36 *North Carolina Clean Energy Plan: Transitioning to a 21st Century Electricity System* (p. 34). (2019). North Carolina Department of Environmental Quality. https://files.nc.gov/ncdeq/climate-change/clean-energy-plan/NC_Clean_Energy_Plan_OCT_2019_.pdf

37 *Energy Storage Working Group Interim Report*. (2017). North Carolina Sustainable Energy Association. https://energync.org/wp-content/uploads/2017/03/Energy_Storage_Working_Group_Interim_Report.pdf

38 *Planning an Affordable, Resilient, and Sustainable Grid in North Carolina*. (2019). NC Clean Energy Technology Center. https://nccleantech.ncsu.edu/our-work/center-projects/planning-an-affordable-resilient-and-sustainable-grid-in-north-carolina/

an investigation of energy storage through a series of educational presentations.[39] To date, the Commission has hosted a dozen presenters who addressed a number of topics from energy storage safety codes to DER interconnection standards.

Emerging Technologies

Along with the deployment of pilot projects, battery technology has become more understood, accessible, and affordable. To date, the most popular and well-known battery technology is lithium-ion (Li-ion). Since taking off in the electric vehicle (EV) sector, lithium-ion has established a lock in the e-mobility market and slowly expanded its influence in the stationary battery storage industry.[40] Lithium-ion's extraordinary **energy density**, familiarity, and bankability makes it difficult for other storage technologies to compete.

While lithium-ion is ideal for EVs and great for short term (up to 4 hours) storage, it is economically unfeasible for mid term (4-12 hours) and long term (days-months) storage.[40, 41] (As shown in Figures 2a-c, different durations of battery storage offer different services.) Despite the steep price drop and new advancements in Li-ion technology, it still falls short of the monetary, safety, and scalability requirements at the utility level. Thus, new research is on the rise to fill the needs of the burgeoning industry.

Energy density – Li-ion's hallmark advantage – doesn't apply to stationary battery storage. The size and weight of the battery matter less than the capacity, cost, lifetime, and safety features of a substation storage facility. Four now-commercialized battery technologies have surfaced as worthy competitors against Li-ion: flow, liquid metal, sodium ion, and zinc ion batteries. Flow batteries store energy in metals dissolved in relatively cheap fluids. The anode and cathode comprise of two holding tanks and can be scaled up or down to meet the capacity needs of grid-scale storage. Currently, the most common flow battery chemistry is zinc-bromine and vanadium redox, whose market prices are not competitive enough against Li-ion.[40] However, new research on organic chemistries and

39 Order Initiating Investigation, Docket No. E-100, Sub 164. (2019, September 4). North Carolina Utilities Commission. https://www.transmissionhub.com/wp-content/uploads/2019/09/NCorderStorageSep42019.pdf

40 Abele, M. (2021, June 25). *David Roberts on the Future of Energy Storage* (No. 51). https://soundcloud.com/energync/episode51?fbclid=IwAR1Jf_3rrRuwBxRy-uz60IioVV4_Tsh8kLZIlyiAVIFoitttx8Ola9spF20

41 National Rural Electric Cooperative Association, National Rural Utilities Cooperative Finance Corporation, CoBank, & NRTC. (2020). *Battery Energy Storage Overview* (p. 7) [Business & Technology Report]. https://www.cooperative.com/programs-services/bts/Documents/Reports/Battery-Energy-Storage-Overview-Report-Update-May-2020.pdf

electrode design could potentially make flow battery's efficiency, cost, and durability competitive in the market.[42, 43]

Liquid metal batteries use molten salts as electrolytes and are currently manufactured by the 11 year-old start-up company Ambri. The company's website flaunts the affordability, safety, and scalability of their product, claiming that their cells are designed to go through dozens of cycles without degradation.[44] Though the company has been met with tremendous on-the-ground success in recent years, time will tell if the technology matures fast enough to compete with Li-ion in the stationary battery market. On the slower end, sodium ion and zinc ion batteries are emerging as competent replacements for lead-acid batteries. Since both chemistries are safer than Li-ion, researchers are also exploring their potential in large-scale deployment and discovering ways to make them more energy dense, scalable, and stable.[45, 46]

The current storage market is particularly unwelcoming for new technologies. Not only is the ever-diminishing cost of Li-ion a moving target, emerging storage technologies must also compete with inexpensive natural gas plants that service most of the state's peak demand.[43] In 2017, ALEVO, a Swiss start-up company for inorganic lithium-ion chemistry grid batteries filed for chapter 11 bankruptcy protection.[47] Since investing over $1 billion to develop its GridBank™ storage unit in Concord, North Carolina, the company encountered major setbacks bringing the technology into

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42 Wan, C. T., Jacquemond, R. R., Chiang, Y., Nijmeijer, K., Brushett, F. R., & Forner Cuenca, A. (2021). Non Solvent Induced Phase Separation Enables Designer Redox Flow Battery Electrodes. Advanced Materials, 33(16), 2006716. https://doi.org/10.1002/adma.202006716

43 Yang, Z., Tong, L., Tabor, D. P., Beh, E. S., Goulet, M., Porcellinis, D., Aspuru Guzik, A., Gordon, R. G., & Aziz, M. J. (2018). Alkaline Benzoquinone Aqueous Flow Battery for Large Scale Storage of Electrical Energy. Advanced Energy Materials, 8(8), 1702056. https://doi.org/10.1002/aenm.201702056

44 *The Ambri Technology*. (n.d.). Ambri. https://ambri.com/technology/

45 Xia, C., Guo, J., Lei, Y., Liang, H., Zhao, C., & Alshareef, H. N. (2018). Rechargeable Aqueous Zinc-Ion Battery Based on Porous Framework Zinc Pyrovanadate Intercalation Cathode. *Advanced Materials*, 30(5), 1705580. https://doi.org/10.1002/adma.201705580

46 Huang, Y., Wang, Z., Guan, M., Wu, F., & Chen, R. (2020). Toward Rapid Charging Sodium Ion Batteries using Hybrid Phase Molybdenum Sulfide Selenide Based Anodes. *Advanced Materials*, 32(40), 2003534. https://doi.org/10.1002/adma.202003534

47 Colthorpe, A. (2017, August 21). *GridBank Li-Ion provider Alevo files for Chapt. 11 bankruptcy protection*. Energy Storage News. https://www.energy-storage.news/news/gridbank-li-ion-provider-alevo-files-for-chapt.-11-bankruptcy-protection

commercial production and obtaining revenue to stay afloat.[48, 49] However, we must not sideline these budding battery chemistries. In light of President Biden's goal of achieving a net-zero carbon electricity sector by 2035, it's important to push research and development (**R&D**) on these Li-ion contenders so that the technology sector is ready to hit the ground and start running when peaker plants retire.

Not only are battery designs undergoing massive technological revolutions, grid modernization projects are also underway to facilitate the incorporation of energy storage onto the grid. Today, tech companies and software developers are devising better ways to integrate **smart grid technologies** with current grid infrastructures to optimize monitoring, communication, and synchronization between batteries and other DERs on a modernized distribution grid. A recent study by Nguyen and Byrne reviews a diverse set of software tools for energy storage valuation and design, evaluating various power system simulation and planning tools for their technical impact on energy storage deployments.[49] Vibrant Clean Energy, LLC's WIS:dom®-P[50] model demonstrates how powerful grid modernization programs can be.[51] The company's flagship energy grid model takes high-resolution weather and energy demand data and simulates optimized scenarios for both **transmission** (utility-scale) and **distribution** (local scale) **grids**. With the help of WIS:dom, Vibrant Clean Energy ran 15 nationwide simulations over the next three decades and published a report confirming that DERs lower costs across the entire electricity system in all scenarios.[52]

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48 Goldenberg, S. (2014, October 30). *Power Storage Group Alevo Plan US$1 Billion Battery Plant*. Our World. https://ourworld.unu.edu/en/power-storage-group-alevo-plan-us1-billion-battery-plant

49 Nguyen, T. A., & Byrne, R. H. (2021). Software Tools for Energy Storage Valuation and Design. *Current Sustainable/Renewable Energy Reports*. https://doi.org/10.1007/s40518-021-00186-4

50 Acronym for Weather-Informed energy Systems: for design, operations and markets planning.

51 *The WIS:dom® Planning Model: The flagship energy grid model of Vibrant Clean Energy, LLC.* (n.d.). Vibrant Clean Energy. https://www.vibrantcleanenergy.com/products/wisdom-p/

52 Clack, C. T. M., Choukulkar, A., Coté, B., & McKee, S. A. (2020). *Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid* [Technical]. Vibrant Clean Energy, LLC. https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf

III. Where to Go from Here

Recommendations for Deploying Battery Storage in North Carolina

A Storage-Ready North Carolina

The rise in pilot project deployment, development in the legislature, and breakthroughs in battery technologies have made North Carolina more storage-ready. Natioanlly ranked in the top three in solar generation capacity, North Carolina is in its prime for battery storage in homes and on the grid.[53] Energy storage resources will enable utilities and homeowners to properly capitalize on their renewable assets as well as stabilize, secure, and ease the grid away from fossil fuel power plants. Even though North Carolina's energy storage sector only accounted for 3% ($436 million) of the state's total clean energy revenue in 2018, the sector is experiencing tremendous growth. In fact, the industry totalled a 216% revenue growth between 2016 to 2018, more than any other clean energy sector in the same period.[54]

North Carolina is also home to a rich deposit of untapped lithium-containing spodumene ore.[55] With Li-ion batteries on the rise, this unique geology puts the state in an advantageous position for market development and employment opportunities. Today, the vast majority of the lithium found in American batteries are mined in Australia and refined in China.[56] Shifting to more local sources of lithium would decrease transportation emissions and costs, enhance clean energy security, and make battery storage more cost-effective. However, this isn't an uncontended issue. Piedmont Lithium, a North Carolina producer of lithium hydroxide – an ingredient used in battery cathodes – is looking to open a lithium mine in northern Gaston County. There has been serious pushback to this proposition because of concerns about long term mining, even though the project would create hundreds of new jobs in the area.[57]

Compared to other states, North Carolina still has a long way to go in the energy storage sector. California's most recent IRP calls for almost 9 GW (9,000 MW) of new battery storage by 2030, which is 30 times the combined battery storage procurement goal of 291 MW proposed by **Duke**

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53 *North Carolina Profile State Profile and Energy Estimates*. (2020, November 19). U.S. Energy Information Administration. https://www.eia.gov/state/analysis.php?sid=NC

54 Carey, J., Parker, D., & Jones, J. (2018). *2018 North Carolina Clean Energy Industry Census* (Clean Energy Industry Census, pp. 14, 21). North Carolina Sustainable Energy Association. https://energync.org/wp-content/uploads/2019/08/NCSEA_2018_NC_Clean_Energy_Industry_Census_Web.pdf

55 Abele, M. (2021, June 25). *David Roberts on the Future of Energy Storage* (No. 51). https://soundcloud.com/energync/episode51?fbclid=IwAR1Jf_3rrRuwBxRy-uz60IioVV4_Tsh8kLZIlyiAVIFoitttx8Ola9spF20

56 Fitch, J. (2020). *2019-2020 Electric Resource Portfolios to Inform Integrated Resource Plans and Transmission Planning* (p. 41). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M330/K357/330357384.PDF

57 Bruno, J., & Lemon, K. (2021, July 21). *Piedmont Lithium presents Gaston County mining plans, neighbors voice concerns*. WSOC-TV. https://www.wsoctv.com/news/local/battery-company-wanting-mine-lithium-will-present-plan-gaston-county/G4C7GTR5VRFLJKQHTRSWFLTJGI/

Energy Carolinas (DEC) and **Duke Energy Progress (DEP)** in 2018.[58, 59] Thus, modelling after successful states and properly leveraging resources, funds, and human resources in the coming years are crucial for North Carolina to catch up to its potential in stationary battery storage.

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58 Fitch, J. (2020). *2019-2020 Electric Resource Portfolios to Inform Integrated Resource Plans and Transmission Planning* (p. 41). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M330/K357/330357384.PDF

59 *North Carolina Clean Energy Plan: Transitioning to a 21st Century Electricity System* (p. 34). (2019). North Carolina Department of Environmental Quality. https://files.nc.gov/ncdeq/climate-change/clean-energy-plan/NC_Clean_Energy_Plan_OCT_2019_.pdf

Recommendations

In the coming years, North Carolina needs to advance battery storage education, R&D, planning, and policies to fully tap into the benefits of stationary battery storage and to meet the demands of its consumers and industry.

Education and Demonstration Projects

Although North Carolina has made giant strides in pilot project deployment (Figure 3) and education, we still have a long way to go before stationary battery storage becomes the norm. To this day, industry and consumer acceptance toward storage technologies has been low. There are still many unknowns and not enough exposure to successful stories of storage for businesses and homeowners to willingly invest in this technology. Building and testing more pilot projects, hosting battery storage forums and webinars, erecting new research facilities, and circulating easy-to-understand educational media will help North Carolinians better understand and appreciate the value of batteries and foster familiarity among prospective customers. These efforts must also be equitably distributed to ensure access and technology acceptance across the diverse citizenry of the state. Finally, education and demonstration programs will also pave the way for clean energy industries to provide the advanced technical support needed to train and equip new staff in the energy storage division.

Research and Development

Battery Technology

While lithium-ion may be sufficient for today's energy storage capacity, development of new electrode chemistries and cell designs is crucial to meet the capacity requirements and diverse needs of a more distributed grid. The maturing of battery technology not only correlates to higher performance attributes, it also has the potential to lower storage costs by switching out rare metals, increasing **roundtrip efficiency** (i.e. store the same amount of energy with the less material), and establishing economies of scale. According to a study published last year, cheaper long-duration storage (>100 hours) is required to achieve optimal wind and solar penetration on the grid (70-90% of the **energy mix**).[60]

Distributed Energy Resource Management Systems

Another field with research needs is **distributed energy resource management systems (DERMS)**. In order to effectively incorporate substation and residential batteries onto the grid, controller softwares and devices must be sophisticated enough to optimize automation and synchronization within the **virtual power plant (VPP)** as well as be compatible with the current electricity system (see Figure 1).

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60 Albertus, P., Manser, J. S., & Litzelman, S. (2020). Long-Duration Electricity Storage Applications, Economics, and Technologies. *Joule*, 4(1), 21–32. https://doi.org/10.1016/j.joule.2019.11.009

Improving automation in DERMS helps minimize manual intervention and human error in operating systems. This involves wifi-compatible devices sensing, signalling, and controlling each other to regulate frequency, predict energy demand, and disconnect during emergencies (i.e grid outages and cybersecurity attacks). In the future, this may also include features like weather forecasting, smartphone apps, and machine learning that would enable a storage system to make specific provisions for future weather events and its users.

Achieving timeless synchronization between components of a distributed grid is also crucial. High speed communication in **advanced distribution management systems (ADMS)** improves the interoperability of smart devices, island inverters, site monitors, and utility controllers. Accurately choreographed equipment deployment must happen in the order of milliseconds to adequately serve distributed electricity users with the least amount of generation assets.

Finally, DERMS must also be able to integrate seamlessly into the current energy ecosystem. The technologies and applications on the grid today are designed to be run from a central power source. Because there's no easy way to install DERs on a traditional grid, existing storage pilot projects had to be highly customized. Until DERMS technology matures to the point of standardized programs and protocols, there will be no cookie-cutter way to install batteries and capital costs will remain high.

Development in DERMS not only optimizes grid performance, it also equips utilities and residents with the ability to quantify the value of stationary battery storage. **Supervisory control and data acquisition (SCADA)** is slowly being integrated into utility systems to help valuate batteries' reliability and resiliency services. Today, there are many approaches to monetizing the benefits of energy storage systems;[61] however, cultivating these technologies further will help us to better evaluate the cost-effectiveness of **non-wires alternatives (NWA)**, identify the location on the distribution system where storage would offer the greatest value, and set price points that would make energy storage cost-effective.

End-of-Life Management

As of today, little research has gone into end-of-life management of grid storage since existing batteries are far from retirement.[62] However, developing safe and sustainable disposal technologies and operations will better prepare North Carolina for large-scale implementation of stationary storage. New ways to recycle dead batteries and scrap materials from factories would allow us to

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61 Balducci, P., Mongird, K., & Weimar, M. (2021). Understanding the Value of Energy Storage for Power System Reliability and Resilience Applications. *Current Sustainable/Renewable Energy Reports*. https://doi.org/10.1007/s40518-021-00183-7

62 Roberts, D. (2021, May 19). *Battery Week: Everything in one place*. https://www.volts.wtf/p/battery-week-everything-in-one-place

"mine our own waste," minimize environmental impacts, and potentially manufacture higher quality batteries at lower costs.[63]

Planning

Battery storage education, pilot projects, and R&D, all help utilities and homeowners to better plan for storage installment. Every other year, Duke Energy is required to file Integrated Resource Plans (IRP) for both DEC and DEP. These biennial reports are meant to evaluate the current trajectory of energy resources and draw up energy resource portfolios for the next 15 years. Starting in 2018, Duke's started to include energy storage in its IRPs; however, these planning documents tend to lack sophistication and depreciate the value of storage. Currently, Duke Energy's 2020 IRPs are under fire from several clean energy organizations for using flawed models, not accounting for all the value streams of DERs, and downplaying the competitiveness of storage.[64] Earlier this year, NCSEA filed comments calling for NCUC to reject the most recent IRPs, accusing Duke for "overly [relying] on natural gas and [using] questionable price modeling to scapegoat renewables."[65] Soon after, Synapse Energy Economics, Inc prepared a report that provided a "reasonable assumptions" scenario against Duke's proposal. The consulting firm modeled 11.8 GW of new battery storage capacity by 2035, more than 1,000 times capacity modeled under the "mimic Duke" scenario.[66] Furthermore, Synapse found that replacing coal-fired units with renewables and storage minimizes risk to customers, cost, and carbon emissions.[66] Planning and goal-setting is crucial for deploying grid batteries, and utilities must accurately and thoroughly evaluate the potential of storage in order to achieve the most resilient and cost-effective grid.

Policy-Making

The recent energy storage policies listed in Table 2 only address a small subset of the regulatory barriers in the energy storage sector. The North Carolina General Assembly (NCGA) and the NCUC still have a lot of loose ends to tie on the legislation front to help prepare, facilitate, and accelerate energy storage deployment.

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63 Roberts, D. (2021, May 19). *Battery Week: Everything in one place*. https://www.volts.wtf/p/battery-week-everything-in-one-place

64 Ongoing 2020 IRP proceedings are found under Docket No. E-100 Sub 165.

65 Jones, J. (2021, March 1). In comments, NCSEA argues against Duke's fossil fuel heavy 2020 IRP. North Carolina Sustainable Energy Association. https://energync.org/wp-content/uploads/2021/03/03-2021-Duke-IRP-Statement-FINAL-2.pdf

66 2020 Integrated Resource Plans, Docket No. E-100, Sub 165. (2021, May 27). Southern Environmental Law Center. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=be90482d-7f8e-4949-babc-c23d33e6d4c5

Interconnection Standards and Tariff Structures

First and foremost, the NCUC must enact policies that amend or clarify interconnection standards for adding new storage units to *existing* solar facilities. Currently, Docket No. E-100 Sub 101 only makes provisions for storage installed at *new* solar facilities.[67] Furthermore, the current rate design stakeholder processes should also draw up interconnection standards that enable household batteries to participate in net metering benefits. Clarifying ownership of battery energy and setting measures for battery owners to profit from generation assets would incentivize customer adoption of storage.

Not only should tariff structures be revised to better incorporate energy storage behind-the-meter, North Carolina must also pass policies to monetize energy storage in front of the meter. While there have been legislative attempts to study energy markets, as the current law stands, there is no value stream to compensate battery owners for storage-related ancillary services (ex. onsite energy supply, black start, and frequency response) provided to non-RTO service areas (i.e. regions serviced by DEC and DEP). Establishing a competitive market to finance these grid services demonstrates demand for storage and is vital for harnessing the many benefits of batteries and the renewable sources it's paired with.

Economic Incentives

One of the biggest barriers deterring utilities, homeowners, and store owners from installing batteries is not knowing whether they would get a return on investment after the initial purchase. Admittedly, utilities may even be disincentivized to take energy efficiency measures or invest in clean energy alternatives like storage because it curtails electricity sales under traditional ratemaking models. In order to motivate utilities to invest in grid resiliency projects, legislation will need to decouple revenue from the amount of energy the utility produces. In 2020, the NC Energy Regulatory Process (NERP) recommended a collection of **performance-based regulation (PBR)** reforms like revenue **decoupling** and **multi-year rate plans (MYRP)** that remove the disincentive toward distributed energy solutions and awards utilities for achieving key outcomes like grid modernization, grid reliability, and **demand side management (DSM)**.[68] To further mitigate the financial risks of investing in grid-scale batteries, the state or federal governments should implement cost-recovery programs and leverage infrastructure funding to subsidize storage projects. These technology-push policies not only lower the stakes of battery installment, they also encourage research, demonstration projects, and the development of new technologies that can compete with Li-ion batteries.

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67 Order Approving Revised Interconnection Standard and Requiring Reports and Testimony, Docket No. E-100, Sub 101. (2019, June 14). North Carolina Utilities Commission. https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=aaf0d39e-44cb-466f-9d1e-ddafd93ab481

68 Brooks, J., Cross-Call, D., House, H., & Shipley, J. (2020). *North Carolina Energy Regulatory Process*. Rocky Mountain Institute & Regulatory Assistance Project. https://files.nc.gov/ncdeq/NERP%202020_Final%20Report%20and%20Products%20%281%29_0.pdf

Homeowners and retailers will also need financial rationales to justify installing stationary battery units. To realize a truly distributed grid, North Carolina needs to implement new rate designs and demand response programs that are easy to understand for those behind-the-meter. For instance, a billing system with super-off peak pricing and raised **demand charges** would widen the profit margin for energy arbitrage and establish price signals to encourage electricity buyers to invest in clean energy alternatives like storage and solar-paired storage. This year, Duke Energy, NCSEA, and other clean energy advocates helped pass the Solar Choice Net Metering program in South Carolina, a successor tariff that credits solar owners for relieving energy demand on the grid during peak periods.[69, 70] While approval from the NCUC is still pending, the passing of this program (or the like) could easily incorporate other DERs like solar-battery systems that can supplement even more onsite energy generation during periods of high demand.[69]

Clean Energy Policies

Finally, clean energy policies and mandates could significantly expedite the deployment of storage technologies. Given the considerable level of reluctance within the energy providers to go storage, imposing requirements for storage units would push industries away from cheap natural gas peaker plants and invest in cleaner energy sources. Currently, North Carolina operates under two key **renewable portfolio standards (RPS)**: Firstly, the **Renewable Energy and Energy Efficiency Portfolio Standard (REPS)** requires investor-owned utilities in North Carolina to meet a portion of their energy needs through renewable energy resources or energy efficiency measures;[71] secondly, the **Competitive Procurement of Renewable Energy (CPRE)** program qualifies renewables to participate in a competitive bidding process.[72] Amending these existing clean energy policies to include storage as a "renewable energy resource" would set the stage for other storage-related policies.

Unlike North Carolina, many other states have already implemented mandatory energy storage procurement targets. For example, Massachusetts passed its **Clean Peak Energy (CPE) Standard** in 2018, becoming the first state to require a percentage of peak period loads to be served by clean

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69 *Agreement to Move to Solar Choice Net Metering in South Carolina & Implications for North Carolina*. (2020). North Carolina Sustainable Energy Association. https://energync.org/wp-content/uploads/2020/10/SC_NEM_Settlement_Summary_10-20.pdf

70 *Strong solar deal sealed in South Carolina*. (2021, May 19). Southern Environmental Law Center. https://www.southernenvironment.org/news-and-press/news-feed/strong-solar-deal-sealed-in-south-carolina

71 N.C. Gen. Stat. § 62-133.8 (2007). https://www.ncleg.net/enactedlegislation/statutes/html/bysection/chapter_62/gs_62-133.8.html

72 N.C. Gen. Stat. § 62-110.8 (2017). https://www.ncleg.gov/EnactedLegislation/Statutes/PDF/BySection/Chapter_62/GS_62-110.8.pdf

peak resources including energy storage.[73] A year later, NCSEA board member Ronald DiFelice published a white paper proposing a similar policy for North Carolina. If passed, the energy storage-centered Clean Peak Standard (CPS-ES) would require utilities to install storage units with renewable energy sources and is estimated to offset one-fifth the state's peaking capacity by 2028 and over 1.8 million metric tons of CO_2 per year.[74]

A recent report written by collaborators from three leading universities proposed a similar policy for the nation at large. In accordance with President Biden's decarbonization goal, the **Clean Energy Futures (CEF)** project offered an 80x30 Clean Electricity Standard, which obligates utilities nationwide to reach annual clean energy milestones in keeping with the interim target of generating 80% of the country's energy with zero-emission resources by 2030.[75] In comparison to the seven other policy cases evaluated, the 80x30 approach was found to provide the largest benefits in terms of health, cost, and carbon-reduction, preventing more than 300,000 premature deaths and totalling net benefits of more than a trillion dollars within the next three decades.[85]

In light of the tremendous advancements in energy storage in the past six years, energy-related policies must evolve to reflect the ever-changing energy landscape in North Carolina. As new battery chemistries, markets, value streams emerge, existing policies must be amended, replaced, and buttressed by new ones in order to keep up with the growing demands of energy suppliers and consumers alike.

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73 An Act to Advance Clean Energy. 2018 Mass. Acts 227. 9 August 2018. https://malegislature.gov/Laws/SessionLaws/Acts/2018/Chapter227

74 DiFelice, R. (2019, March 7). *Deploying more renewables now through an energy storage-centric Clean Peak Standard*. Utility Dive. https://www.utilitydive.com/news/deploying-more-renewables-now-through-an-energy-storage-centric-clean-peak/549787/

75 Driscoll, C., Lambert, K. F., & Wilcoxen, P. (2021). *An 80x30 Clean Electricity Standard: Carbon, Costs, and Health Benefits*. Clean Energy Futures. https://cleanenergyfutures.syr.edu/wp-content/uploads/2021/07/CEF-80x30-CES-Report_Final_July_15_21.pdf

Conclusion

As the North Carolina energy sector evolves into a state powered by clean and distributed energy sources, stationary battery storage research, pilot projects, and deployment have moved up in priority. Battery storage on the grid and in homes act as a necessary complement to the growing prevalence of intermittent renewable sources and serves as an advantageous supplement to centralized generation resources. It provides short, mid, and long term utility services as well as energy security to residents. In fact, it is an essential component of a future carbon-free grid called for by President Biden and Governor Cooper.

Since the publication of NCSEA's 2015 report *Batteries ~~Not~~ Included*, the state has experienced substantial growth in the energy storage sector. Stakeholders, policy-makers, utilities, and scientists alike have conducted investigations on the feasibility of incorporating battery storage into North Carolina's current grid ecosystem. Demonstration projects, storage workshops, softwares, and battery chemistries sprung up to spur further the development and deployment of battery technologies on the ground. Moreover, Congress and the NCUC have also been making headway on the energy storage front, clarifying interconnection and jurisdiction specifications and adding storage to proposed generation portfolios.

Currently, North Carolina is favorably-situated for further growth in storage deployment. The current status of battery deployment among energy storage leaders allows North Carolina to learn from the successes and mistakes of similarly-situated states and to capitalize on available resources. This includes education, pilot projects, R&D, planning, and policy-making efforts that promote stationary battery storage in front of and behind the meter. Besides establishing leadership in the clean energy domain, forthcoming advancements in stationary battery storage will also allow North Carolina to amply reap the health and economic benefits of a cleaner, cheaper, and more resilient grid.

Glossary

Term	Definition
Advanced Distribution Management Systems (ADMS) (Source: DOE)	A software platform that integrates numerous utility systems and provides automated outage restoration and optimization of distribution grid performance. It transitions utilities from paperwork, manual processes, and siloed software systems to systems with real-time and near-real-time data, automated processes, and integrated systems.
Ancillary Services (Source: Greening the Grid)	Functions that help grid operators maintain a reliable electricity system. Ancillary services maintain the proper flow and direction of electricity, address imbalances between supply and demand, and help the system recover after a power system event. In systems with significant variable renewable energy penetration, additional ancillary services may be required to manage increased variability and uncertainty.
Black Start	Starting a generator unit from a completely unenergized state without external power from the grid.
Capacity Firming	The maintenance of variable, intermittent power output from a renewable power generation plant, such as wind or solar, at a committed level for a period of time.
Clean Energy Futures (CEF)	A multi-institutional research initiative that aims to quantify the carbon emissions, costs, and air quality outcomes of contrasting electricity sector policies that are relevant to current national discussions.
Clean Peak Energy (CPE) Standard (Source: ESA)	A market mechanism to encourage the deployment of a diverse set of clean energy technologies (ex. energy storage) that can supply electricity or reduce demand during peak demand periods.
Competitive Procurement of Renewable Energy (CPRE)	A key program implemented by HB589 that set up a competitive bidding process for renewable energy produced by large utilities like Duke Energy. It requires bids to be priced below the utility's avoided cost and offers consumers cheaper renewable energy compared to traditional PURPA rates. See, N.C.G.S. § 62-110.8.
Curtailment	Reduction in the output of a generating unit from what it could otherwise produce given available resources.
Demand Charges	Charges to larger utility consumers that reflect the cost of additional investments needed to meet their load that are based on the peak demand of these customers during a billing period.
Demand Side Management (DSM)	Activities, programs, or initiatives undertaken by an electric power supplier or its customers to shift the timing of electricity use from peak to non-peak demand periods.
Department of Energy (DOE)	The United States federal government agency concerning energy policy and safety regarding nuclear material.
Distributed Energy Resources (DER)	Small energy resources that are able to be located close to their point of consumption.

Term	Definition
Distribution Grid (Source: Volts)	The nests of low-voltage power lines (strung from the familiar brown poles) that carry electricity to local consumers.
Dominion Energy North Carolina (DENC)	One of three investor-owned utilities operating in North Carolina, primarily serving northeastern parts of the state. An operating division of Virginia Electric and Power Company and a subsidiary of Dominion Resources.
Duke Energy Carolinas (DEC)	One of three investor-owned utilities operating in North Carolina, primarily serving western parts of the state. A subsidiary of Duke Energy Corporation.
Duke Energy Corporation (Duke Energy)	A holding company based in Charlotte, NC that owns several public utilities operating in various states as well as unregulated subsidiaries. The parent company of Duke Energy Carolinas, Duke Energy Progress, and Duke Energy Renewables.
Duke Energy Progress (DEP)	One of three investor-owned utilities operating in North Carolina, primarily serving central and southeastern parts of the state. A subsidiary of Duke Energy Corporation.
Energy Arbitrage (Source: Markus Dickerson)	Buying electricity when the tariff is low and using that electricity during peak periods when the tariff rates are at their highest. This profits utilities and leads to energy bill savings for customers.
Energy Density	The amount of energy stored per unit of battery volume or mass.
Energy Mix	The array of primary energy sources used in a given area to meet its energy consumption needs.
Energy Resource Management Systems (DERMS) (Source: Microgrid Knowledge)	A suite of software management tools that allow distribution utilities and wire operators to manage an array of DERs and control grid assets in real-time.
Energy Security (Source: iea)	The uninterrupted availability of energy sources at an affordable price.
Executive Order #80 (EO80)	The 2018 Executive Order signed by Governor Cooper that put forth three goals to achieve by 2025—increasing zero-emission vehicles on the road to 80,000; reducing energy consumption in state-owned buildings by 40 percent (from 2002-2003 baseline); and achieving a 40 percent reduction in greenhouse gas emissions from 2005 levels.
Grid / Transmission Congestion (Source: Electricity Today)	A situation wherein the existing transmission and/or distribution lines are unable to accommodate all required load during periods of high demand or during emergency load conditions.
House Bill 589 (HB589)	The "Competitive Energy Solutions for NC" passed in 2017 and signed by Governor Cooper.
Independent System Operator (ISO) / Regional Transmission Organization (RTO)	An organization responsible for moving electricity through multi-state areas. Regional transmission organizations were formed pursuant to an order from the Federal Energy Regulatory Commission (FERC) in 1999. The only regional transmission organization operating in North Carolina is PJM Interconnection.

Term	Definition
Integrated Resource Plan (IRP)	A utility plan for meeting forecasted annual peak and energy demand, with some reserve margin, over a specified future period.
Interconnection Standards	Requirements for connecting utilities (such as solar and storage) to the grid.
Load Shifting (Supply Shifting, Time Shifting) (Source: Next Kraftwerke)	A short term reduction in electricity consumption followed by an increase in production at a later time when power prices or grid demand is lower.
Load Smoothing (Demand Smoothing)	The smoothing of variable electricity demand.
Microgrid	Smaller, localized electricity grids that have the ability to disconnect and operate independently from outside resources. The independence of a micro grid can be permanent or achieved temporarily through a switch.
Multi-Year Rate Plan (MYRP) (Sources: NERP & Wood Mackenzie)	A ratemaking mechanism through which base rates and revenues are fixed for a multi-year term and a utility is barred from filing a rate case during that term. MRPs generate stronger incentives for cost containment, helping utilities to better appreciate the cost-saving potential of DERs.
Non-Wires Alternatives (NWAs) (Source: Navigant Research)	An electricity grid investment or project that uses nontraditional transmission and distribution (T&D) solutions, such as energy storage, to defer or replace the need for specific equipment upgrades by reducing load at a substation or circuit level.
North Carolina Department of Environmental Quality (NC DEQ)	Agency for the protection of North Carolina's environmental resources.
North Carolina Utilities Commission (NCUC)	The North Carolina agency with jurisdiction over public utilities and electric generating facilities.
Performance-Based Regulation (PBR) (Sources: Wood Mackenzie)	A regulatory approach that emphasizes incentives for good performance. It can reduce utilities' incentives to grow their rate base and use of their system and strengthen incentives to use DERs to reduce costs.
PJM Interconnection	A regional transmission organization serving all or parts of 13 states and Washington D.C. Membership includes Dominion Energy North Carolina.
R&D	Research and Development.
Ramp Control (Ramp Rate Control)	Slowing down ramp rates of renewable power generation plants such as wind or solar.
Regional Transmission Organization (RTO)	See, Independent System Operator (ISO).

Term	Definition
Renewable Energy and Energy Efficiency Portfolio Standard (REPS)	A law that requires investor-owned utilities in North Carolina to meet up to 12.5% of their energy needs through renewable energy resources or energy efficiency measures by 2021. See, N.C.G.S. § 62-133.8.
Renewable Portfolio Standards (RPS) (Source: EIA)	Policies that require or encourage electricity suppliers to provide their customers with a stated minimum share of electricity from eligible renewable resources.
Resiliency	An electrical system's ability to maintain critical infrastructure and services despite adverse events and chronic stressors. Most renewable energy systems do not require inputs of fuel and therefore supply will not be disrupted by adverse conditions affecting roads or pipelines.
Resource Adequacy (Source: bpa.gov)	Ability to meet consumers' energy needs.
Roundtrip Efficiency (Source: Energy Sage)	A system-level metric that compares the units of electricity you'll get out of a battery for every unit of electricity you put into it.
Smart Grid Technologies	Technologies (power meters, voltage sensors, fault detectors, and more) characterized by an ability for two-way communication between the device and power supplier to help automate and modernize the electricity grid.
Stationary Battery Storage	Immobile electrochemical cells that collect energy when supply is high and dispense energy when supply is low; like conventional lead-acid batteries, these cells store chemical energy, which is converted into electrical energy through a series of oxidation reactions.
Supervisory Control and Aata Acquisition (SCADA) (Source: All About Circuits)	An automation control system that is used in industries such as energy to help with distribution monitoring and data gathering. It works by operating with signals that communicate via channels to provide the user with remote controls of any equipment in a given system.
T&D Upgrade Deferral (Source: ESA)	The process of deferring or avoiding the need to upgrade electrical transmission and distribution (T&D) equipment or extending the life of existing T&D equipment.
Transmission Grid (Source: Volts)	The high-voltage power lines that carry electricity over longer distances.
Virtual Power Plant (VPP) (Source: Next Kraftwerke)	A network of decentralized, medium-scale power generating units, flexible power consumers, and storage systems that help its participants monitor, forecast, optimize, and dispatch their energy generation or consumption.
Voltage Support	Maintenance of a constant voltage level by electric generators, capacitors, or batteries.