NORTH CAROLINA
Environmental Quality

North Carolina Energy Security Plan

May 2025 - DRAFT

Note from North Carolina's State Energy Office Director

North Carolina's (NC) energy system is the underpinning of our state's economy and our community members' health and safety. It fuels our transportation and ability to get from work to our homes. It allows our hospitals and health systems to provide people with critical treatment. It supports our commerce and trade from our ports to our businesses and grocery stores. It allows people to enjoy our state, visiting our cities, beautiful beaches, and rolling mountains in the West. It enables our children to live healthy lives, grow, and learn and supports our thriving higher education and research institutions.

Our over 100 utilities, investor-owned utilities (IOUs) and university-owned utilities, electric membership corporations (EMCs or "co-ops"), and municipally owned electric utilities (MOUs) provide power across NC. These entities manage complex supply chains and infrastructure to generate, transmit, and distribute energy. And, minimizing and preventing disruptions and negative impacts to this complex system is paramount for NC to continue to thrive.

The NC Energy Security Plan (ESP) was comprehensively updated to align with federal mandates outlined in the 2021 Infrastructure Investment and Jobs Act (IIJA), which directed states to develop robust ESPs to enhance energy resilience and security. The ESP was revived from an earlier federal mandate, the Energy Assurance Plan (EAP) initiative in 2009, which provided funding to states to develop similar strategies surrounding preparation and planning, mitigation and response, and education and outreach.

This plan provides an assessment of the key threats, vulnerabilities, consequences, and risks that the state's energy system faces today and will likely continue to face in the near future. These include severe weather, cybersecurity, aging infrastructure, supply interdependencies, and physical attack risks. This plan also provides mitigation strategies that can reduce the severity or prevent a threat from occurring, such as microgrid deployment, strengthening infrastructure to mitigate severe storm damage, adopting cybersecurity protocols, diversifying generation resources, and installing advanced grid-enhancing technologies. These strategies draw from the state's existing efforts, such as the Climate Risk Assessment and Resilience Plan, the Clean Energy Plan, and broader energy resilience frameworks, while addressing gaps and emerging threats.

We acknowledge that the responsibility to mitigate these threats largely falls in the hands of the utilities, but the State will continue to play an important role in facilitating statewide planning and collaboration to shore up and secure the state's energy system. This plan outlines how the State can do that.

We hope that this plan is used as a foundation for greater collaboration between all of the state's energy stakeholders to create a more secure, reliable, and resilient energy system for our home state.

Julie Woosley
Director
State Energy Office

Executive Summary

NC's energy system faces a set of multifaceted challenges that threaten its reliability, affordability, and resilience. Dependence on imported fossil fuels, aging infrastructure, growing energy demand, and vulnerability to natural disasters like hurricanes and floods highlight the urgent need for strategic solutions to secure the state's energy future. While advancements in renewable energy, electrification, and emerging technologies offer opportunities, policy and regulatory uncertainties at both state and federal levels complicate long-term planning and investment in robust energy infrastructure.

The Energy Security Plan (ESP) evaluates threats and vulnerabilities, identifying critical risk areas in the state, with the mitigation assessment offering targeted, cost-effective recommendations to address them. Natural threats, particularly severe storms and flooding, pose the highest risk due to their likelihood and potential to cause widespread damage and prolonged disruptions. Human-caused threats such as cybersecurity and misinformation also pose a significant risk, with the growing sophistication of cyber-attacks on critical infrastructure compounded by the rapid spread of misinformation, which can erode public trust and disrupt effective response efforts. The vulnerability of aging infrastructure exacerbates these risks as outdated systems are less resilient to both natural and human-induced disruptions. A unified planning and response process is critical to NC's energy security, ensuring coordinated efforts to address vulnerabilities and enhance system reliability.

To address these threats and vulnerabilities, a comprehensive mitigation strategy is proposed, focusing on infrastructure modernization, enhanced cybersecurity measures, combatting misinformation, stakeholder and policy collaboration, demand/supply side strategies, and workforce development. Key recommendations include elevating/hardening distribution and substation equipment, upgrading transmission systems, diversifying energy sources through utility-scale renewables, integrating technologies such as Battery Energy Storage Systems (BESS) or Long Duration Energy Storage (LDES), debunking misinformation, deploying microgrids or backup generation at critical facilities, and expanding access to natural gas and liquid fuel import pipelines. Addressing policy and regulatory uncertainty through stable and supportive policies will also be crucial in attracting investment and facilitating the transition to a more sustainable energy system. Proactive planning is essential to ensure affordable, accessible, and reliable electricity, liquid fuels, and natural gas markets.

Implementing these strategies will bolster the resilience and reliability of NC's energy system, minimizing the economic and social toll of energy disruptions. By preventing or limiting the length of power outages, businesses avoid costly downtime, and residents maintain access to essential services. Resilient infrastructure will also enhance public safety, ensuring critical facilities like hospitals remain operational during crises, ultimately reducing mortality rates during extreme weather events.

A mix of mitigation strategies should be considered to improve the NC's energy security as no single intervention will address all potential threats and vulnerabilities. In *Section 7: Risk Mitigation Assessment*, these mitigation strategies have been identified to effectively address the state's most immediate threats. Mitigation strategies include:

- **Regulations and Policies**
    - Update zoning and subdivision codes to support the development of resilient energy infrastructure.

  - Implement floodplain planning tools and management approaches that protect critical energy facilities from flood risks.
  - Strengthen building codes to ensure that new construction and retrofits are designed to withstand extreme weather events and other threats.
- **Programs**
  - Invest in capacity-building programs through grants, subsidies, public-private initiatives, and collaborative partnerships to enhance the skills and knowledge of stakeholders involved in energy security.
  - Continued State investment in energy security planning and risk mitigation.
  - Pursue land acquisition initiatives to secure strategic locations for energy infrastructure and backup generation systems.
  - Support low-income housing programs that incorporate energy-efficient and resilient design principles.
- **Long-Term Planning**
  - Develop comprehensive community plans that integrate energy assurance and resilience measures.
  - Develop comprehensive threat mitigation plans to proactively identify and address potential risks to energy infrastructure.
  - Create watershed plans that consider the impact of water resources on energy generation and distribution.
  - Conduct further integrated planning between NC's energy ecosystem partners (e.g., state and local governments and utilities).
- **Capital Projects**
  - Prioritize capital improvement projects (i.e. transmission/distribution upgrades, building new utility-scale renewable energy, energy storage and microgrids) that enhance the robustness and reliability of the energy grid.
  - Implement decentralized backup energy generation systems at critical facilities to support continuous operation during outages.
  - Design and construct passive stormwater management systems to mitigate the impact of severe weather on energy infrastructure.

The North Carolina Department of Environmental Quality (NCDEQ) aims to update the ESP on a regular basis. This regular update will incorporate new and evolving threats, vulnerabilities, and mitigation strategies, thereby keeping the state's ESP relevant and robust in the face of changing conditions. Central to this effort is the continuous refinement of the threats, vulnerabilities, and risk matrix detailed in *Sections 4 through7*. A dynamic risk matrix serves as a critical tool for assessing risks at both state and county levels, empowering precise, prioritized, data-driven mitigation strategies. By consistently refining and enhancing this matrix, NCDEQ can help NC energy systems remains resilient, adaptable, affordable, and capable of meeting evolving challenges with robust, forward-thinking solutions.

Collaboration with a diverse range of stakeholders is essential to enrich the ESP's assessments and mitigation approaches. By actively seeking input on threats, vulnerabilities, and risk evaluations, the ESP reflects comprehensive perspectives and works to address the needs of relevant parties, strengthening the effectiveness of the state's energy security initiatives.

To prepare for inevitable emergencies, NC State government can adopt a robust planning process to minimize damage and ensure swift recovery. By implementing these strategies, NC can maintain a proactive and adaptive approach to energy security, helping infrastructure remain resilient against emerging risks. This plan will help secure a robust, affordable, and sustainable energy system, driving economic growth, improving public safety, and enhancing the quality of life for NC's residents and businesses.

Introduction

NCDEQ prepared the 2025 NC ESP with input from the NC Office of Recovery and Resiliency (NCORR) and NC Department of Public Safety (NCDPS). The NC ESP provides a comprehensive overview of the state's energy infrastructure, identifies threats and vulnerabilities that could lead to disruptions to energy security, and proposes mitigation measures that the state and its partners can implement to reduce these risks.

NC's energy systems are foundational to its economy and public well-being, powering industries like manufacturing and agriculture, and sustaining essential services such as healthcare and emergency response. This comprehensive plan profiles the state's energy infrastructure—spanning electricity, liquid fuels, and natural gas—quantifies critical threats and vulnerabilities, and outlines targeted mitigation strategies to safeguard energy security.

Recent events illustrate the increasing threats and vulnerabilities to the NC energy system: Hurricane Helene in 2024 disrupted power for over 1 million customers and inflicted more than $59 billion in damages, with widespread devastation to the western part of the state, including extended loss in communications, water, and wastewater services due to power outages. Winter Storm Elliott in 2022 caused 500,000 outages amid natural gas shortages and extreme peak demands. Physical and cyber related attacks on energy infrastructure, such as the substation attack in Moore County, can lead to eroded confidence in public safety.

Maintaining a secure energy system is a challenge; the abundant number of smaller Electric Membership Cooperations (EMCs) and MOUs in NC may lack the resources to recover without external support or raising rates on members and customers. With a unified statewide strategy to enhance energy security NC can bolster readiness for emerging risks, improve resilience against future disruptions, accelerate recovery timelines, keep energy costs affordable, and help safeguard a sustainable future for North Carolinians.

Document Objective and Intended Audience

The intended audience of the ESP is the entities engaged in energy planning, generation, distribution, emergency response, and those with a stake in a secure energy future for NC including, NC utilities, state and local government leaders, and emergency responders. NCDEQ's objective is to align these entities around a set of priorities to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from power disruptions through adaptable and holistic planning and technical solutions.

Document Structure

This ESP is structured into three parts.

- **Part I, State Energy Profile**: *Section 1: Energy Landscape & Interdependencies* which provides an overview of the state's energy profile, including key sources of energy and key entities who manage generation, procurement, and supply of that energy across the state; *Section 2: Energy Infrastructure and Cross-Sector Interdependencies* which provides interdependencies between the energy sector and other critical sectors; *Section 3: Energy Emergency Preparedness and Response* which details the state's current emergency response structure for energy emergencies.

- **Part II, Hazards, Threats, Vulnerabilities, and Consequences**: *Section 4: Energy Sector Threats and Impacts* which assesses key threats to NC energy systems and the impacts of those threats; *Section 5: Vulnerability and Severity Assessment* which evaluates the severity of vulnerable parts of NC energy systems; *Section 6: Risk Assessment* integrates the threats and vulnerabilities to deliver a comprehensive energy system risk analysis.
- **Part III, Risk Mitigation and Coordination.**: *Section 7: Risk Mitigation Assessment* & *Section 8: Risk Mitigation Descriptions and Case Studies* which evaluate and identify optimal mitigation strategies to strengthen the state's energy security.

While Part I is foundational, Part II and Part III should be updated periodically to reflect emerging threats and mitigation strategies based on the evolving energy landscape in NC and beyond.

Energy Security Definition and Methodology

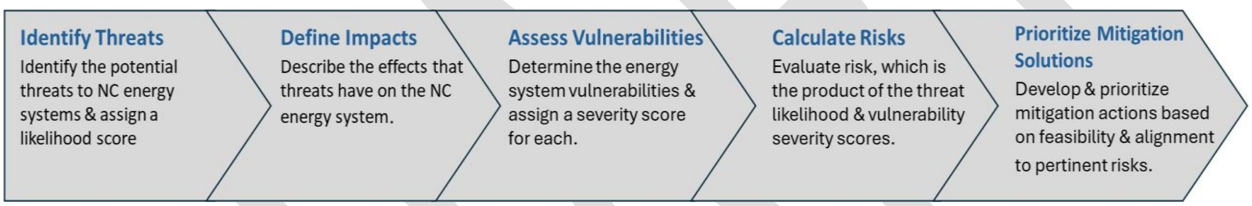
Energy security is the state's ability to support a reliable, affordable, and resilient supply of energy to its customers, while mitigating various risks including extreme weather, aging/failing infrastructure, supply chain disruptions, and cyber-attacks, through a balanced mix of local generation, diversified fuel sources, and advanced grid technologies. The major themes associated with energy security that are addressed in the ESP are:

- **Reliability:** consistent and uninterrupted delivery of electricity to meet demand across all sectors—residential, commercial, and industrial—under normal and stressed conditions, achieved through robust infrastructure, adequate generation capacity, and proactive maintenance to minimize service disruptions.
- **Affordability:** capacity of an energy system to provide electricity at costs that remain accessible to all consumers, balancing the expenses of infrastructure upgrades, fuel procurement, and technological innovation with equitable rate structures to avoid undue financial strain on households and businesses.
- **Resilience:** energy system's ability to withstand, adapt to, and rapidly recover from disruptive events—natural disasters, cyberattacks, or equipment failures—by leveraging flexible resources, decentralized generation, and adaptive strategies to maintain critical functions and minimize downtime.
- **Diversification:** operating a varied portfolio of energy sources and technologies—fossil fuels, renewables, nuclear, storage—to reduce dependency on any single resource, mitigate supply risks, and enhance adaptability to market, environmental, or geopolitical shifts.
- **Risk Mitigation:** identifying, assessing, and reducing vulnerabilities in the energy supply chain, infrastructure, and operations—whether from physical threats, cybersecurity breaches, economic volatility, or environmental hazards—through strategic planning, technological upgrades, and contingency measures.

The methodology for assessing risk includes determining the key threats and vulnerabilities to the NC energy system helps determine the prioritized risks. The prioritized risk rankings facilitate the proposed mitigation strategies and targets the highest value NC risks in a cost/time effective manner. The Department of Energy (DOE) defines several of the ESP's themes as per the following:

- **Threat:** anything that can damage, destroy, or disrupt energy systems, including natural, technological, or human caused.
    - **Threat Impact:** effect of the loss or degradation of an energy infrastructure system or asset, including the "immediate or "direct impact" and subsequent "indirect impact."
    - **Threat Likelihood:** probability that a threat will occur in the future.
- **Vulnerability**: a weakness within infrastructure, processes, and systems, or the degree of susceptibility to various threats.
    - **Vulnerability Severity**: the magnitude or extent to which each vulnerability could negatively impact the energy sector if it were to occur.
- **Risk**: the potential for loss, damage, or destruction of key resources or power system assets resulting from exposure to a threat.

The figure below depicts the methodology applied in the plan, designed to help NC identify threats and impacts, assess vulnerabilities, calculate risks, and develop mitigation strategies which are tailored to the state's needs.



Section 4.1 ***Section 4.2*** ***Section 5*** ***Section 6*** ***Section 7***

The 2025 NC ESP underscores the critical role of collaboration among utilities, government leaders, and emergency responders to safeguard the state's energy future against a set of evolving risks. Understanding the foundational elements of NC's energy profile is essential for appreciating the context in which the risk assessment and mitigation strategies are developed. The following section provides a comprehensive overview of the state's energy infrastructure, key sources of energy, and the entities responsible for managing generation, procurement, and supply. The energy profile lays the foundation for analyzing interdependencies, threats, vulnerabilities, and risks, guiding a relevant and effective energy security strategy tailored to NC's unique challenges.

Acronyms

AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
AWS	Amazon Web Services
BCF	Billion Cubic Feet
BESS	Battery Energy Storage Systems
BSEE	Bureau of Safety and Environmental Enforcement
CBP	Customs and Border Protection
CDC	Centers for Disease Control and Prevention
CESER	Office of Cybersecurity, Energy Security, and Emergency Response
CFVMC	Cape Fear Valley Medical Center
CISA	Cybersecurity and Infrastructure Security Agency
CO	Carbon Monoxide
CO2	Carbon Dioxide
CIPAC	Critical Infrastructure Partnership Advisory Council
DAQ	Division of Air Quality
DEC	Duke Energy Carolinas
DEP	Duke Energy Progress
DER	Distributed Energy Resource
DF	Demand Flexibility
DLR	Dynamic Line Rating
DOE	Department of Energy
DOT	Department of Transportation
DR	Demand Response
DSM	Demand Side Management
EA	Office of Enterprise Assessments
EAL	Expected Annual Loss
EE	Energy Efficiency
EIA	Energy Information Administration
EMC	Electric Membership Corporation
ENRD	Energy and Natural Resources Division
EO	Executive Order
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
EPC	Energy Policy Council
ESF	Emergency Support Function
ESP	Energy Security Plan
EV	Electric Vehicle
EEWG	Energy Emergency Working Group
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FMCSA	Federal Motor Carrier Safety Administration
GCC	Government Coordinating Council
GIS	Geographic Information System
GRIP	Grid Resilience and Innovation Partnerships

GW	Gigawatt
HB	House Bill
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Interruption Cost Estimate
ICS	Incident Command System
IIJA	Infrastructure Investment and Jobs Act
IOU	Investor-Owned Utility
IRA	Inflation Reduction Act
IRP	Integrated Resource Plan
IRS	Internal Revenue Service
ISAC	Information Sharing and Analysis Center
IT	Information Technology
JIC	Joint Information Center
LDC	Local Distribution Company
LDES	Long Duration Energy System
LNG	Liquefied Natural Gas
MDA	Mississippi Development Authority
ML	Machine Learning
MOU	Municipally Owned Utility
MW	Megawatt
MWh	Megawatt-Hour
NASEO	National Association of State Energy Offices
NC	North Carolina
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCDPS	North Carolina Department of Public Safety
NCEOP	North Carolina Emergency Operation Plan
NCEM	North Carolina Emergency Management
NCESF-12	North Carolina Emergency Support Function 12
NCNG	North Carolina National Guard
NCPCM	North Carolina Petroleum & Convenience Marketers
NCUC	North Carolina Utilities Commission
NCORR	North Carolina Office of Recovery and Resiliency
NERC	North American Electric Reliability Corporation
NIMS	National Incident Management System
NIPP	National Infrastructure Protection Plan
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NRI	National Risk Index
NTP	National Transmission Planning
NYISO	New York Independent System Operator
ODNI	Office of the Director of National Intelligence
OE	Office of Electricity
OEP	Office of Energy Programs
OSBM	Office of State Budget & Management
OT	Operational Technology

PHMSA	Pipeline and Hazardous Materials Safety Administration
RFG	Reformulated Gasoline
ROW	Right-of-Way
RRC	Railroad Commission
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SC	South Carolina
SCC	Sector Coordinating Council
SEO	State Energy Office
SERT	State Emergency Response Team
SIS	Safety Instrumented System
SHP	State Highway Patrol
SLTT	State, Local, Tribal, and Territorial
SMART-POWER	Southeast and Mid-Atlantic Regional Transformative Partnership for Offshore Wind Energy Resources
SRPSC	Southeast Regional Petroleum Shortage Collaborative
TDEC	Tennessee Department of Environment and Conservation
TSA	Transportation Security Administration
TTX	Tabletop Exercise
TOU	Time of Use
TVA	Threat and Vulnerability Assessment
TWIC	Transportation Worker Identification Credential
US	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
WAP	Weatherization Assistance Program

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PART ONE: State Energy Profile

1. Energy Landscape & Interdependencies

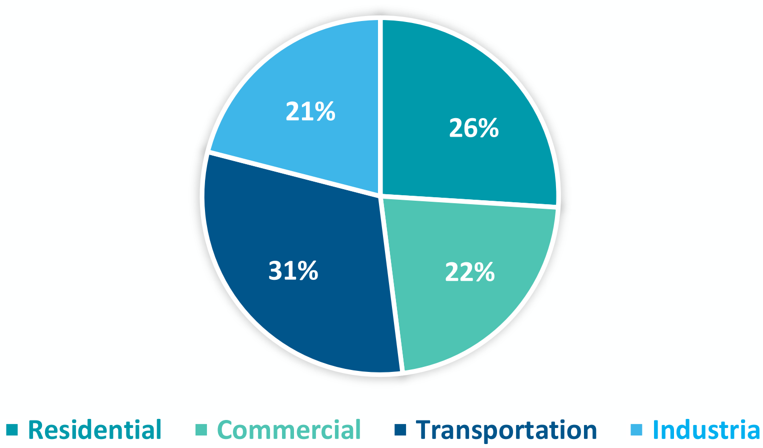
This section provides an overview of the state's energy profile, encompassing electricity, natural gas, and liquid fuels, while also addressing the specific energy dynamics on tribal lands, all within the framework of enhancing state energy security.

1.1. State Energy Profile

NC's energy profile reflects a mix of electricity, natural gas, and liquid fuels, shaped by its diverse geography, growing population, and evolving energy policies. Overall, the state's primary energy mix is reliant on fossil-fuel imports for end-uses such as power generation and transportation; however, current trends indicate a shift towards more renewable energy (i.e., solar) and electrification through efforts such as vehicle electrification, presenting the state with new risks and opportunities to advance the reliability and sustainability of the NC energy sector. The state relies heavily on natural gas and nuclear power, followed by coal for electricity production. Renewable electricity sources, particularly solar power, have seen substantial growth in recent years, making NC one of the leading states in installed solar energy capacity. The natural gas sector consists of extensive pipeline networks that facilitate the distribution of gas throughout the state, supporting residential and industrial needs, along with power generation. In terms of liquid fuels, the state's market is driven by transportation demands, with a well-established network of distribution channels ensuring a steady supply of gasoline and diesel, despite no local reserves.

NC ranked 35th in overall energy consumption in the United States (US) in 2022 with roughly 2,568 trillion British thermal units (BTU) consumed, however NC consumes four times more energy than it produces given the lack of in-state natural gas and liquid fuel production (NC State Energy Profile, 2024). The residents, tourists, and truckers who use motor gasoline and diesel fuel on the state's heavily traveled highway system and the jet fuel consumed at the busy Charlotte Douglas International Airport—one of the top 10 US airports as ranked by passenger traffic—make the transportation sector NC's largest end-use energy-consumer, accounting for three-tenths of the state's total energy consumption (NC State Energy Profile, 2024). The figure below shows the US Energy Information Administration's (EIA) reported percent breakdown of energy consumption by end-use sector in 2022.

Figure 1: 2022 Energy Consumption by End-Use (%)



Source: EIA

NC is the top US producer of tobacco, sweet potatoes, poultry and eggs, and the third top producer of pork, making agriculture one of the state's major industries (NC State Energy Profile, 2024). The state's other key industries include business and financial services; aerospace; auto and truck manufacturing; biotechnology and pharmaceuticals; food processing; furniture manufacturing; information technology (IT); plastics and chemicals; and textiles. About 13% of the state's Gross Domestic Product (GDP) comes from manufacturing, with key energy-intensive industries such as chemical manufacturing; food and beverage, and tobacco products industry; computer and electronics products sector; and petroleum and coal products (NC State Energy Profile, 2024). Energy-intensive manufacturing is projected to rise sharply with the evolution of technologies such as Artificial Intelligence (AI), as highlighted in *Section 4: Energy Sector Threats and Impacts*. As this demand intensifies, proactive strategies will be critical to address the associated challenges and maintain a robust energy system. Implementing planning measures to help ensure that electricity, liquid fuels, and natural gas markets remain affordable, accessible, resilient, and reliable will enhance the future well-being of North Carolinians and therefore sets the stage for a detailed examination of each sector in the sections that follow.

1.1.1. Electricity Overview

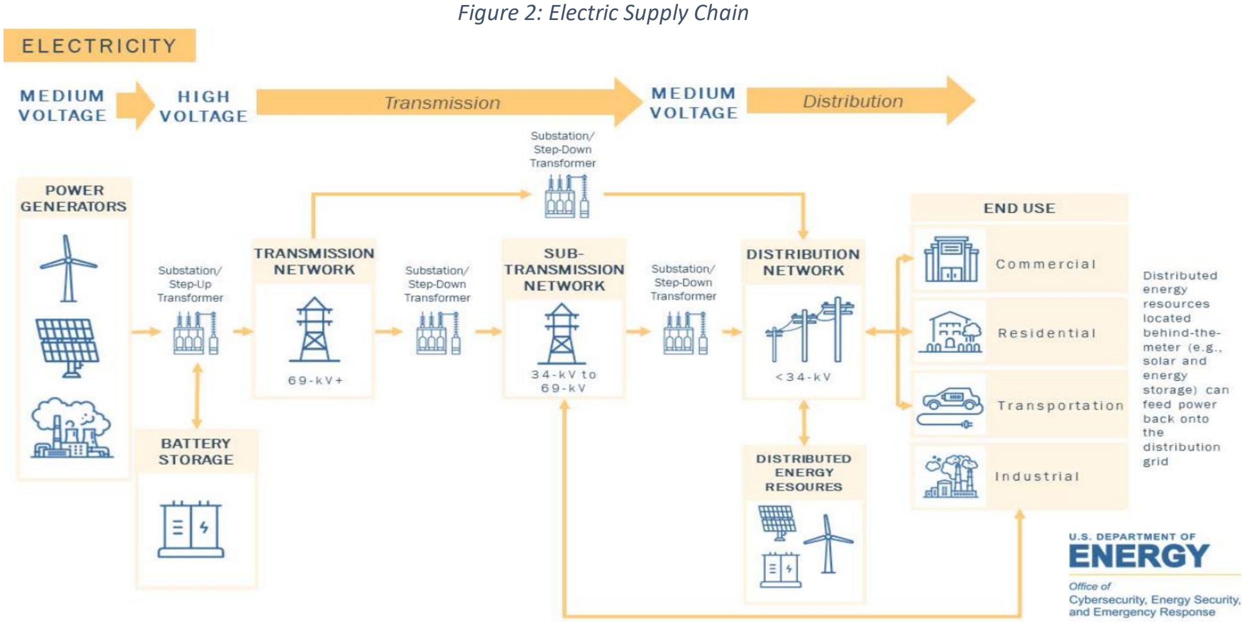
The electricity supply chain consists of generation facilities, a network of bulk power transmission lines, and a distribution network to connect end customers to the bulk power grid.[1] The transmission system was originally built to transmit electricity from large baseload (coal/gas) plants to large groups of nearby users. The electric grid is becoming more bidirectional and distributed as advancements in renewable energy, energy storage, and smart grid technologies enable consumers to both draw power from and supply excess electricity back to the grid. These trends decentralize traditional energy systems requiring updates to the grid infrastructure that are discussed further in *Section 4: Energy Sector Threats and Impacts* and *Section 5: Vulnerability and Severity Assessment*.

The general electricity supply chain components are represented in the bullets and figure below:

- **Generation:** Electricity is produced at power plants using various energy sources like coal, natural gas, nuclear, hydropower, wind, or solar. These facilities convert raw energy into electrical power.
- **Transmission:** High-voltage electricity is sent from power plants over long distances through a network of transmission lines and substations. Transformers step up the voltage to reduce energy loss during transport.
- **Distribution:** Once closer to end users, the voltage is stepped down at substations and distributed through a local grid of power lines, poles, and transformers to homes, businesses, and industries.
- **Retail/Consumption:** Utilities or energy providers manage the distribution, final delivery, and billing to consumers, who use electricity for lighting, heating, appliances, and more.

[1] The generating resources and high-voltage transmission equipment that make up the backbone of the US electricity grid constitute the bulk power system.

Figure 2: Electric Supply Chain



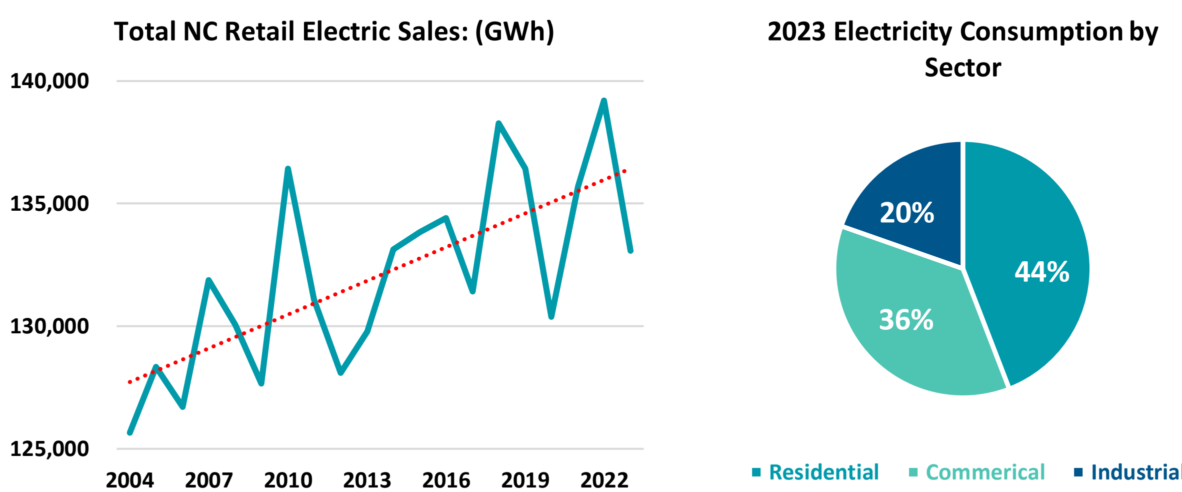
Source: Office of Cybersecurity, Energy Security, and Emergency Response (CESER)

As the electricity supply chain evolves with advancements in renewable energy, energy storage, and smart grid technologies, the need for updates to grid infrastructure becomes increasingly critical, ensuring a resilient and efficient energy system for the future, and is explored more in *Section 8.1: Proactive Mitigation Measures*.

Consumption

Electricity demand has been trending higher in NC driven by population growth, widespread electrification, the expansion of data centers, and the increasing adoption of electric vehicles (EVs). In 2023, NC ranked among the top 10 states in total electricity consumption and ranked fourth for residential sector electricity use (NC State Energy Profile, 2024).

Figure 3: Total NC Electric Sales (2004-2023) & 2023 Electricity Consumption by Sector



Source: EIA

The residential sector accounts for 44% of the total electricity end use in NC. Almost 7 out of 10 NC households use electricity for home heating and 9 out of 10 households have air conditioning. The commercial sector makes up 36% of the state's electricity use and the industrial sector accounts for about 20%. The figures above show the total annual NC retail electric sales since 2004, and the 2023 electricity consumption by end-use sector.

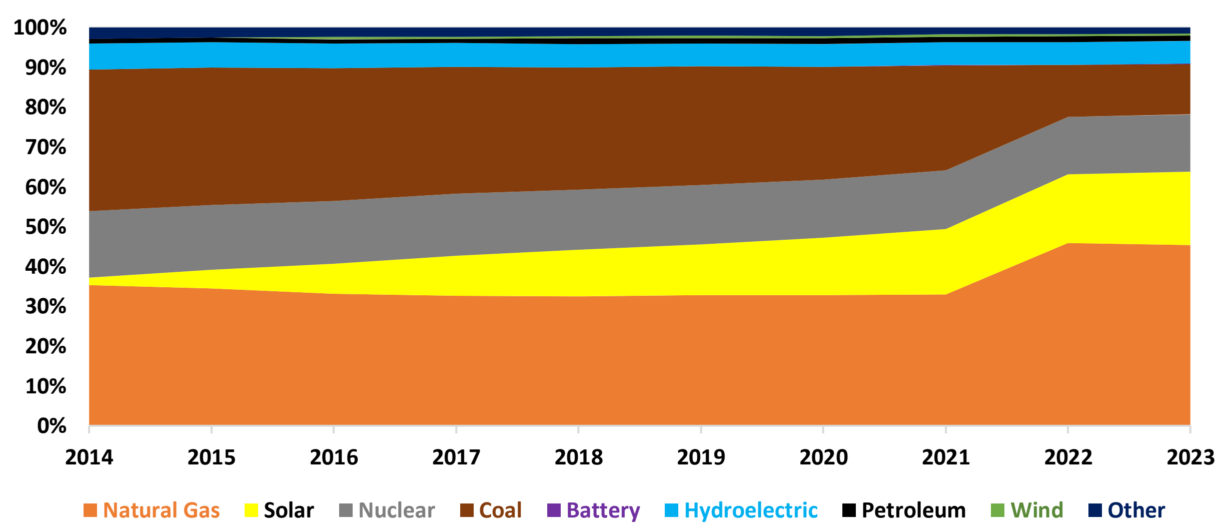
As electricity demand continues to rise in NC, ensuring a reliable and affordable energy supply becomes paramount to support the state's expanding residential, commercial, and industrial sectors.

Supply

The state's power generation mix has shifted from 2014-2023. Installed capacity in power generation refers to the maximum amount of electricity a power plant or generating station can produce under ideal conditions, essentially representing the total potential power output of the facility, typically measured in megawatts (MW) and considered the "nameplate capacity" of the plant; it is the capacity available at the time of installation, not necessarily the actual power generated which can be affected by factors like weather or maintenance needs. For example, NC has more installed solar capacity than nuclear and coal in 2023, however the total 2023 solar generation output was less than the individual nuclear and coal generation.

NC added a net total (capacity additions – capacity retirements) of roughly 5 gigawatts (GW) of installed capacity from 2014-2023. The most significant decline in NC's energy capacity occurred in coal-fired generation, in which planned retirements decreased the capacity by 6.2 GW, representing a 23% reduction in its share of total capacity. Meanwhile, natural gas and solar saw the largest gains, with natural gas adding 5.5 GW (a 10% increase in share) and solar expanding by 5.9 GW (a 17% increase in share), reflecting a notable shift in the state's energy mix. NC ranked fifth in the nation in solar generating capacity, with over 9.6GW of solar installed at the end of 2024. Continuing the increase in diversification of generation assets will be a crucial step for maintaining a secure and reliable supply of energy, which is highlighted throughout the Plan. The figure below shows total percentage of the utility-scale installed capacity by fuel type over from 2014-2023.

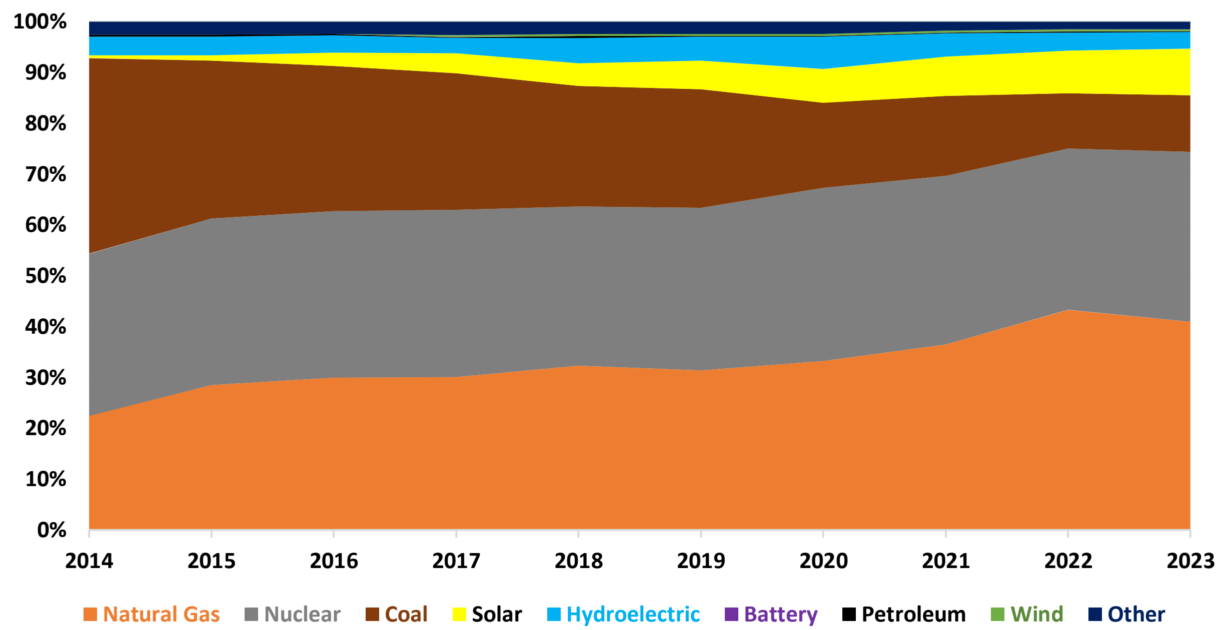
Figure 4: NC Installed Capacity by Fuel Type (%)



Source: EIA

In parallel with the change in installed capacity, the electric generation by fuel type has changed from 2014-2023. Historically, NC generated most of its electricity from coal-fired resources; however, natural gas has taken over as the highest share of generation within the state. Natural gas and solar generation have had the largest increase in generation share from 2014-2023, with 18% and 8% increases, respectively. While coal-fired generation lost the most generation share, with a 27% decrease during that same period. Nuclear generation remained between 31%-34%, and hydro remained 3%-6% of NC's total share from 2014-2023. The figure below reflects the generation percentage by fuel from 2014-2023.

Figure 5: NC Generation by Fuel Type (%)



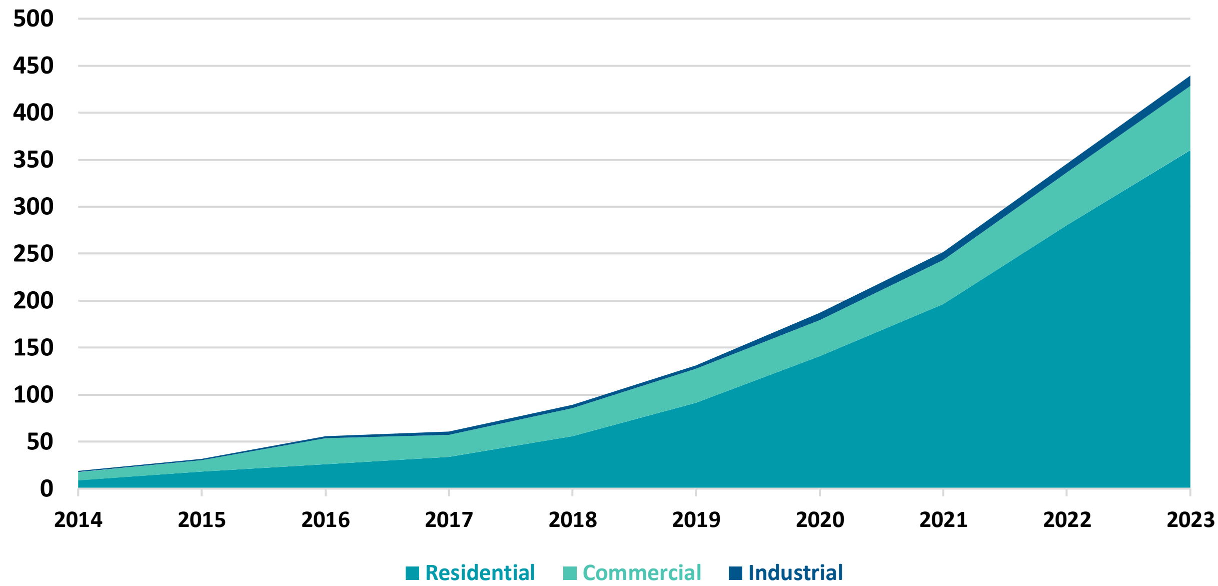
Source: EIA

As demonstrated in the figure below, distributed solar generation within NC has increased 96% from 2014-2023, with the biggest increase from the residential sector[2] (NC State Energy Profile, 2024). Distributed solar capacity in NC has increased due to a combination of supportive policies, economic incentives, technological advancements. Net metering is an example of a supportive policy that helps customers who generate their own electricity from renewable energy resources receive a credit on their electric utility bill for any extra electricity produced by the customer that flows back onto the electric utility's distribution system. State law (N.C. Gen. Stat. 62-126.4) that mandated IOUs, Duke Energy Progress (DEP), Duke Energy Carolinas (DEC), and Dominion Energy North Carolina, to offer net metering to their solar customers helped drive distributed solar growth. However, effective October 2023, the new NCUC net metering rules may impede additional growth of distributed solar in NC. The rule changes include replacing full retail credits with lower avoided cost rates, imposing grid access fees, and introducing minimum bills. These adjustments reduce financial incentives, making solar installations less economically viable for both residential and nonresidential customers. Other programs such as Solar for All, explored further in *Section*

[2] Distributed generation solar refers to generating electricity from solar panels on a smaller, decentralized scale, often on rooftops or at individual sites, rather than large, centralized (utility-scale) power plants.

8: Risk Mitigation Descriptions and Case Studies, create financial incentives to increase the rooftop solar capacity within NC, helping NC diversify and increase overall energy capacity within the state.

Figure 6: NC Distributed Solar Generation by Sector (MW)



Source: EIA

The table below shows the top ten generating units by generation in 2023. Nuclear generation remains an integral asset, providing NC with carbon-free electricity; the resource also stands as the top three generating units in the fleet.

Figure 7: The Highest Generation Power Plants, 2023 (megawatt-hour (MWh))

Plant Name	Fuel Type	Operating Company	Generation (MWh)
McGuire Nuclear Station	Nuclear	DEC	18,068,372
Brunswick Nuclear Plant	Nuclear	DEC	15,658,076
Harris Nuclear Plant	Nuclear	DEC	8,609,278
Smith Energy Complex	Natural Gas	DEP	8,597,617
Belews Creek Steam Station	Natural Gas	DEC	8,487,941
Marshall Steam Station	Coal	DEC	6,899,395
H.F. Lee Combined Cycle Plant	Natural Gas	DEP	6,374,630
Rogers Energy Complex (Cliffside Steam Station)	Natural Gas	DEC	5,244,807
Plant Rowan	Natural Gas	Southern Power Co	4,318,637
Roxboro Steam Plant	Coal	DEP	4,040,825

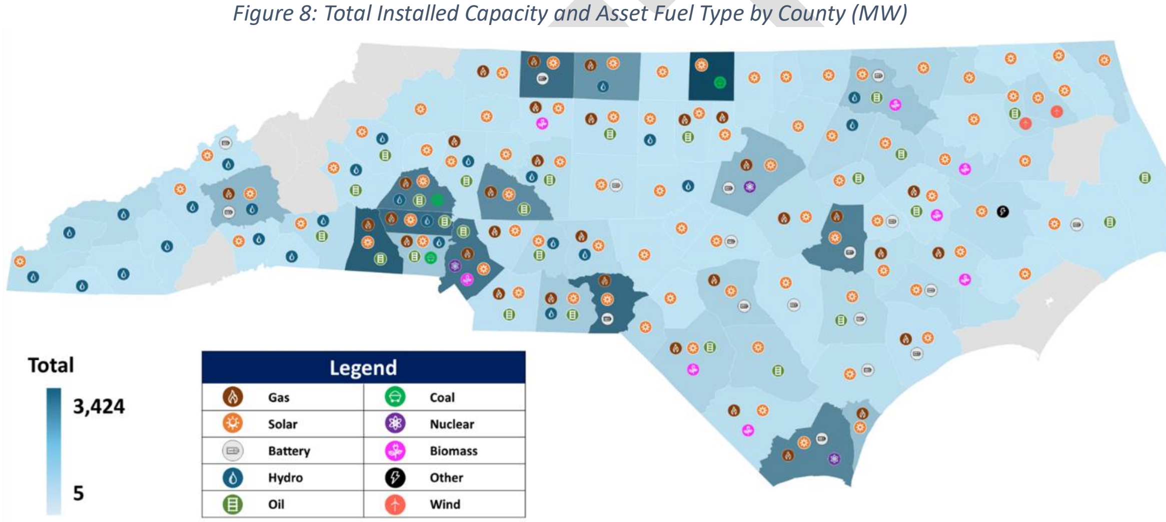
Source: EIA

The figure below shows a map of the generation units within NC. Please note a fuel icon (such as gas, solar, nuclear, etc.) indicates the presence of at least one facility of that type; however, while a county may host multiple generation sources of the same fuel, the map displays only one icon per fuel type per county for simplicity. The state's generation is spread across three distinct regions: the Coastal Plain (east), Piedmont (central), and Mountains (west).

- Nuclear Plants: Centrally located near the densely populated Raleigh region.
- Natural Gas Plants: Spread across central and eastern regions.
- Coal Plants: Scattered, with larger sized ones in the western and central regions.
- Hydroelectric Plants: Predominantly in the western mountainous regions.
- Grid-Scale Solar Farms: Increasingly common in central and eastern regions.
- Biomass Plants: Primarily in the eastern agricultural areas.
- Wind Power: Planned onshore growth and emerging potential in coastal areas.

There is less concentration of plants in the rural western mountain areas. Suppliers may have to rely on fewer, longer distribution lines from distant plants, increasing vulnerability to localized disruptions, which is further addressed in *Section 5: Vulnerability Severity Assessment*.

Figure 8: Total Installed Capacity and Asset Fuel Type by County (MW)



Data Source: EIA 860 (as of 2023)

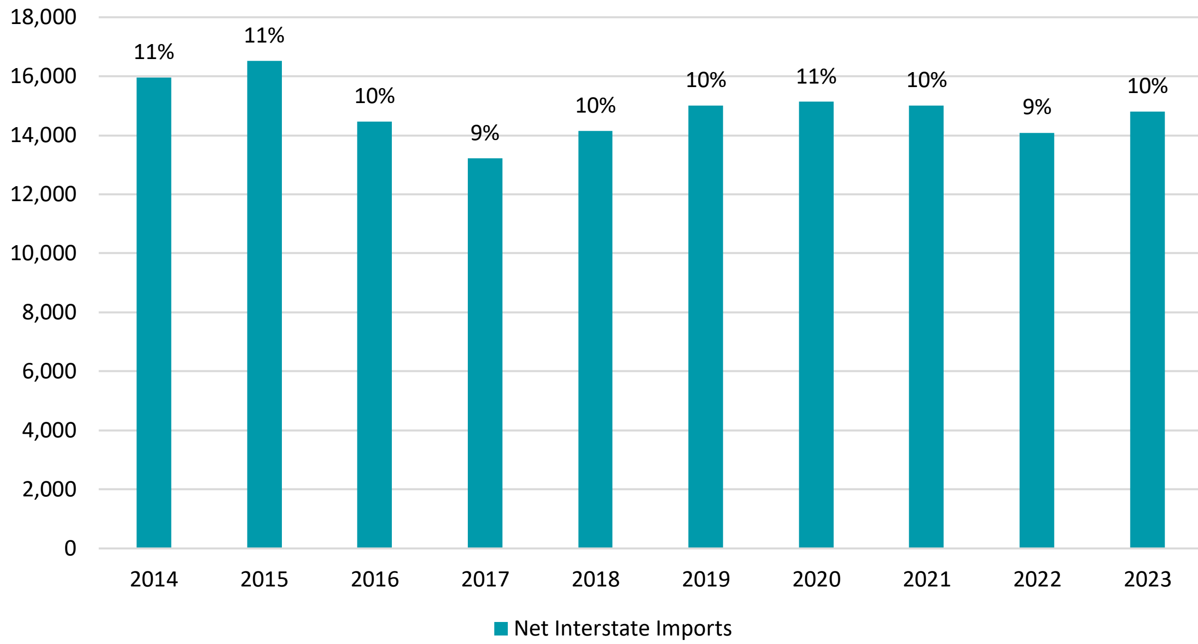
State Imports

NC can import electricity primarily through a network of interstate transmission lines that connect the state to neighboring regions and are typically used during peak demand periods or when local generation is insufficient. NC's electric imports, especially from the Pennsylvania-Jersey-Maryland Interconnection (PJM) grid, are coordinated through a combination of wholesale market purchases, ownership of generating facilities, and cooperative efforts between the North Carolina Electric Membership Corporation (NCEMC) and other utilities, including Duke Energy (North Carolina Electric Cooperatives , n.d.).

Duke Energy operates a single interconnected electric system across the NC and South Carolina (SC) border. The integrated system facilitates seamless energy imports and exports between the two states. This integrated approach helps optimize resource utilization and enhances grid reliability across the region.

The figure below illustrates the annual electricity imports and the percentage of total electricity supply that is imported. NC has imported an average of 10% of electricity over the past decade, highlighting the risk of relying on electric/fuel imports, one of the key vulnerabilities discussed in *Section 5: Vulnerability and Severity Assessment*.

Figure 9: Electricity Imports (GWh) & Total Percent of Electric Supply (%)



Source: EIA

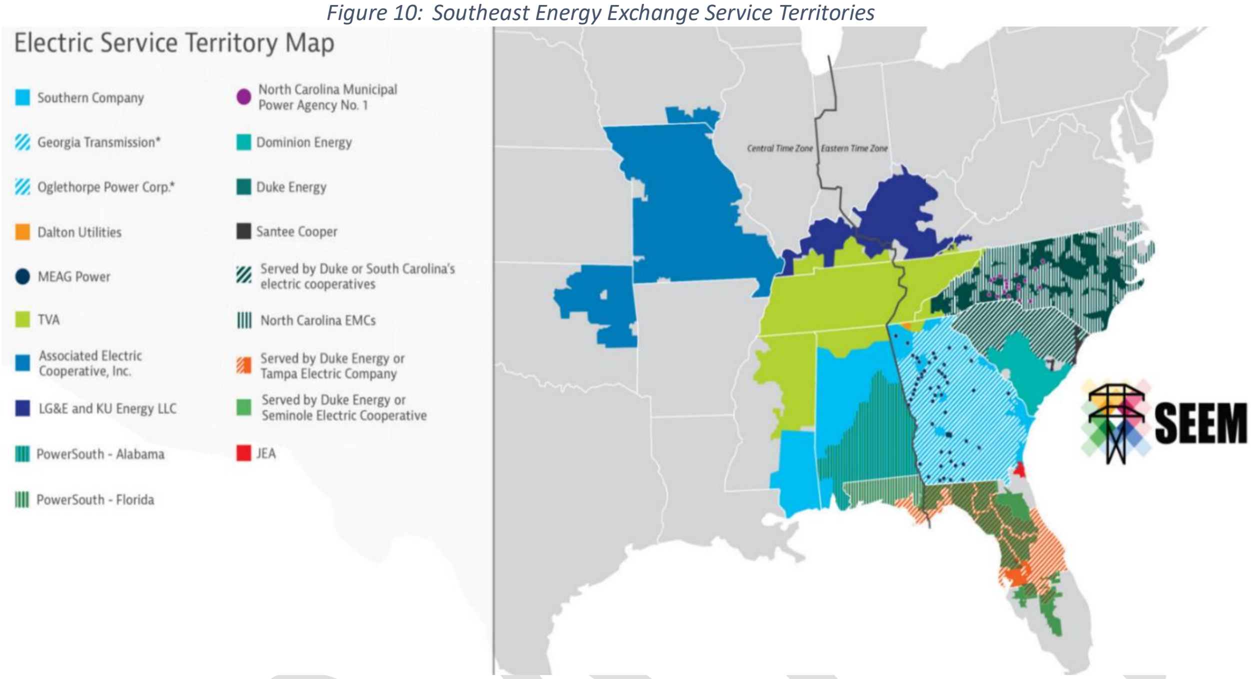
The Southeast Energy Exchange Market (SEEM)

SEEM is a regional energy trading platform launched in November 2022, designed to enhance the existing bilateral market in the southeastern US by enabling automated 15-minute bilateral trades using unreserved transmission capacity. SEEM allows participating utilities to buy and sell power closer to real-time consumption using unreserved transmission capacity, aiming to reduce costs and optimize resource use, including renewables. (Southeast Energy Exchange Market, n.d.) SEEM includes 23 entities, including Duke Energy, Dominion Energy North Carolina, and NCEMC. SEEM territory spans across 12 states, managing over 180,000 MW of summer capacity, and serves approximately 36 million retail customers (Southeast Energy Exchange Market, n.d.). The 2023 monthly trading volumes averaged 80,000 megawatt-hour (MWh) (Southeast Energy Exchange Market, n.d.). In comparison, the Western Energy Imbalance Market[3] which commenced in 2014 and contains 22 members across 11 states, had 1.1 million MWh of traded volumes in June 2024 alone, showcasing the potential size of similar markets (WEIM entities share sizeable energy transfers during Q2 2024, 2024).

The figure below shows the members and electric service territory map of SEEM.

[3] The Western Energy Imbalance Market is a real-time energy market launched in 2014 by the California Independent System Operator and PacifiCorp, enabling participating Balancing Authority Areas in the Western Interconnection to buy and sell power every five minutes to balance supply and demand efficiently. There are 22 members across 11 states that participate.

Figure 10: Southeast Energy Exchange Service Territories



Source: Southeastern Energy Exchange Market

In July 2023, the D.C. Circuit Court ruling found that the Federal Energy Regulatory Commission (FERC) had unlawfully approved SEEM, stating FERC failed to explain how SEEM's exclusive, free transmission service was consistent with FERC's own Open Access Rules for transmission (FERC Order 888[4]). On March 28, 2025, FERC unanimously reaffirmed transmission rules for SEEM (Howland, 2025). FERC rejected claims that SEEM is a "loose power pool" requiring stricter oversight or that it unfairly limits competition, upholding its consistency with open-access requirements under FERC Order 888. FERC dismissed the challengers' arguments, calling SEEM's participant restrictions reasonable, though it mandated tariff changes to allow external participation via pseudo-ties[5]. This addition is intended to expand the number of entities that can take advantage of SEEM, as entities outside the SEEM footprint may participate in the market if they wish to invest in establishing a pseudo-tie (George Cannon, 2025). The FERC decision confirms the continued operation of SEEM.

Given the nascency of SEEM, market improvements have been recommended, as market auditor Potomac Economics reported SEEM performs well within its limited scope, suggesting real-time price transparency and a day-ahead market to enhance efficiency and resource use (Howland, 2025). Currently, the potential NC consumer price benefits are hard to distinguish since SEEM does not publicly report detailed price data in real-time or through regular market reports accessible to the public.

Electric Suppliers

Electric service is provided to consumers in NC by IOUs and university-owned utilities subject to the jurisdiction of the Commission, EMCs, and MOUs (NCUC, 2024). The three IOUs within NC are DEC, DEP,

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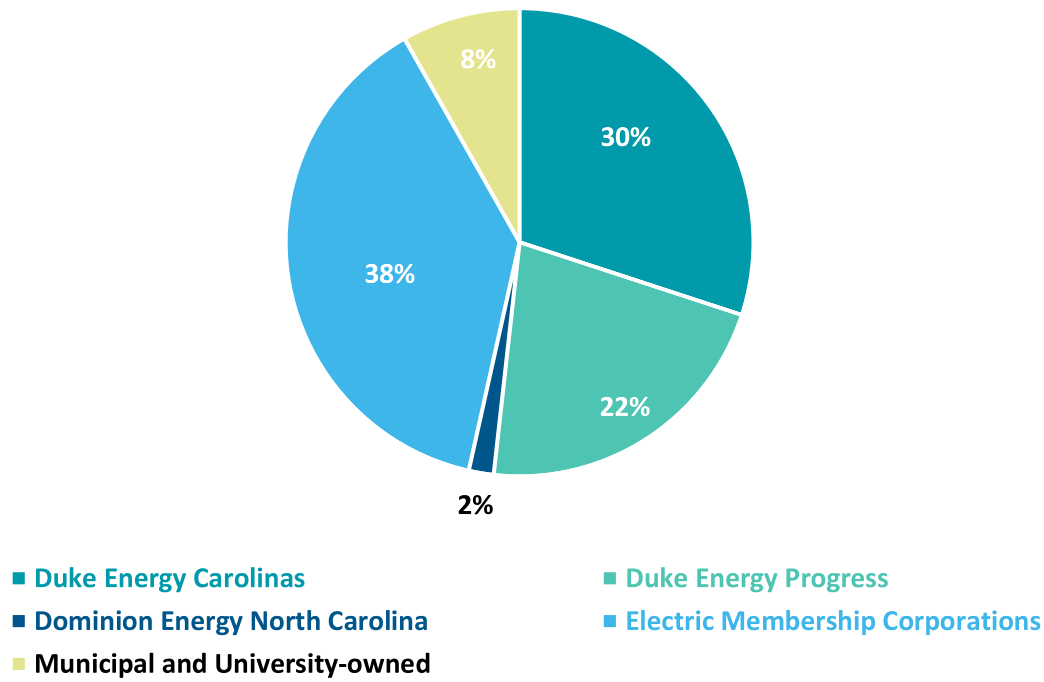
[4] FERC Order 888: Promotes Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities

[5] Pseudo-tie is a virtual or simulated tie line that represents the real-time transfer of control of a generating unit or load from one Balancing Authority to another, even if there's no physical connection between them

and Dominion Energy North Carolina. There are 32 EMCs and 76 MOUs within NC that serve electricity to customers (NCUC, 2024). The figure below shows the estimated percentage distribution of customer counts for the electricity providers as of September 30, 2024:

Figure 11: NC Electric Customer Percentage Distribution



Source: NCUC

The table below shows the MWh sales of the top 5 retailers of electricity in NC from 2023, broken out into different end-use sectors. DEC and DEP accounted for roughly 70% of the total sales of electricity in 2023.

Figure 12: Top Five Retailers of Electricity, 2023 (MWh Sales)

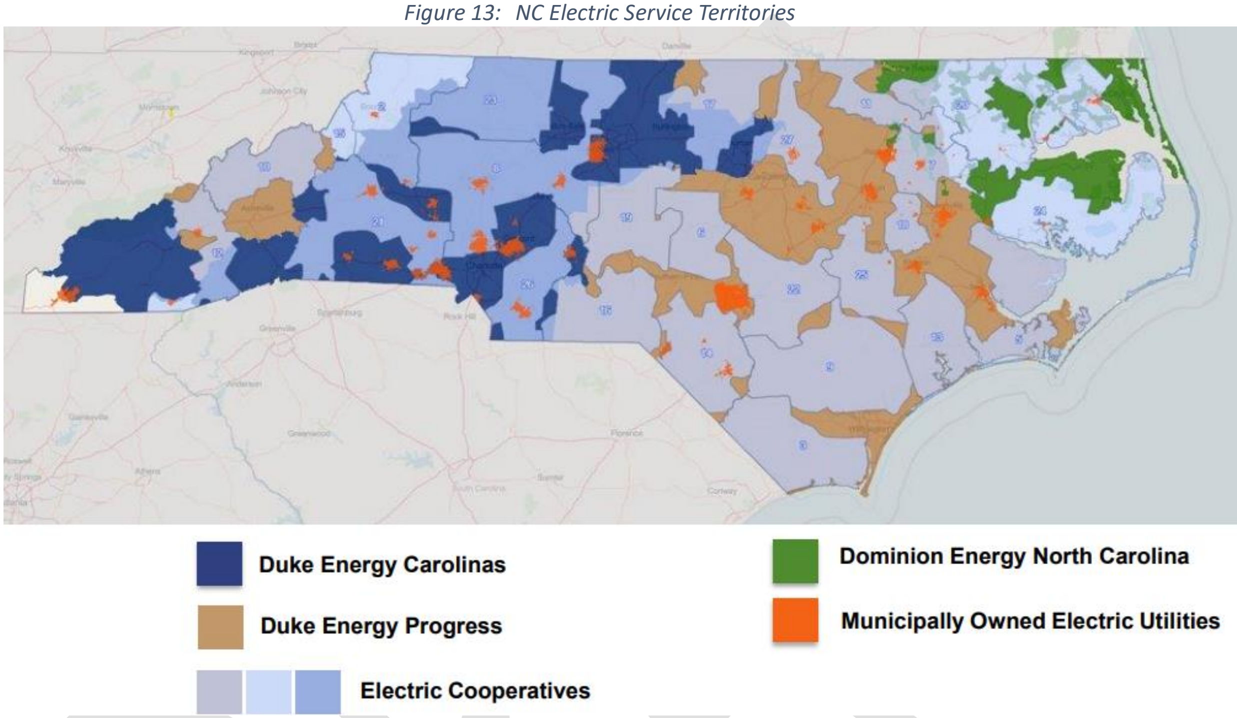
Rank	Entity	Type of Provider	All Sectors	Residential	Commercial	Industrial
1	Duke Energy Carolinas	IOU	57,139,511	21,363,532	24,220,602	11,542,669
2	Duke Energy Progress	IOU	36,263,803	15,616,376	13,016,315	7,631,112
3	Dominion Energy North Carolina	IOU	4,075,831	1,508,594	891,259	1,675,978
4	EnergyUnited Electric Member Corp.	Cooperative	2,655,615	1,631,735	627,434	396,446
5	Fayetteville Public Works Commission	Public	1,915,389	861,359	663,558	390,472

Total Sales, Top Five Providers	**102,050,149**	**40,981,596**	**39,419,168**	**21,636,677**
Percent of Total State Sales	**77%**	**70%**	**82%**	**83%**

Source: EIA, Form EIA-861, Annual Electric Power Industry Report.

The figure below shows a map of the NC electric service territories.

Figure 13: NC Electric Service Territories



Source: NC Sustainable Energy Association

NC's electricity sector is characterized by a diverse supply mix, robust consumption driven by population growth and industrial demand, and strategic imports to balance needs, all managed by a network of electric suppliers including IOUs, cooperatives, and MOUs. This dynamic system is evolving to meet rising demands and integrate renewable energy, setting the stage for further exploration of its vulnerabilities and mitigation strategies in subsequent sections.

1.1.2. Liquid Fuels

Liquid fuels, like gasoline, diesel, and ethanol, are a primary source of energy and provide critical inputs for end uses like transportation and industrial production processes. The state's liquid fuels infrastructure includes pipelines for refined products, storage terminals, and limited biofuels refining capacity. NC does not have any crude oil reserves or in-state production capabilities. More than 125 exploratory oil and natural gas wells have been drilled in the state since 1925, but none were sufficient for commercial development despite finding traces of crude oil and natural gas.

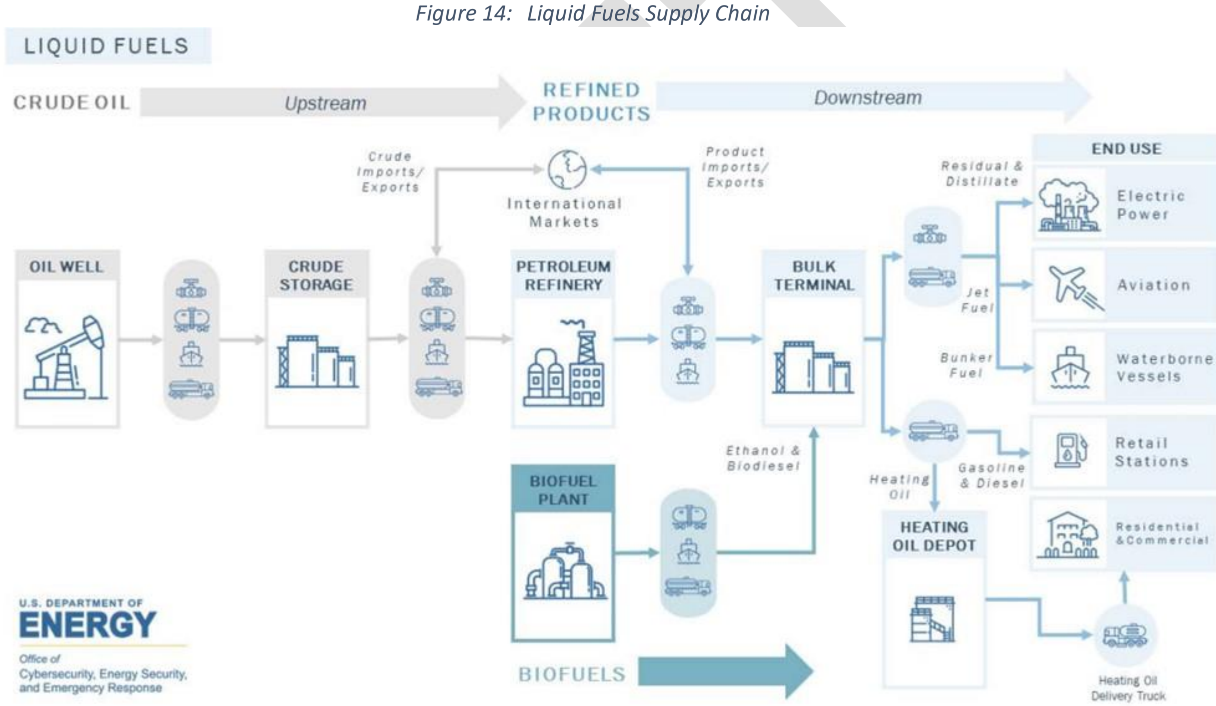
The following is a brief description of the liquid fuels supply chain components:

- **Extraction:** It begins with crude oil extraction from underground reservoirs via drilling (onshore or offshore) or, less commonly, from alternative sources like oil sands or shale. Fuel can be stored before upstream transportation.

- **Transportation (Upstream):** Crude oil is moved from extraction sites to refineries via pipelines, tankers, rail, or trucks, depending on location and infrastructure.
- **Refining:** At refineries, crude oil is processed and distilled into various liquid fuels and byproducts (e.g., gasoline, diesel, kerosene). This involves chemical processes like cracking and blending to meet specifications.
- **Distribution:** Refined fuels are transported through pipelines, barges, rail, or trucks to storage terminals and distribution hubs closer to markets.
- **Retail/Consumption:** Fuels are delivered to gas stations, airports, or industrial users. Retailers sell to consumers for vehicles, machinery, or heating, while some industries use bulk deliveries.

The figure below shows visual representation of the liquid fuels supply chain.

Figure 14: Liquid Fuels Supply Chain

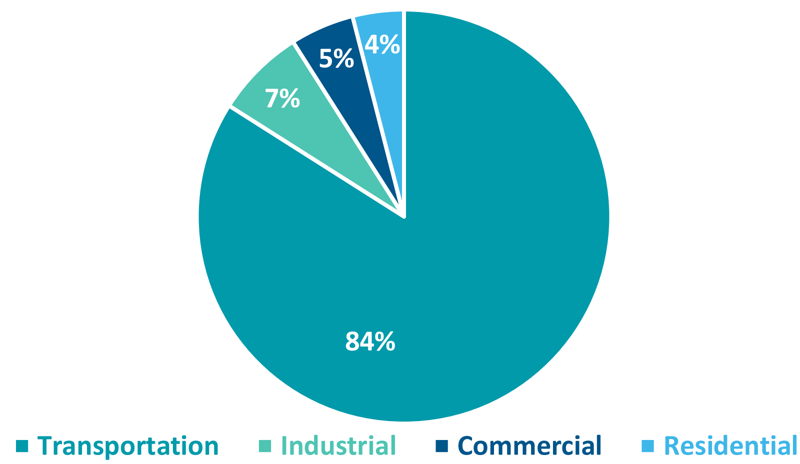


Source: DOE CESER

Consumption

As of 2023, NC ranks among the top ten states with the highest use of petroleum liquid fuels. The high consumption is mainly driven by the transportation sector, as the state is among the top five nationwide in motor gasoline consumption (NC State Energy Profile, 2024). The figure below shows the liquid fuel consumption by sector.

Figure 15: NC Liquid Fuel Consumption by Sector

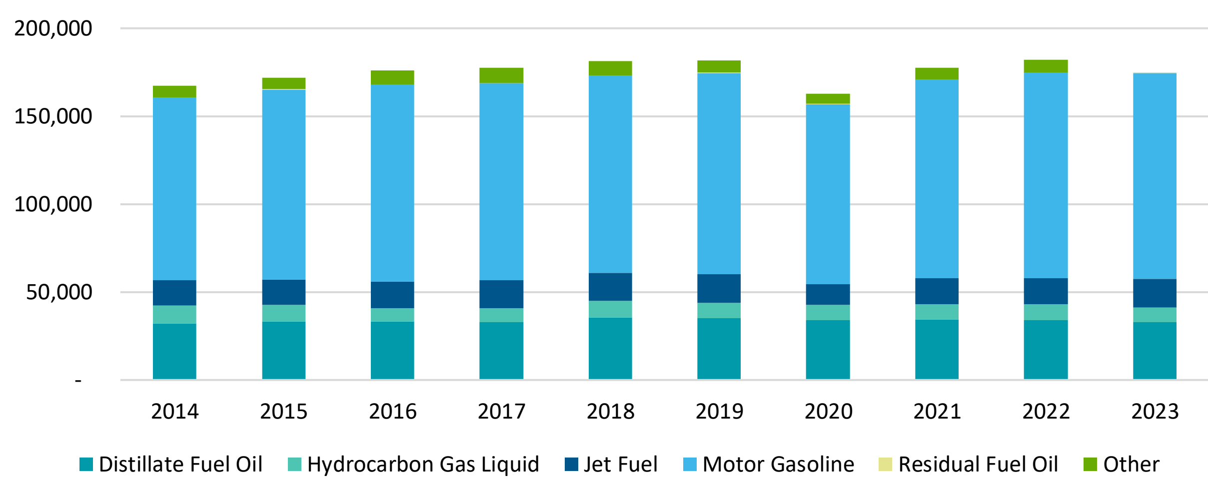


Source: EIA

Roughly 8% of households in the state use propane, fuel oil, or kerosene for home heating. In addition, petroleum liquid fuels are used occasionally for electricity generation by back-up diesel generators or during times of higher than usual electricity demand.

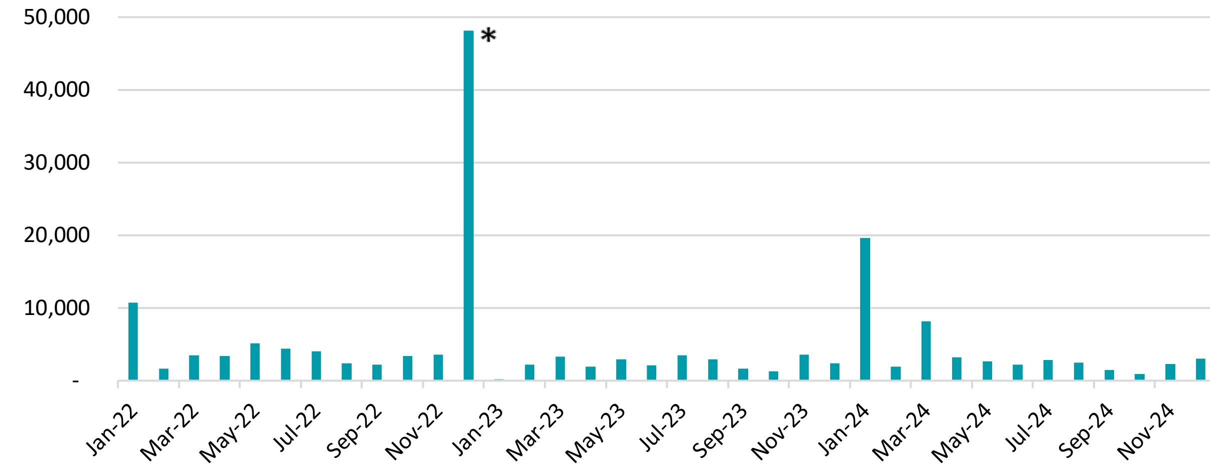
The figures below show the breakdown of liquid fuel consumption by end-use, and the generation of petroleum for electricity. The ratio of petroleum end-use has remained constant over the past 10 years, with a noticeable overall drop in 2020 due to low demand from the COVID-19 pandemic shutdowns. The use of petroleum for electricity generation is relatively small compared to other end uses. The spike in December 2022 is a result from Winter Storm Elliot, which constrained natural gas imports from the Northeast into southern regions, including NC, requiring the state to use petroleum to meet electricity demands during that period.

Figure 16: Total NC Petroleum Consumption by End-Use



Source: EIA

Figure 17: NC Monthly Electric Generation from Petroleum (MWh)



Source: EIA

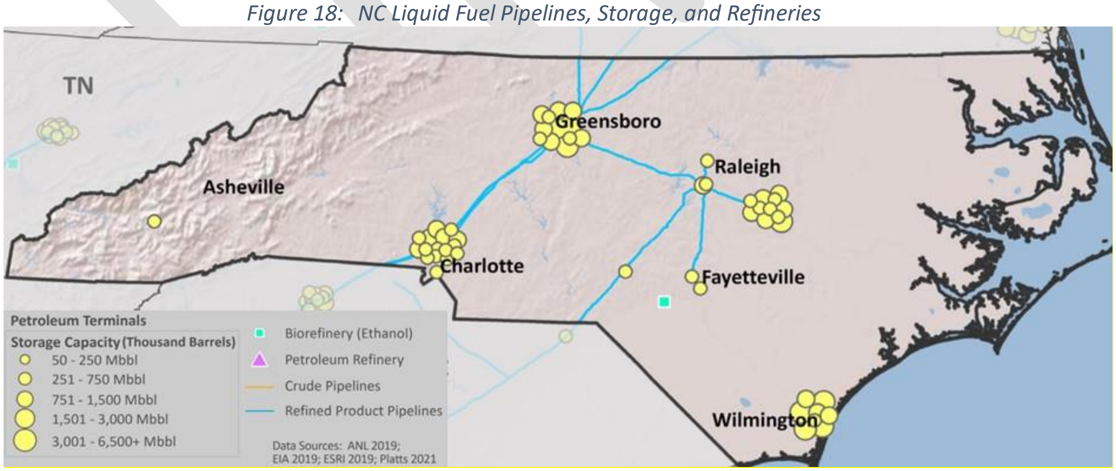
* The spike in December 2022 is a result from Winter Storm Elliot, which constrained natural gas imports from the Northeast into southern regions, requiring NC to use petroleum to meet electricity demands during that period.

Supply

As noted above, NC does not possess any petroleum refining facilities, instead the state receives refined petroleum products from three major pipelines and through the Port of Wilmington. The Colonial and Plantation pipelines deliver refined petroleum products to NC enroute to their termini in the Northeast. The Dixie pipeline transports propane from the Gulf region to NC before terminating in Apex, NC. The liquid fuels storage facility in Greensboro is the state's largest. As the endpoint of Colonial's mainlines from Houston and a major distribution hub for gasoline, diesel, and jet fuel, the Greensboro fuel storage facility supports the state's high petroleum demand. Its size surpasses smaller terminals like those in Charlotte or Selma, making it a critical asset in the state's fuel supply chain.

The figure below shows the refined product and crude pipeline infrastructure, biorefinery and petroleum refineries, along with the petroleum storage terminals.

Figure 18: NC Liquid Fuel Pipelines, Storage, and Refineries



Source: DOE

Liquid Fuel Suppliers

Considering most of the gasoline and diesel supplies come into the NC via interstate pipelines and smaller distribution channels, the table below describes the key suppliers in the petroleum pipeline and distribution/marketing industry.

Figure 19: Key Liquid Fuel Suppliers

Organization	Description
Colonial Pipeline: Colonial Partners	Delivers refined petroleum products (gasoline, diesel, jet fuel) from Gulf Coast refineries to NC. Multiple delivery points in the state (e.g., Greensboro, Charlotte) make it a linchpin in the supply chain.
Plantation Pipeline: Kinder Morgan & Exxon Mobil	Delivers refined petroleum products from Gulf Coast refineries to terminals in NC (e.g., Selma, Charlotte), supporting fuel availability for distributors and retailers.
Dixie Pipeline: Enterprise Products Partners	Supplies propane to NC and six other Southeastern states, terminating in Apex, NC, serving residential and industrial heating needs.
North Carolina Petroleum & Convenience Marketers (NCPCM)	Trade association representing over 2,500 convenience stores, petroleum marketers, and distributors across the state. Members include local businesses handling gasoline, diesel, heating oil, and propane, making NCPCM a collective stakeholder advocating for the downstream petroleum sector.
Campbell Oil Company	Distributor of petroleum products (e.g., gasoline, diesel, lubricants) serving residential, commercial, and aviation sectors in NC, South Carolina, and Virginia. It partners with brands like Shell, Marathon, and Phillips 66.
Sampson-Bladen Oil Company	Regional petroleum distributor focusing on fuel and lubricant supply, including branded gasoline stations, serving Southeastern NC.
Great Lakes Petroleum	Charlotte-based distributor delivering bulk fuel (gasoline, diesel) and lubricants to commercial and industrial clients across the Southeast, including NC.

Source: NCUC

NC's liquid fuels sector relies on a steady supply of gasoline, diesel, and other fuels, with consumption driven by transportation and industrial needs, supplemented by imports through pipelines and ports, and managed by a network of refiners, distributors, and retailers. This critical system faces evolving challenges in reliability and resilience and contains several cross-sector interdependencies which are explored in *Section 2: Critical Energy Infrastructure and Cross-Sector Interdependencies*.

1.1.3. Natural Gas

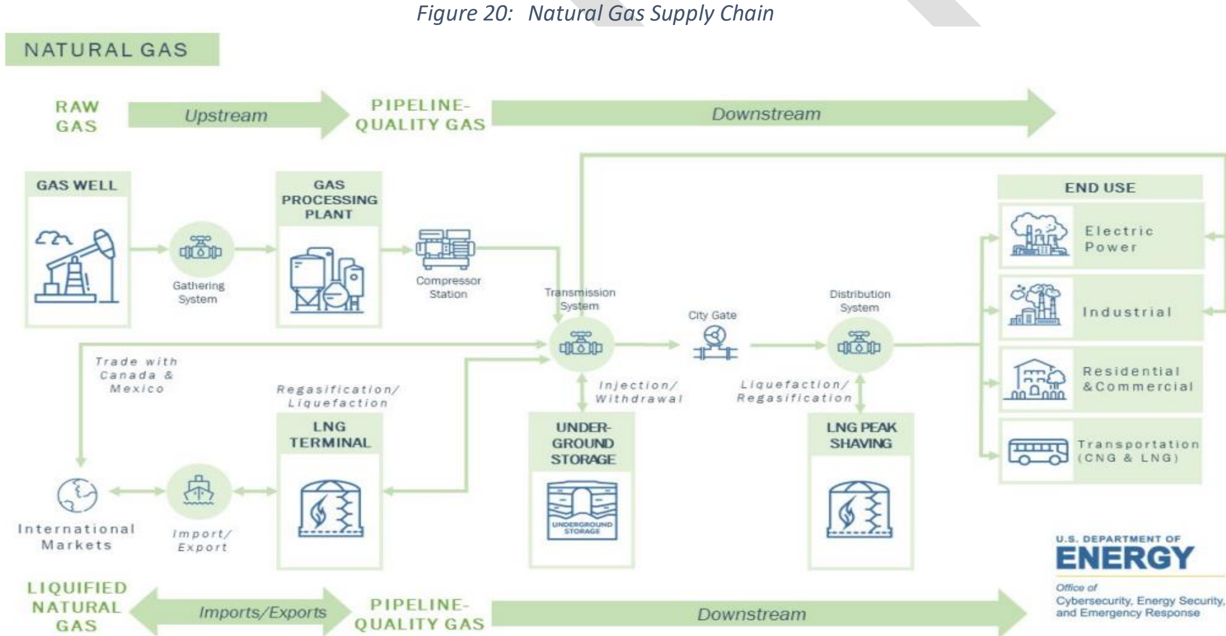
Natural gas is a critical resource for NC with a range of end-uses including electricity generation, residential/commercial heating, industrial processes, transportation, and in the form of liquefied natural gas (LNG). Natural gas is expected remain an important energy source for NC, as evidenced by significant investments being made to expand the reliable supply of gas such as the Moriah Energy Center, a Person County LNG storage project led by Dominion Energy North Carolina. NC is heavily dependent on the downstream supply chain of natural gas, the state does not have any upstream gas producing wells or processing plants. The dependence on downstream supply creates interdependency risk where NC is dependent on external entities to the state to provide this critical resource upon demand, which is explored further in *Section 4: Energy Sector Threats and Impacts*.

Below is a brief description of the components of the natural gas supply chain:

- **Extraction:** Natural gas is extracted from underground reservoirs, often alongside oil, through drilling (conventional wells or hydraulic fracturing for shale gas).
- **Processing:** Raw gas is purified at processing plants to remove impurities (e.g., water, sulfur, carbon dioxide (CO2)) and separate valuable byproducts like natural gas liquids such as propane and butane.
- **Transportation:** Processed gas is moved through a network of high-pressure pipelines over long distances.
- **Storage:** Gas is stored in underground facilities (e.g., depleted reservoirs, salt caverns) or LNG tanks to balance seasonal demand and support supply stability.
- **Distribution:** Local utilities distribute gas through smaller pipelines to homes, businesses, and power plants for heating, cooking, electricity generation, or industrial use.

The figure below shows visual representation of the natural gas supply chain.

Figure 20: Natural Gas Supply Chain



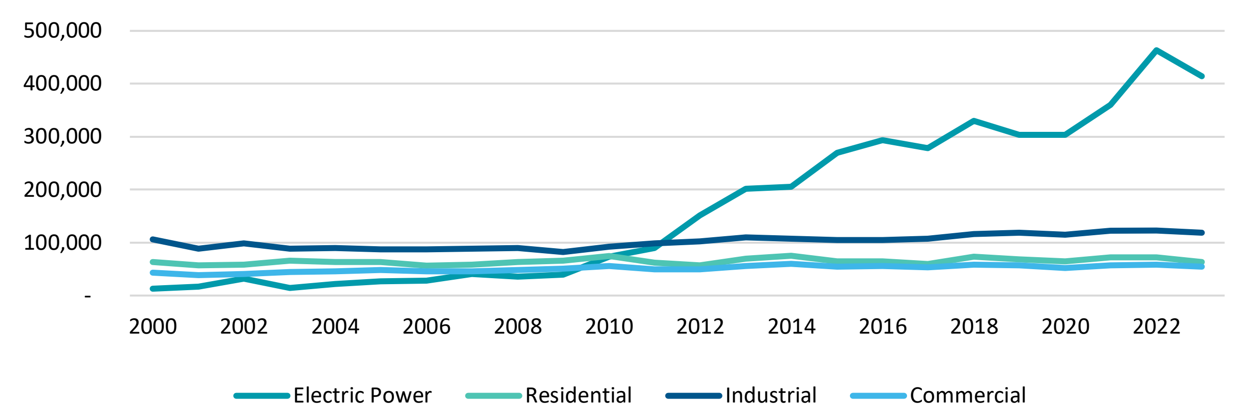
Source: DOE CESER

Natural Gas Consumption

Natural gas consumption for electricity generation has gone through a sizeable shift over the past 15 years. It has overtaken coal as the primary fuel source for electric generation. The shift was largely due to a decrease in natural gas prices, driven by new supply deposits found in the Marcellus and Utica shale formations in the Appalachian region. Despite the large increase of consumption for power generation, NC is in the bottom third of natural gas consumption on a per capita basis, in part due to the state's mild climate (NC State Energy Profile, 2024).

In 2023, the electric power sector comprised 64% of natural gas consumption, followed by the industrial sector at 18%, residential sector about 10%, and the commercial sector at 8%. In addition, about 25% of residential customers in the state use natural gas for home heating as of 2023. The figure below shows the rise in natural gas use for electric power since 2010 (roughly when the Marcellus/Utica shale boom started), while the residential, commercial, and industrial consumption ratio has remained relatively constant.

Figure 21: Natural Gas Consumption to End-Users (MMCf)

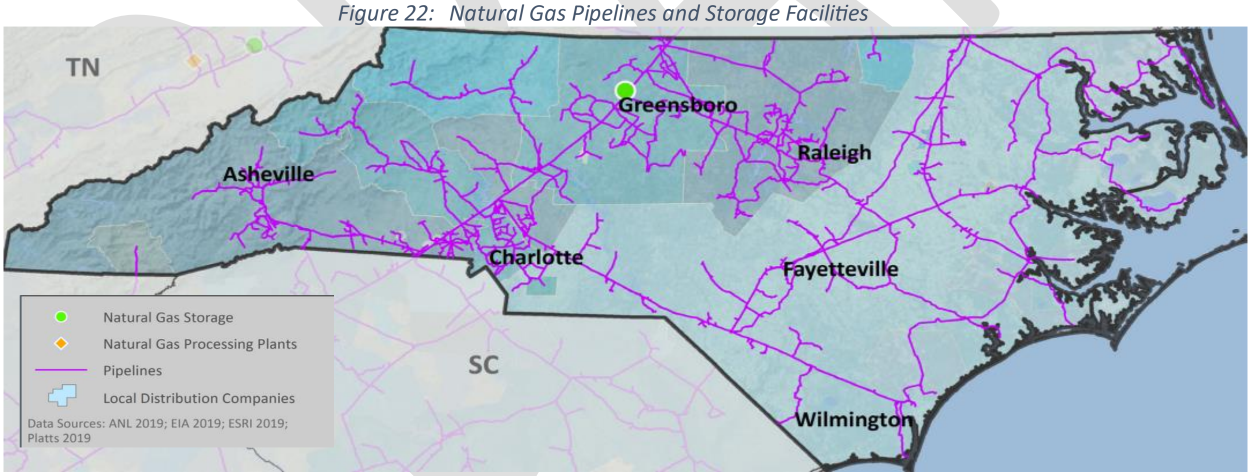


Source: EIA

Natural Gas Supply

Natural gas supply is imported through the pipelines running through Virginia, South Carolina, and Georgia. As of 2018, NC had about 4,188 miles of transmission pipelines and 31,801 miles of distribution pipelines (NC Energy Risk Profile, 2021). NC is served by the Transcontinental pipeline (Transco) and East Tennessee pipeline. The Transco pipeline runs from Texas to New York, connecting NC to natural gas reserves in the Gulf and Northeastern regions of the country, while the East Tennessee pipeline transports gas from Tennessee. The figure below shows the natural gas pipeline infrastructure and natural gas storage and processing plants within NC as of 2019.

Figure 22: Natural Gas Pipelines and Storage Facilities



Source: DOE

Since the mid-2010s, natural gas imports have been increasingly sourced from reserves in the Northeast rather than the Gulf and now constitute most interstate natural gas imports. The increase in imports from the Northeast is driven from the large Marcellus gas shale deposits found in Pennsylvania, which created a cost competitiveness to gas supplied from the Gulf. The lack of economically viable natural gas reserves in-state and the reliance on imports from other states to support natural gas consumption in NC creates a vulnerability that can be exposed by events both inside and outside the borders of NC, which is detailed in *Section 5: Vulnerability and Severity Assessment*. Expanding the import pipeline footprint to bolster natural gas supply for NC or reducing natural gas consumption could mitigate this vulnerability.

In addition to pipeline supply, NC possesses six LNG storage facilities, each serving a specific purpose for the state's energy needs. Primarily, these storage facilities help ensure reliable supply during peak demand periods, as opposed to exporting the gas or using it for industrial production and reduce reliance on emission intensive back-up fuel alternatives for power generation like ultra-low Sulphur diesel fuel. For example, the 300,000-gallon Greenville Utilities Commission LNG Plant has used LNG during periods of high demand as a cost-saving measure. However, technologies such as BESS or LDES can also provide supply during peak demand periods, presenting a more reliable and potentially lower emission power supply option than LNG imports. The table below shows the major natural gas supply facilities within NC.

Figure 23: Major Pipelines & LNG Storage Facilities Serving NC

Facility Name	Facility Type	Description
Cardinal Pipeline	Intrastate pipeline	Transports natural gas in the North-Central region of the state
East Tennessee Pipeline	Interstate pipeline	Transports natural gas via Virginia to Northern NC
Columbia Gas Transmission	Interstate pipeline	Transports natural gas via Virginia to Northern MC
Transco	Interstate pipeline	Connects NC to natural gas reserves in the Gulf and Northeastern regions.
Pine Needle LNG Storage	LNG storage	Williams-operated storage facility with a capacity of 2 billion cubic feet (BCF)
Greenville LNG Plant	LNG storage	Municipally owned 300,000-gallon storage facility
Bentonville LNG	LNG storage	Serves the Raleigh-Durham area
Robeson LNG facility	LNG storage	1 BCF LNG storage facility owned and operated by Piedmont Natural Gas (PNG)
Huntersville LNG Facility	LNG Storage	Provides capacity for the Charlotte region
Moriah Energy Center	LNG storage	Proposed LNG storage facility in Person County, anticipated to be in service in 2027.

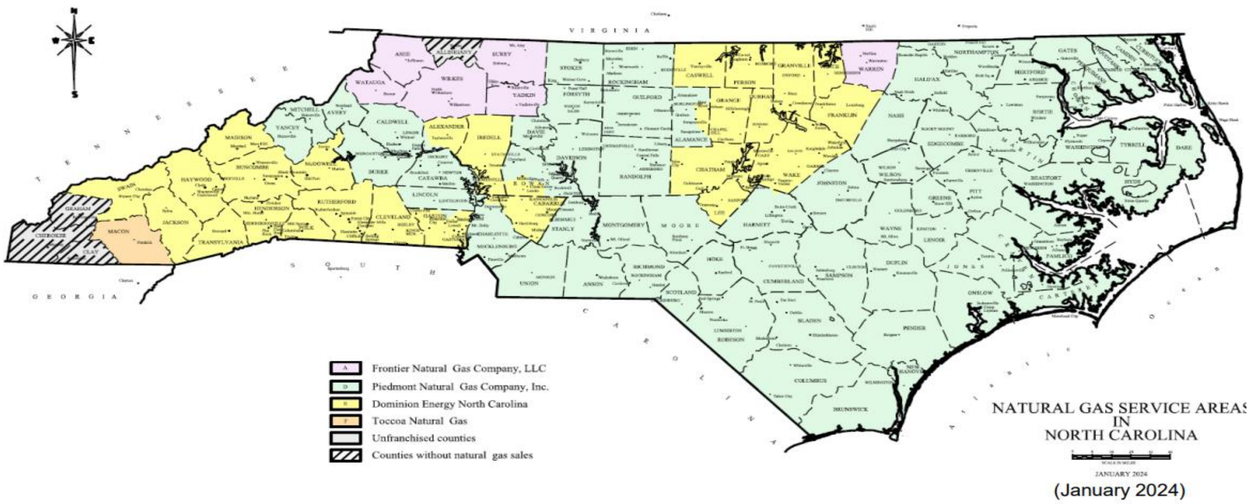
Source: NCUC

Natural Gas Stakeholders

The natural gas stakeholders in NC include several organizations across the supply chain. These organizations deliver natural gas service to end-use customers. These utilities also operate distribution pipelines that deliver gas from the transmission system to customers.

There are four local distribution companies (LDCs) and eight municipal gas systems operating in the state. The two biggest LDCs are PNG Company, Inc. and Enbridge Gas North Carolina (formerly known as Public Service Company of North Carolina, Inc. or Dominion Energy North Carolina). As of September 2024, Piedmont has roughly 809,000 customers, and Enbridge has roughly 655,000 customers. The breakout of customer classes for both companies average roughly 92% residential, 8% commercial, and less than 1% industrial. The figure below shows the LDC service territories within NC.

Figure 24: LDC Service Territories



Source: NCUC

The table below lists the major natural gas stakeholders within NC.

Figure 25: Natural Gas LDCs

Organization	Description
PNG	Serves customers in Charlotte, Greensboro, Winston-Salem, and some counties in the Eastern and South-Central regions of the state. Acquired by Duke Energy in 2016, it operates as a business unit of Duke Energy.
Enbridge Gas North Carolina	Enbridge Gas North Carolina serves customers across the state, including Raleigh, Durham, Gastonia, and Asheville. Acquired by Enbridge from Dominion Energy in 2024.
Frontier Natural Gas Company	Serves customers in Surry, Yadkin, Wilkes, Watauga, Ashe, and Warren counties.
Toccoa Natural Gas	Macon County has a contract with the Municipal Gas Authority of Georgia and the city of Toccoa, Georgia for natural gas services.
Municipal Natural Gas Providers	The cities of Greenville, Kings Mountain, Lexington, Monroe, Rocky Mount, Shelby, Wilson, and Bessemer City own and operate municipal gas providers for customers. These municipal gas systems are not regulated by the North Carolina Utilities Commission (NCUC). All are members of the American Public Gas Association.

Source: NCUC

NC's natural gas sector features rising consumption, especially for power generation, and a reliance on imports to satisfy the growing demand. The reliance on natural gas imports, and risk of pipeline failure due to aging infrastructure, are key threats and vulnerabilities which are detailed further in *Section 4.2: Technological Threats and Section 5: Vulnerability and Severity Assessment.*

1.1.4. Energy on Tribal Lands

There are 8 state-recognized tribes located in NC: the Coharie, the Eastern Band of Cherokee Indians (EBCI), the Haliwa-Saponi, the Lumbee Tribe of North Carolina, the Meherrin, the Sappony, the Occaneechi Band of the Saponi Nation and the Waccamaw Siouan (FAQs About American Indians, n.d.). The EBCI is fully recognized by the federal government. The Lumbee tribe has partial federal recognition because of the Lumbee Act of 1956, and in January 2025, President Donald J. Trump signed a Presidential Memorandum to the Secretary of the Interior to submit a plan to advance full federal recognition of the Lumbee Tribe of North Carolina. There were 122,110 American Indians located in the state of NC when the 2010 US Census was conducted, and NC is home to the largest population of American Indians east of the Mississippi River (FAQs About American Indians, n.d.). NC tribes have been proactive in pursuing climate-related goals by securing federal funding from agencies like the US DOE (e.g. EnergizeNC project) and the US Environmental Protection Agency (EPA) to implement renewable energy projects, reduce greenhouse gas (GHG) emissions, and enhance climate resilience through initiatives like solar installations, installing EV infrastructure, and comprehensive climate action planning.

The EBCI has implemented strategic climate roadmaps and have successfully secured funding for energy projects from both the DOE and the EPA. For example, the EBCI created a Climate Action Plan that is being funded through various IIJA/IRA grants overseen by the State Energy Office (SEO) and private donations. The EBCI was awarded roughly $5,000,000 to provide cleaner transportation options, increase climate resiliency, and promote learning in the EBCI community. The EBCI's Climate Action Plan is estimated to reduce 151,000 metric tons of CO2 from 2025-2050, equivalent to the annual emissions from approximately 2,300 homes or 4,600 passenger vehicles (Eastern Band of Cherokee Indians, 2024). The selected project will deliver the following benefits to reduce GHGs and support communities:

- Purchase and deploy 15 electric school buses and one Class 8 heavy-duty electric truck.
- Develop a 400-kilowatt solar microgrid and 80-kilowatt diesel energy storage system to help power eight fast charging stations to support the electric school bus fleet.
- Construct a 52-kilowatt solar array on the Tribal Council House Complex and a 121-kilowatt solar array on the New Kituwah Academy rooftop.
- Install 20 publicly accessible Level 2 EV public charging stations.
- Enhance energy affordability and equity by providing access to clean, affordable energy options.

Other programs, such as the Heating Assistance Program run by the Lumbee Tribe of North Carolina's Department of Energy, provide eligible households with assistance towards their heating and cooling source. The mission is to serve as a service institution for American Indian families in Cumberland, Hoke, Robeson, and Scotland counties by addressing household heating and cooling issues through safe, healthy and educational initiatives (Lumbee Tribe of North Carolina, n.d.).

Expanding energy access to tribal lands in NC is crucial for fostering economic development, improving quality of life, and advancing tribal sovereignty. By harnessing a mix of resources, renewables like solar and wind, alongside traditional options such as natural gas and small-scale hydropower, tribes can create a more robust, flexible energy system. This comprehensive approach bolsters consistent supply for critical services, reduces dependence on external grids, and enhances tribal sovereignty by empowering communities to tailor their energy mix to local conditions and economic goals.

1.1.5. Conclusion

The energy profile section underscores NC's dynamic energy landscape, where electricity, natural gas, and liquid fuels collectively power the state's economy and daily life, highlighting the need for strategic enhancements to meet growing demands, diversify supply, and mitigate risks. Building on this foundation, the Critical Energy Infrastructure and Cross-Sector Interdependencies section below explores how these energy systems interconnect with other vital sectors, shaping the state's overall resilience.

2. Critical Energy Infrastructure and Cross-Sector Interdependencies

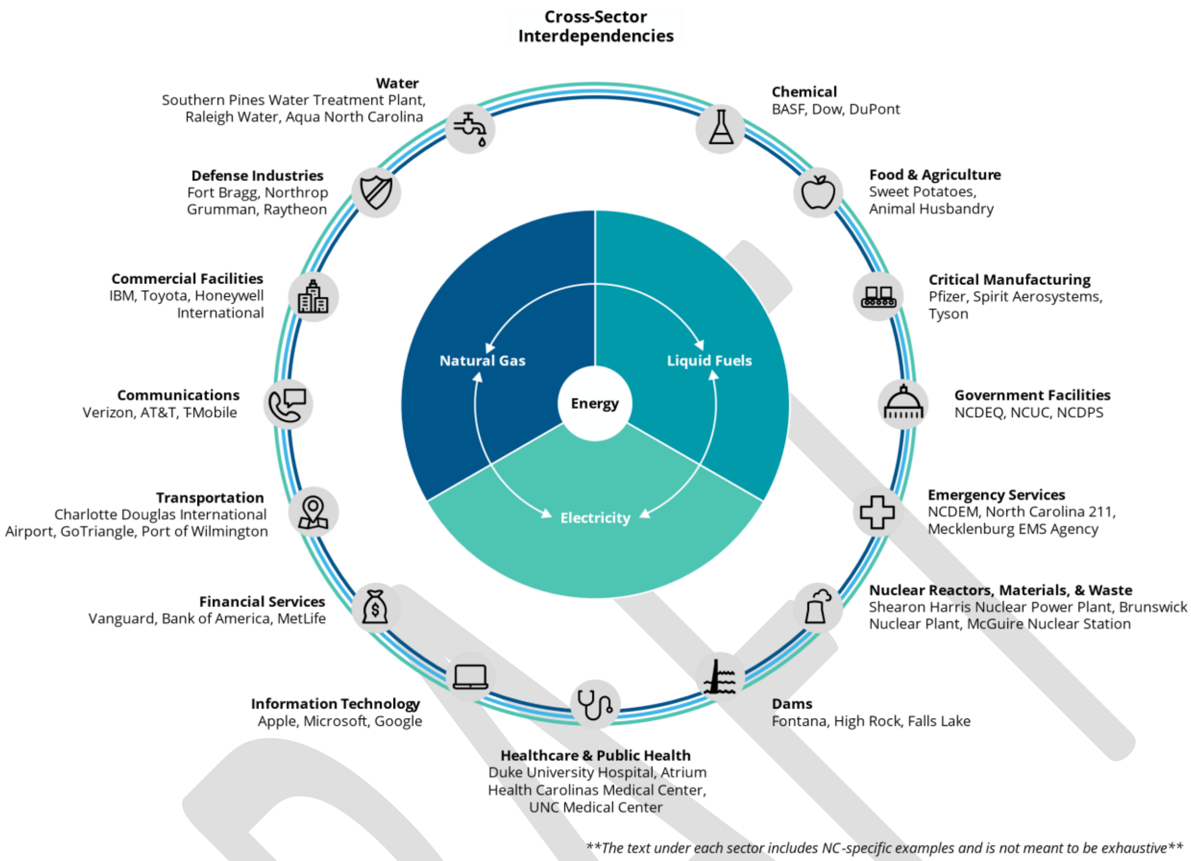
This section describes how the interdependencies between the energy sector and other critical sectors, such as water, transportation, communications, and healthcare, highlight the complex and interconnected nature of modern infrastructure systems. By mapping these dependencies, this analysis reveals vulnerabilities that could cascade across sectors during disruptions, underscoring the need for coordinated resilience strategies.

2.1. Critical Infrastructure

NC relies heavily on the 16 critical infrastructure sectors identified by the Cybersecurity and Infrastructure Security Agency (CISA) (as demonstrated in the Figure below) to maintain its economic stability, public safety, and overall quality of life for state residents. These sectors, ranging from energy and transportation to healthcare and water systems, are vital to the state's daily operations and resilience against both natural and human caused threats and are often interconnected or interdependent upon one another. In NC, the significance of these sectors is amplified by the state's unique geographic and economic landscape, which includes coastal and mountainous vulnerabilities, a robust agricultural base, and growing urban centers like Charlotte and Raleigh. Recognizing and analyzing dependencies (one-directional) and interdependencies (bidirectional) among critical infrastructure assets within each of these sectors is crucial for evaluating energy-related risks and vulnerabilities, as well as for planning energy security and resilience. By aligning with CISA's framework, NC works to safeguard these interconnected systems, ensuring they remain secure and functional to meet the needs of its residents and contribute to national security.

The energy sector is intricately linked with other critical infrastructure sectors essential to health, safety, and economic stability. Each critical infrastructure sector depends on electricity or fuel to operate. Energy disruptions, such as fuel shortages, threaten the functioning of vital facilities and transportation systems that need a steady energy supply. In addition to their dependence on the energy sector for power and fuel, some critical infrastructure sectors also support the energy sector. The sixteen infrastructure sectors are shown in the Figure below.

Figure 26: Cross-Sector Interdependencies



Data Source: CISA

2.1.1. Electricity Sector

The electricity subsector serves as a linchpin for several critical infrastructure sectors, underscoring its role as an enabling force across the state's economy and public welfare. The healthcare sector depends on reliable electricity to power hospitals, medical equipment and sterilization processes, and emergency response systems. Power outages can jeopardize patient care and can lead to negative health outcomes. Electricity supports refrigeration, food processing, and heating or cooling of homes, with disruptions threatening food security and livability, particularly in rural areas. Reliable electricity is crucial for law enforcement operations, fire services, and public safety communications, where power loss can hinder emergency response. The transportation sector, vital to the state's logistics hubs and tourism, leans on electricity for traffic systems, fuel pumps, and increasingly electrified transit, while the communications sector requires power for cell towers, internet infrastructure, and media, all essential for coordination during crises. These interdependencies highlight how electricity's stability is critical to the state's resilience across these interconnected sectors.

2.1.2. Natural Gas Sector

The natural gas subsector underpins key critical infrastructure sectors through its role as a fuel source and its interconnections with electricity and other systems, making it a vital component of the state's infrastructure resilience. The healthcare sector relies on natural gas for heating, backup power generation, and sterilization processes in medical facilities where disruptions could compromise patient health and safety. Natural gas can power industrial manufacturing, residential heating, cooking, and agricultural processing, while also supporting water treatment facilities that often use gas-fired systems, with shortages potentially affecting rural and urban communities alike. Natural gas is used for emergency facilities and heating public buildings, where interruptions could impair law enforcement or fire response during cold weather events like the 2021 polar vortex. The transportation sector uses natural gas as a fuel for some fleets and indirectly through its role in electricity generation for transit systems, while the communications sector benefits from gas supporting power plants that keep telecom networks operational. These interdependencies illustrate how natural gas is woven into the state's critical infrastructure fabric, amplifying the stakes of its reliability via imports from other natural gas producing states and NC's own stored natural gas reserves.

2.1.3. Oil & Gasoline Liquid Fuels Sector

The liquid fuels subsector serves as a critical lifeline for the state's infrastructure. The healthcare sector relies on liquid fuels to power emergency generators, ambulances, and medical supply transport, where shortages could disrupt life-saving operations. Liquid fuels drive agricultural equipment, delivery trucks, and backup systems for water treatment plants, with disruptions threatening food availability and potable water access. Emergency vehicles such as fire trucks, police vehicles, and ambulances depend on liquid fuels, where fuel scarcity could hinder public safety efforts. These interconnections underscore how liquid fuels are essential to the state's ability to maintain functionality across these vital sectors.

2.1.4. Conclusion

While a disruption or loss of the services provided by the energy sector can directly affect the security and resilience within and across numerous sectors, the energy sector also depends on other sectors to help provide its services (such as the transportation of liquid fuels or communication services between energy suppliers). There are also interdependencies within the energy sector itself which are explored further in *Section 4: Energy Sector Threats and Impacts*. An understanding of these interdependencies enables the sector to mitigate vulnerabilities and enable the state's prosperity.

3. Energy Emergency Preparedness and Response

Energy outages can arise from natural, human-caused, and technological threats, leading to widespread consequences that affect public safety, economic stability, and overall quality of life. In an interconnected world, the ripple effects of energy outages can be profound, impacting everything from healthcare services to transportation systems and communication networks. Given the critical nature of energy infrastructure, a coordinated and efficient response to energy emergencies is paramount.

Effective emergency planning and coordination support stakeholders, including government agencies, energy providers, emergency responders, and the public, are prepared to act swiftly and cohesively. Collaboration is essential to mitigate the immediate impacts of outages, restore services promptly, and maintain public confidence. By implementing robust energy emergency response plans, NC can enhance resiliency against potential threats, minimize downtime, and protect the well-being of its communities. Emergency response preparedness safeguards essential services and supports economic stability and health and safety of North Carolinians.

Section 3: Energy Emergency Preparedness and Response defines the authorities granted to various stakeholders at the federal, state, and local level, and describes the State procedures for preventing and responding to energy emergencies.

3.1. Federal Government

There are numerous federal departments and agencies involved in ensuring energy security. Several of these entities have duties and functions that go beyond just the energy sector. The energy-related efforts of each agency have been classified according to their relevance to electricity, liquid fuels, or natural gas. Agencies responsible for protecting the cybersecurity and physical integrity of energy infrastructure are also highlighted. The energy security tasks of these agencies might include:

- Energy emergency preparedness and response, including hosting and participating in preparedness planning and exercises and deploying responders or resources during an emergency event.
- Information sharing and situational awareness, including publishing data and threat information and issuing situation reports during emergency events.
- Development and enforcement of standards and regulations for energy industry safety and security. During emergency events some of these standards and regulations may be waived to facilitate faster response and restoration.

3.1.1. White House

The White House, particularly the National Security Council, participates in public briefings and interagency situational awareness activities. Under the National Emergencies Act of 1976, the President also has the authority to declare a national state of emergency. The President will consult the Governor of an affected state to determine whether such an emergency exists, if practicable.

3.1.2. Department of Homeland Security

Federal Emergency Management Agency (FEMA)

FEMA coordinates federal incident response and recovery activities. FEMA's duties during an event include assisting the President in carrying out the Stafford Act, operating the National Response Coordination Center (NRCC), supporting all Emergency Support Functions (ESFs) and Recovery Support Functions. FEMA mission assigns the Defense Logistics Agency to provide fuel support to federal responders and, if requested, state, local, tribal, and territory (SLTT) responders and critical infrastructure. FEMA also provides disaster funds through the Public Assistance Program, Hazard Mitigation Grant Program, and others. Previously, FEMA funded hazard mitigation projects through the Building Resilient Infrastructure and Communities (BRIC) Program as part of the IIJA of 2021; however, this program was cancelled by the Trump Administration in April 2025.[6]

CISA

CISA leads the national effort to understand, manage, and reduce risk to cyber and physical infrastructure. CISA manages the Pipeline Cybersecurity Initiative, leveraging expertise from government and private partners to identify and address cybersecurity risks to pipeline infrastructure. CISA publishes best practices for cybersecurity protection. During a cyber incident, CISA assists impacted infrastructure, helps investigate the responsible actors, and coordinates the national response to significant cyber events.

United States Coast Guard (USCG)

[6] This decision is currently under litigation.

UCSG is the principal federal agency responsible for maritime safety, security, and environmental stewardship in US ports and inland waterways used for the movement of energy products, including petroleum, natural gas, and coal. UCSG reviews and approves security assessments and security plans developed by vessel owners and terminal operators and inspects terminals for compliance with security requirements. UCSG's role is particularly important during hurricanes and other severe weather that can disrupt energy supplies (primarily liquid fuels) into and out of US ports.

Transportation Security Administration (TSA)

TSA oversees the physical security and cybersecurity of all US pipelines. TSA issues directives for owners and operators of pipelines to better secure pipelines against cyberattacks. TSA also oversees security at marine ports, where oil and gas marine terminals, petroleum refineries, and other energy infrastructure may be located. TSA conducts background checks and issues federal transportation worker identification cards (TWIC) to workers accessing secure areas within port boundaries, including fuel truck drivers, refinery workers, and other energy industry workers. TSA may waive TWIC requirements during energy emergencies to facilitate energy restoration and response activities.

Customs and Border Protection (CBP)

CBP is the primary federal agency tasked with ensuring the security of the nation's borders. CBP is responsible for enforcing and administering laws and regulations to control and oversee vessel movements in to, out of, and between US ports. CBP enforces the Merchant Marine Act of 1920, also called the Jones Act, which generally prohibits the transportation of merchandise between two US ports in any vessel not built in, documented under the laws of, and owned by citizens of the US. Applications may be made to CBP for the Secretary of Homeland Security to grant a Jones Act waiver, which can help facilitate the delivery of fuel and equipment during energy shortages.

3.1.3. DOE

Office of Cybersecurity, Energy Security, and Emergency Response (CESER)

CESER's mission is to enhance the security of US critical energy infrastructure to all hazards, mitigate the impacts of disruptive events and risk to the sector overall through preparedness and innovation, and respond to and facilitate recovery from energy disruptions in collaboration with other federal agencies, the private sector, and SLTT governments. CESER's preparedness and response activities include SLTT capacity building, energy security and resilience planning, hosting energy emergency exercises and deploying Emergency Support Functions (ESF-12) responders to impacted regions during emergencies.[7] CESER also advances research, development, and deployment of technologies, tools, and techniques to reduce risks to the Nation's critical energy infrastructure posed by cyber and other emerging threats.

CESER administers programs that can be used to mitigate impacts to energy infrastructure and energy supply, and to provide resources during energy emergencies:

- The Federal Power Act Section 202(c) grants DOE the power to temporarily order connections of facilities, and generation, delivery, interchange, or transmission of electricity during grid emergencies.

[7] ESF-12 is the set of Emergency Support Functions specific energy emergencies.

- The Strategic Petroleum Reserve is a federally owned emergency supply of crude oil. Volumes can be released to mitigate the impact of crude supply disruptions.
- The Northeast Home Heating Oil Reserve and Northeast Gasoline Supply Reserve provides protection for homes and businesses in the northeastern US by stockpiling an emergency supply ultra-low sulfur distillate (diesel) for building heating.

Office of Electricity (OE)

OE provides national leadership to ensure that the Nation's energy delivery system is secure, resilient and reliable. Through research and development, OE develops new technologies to improve electric infrastructure. OE also oversees the Federal and state electricity policies and programs that shape electricity system planning and market operations.

Office of Enterprise Assessments (EA)

EA oversees four federal Power Marketing Administrations - Bonneville Power Administration, Southeastern Power Administration, Southwestern Power Administration, and Western Area Power Administration – that operate electric systems and sell the electrical output of federally owned and operated hydroelectric dams in 34 states.

EIA

EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. EIA's data can be used in energy security planning and energy emergency response activities. EIA publishes state energy profiles, data products related to energy supply, demand, infrastructure, and prices, as well as Geographic Information System (GIS) maps.

FERC

FERC is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC's role includes oversight of the transmission and wholesale sale of electricity in interstate commerce, transportation of oil by pipeline in interstate commerce, and proposals to build LNG terminals and interstate natural gas pipelines as well as licensing hydropower projects. During energy emergencies, FERC also has emergency authority under the Interstate Commerce Act to direct companies to provide preference or priority in transportation, embargoes, or movement of traffic. This authority can be used to direct interstate pipeline operators to prioritize shipments of specific fuels to address shortages.

3.1.4. Department of Transportation (DOT)

Federal Motor Carrier Safety Administration (FMCSA)

FMCSA sets safety requirements for interstate commercial drivers, such as hours of service requirements limiting how long drivers can be on the road before a mandatory break. During energy shortages, FMCSA can waive these requirements to facilitate the delivery of specific energy products, most often liquid fuels, or to facilitate the movement of utility crews, trucks, and other resources involved in the restoration of electric power.

Pipeline and Hazardous Materials Safety Administration (PHMSA)

PHMSA regulates pipelines and rail tank cars to advance the safe transportation of petroleum, natural gas, and other hazardous materials. The agency establishes national policy, sets and enforces standards, educates, and conducts research to prevent incidents. The agency also prepares the public and first responders to reduce consequences if an incident does occur. During pipeline incidents (explosions or spills), PHMSA investigates and issues corrective action orders to pipeline operators before pipeline service can resume. During energy shortages, PHMSA can issue emergency special permits and waivers of certain regulations to facilitate the pipeline supply of fuel to the affected region. PHMSA also regulates rail tank cars that carry petroleum, biofuels, or LNG.

3.1.5. EPA

EPA sets standards for certain fuels, including regulating the vapor pressure of gasoline, requiring reformulated gasoline (RFG) in certain markets, and specifying the sulfur content in diesel fuel. These fuel specifications can be waived during emergencies to facilitate the supply of fuel into the affected region, or to provide fungibility of available supply within the affected region.

EPA also regulates air emissions from energy infrastructure, including power generating facilities and fuel storage terminals. During events, EPA may choose not to enforce these regulations to facilitate power supply and fuel supply in the affected region.

3.1.6. Internal Revenue Service (IRS)

IRS collects federal motor taxes on diesel fuel used for on-highway transportation. Diesel used for off-highway purposes (heavy machinery, generators, farm equipment, etc.) is not subject to tax and is dyed red. In coordination with EPA, the IRS can choose to not collect the penalty typically imposed on using non-highway diesel in on-road vehicles (although the IRS still collects tax on this fuel).

3.1.7. Department of Defense

United States Army Corps of Engineers (USACE)

USACE assists FEMA during disaster response, including installing generators and delivering generator fuels in communities through its Temporary Emergency Power Mission and sending responders to assist in disasters and provide situational awareness.

3.1.8. Nuclear Regulatory Commission (NRC)

The NRC is involved in emergency preparedness and response involving nuclear facilities or materials. The NRC also publishes a daily status report on all nuclear power reactors.

3.1.9. Department of Justice

Federal Bureau of Investigation (FBI)

The FBI leads investigations into both cyber and physical attacks and intrusions. The FBI collects and shares intelligence and engages with victims while working to unmask those committing malicious cyber activities.

3.1.10. Department of the Interior

Bureau of Safety and Environmental Enforcement (BSEE)

BSEE has responsibility for the safety of the environment and conservation of offshore resources. BSEE administers the Oil Spill Preparedness Program and provides support for oil spill response efforts. During hurricanes and other inclement weather in the Gulf of Mexico, BSEE publishes data on the offshore oil and gas rigs that have been evacuated, as well as the amount of production that has been temporarily shut in. BSEE also leads the development of workplace safety and environmental compliance strategies for offshore renewable energy projects on the Federal Outer Continental Shelf. The figure below illustrates the relevant energy sectors associated with each Federal entity.

Figure 27: Federal Authorities in Energy Security

Federal Entity		Energy Sector Purview
White House		Electricity, Liquid Fuel, Natural Gas, Cybersecurity
DHS	FEMA	Electricity, Liquid Fuel, Natural Gas
	CISA	Cybersecurity
	USCG	Liquid Fuel, Natural Gas
	TSA	Electricity, Natural Gas, Cybersecurity
	CBP	Electricity, Liquid Fuel, Natural Gas
DOE	CESER	Electricity, Liquid Fuel, Natural Gas, Cybersecurity
	OE	Electricity
	EIA	Electricity, Liquid Fuel, Natural Gas
	FERC	Electricity, Liquid Fuel, Natural Gas
DOT	FMCSA	Electricity, Natural Gas
	PHMSA	Liquid Fuel, Natural Gas
EPA		Electricity, Liquid Fuel, Natural Gas
IRS		Natural Gas
DOD	USACE	Electricity, Liquid Fuel, Natural Gas
NRC		Electricity
DOJ	FBI	Cybersecurity
DOI	BSEE	Liquid Fuel, Natural Gas

Electricity	**Natural Gas**	**Liquid Fuel**	**Cybersecurity**

Source: DOE

The Federal Authorities play a critical role in NC's energy emergency response by providing coordinated support, resources, and regulatory guidance to support rapid recovery and resilience against disruptions.

3.2. State Government

How NC responds to emergencies, specifically energy emergencies, has changed over time. Beginning with the adoption of the NC Energy Policy Act of 1975, the General Assembly created the Energy Policy Council (EPC). Of the council's various responsibilities, it was mandated to develop energy emergency plans that sought to safeguard the NC economy and public safety (NC Energy Policy Act of 1975, Chapter 113B, Article I § 113B-9). When necessary to update, these plans were supplemented by filings submitted by electric and gas utilities and oil companies operating in the state. In addition, the Council possessed the authority to apply for and use grants, contributions, and appropriations to carry out its duties if those requests were "made through and administered by NCDEQ" (NC Energy Policy Act of 1975, Chapter 113B, Article 1 § 113B-11).[8]

Statutory authorities and procedures were further established with the NC Emergency Management Act of 1977. This act codified the Governor's authority during emergencies and delegated some authorities and responsibilities to the Secretary of Public Safety and Division of Emergency Management. One of these delegated responsibilities was "the preparation and maintenance of State plans for emergencies" (NC Emergency Management Act of 1977, Chapter 166, Article 1A § 166A-19.12). It also included the creation of State Emergency Response Teams (SERT), which includes NCDEQ to assist NCDPS and North Carolina Emergency Management (NCEM) in preparing for and responding to emergencies. For instance, the SERT is required to report to the Emergency Operations Center (EOC) and to maintain 24-hour staffing through the duration of the emergency. In addition, NC adopted an Emergency Operations Plan (NCEOP) to establish procedures for responding to emergencies and disasters that occur. The NCEOP, by order of the Governor, adopted the National Incident Management System (NIMS) as its approach to responding to emergencies in the state.[9] Specific to energy-related emergencies, annex A of appendix 3 of the NCEOP establishes procedures for response and recovery efforts for addressing disruptions to electricity, natural gas, liquid fuels, and propane supply in the state.

3.2.1. Governor's Office

Chapter 166A of the NC General Statutes establishes the authority and responsibilities of the Governor as it relates to emergency management. The Governor delegates this authority to the Secretary of the NCDPS, who is responsible for the direction and control of the State's operations and reports to the Governor. The Secretary of the NCDPS delegates authority to the Director of NC Emergency Management who is responsible for responding to the various kinds of emergencies found in the NCEOP. The Governor may trigger an emergency response by issuing an executive order (EO) or proclamation of State of Emergency.

3.2.2. Lead State Agencies

North Carolina Department of Public Safety (NCDPS), Division of Emergency Management (NCEM)

NCEM serves as the coordinating agency for state resources, providing space and communications for the state's ESF for energy emergencies (NCESF-12). On communications, NCEM provides a communications link with both local and federal government stakeholders for the exchange of information regarding situation status and resource requests. In addition, NCEM maintains communications with the NRC and nuclear facilities in the state during the response and recovery from a radiological emergency at a nuclear power plant. NCEM also coordinates the damage assessment and recovery efforts in the disaster area, and acts as the primary administrator of the NC Mutual Aid System.[10]

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[8] Please note, the EPC was disbanded by law, and the law modified to shift this responsibility to the NCUC. Please see *Section 3.8 Recent Changes to NC Law*.

[9] Originally issued in 2004, NIMS provides a consistent nationwide template to enable partners across the nation to work together to prevent, protect against, respond to, recover from, and mitigate the effects of incidents (Federal Emergency Management Agency, 2017).

[10] The NC Mutual Aid System is a voluntary agreement among local governments in NC to share emergency response equipment and resources, since it is unlikely that any given county can own and maintain all the resources necessary to respond to all disasters.

North Carolina Department of Environmental Quality (NCDEQ), State Energy Office (SEO)

The SEO acts as a liaison between the NCDEQ infrastructure support partners and the energy companies during energy emergencies. During an energy emergency, or when the potential exists for a disaster, the SERT activated and the SEO reports to the State Emergency Operations Center (SEOC).[11] When requested and available to do so, SEO may staff the SERT within the Operations Infrastructure Support Group. SEO's primary responsibilities during an energy emergency are to gather information about the condition of the state's energy supply and infrastructure. This information is sourced from commercial news sources, government information sharing systems, industry information services, and through outreach to private sector contacts. The information SEO gathers is then shared internally and with the NCESF-12 SERT, including NCEM, federal ESF-12 partners, and energy industry stakeholders as appropriate.

In addition, in response to the Great Recession, the federal government created the EAP initiative in 2009 and provided funding to states to develop or refine their EAPs as part of the American Recovery and Reinvestment Act of 2009. This program concluded in 2012; however, it was revived in the IIJA. As part of IIJA, states once again received funding to develop or refine their ESPs, formerly energy assurance plans, with updated guidelines and requirements. NCDEQ received funding from US DOE to refine its ESP, which informs both current and future energy emergency preparedness and response. Federal funding for ESPs through IIJA is scheduled to sunset in October 2025, and it remains uncertain whether it will be extended at the time of writing this plan (May 2025). With Federal appropriations sunsetting and continuous shift in the threats facing North Carolina's energy sector, the State could enhance its energy emergency preparedness by appropriating funds to continue periodic energy security planning to support reliable energy access for North Carolinians.

North Carolina Utilities Commission (NCUC)

The NCUC is an independent state agency that regulates rates and services of public utilities in NC, including electricity, natural gas, pipeline activities, water, telecommunications and more. Generally, the commission certifies new facilities, conducts an oversight of service quality, and establishes and reviews utility rates. NCUC's role in energy emergency preparedness and response has recently changed. In late 2024, North Carolina Senate Bill 382 (S.L. 2024-57, "The Disaster Recovery Act of 2024 – Part III") transferred responsibilities previously held by the EPC to NCUC. For additional information on these changes and their impact on NCUC's statutory responsibility, please see *Section 3.8: Recent Changes to NC Law* for more information on the change.

3.2.3. Supporting State Agencies

North Carolina Department of Public Safety (NCDPS), Division of State Highway Patrol (SHP)

SHP coordinates all law enforcement, traffic control measures, and additional assistance as directed.

North Carolina Department of Public Safety (NCDPS), Division of North Carolina National Guard (NCNG)

NCNG has several responsibilities during an energy emergency. NCNG is responsible for providing emergency generators to supply emergency power to critical facilities. NCNG provides labor force and

[11] Previously, the SEO served as the staffing agency for the EPC and fulfilled some of the planning duties of the EPC. However, this has since changed. Please see section 3.8 *Recent Changes to NC Laws*.

equipment for clearing debris where electrical restoration being undertaken. NCNG provides support to local governments as their resources and other priorities allow.

North Carolina Department of Transportation (NCDOT)

NCDOT provides labor force and equipment for clearing debris from state-maintained roadways in affected areas to enable electrical service restoration. NCDOT supports DOT and NCEM vehicles and equipment being used in emergency response and recovery. NCDOT facilitates waiver applications to FMCSA for driver hour limits on an as-needed basis.

North Carolina State Bureau of Investigations (SBI)

The SBI maintains oversight of the state fusion center, the state's Information Sharing and Analysis Center (ISAC). NC ISAC develops actionable intelligence on active and potential threats, which may include threats to energy infrastructure.

North Carolina Department of Environmental Quality (NCDEQ), Division of Energy, Mineral, and Land Resources (DEMLR)

DEMLR is responsible for the North Carolina Dam Safety Program, which oversees certification and inspection of the more than 3,000 dams in NC. Their efforts reduce the risk of dam failures, which could result in catastrophic damage.

North Carolina Department of Environmental Quality (NCDEQ), Division of Air Quality (NCDAQ)

DAQ is responsible for waiver applications to the EPA for environmental requirements for motor vehicle fuels during events that disrupt the supply of petroleum products.

3.3. Local Government

Under Chapter 166A of the NC General Statutes, local governments in NC are responsible for identifying and establishing a local ESF-12 coordinator who develops a response and recovery plan for their local community. As part of the development of this plan, the local ESF-12 contact creates a list of critical infrastructure for priority restoration. This list should include energy requirements for each facility. In addition, the local ESF-12 coordinator establishes contacts with local energy providers for coordination prior to energy emergencies to be leveraged in the event of a disruption to energy service. For local governments that operate municipal utilities, the responsibility for service restoration lies with that municipality. The ESF-12 coordinator provides status reports to NCEM on outages and restoration activities. If an energy emergency rises beyond the capabilities of the local government, they may trigger mutual assistance agreements with neighboring counties or request assistance from State resources.

3.4. Tribal Coordination

NC is home to eight tribal communities recognized by the State, including one actively recognized by the federal government and another pursuing federal recognition. No tribal community in the state owns or operates its own energy infrastructure; however, they are equally vulnerable to the potential impacts of disruptions to the supply of energy. Like State and local governments, federally recognized tribal communities are required to adopt a FEMA-approved hazard mitigation plan as a condition to receive some types of non-emergency funding. The Sandy Recovery Improvement Act of 2013 amended the Stafford Act to enable federally recognized tribes to directly appeal for a Presidential emergency or major disaster declaration. In NC, both federally and non-federally recognized tribal communities are covered by the emergency management plans adopted by their local communities as mandated by Chapter 166A of the NC General Statutes.

3.5. Private Sector

Most electric and natural gas utilities, and all petroleum services organizations in the state are private sector entities. During an energy emergency these entities are responsible for assessing damage to infrastructure, available supply, and any safety hazards resulting from damage. These damage reports are then provided to NCESF-12 stakeholders. Damage to infrastructure such as electrical transmission and distribution lines, pipelines, and petroleum terminals is assessed by its respective owner/operator. These organizations will work to restore the functionality of damaged energy infrastructure. In the case of propane organizations, they will work with local emergency management personnel to locate and recover displaced propane tanks.

3.6. State and Regional Coordination Activities

As discussed in *Section 2: Critical Energy Infrastructure and Cross-Sector Interdependencies*, the energy sector is a vast interconnected network that includes resources and infrastructure from outside of NC. Given this interconnected nature, it is important for states to communicate and coordinate responses with neighboring states or regional stakeholders in times of energy disruption. NC leverages regional partnerships to improve resiliency to said disruptions through convening groups like the Energy Emergency Working Group (EEWG) and the Southeast Regional Petroleum Shortage Collaborative (SRPSC).

3.6.1. Energy Emergency Working Group (EEWG)

The EEWG holds meetings to provide technical updates, share best practices, develop and maintain interagency relationships, and improve situational awareness across State, regional, and industry stakeholders. The EEWG includes staff from the SEO and other stakeholders invited to participate including staff from NCEM, utilities, federal partners, and other regional and industry stakeholders in North Carolina and surrounding states.

3.6.2. Southeast Regional Petroleum Shortage Collaborative (SRPSC)

NC joined SRPSC with other Southeastern States to enhance the region's preparedness levels for fuel shortage events. The SRPSC developed a framework of actions and programs that can be implemented by all states in the region to coordinate responses during a fuel shortage event.

3.6.3. National Association of State Energy Offices (NASEO)

NASEO is a national non-profit organization for officials within SEOs that facilitates information sharing, learning of best practices, and exercises. NC participates in national and regional NASEO meetings and other electricity committees. NC also participates in energy system planning, resilience, and response initiatives like the Energy Emergency Assurance Coordinators Program, monthly Energy Security Subcommittee meetings, monthly All-Hazards calls, and the annual Severe Summer Weather Energy Outlook. These initiatives enhance situational awareness of both energy emergencies in other states, some of which may impact NC, and how other states are responding to energy emergencies.

3.6.4. Southeast and Mid-Atlantic Regional Transformative Partnership for Offshore Wind Energy Resources (SMART-POWER)

SMART-POWER is a collaboration between NC, Virginia, Delaware, and Maryland to advance offshore wind projects in the region and promote the Southeast and Mid-Atlantic regions as hubs for the offshore wind energy industry in the US. This collaboration provides a framework for the four states to promote, develop, and expand offshore wind energy. In addition to enhancing the resiliency of the electric grid, this collaboration aims to capture the economic benefits of developing an industry supply chain and workforce for offshore wind.

3.6.5. SEO Exercises

Exercises, including tabletop exercises (TTX), are structured activities designed to simulate emergency scenarios and evaluate the preparedness and response capabilities of organizations. These exercises range from discussion-based sessions to full-scale drills, allowing participants to practice their roles, test emergency plans, and identify areas for improvement. SEOs use these exercises to prepare for energy emergencies by cross-coordinating with government agencies, utility companies, and other stakeholders to address potential disruptions. Through these simulations, participants can refine communication strategies, enhance interagency collaboration, and ensure that all parties are familiar with their roles and responsibilities during an actual crisis. By regularly conducting such exercises, SEOs can strengthen their overall readiness, ensuring a more resilient and effective response to energy emergencies.

Natural Gas Supply and Delivery Disruption TTX

In February of 2024, the SEO, NCEM, and NASEO jointly hosted a statewide natural gas TTX, involving public and private sector partners such as the NC EPC, NCUC, local officials, Dominion Energy North Carolina, Duke Energy Corporation, Piedmont Natural Gas, and Williams Companies. The purpose of this exercise, recommended in the 2022 Biennial Report from the state's EPC, was to assemble local, state, and other stakeholders to discuss coordination and response activities during a disruption to natural gas supply and delivery. More specifically, it focused on a hypothetical ransomware attack on a natural gas pipeline during severe winter weather, which disrupted natural gas delivery. Participants discussed response strategies, public information sharing, and coordination between public and private entities.

Motor Fuels Shortage TTX

In September of 2021, NCEM, SEO, and NASEO jointly hosted a statewide motor fuel shortage TTX. This exercise involved state, local, and other stakeholders such as the American Petroleum Institute, Colonial Pipeline Company, and Kinder Morgan to assess response capabilities and plans to two different types of disruptions to the supply of motor fuel. The exercise specifically focused on two hypothetical scenarios, a ransomware attack and hurricane that caused significant damage to liquid fuel infrastructure. In addition, there was a separate module focused on public messaging. Participants discussed response and coordination strategies for a prolonged motor fuels shortage.

3.7. State Emergency Response Protocols (ESF-12)

In congruence with the NIMS and as defined in the National Response Framework, ESFs are the primary response coordinating structure during emergencies. NC has adopted this framework to respond to state emergencies, including energy emergencies. In NC, the Director of NCEM is designated as the SERT lead to serve as the coordinator for each ESF. This team includes NCDEQ. ESFs provide the structure for coordinating an interagency response during an incident and group together the functions most frequently used to provide federal support to states and other federal agencies. At the federal level, the DOE is the lead agency for ESF-12 (energy). The responsibilities for ESF-12 fall to the DOE CESER.[12] In NC, NCEM is the lead agency in the federal ESF-12, and the SEO is the lead technical agency for our state.

3.7.1. Activation Levels of an Energy Emergency

The NCEOP defines the five activation levels and associated triggers of energy emergencies. These levels are intended to serve as a guide to assist in the decision-making process before and during an active emergency. If an energy disruption requires it, NCEM will request the SEO to report to the SEOC to provide support. In addition, SEO will keep an open line of communication with relevant energy stakeholders, maintaining awareness of current and forecasted status of the incident and restoration activities. The figure below summarizes each activation level, the related trigger, and actions to be taken at each respective level.

Figure 28: NCESF-12 Energy Emergency Cell Activation Checklist

Activation Level	Trigger	Actions Taken
Level 4-5 (No Shortage)	N/A[13]	• Normal operations; monitor phase by all stakeholders.
Level 3 (Mild Shortage)	Isolated incident/degradation of service, reliability, 5 to 10% Supply reduction lasting up to one week.	• Review operating guidelines, continue monitoring and review/analyze results. • Communicate with energy providers to determine extent, cause, and expected duration of the disruption. • Communicate with affected jurisdictions to identify energy shortages. • Coordinate public information efforts with NCEM Joint Information Center (JIC). • Provide situation updates to NCEM. • Recommend voluntary demand reduction measures.
Level 2 (Moderate Shortage)	10-15% Supply reduction lasting up to three weeks	• Continue all Mild shortage actions. • Coordinate with energy providers to identify and recommend voluntary conservation measures. • Advise NCEM regarding declaration of Energy Emergency. • Recommend mandatory demand reduction measures.
Level 1 (Severe Shortage)	>15% supply reduction lasting	• Continue all Moderate Shortage Actions. • Recommend declaration of Energy Emergency.

[12] During events requiring a federal response, CESER activates its Energy Response Organization to manage response activities, including deploying ESF-12 responders, sharing situational awareness products, and coordinating with and providing technical assistance to federal, SLTT, and industry partners.

[13] NCESF-12 will prepare for activation when the National Hurricane Center advises that a tropical cyclone threatens the southeastern or mid-Atlantic coastline.

	more than three weeks	• Recommend implementation of Petroleum Set-Aside Plan.

Electricity Shortage

As discussed in *Section 2: Critical Energy Infrastructure and Cross-Sector Interdependencies*, electricity shortages in NC present significant risk for the state's residents, businesses, and critical infrastructure. Reliable electricity is crucial to maintaining economic stability and quality of life as it is a fundamental resource for powering homes, industries, essential services, and gas and fuel delivery. Shortages can be triggered by various factors, including natural hazards, increased demand, cyber-attacks, supply chain issues, or grid infrastructure failures. Consequences of electricity shortages can be severe, leading to higher energy costs, operational disruptions, and potential safety concerns. In response to an electricity shortage, utilities may implement a range of corrective actions designed to reduce demand and maintain system stability. Utilities may curtail non-essential or non-firm loads and implement voltage reductions. Curtailment of non-essential loads involves shutting off power to facilities that are not critical to public health and safety. This prioritizes the availability of electricity for these facilities to enable their continued operation. Curtailment of non-firm loads refers to the intended reduction or shutdown of power to facilities who previously agreed to reduce their demand during periods of peak demand or emergencies, which includes industrial and commercial power customers. Utilities may implement load reductions; the resulting in reduced performance of equipment and facilities that use electricity to operate. Ultimately, it is the responsibility of utilities to develop curtailment plans to be submitted to NCUC, and to maintain and restore service. These measures collectively help to support the reliability and resilience of the electric grid during periods of high demand or supply disruptions. Responding to disruptions to electric reliability requires comprehensive planning to enable utilities to maintain and restore service. The figure below summarizes each activation level, the related trigger, and actions to be taken at each respective level of an electricity emergency.

Figure 29: NCESF-12 Electricity Shortage

Activation Level	Trigger	Actions Taken
Level 3 (Mild Shortage)	Isolated outage or service degradation affecting >2,500 customers, restoration anticipated within 48 hours	• Continue monitoring and determination actions. • Query utility about expected duration and grid-protective measures. • Identify any affected critical infrastructure. • Coordinate with NCESF stakeholders to address energy requirements. • Coordinate public information announcements with NCEM JIC.
Level 2 (Moderate Shortage)	Region-wide outage or service degradation affecting >10,000 customers, restoration	• Continue all Mild shortage actions. • Recommend voluntary conservation measures, which may include: ○ Adjusting heating, ventilation, and air conditioning (HVAC) setpoints to no higher than 65°F during winter and no lower than 78°F during summer (with possible exceptions for critical facilities).

	anticipated within 168 hours	○ Reducing water heater thermostats to 105°F (with possible exceptions for critical facilities). ○ Reducing operating hours of State government facilities. ○ Temporary closure of State government facilities. ○ Limiting the use of electronic signage, window displays, and other non-essential lighting. ○ Restricting the operating hours of retail businesses.
Level 1 (severe shortage)	Widespread and persistent outage or service degradation affecting >20,000 customers, restoration not expected within 168 hours	• Continue all Moderate Shortage Actions. • Recommend mandatory conservation measures, which may include: ○ HVAC setpoints to no higher than 65°F during winter and no lower than 78°F during summer (with possible exceptions for critical facilities). ○ Reducing water heater thermostats to 105°F (with possible exceptions for critical facilities). ○ Reducing operating hours of State government facilities. ○ Temporary closure of State government facilities. ○ Limiting the use of electronic signage, window displays, and other non-essential lighting. ○ Restricting the operating hours of retail businesses. • Notify DOE, ESF-12.

Natural Gas Shortage

Natural gas shortages in NC can pose significant challenges for the state's residents, businesses, and industries. Shortages can arise from a variety of factors, including extreme weather events, supply chain disruptions, infrastructure failures, and increased demand during peak usage periods. The impact of these shortages can be widespread, leading to higher energy costs, operational disruptions, and potential hardships for households and businesses. In the event of a disruption to natural gas service, providers may need to act to maintain line pressure, continuity of service, and safety. To achieve these priorities, natural gas providers may need to curtail service to customers in accordance with the rules and regulations of the NCUC, which oversees pipeline safety. Under Chapter 6, Rule R6-19.2, services are first curtailed for customers paying the least margin per dekatherm; however, NCUC may change the curtailment priorities from a margin-based system to an end-use characteristics-based system at its discretion with notice and comment opportunity given to utilities and other State stakeholders (Chapter 6. Natural gas, n.d.). Responding to natural gas shortages requires coordination among government and industry stakeholders, as well as the commitments of industrial, commercial, and residential customers. The figure below summarizes each activation level, the related trigger, and actions to be taken at each respective level of a natural gas emergency.

Figure 30: NCESF-12 Natural Gas Shortage

Activation Level	Trigger	Actions Taken

Level 3 (Mild Shortage)	Up to 10% supply reduction lasting up to one week	• Continue monitoring and determination actions. • Communicate with suppliers and provide situation update to NCEM. • Coordinate public information announcements with NCEM JIC. • Coordinate with NCESF stakeholders to address energy requirements. • Recommend voluntary conservation measures, which may include: ○ Adjusting HVAC setpoints to no higher than 65°F during winter (with possible exceptions for critical facilities). ○ Reducing water heater thermostats to 105°F (with possible exceptions for critical facilities). ○ Reducing hours of operation at large employers (100 or more employees at a single location) with natural gas-heated buildings or allowing employees to telecommute. ○ Weatherizing structures. ○ Reducing operating hours of State government facilities. ○ Temporary closure of State government facilities.
Level 2 (Moderate Shortage)	10-15% supply reduction lasting up to three weeks	• Continue all Mild shortage actions. • Query electric utilities about the potential for cascading effects. • Query gas providers about expected duration of curtailment measures. • Recommend mandatory conservation measures, which may include: ○ Adjusting HVAC setpoints to no higher than 65°F during winter (with possible exceptions for critical facilities). ○ Reducing water heater thermostats to 105°F (with possible exceptions for critical facilities). ○ Reducing hours of operation at large employers (100 or more employees at a single location) with natural gas-heated buildings or allowing employees to telecommute. ○ Weatherizing structures. ○ Reducing operating hours of State government facilities. ○ Temporary closure of State government facilities.
Level 1 (severe shortage)	>15% supply reduction lasting more than three weeks	• Continue all Moderate Shortage Actions. • Notify DOE, ESF-12.

Petroleum Shortage

Petroleum shortages occur when the supply of refined petroleum products, such as gasoline, diesel, and heating oil, fails to meet the demand. These shortages are extremely difficult to predict and can arise from a variety of factors, including natural disasters, geopolitical conflicts, industrial accidents, and regulatory changes. As discussed in *Section 1: Energy Landscape & Interdependencies*, NC is vulnerable to petroleum supply shortages given the state's reliance on imports for its refined petroleum products. Petroleum disruptions that occur in other parts of the country, such as in the Gulf Coast, may result in supply shortages that affect North Carolinians, as NC does not produce any petroleum products in-state. When a disruption occurs, petroleum industry entities may act to ensure that they are meeting their contract obligations, for example, implementing an allocation. A terminal allocation results in only wholesalers with existing contracts receiving supply. Terminal allocations can exacerbate supply shortages when a state or region has a high proportion of non-contract wholesalers, which is the case in western NC. In extreme cases, such as natural disasters, labor strikes, and major facility failures, petroleum suppliers may declare force majeure to relieve themselves of their contractual obligations. This can lead to significant supply shortages, price increases, disruptions to operations requiring petroleum products, and general economic loss.

The impact of petroleum shortages can be widespread, affecting transportation, manufacturing, agriculture, and consumer activities. Petroleum shortages can lead to significant economic disruptions, increased prices, and challenges in maintaining essential services. In the event of a disruption to the supply of refined petroleum products, such as gasoline and diesel, the State government may implement several measures to conserve fuel supplies. Measures taken by the State depend on the severity of the emergency and will remain in effect until the situation is resolved. These measures are essential to procure sufficient supplies of petroleum for critical services to maintain public health and safety. The figure below summarizes each activation level, the related trigger, and actions to be taken at each respective level of a petroleum emergency.

Figure 31: NCESF-12 Petroleum Shortage

Activation Level	Trigger	Actions Taken

Level 3 (Mild Shortage)	Up to 10% supply reduction lasting up to one week	• Continue monitoring and determination actions.
		• Communicate with suppliers and provide situation update to NCEM.
		• Coordinate public information announcements with NCEM JIC.
		• Coordinate with NCESF stakeholders to address energy requirements.
		• Recommend voluntary conservation measures, which might include:
		  ○ Encourage the reduction of travel (e.g., eliminating non-essential travel, combining trips, efficient routes, etc.).
		  ○ Encourage the use of multi-passenger travel (e.g., public transportation, carpools, etc.).
		  ○ Encourage the use of alternative methods of transportation (walking, bicycles, etc.).
		  ○ Encourage practices that improve vehicle efficiency (e.g., reducing average speeds, minimizing idling, performing

		regular vehicle maintenance, proper tire pressure, using the most fuel-efficient vehicle available, etc.). o Selective or enhanced speed limit enforcement.
Level 2 (Moderate Shortage)	10-15% Supply reduction lasting up to three weeks	• Continue all mild shortage actions. • Contact petroleum terminals, pipeline operators, and prime suppliers for data to estimate available supply. • Consider the implementation of conservation options with relevant stakeholders. • Consider travel reduction planning for public or private entities, colleges, and employers with greater than 50 employees (e.g., encouraging employees to carpool, offering the ability to telecommute, adjusting working or operating hours, etc.). • Consider travel reduction planning for schools and coordinate with the Department of Public Instruction, local government officials, and school boards to formalize rules for students driving to school and determine enforcement (e.g., encouraging students to ride the bus, limiting, or eliminating field trips and distant travel to sporting events, etc.). • Consider travel reduction planning for State government (e.g., suspending non-essential travel, initiating a no-idling policy for government vehicles, designating a no travel day, encouraging telecommuting, carpooling, and adjusting working or operating hours, etc.). • Recommend mandatory conservation measures, which might include: o Travel reduction policies for State government. o Travel reduction policies for schools or colleges.
Level 1 (severe shortage)	>15% supply reduction lasting more than three weeks	• Continue all mild and moderate shortage actions. • Consult industry and government stakeholders on available options. • Consider the implementation of policy interventions (e.g., odd/even purchase plan, minimum fuel purchase, maximum fuel purchase, priority end-users, speed limit reductions, enhanced speed limit enforcement, fuel set asides, etc.). • Recommend implementation of Petroleum Set-Aside Plan. • Request Governor to declare a State of Emergency. o Declaring a State of Emergency enables the potential waiver of restrictions on commercial drivers' working hours, Federal RFG requirements, and the Jones Act[14]. • Notify DOE, ESF-12.

[14] The Jones Act, part of the Merchant Marine Act of 1920, mandates that goods transported between U.S. ports be carried on U.S.-built, owned, and crewed ships, while also providing protections for maritime workers.

Propane Shortage

The public sector can take both voluntary and/or mandatory measures to reduce its consumption of propane and conserve resources for other customers. The decision to implement these measures, and whether they are voluntary or mandatory, depends on the severity of the emergency. In extreme situations, the Governor may issue an EO mandating these measures for industrial, commercial, or government users. Additionally, the State government can launch awareness campaigns to encourage propane conservation among residents and businesses. The following measures reduce demand:

- Adjusting heating, ventilation, and air condition (HVAC) setpoints to no higher than 65°F during winter (with possible exceptions for critical facilities).
- Reducing water heater thermostats to 105°F (with possible exceptions for critical facilities).
- Curtailing deliveries to non-essential customers or critical facilities.

In times of supply constraints or increased demand, propane suppliers might implement strategic actions to conserve their supply. These actions can include encouraging customer conservation measures and curtailment of fuel deliveries to non-essential customers. By adopting these proactive measures, propane suppliers can mitigate the impact of supply shortages.

3.8. Recent Changes to NC Law

As previously discussed, in December 2024, the NC General Assembly enacted S.L. 2024-57 (Senate Bill 382 or "The Disaster Recovery Act of 2024 – Part III"). This legislation repealed the Energy Policy Council (EPC) and shifted its statutory responsibility of energy emergency preparedness and response to the North Carolina Utilities Commission (NCUC). As a result, current law requires the NCUC to develop contingency and emergency plans to deal with possible energy shortages. Each electric and natural gas utility is required to prepare and submit proposals for energy curtailments that include priority end-use consumers and proposals to ensure priority consumers receive an allocation of supply during emergencies. Further, major oil companies are required to similarly submit an analysis of impacts resulting from a national supply curtailment and priority consumers to receive allocations of supply during emergencies.

NCUC shall review submissions and carry out analyses as needed to determine the risks facing energy supply in NC. Ultimately, NCUC replaces SEO as the agency responsible for energy emergency planning and shall recommend energy curtailment guidelines to the Governor to be implemented during a declared emergency. The Governor maintains the authority to administer federal programs and can be delegated authority given by the President, Congress, or the DOE. The Disaster Recovery Act of 2024 – Part III does not alter the authorities of NCDPS and NCEM, as delegated from the Governor. Additionally, NCDEQ's responsibility as a member of SERT is unchanged, and the SEO will still report to the SEOC if called upon by NCEM to support energy emergency responses and liaise with utilities and liquid fuels companies.

3.9. Conclusion

Maintaining public safety and the economic wellbeing of North Carolinians is the paramount reason behind energy emergency preparedness and response. As detailed in *Section 2: Critical Infrastructure and Cross-Sector Interdependencies and Section 4: Energy Sector Threats and Impacts,* the potential fallout of energy system failures is vast and the number of threats these systems are exposed to are numerous.

Moreover, many of these threats are growing in their potential severity. As such, it is necessary that the State Government of NC undergoes a robust planning process that enables sufficient preparedness to respond to emergencies when they do occur to limit the potential damage to the state. Given the recent changes to NC law, SEO's role has changed; however, this presents an opportunity for SEO to find other ways to enhance energy security in the state.

PART TWO: Hazards, Threats, Vulnerabilities, and Consequences

4. Energy Sector Threats and Impacts

Section 4: Energy Sector Threats and Impacts explores the range of natural, human-caused, and technological threats facing the state's energy system, detailing their likelihood of occurrence based on environmental patterns, human activities, and technological trends. The threats are categorized into three primary categories:

- **Natural:** resulting from acts of nature.
- **Technological:** resulting from failures of systems and structures.
- **Human-Caused:** resulting from accidents or intentional actions of an adversary, and the spread of misinformation/disinformation.[15]

The following inventory of threats leads into a Threat Likelihood analysis, evaluating future probability of the threats to occur within NC, setting the stage for a deeper evaluation of their potential impacts and mitigation needs.

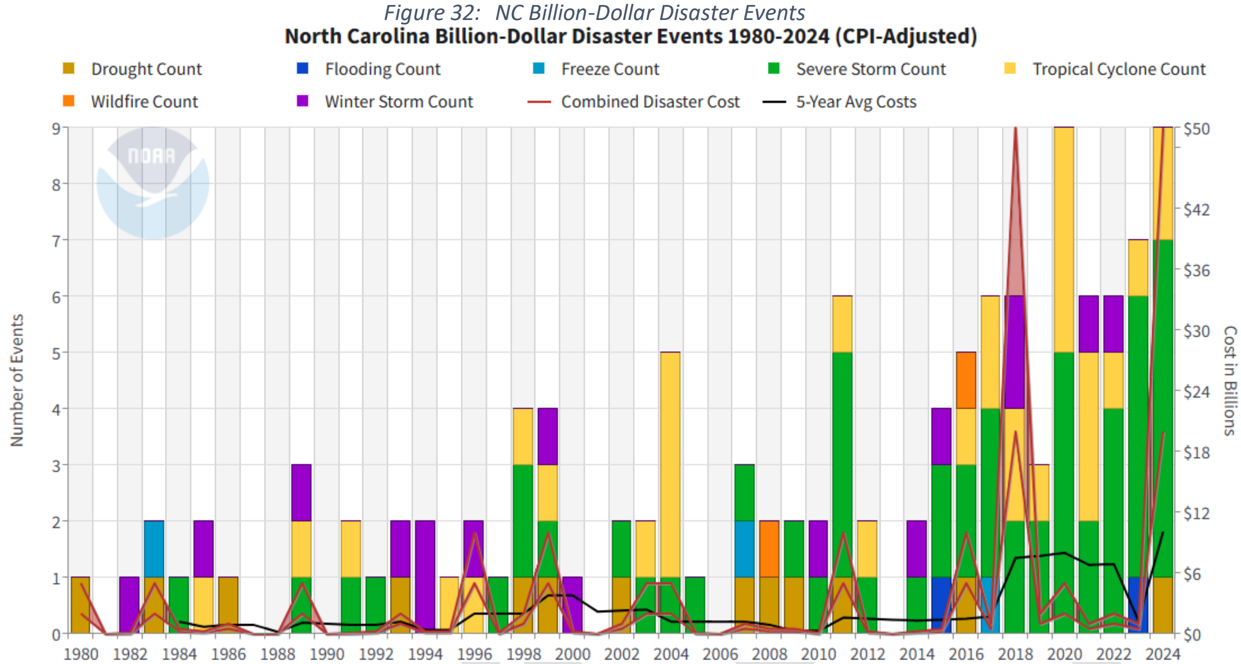
4.1. Natural Threats

The state's energy infrastructure and supply chain are vulnerable to a wide range of environmental threats, which can cause significant disruptions to the state's economy, security, and resident safety. Often these disruptions can persist for days, leaving residents and businesses without the electricity or fuel needed to provide critical services or stay safe in their homes.

Environmental threats have been trending higher in NC over the past 40 years, as the figure below shows the billion-dollar disaster events from 1980-2024, estimated by the National Oceanic and Atmospheric Administration (NOAA).

[15] Please note, loss of communication services during an emergency is not included in this section; however, this is a threat that NC can face during an emergency response situation. Information and examples regarding communication service challenges and mitigation strategies can be found in *Section 8.4.4 Communication Coordination*.

Figure 32: NC Billion-Dollar Disaster Events



Source: NOAA

High Wind and Lightning (Hurricanes, Tornados, and Severe Thunderstorms)

Severe thunderstorms, hurricanes, and tornados are some of the most destructive natural hazards facing the energy sector in NC. The high winds, heavy precipitation, and lightning brought on by these natural hazards represent a significant risk to infrastructure (see the Flooding and Increasing Precipitation section for more information on the impacts of heavy precipitation). Severe thunderstorms are the most common natural hazard affecting the state, according to data from the DOE CESER (NC Energy Risk Profile, 2021). While hurricanes and tornados are less common, their destructive force exceeds that of severe thunderstorms, as is evident in damage estimates resulting from Hurricane Helene, where estimated damages exceed $59 billion within NC (Hurricane Helene Recovery, 2024).

Hurricanes are tropical cyclones fueled by factors like ocean temperatures and low wind shear. Given the large Atlantic coastal area of NC, hurricane-related risks along the coast are among the highest in the country; however, all counties in the state are vulnerable, as shown in the figure below.[16] While climate studies differ on forecasting changes in the frequency of hurricanes in the future, evidence shows that hurricanes are moving slower, decaying slower over land, intensifying more rapidly, and continuing to intensify on average (Fifth National Climate Assessment, 2023; IPCC, 2023). The slower movement and over land decay means that energy infrastructure, along with other structures, can result in more damage from high winds (Grinsted, Ditlevsen, & Hesselberg Christensen, 2019). The figure below displays the FEMA National Risk Index (NRI) Expected Annual Loss (EAL)[17] forecast for NC counties.

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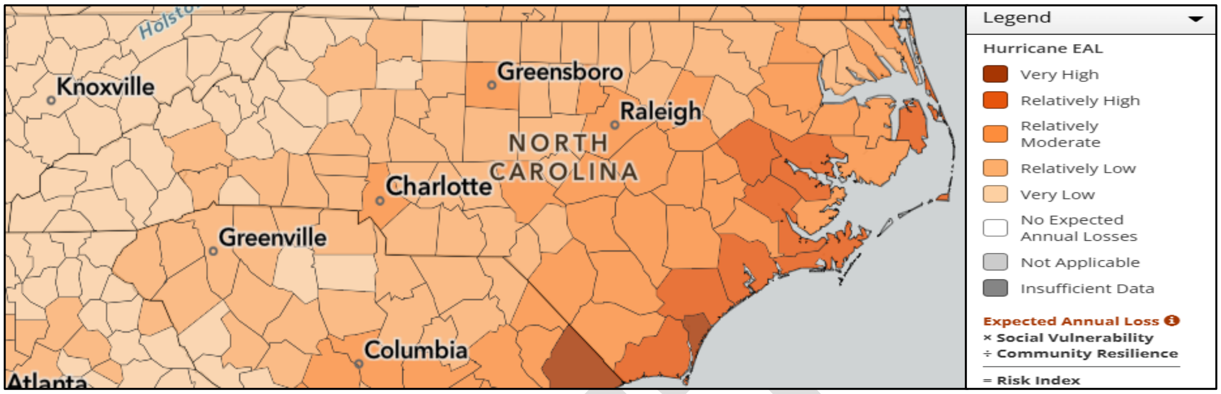
[16] The 2023 State Hazard Mitigation Plan states that 50% of hurricane impacts occur in western NC.

[17] EAL represents the average economic loss in dollars resulting from natural hazards each year (Zuzak, et al., 2023).

Figure 33: EAL due to Hurricanes

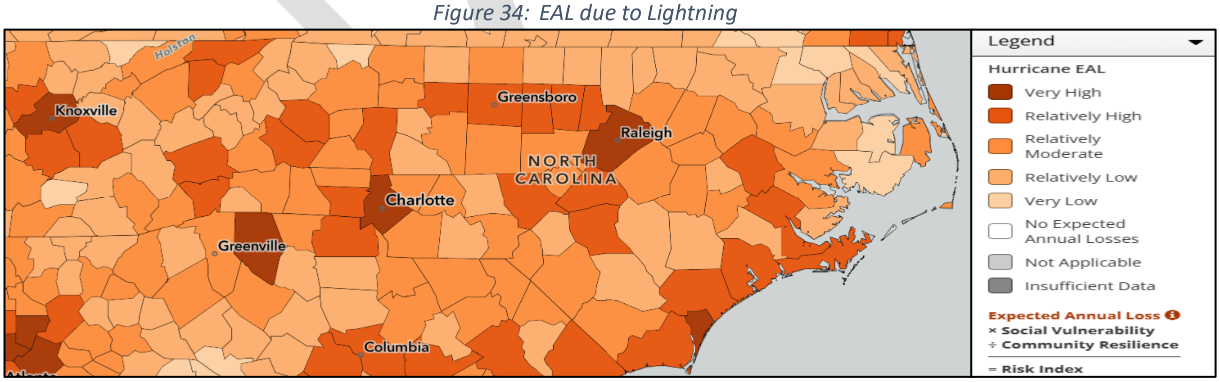


Source: FEMA NRI

Tornados are extremely dangerous weather events characterized by a high-speed wind vortex. Tornados have the potential to cause significant damage through high winds that can destroy buildings and hurl pieces of debris at great speed. Tornados may be generated by severe storms or as a secondhand effect resulting from hurricane activity. The risk of tornados is greater in the south-central and southeastern regions of the state; however, all counties in the state are at risk. According to DOE CESER, NC averaged over 15 tornados each year from 2009 to 2019 (NC Energy Risk Profile, 2021). Climate forecasts differ on tornado trends as well; however, there is evidence that tornado outbreaks (singular events that generate multiple tornados) and tornado strength have increased (Fifth National Climate Assessment, 2023). Studies have also shown evidence that "Tornado Alley" is expanding eastward, which may increase risks to western NC (Gensini & Brooks, 2018).

Severe thunderstorms are the most common natural hazard facing the state's energy infrastructure. These storms are often accompanied by high winds, hail, lightning, and heavy precipitation. Future trends for severe storms are difficult to forecast due to issues in the historical record and reliance on visual confirmation. This uncertainty extends to trends in cloud-to-ground lightning, where no discernable trends have been detected, but analysis is limited due to data availability and quality (Villarini & Smith, 2023). The figure below shows the EAL to buildings resulting from lightning strikes in NC. Climate forecasts show it is likely (>66% probability) that the frequency of severe storms in NC will increase (NC Climate Science Report, 2020). Late century estimates from the National Aeronautics and Space Administration's Convective Available Potential Energy (CAPE) index show that the potential for severe storms and tornados in NC will increase.

Figure 34: EAL due to Lightning



Source: FEMA NRI

Flooding and Increasing Precipitation

Flooding is the second most common and costly natural hazard in NC based on an annualized frequency and property damage (NC Energy Risk Profile, 2021). The state is vulnerable to both coastal and riverine flooding. Coastal flooding is the result of storm surges, abnormal tide or wave activity, or excessive precipitation. These conditions are brought on by hurricanes, tropical storms, or other coastal storms. Riverine flooding is the result of heavy precipitation and runoff volume in the floodplain of a stream, river, or lake. While only coastal counties in the state are under threat of coastal flooding, all counties in the state are at risk to riverine flooding, which is more common. From 1996-2019, the state experienced over 2,900 riverine flood events (The National Risk Index, n.d.). Studies have shown that the proportion of higher intensity hurricanes have increased over the past four decades and it is highly likely that they are causing heavier rainfall and higher storm surges than before (Fifth National Climate Assessment, 2023; IPCC, 2023).

In western NC, Tropical Storm Frances, Hurricane Ivan, and Tropical Storm Fred each caused severe flooding and nearly $60 million in damage within the past 25 years (NCDPS, 2023, pp. 3-10:3-12). More recently, Hurricane Helene produced a 1,000-year flood event that wrought unprecedented damages to western NC communities, including $41 million in damages to gas and propane supply chains (Hurricane Helene Recovery , 2024). In the Piedmont and coastal regions of the state, recent flood events resulting from Hurricanes Matthew and Florence caused nearly $3 billion in damage (NCDPS, 2023).

The threat of both riverine and coastal flooding is expected to increase in the future, as both coastal and riverine flooding risks will worsen due to varying increases in the severity and frequency of flood triggering events and related factors (Fifth National Climate Assessment, 2023; NC Climate Science Report, 2020). Further, it is virtually certain (99-100% probability) that rising sea levels and increasingly intense and frequency coastal storms will lead to an increase in coastal flooding (NC Climate Science Report, 2020). In addition, the report states that it is likely (>66% probability) that increased frequency and intensity of extreme precipitation events will lead to increased inland flooding (NC Climate Science Report, 2020).

Extreme Temperatures

The state's climate is generally humid, with hot summers and moderately cold winters. Given the topological variation in the state, regional temperatures tend to be similarly varied with cooler temperatures in the western mountainous region relative to the inland (Piedmont) and coastal plains. Generally, temperatures in the state have been climbing with limited exceptions and have been above the long-term historical averages in 20 of the previous 29 years, as of 2020 (NC Climate Science Report, 2020). The 2020 NC Climate Science Report states that summer multi-year averages from 2005-2018 were the warmest on record while the number of very hot days and warm nights in NC has risen and is projected to keep climbing, no clear trend has emerged in the number of cold days, though the state has seen higher-than-average winter temperatures and fewer extremely cold nights. Long-term forecasts show that the Piedmont and coastal regions are likely to see minimal decreases in the number of cold days and very cold nights, but the historically colder mountainous region of the state is likely to see a decrease in both (NC Climate Science Report, 2020).

For the energy sector, extreme temperatures have caused reliability issues across the nation. In Texas, extreme cold caused a near catastrophic system failure of the grid and natural gas infrastructure during Winter Storm Uri in 2021. Coal, nuclear, and wind generation all suffered from freezing temperatures and icing; however, natural gas transmission and generation was most affected. Freeze-offs in natural gas equipment led to dramatic failures from both pipeline infrastructure and generation facilities (EIA, 2021). The result was nearly half of the state's households losing power, some for several days, as temperatures were dangerously low (Busby, et al., 2021).

Winter Storm Elliott, striking the Northeast in December 2022, significantly impacted NC's natural gas generation and led to widespread power outages. The extreme cold caused unplanned outages at several of the State's gas-fired plants, with some units derated or offline due to frozen equipment and fuel supply issues, while demand soared 10% above forecasts, peaking at record levels. This forced Duke Energy to implement rolling blackouts, affecting about 500,000 customers for hours, highlighting vulnerabilities in gas infrastructure reliability during severe weather.

Impacts of extreme heat can drive electricity demand higher as cooling loads spike. This increase in demand coincides with reduced efficiency of critical infrastructure in the electricity and natural gas supply chains. In recent years, there have been several highly publicized heatwaves impacting western and Northeastern states. In September of 2022, the California Independent System Operator recorded its all-time peak demand, with the grid operator requesting consumers to voluntarily reduce consumption for ten consecutive days to avoid rolling blackouts (Subakti, 2024). DEC and DEP also achieved a new combined summer peak usage record recently. In June 2022, 34,089 MWh of electricity consumption was logged for the hour ending at 6 p.m. This exceeded the previous combined record of 33,631 MWh, set in July 2020.

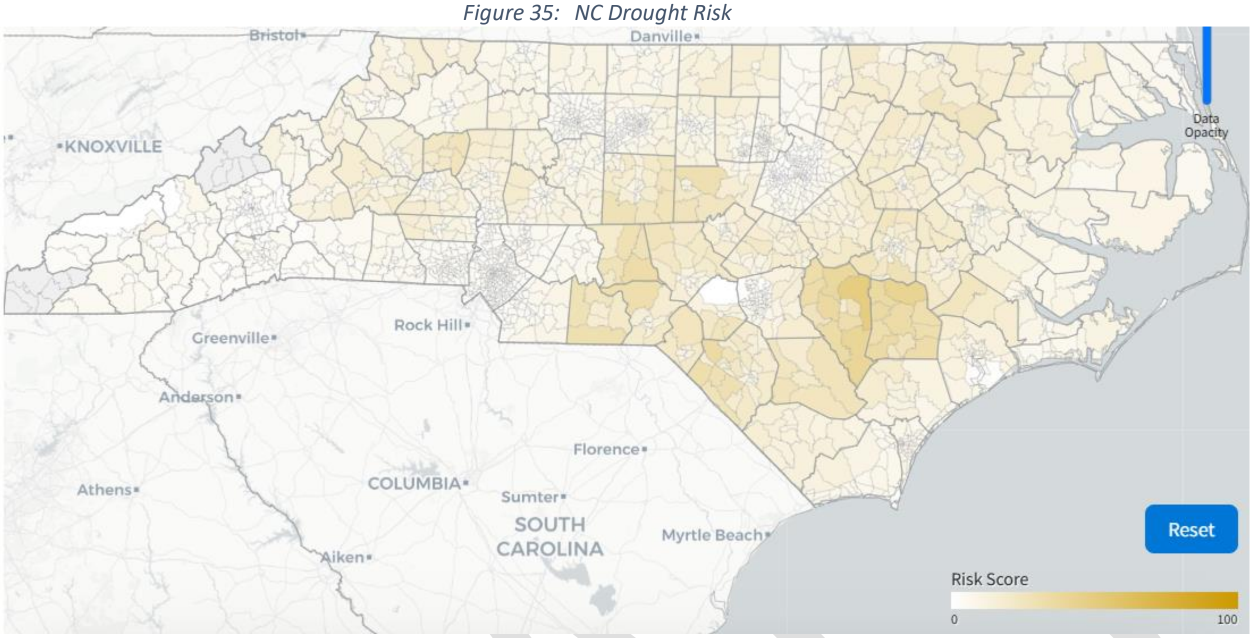
Extreme temperatures are a risk to the state's energy infrastructure, and these risks will likely become increasingly severe in the medium- to long-term based on the 2020 Climate Risk Assessment and Resilience Plan released from NCDEQ. Based on the FEMA NRI, it is evident that EAL for buildings from extreme heat are concentrated in the Piedmont and coastal regions. Meanwhile, the EAL from extreme cold are concentrated in the mountainous region in the western counties. These regional differences can help prioritize mitigation actions discussed in *Section 8: Risk Mitigation Descriptions and Case Studies*.

Drought

Droughts, which is the lack of precipitation over an extended period, can cause significant economic harm, particularly affecting agriculture, forestry, water resources, and can lead to higher likelihoods of other natural threats, particularly wildfires. Droughts also impact energy infrastructure as is discussed in *Section 4.5.1 Natural Threat Impacts*. According to the Fifth National Climate Assessment, the Southeast US is prone to both flash and extreme droughts.[18] While NC is generally known to have a wetter and humid climate, it is not immune to drought effects. NC experienced drought conditions along with much of the nation for all of 2024, and those conditions have persisted into 2025. The figure below shows the NC drought risk by county according to NOAA.

[18] A "flash drought" is characterized by the rapid intensification of drought conditions; however, the exact definition is still up for debate (Otkin, et al., 2018).

Figure 35: NC Drought Risk



Source: NOAA

According to data from NOAA's Billion-Dollar Weather and Climate Disaster analysis[19], droughts represented approximately 8% (estimated between $10-20B) of total statewide costs from 1980 to 2024. At the time of writing this plan (Q2 2025), nearly 95% of the total area of the state is experiencing drought conditions (US Drought Monitor, 2025). With a changing climate, drought-related challenges are expected to persist in NC. The NC 2020 Climate Science Report suggests that more severe droughts in the future are likely (>66% chance) due to higher temperatures increasing evaporation and estimates from the 2023 Fifth National Climate Assessment support this conclusion as well. As discussed in *Section 4.2.1 Natural Threat Impacts*, drought conditions cause unique challenges to a considerable proportion of energy infrastructure, especially for electricity generation infrastructure.

Wildfire

Wildfires are extremely dangerous events, triggered by both human and natural activity, which can cause significant property damage, impact on human health, and result in the loss of life. Natural factors that can create conditions conducive to wildfires include lack of precipitation, temperature, atmospheric water vapor content, solar energy, and wind (Kunkel 2001). These factors directly influence the dryness of plant matter, increasing its susceptibility to events that could spark a wildfire. A trigger event may include human activity, lightning, arcing by electrical infrastructure, and other incidents.[20] In March/April 2025, there were several widespread wildfires in the western region of NC, which were exacerbated by Hurricane Helene damage, due to higher-than-normal amounts of dead trees, leaves, and other plant material (Doran, 2025). Officials reported that Black Cove Fire was started by a downed power line and burned over 3,200

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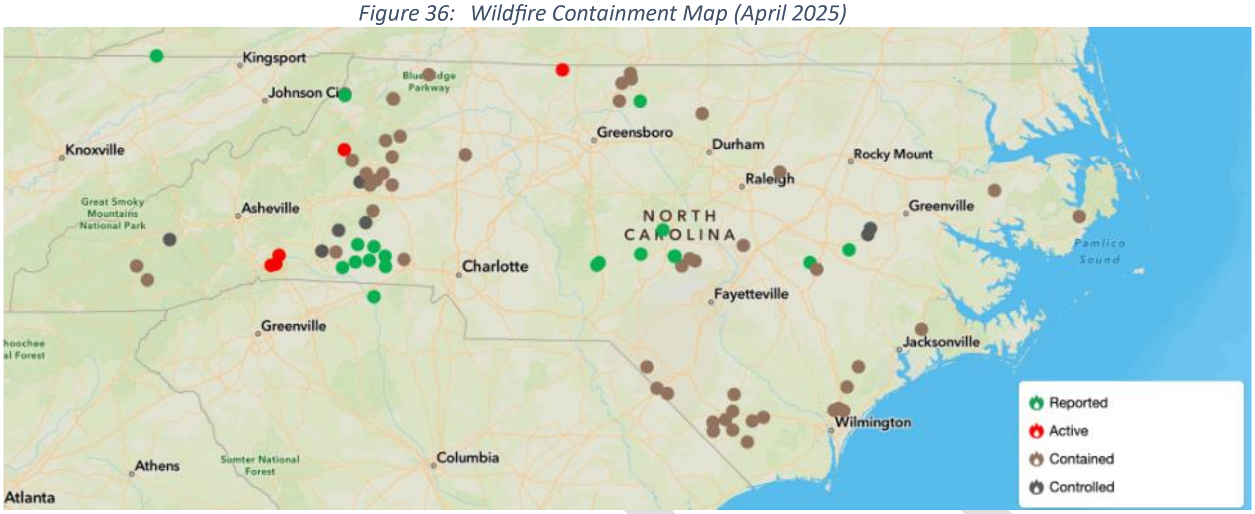
[19] The Billion-dollar disasters product is intended to show the impact of extreme weather and climate events on the economy in inflation adjusted dollars.

[20] This has been realized to devastating consequences in other states, for example, when 85 people lost their lives during the 2018 Camp Fires in California, for which Pacific Gas & Electric admitted fault for improperly maintained equipment arcing and triggering the fires (PG&E Pleads Guilty On 2018 California Camp Fire: 'Our Equipment Started That Fire', 2020).

acres. The figure below shows the extent of the recent wildfires within NC (Morning update on the Black Cove Complex fires in Polk and Henderson counties, 2025).

Figure 36: Wildfire Containment Map (April 2025)



Source: NC Forest Service

In addition, the Southeast sees a large amount of prescribed, or controlled, burning to help reduce the risk of wildfire. In NC, prescribed fires are leveraged by the NC Wildlife Resources Commission (NCWRC), in part to mitigate wildfire risk. However, the effectiveness of prescribed fires in NC may be diminished due to the likely increase in drought conditions, which would make controlled burning too risky (Mitchell, 2014).

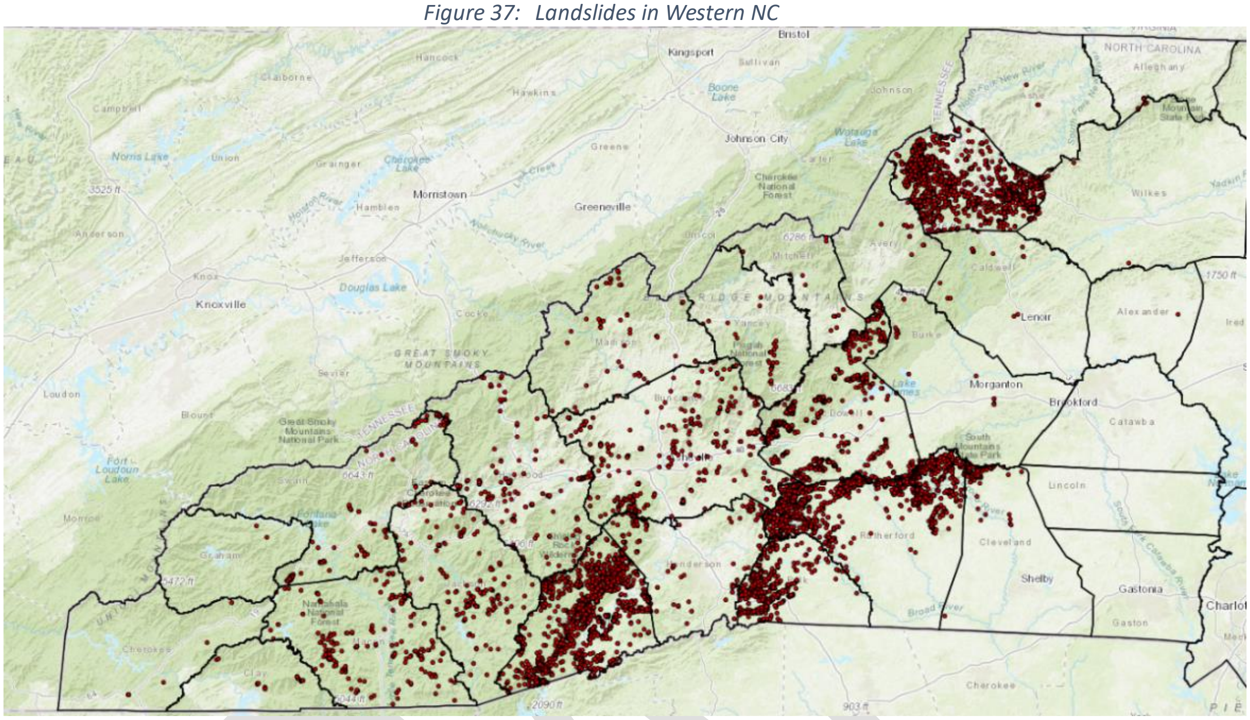
The FEMA NRI suggests most NC counties, relative to all US counties, have a relatively low EAL for property resulting from wildfires, however several counties are estimated to have relatively moderate risk. In the Southeastern US, models indicate an increased fire risk and an extended fire season, projecting at least a 30% rise in the area burned by lightning-ignited wildfires by 2060 compared to 2011 (Wildfires, n.d.). This conclusion is also supported by the NC Climate Science Report, which concluded that it is likely (>66% probability) that the frequency of climate conditions leading to wildfires will increase in NC (NC Climate Science Report, 2020). This is exacerbated by increasing land development near woodland areas, which both increases the risk of triggering a wildfire and potential damages resulting from wildfire (Fifth National Climate Assessment, 2023).

Landslides

Landslides are devastating compound natural hazards that can occur with little to no warning where masses of rock and earth move down a slope. The likelihood of a landslide occurring is generally higher during or after heavy rainfall or rapid snowmelt, and after extended periods of drought resulting in subsidence. Mismanagement and overdevelopment of land, especially in mountainous areas with steep slopes, can significantly increase the likelihood of landslides. In NC, landslides can occur in nearly all counties in the state, but counties in western, mountainous counties have higher modeled risks. From 2009—2019, the state averaged two landslides per year (NC Energy Risk Profile, 2021).

Hurricane Helene was estimated to have caused over 2,000 landslides, according to the NC Geological Survey. Most of the landslides happened just east of Asheville toward Swannanoa, Black Mountain, Lake Lure and into the northern mountains. These were areas that are located along the slope that separates the higher elevations from the lower. The figure below shows the “landslide points” within the western region of NC. Landslide points identify areas of slope movements. This map was pulled from the "Western NC Landslide Hazard Data Viewer" (sourced from the NC Geological Survey).

Figure 37: Landslides in Western NC



Source: NCDEQ – NC Geographic Survey

Earthquakes

Earthquakes, while not a frequent occurrence in NC, can cause severe damage to NC infrastructure. There were no earthquakes exceeding 3.5 magnitude on the Gutenberg-Richter scale observed between 2009-2019 (NC Energy Risk Profile, 2021). However, the NRI model, which leverages data from the US Geological Service, estimates that there is a non-zero risk of an earthquake affecting NC (National Risk Index Data Version and Update Documentation, 2023). This underscores the importance of preparedness and risk mitigation strategies to safeguard against potential seismic events.

Winter Storms

Winter storms in NC can be extremely hard to predict and often result in mixed forms of wintry precipitation. Winter storms can involve sleet, freezing rain, icing, or dangerously low temperatures that can be accompanied by fierce winds. The FEMA NRI lists several counties in western NC such as Catawba, Lincoln, and Gaston, as a "very high" risk for future ice storms. A winter storm in January 2022 caused over five inches of snow in the Coastal Plain and Sandhills, while locations across Piedmont received roughly 1 to 4 inches of snow. The snow caused numerous accidents and scattered power outages, especially across the eastern and southern half of the area, where snowfall totals were the greatest. The Crystal Coast experienced icing amounts ranging from a quarter to half an inch, marking the most significant and widespread ice accumulation in the area since the late 1990s (Winter Storm Event, n.d.). Winter storms can cause power outages and lead to health and safety risks. The National Weather Service calls winter storms "deceptive killers" because most deaths are not directly related to the storm. Instead, people die in traffic accidents on icy roads and from carbon monoxide (CO) poisoning while using alternative ways to heat or power a home.

Electromagnetic Disturbances

Electromagnetic disturbances encompass geomagnetic storms, solar radiation storms, radio blackouts, or electromagnetic pulses. These types of events can cause disruptions to the electric grid by interfering with sensitive equipment on the power grid and in fuel transportation.

4.2. Technological Threats

This section examines the technological threats facing NC's energy system, focusing on the challenges posed by rising demand and infrastructure failures across generation, transmission, and pipeline networks. As the state grapples with increasing electricity needs, driven by population growth, electrification trends like EVs, these pressures expose vulnerabilities in aging and interdependent systems. By analyzing these threats, this section aims to highlight their potential to disrupt energy security, strain affordability, and test the resilience of NC's electric customers.

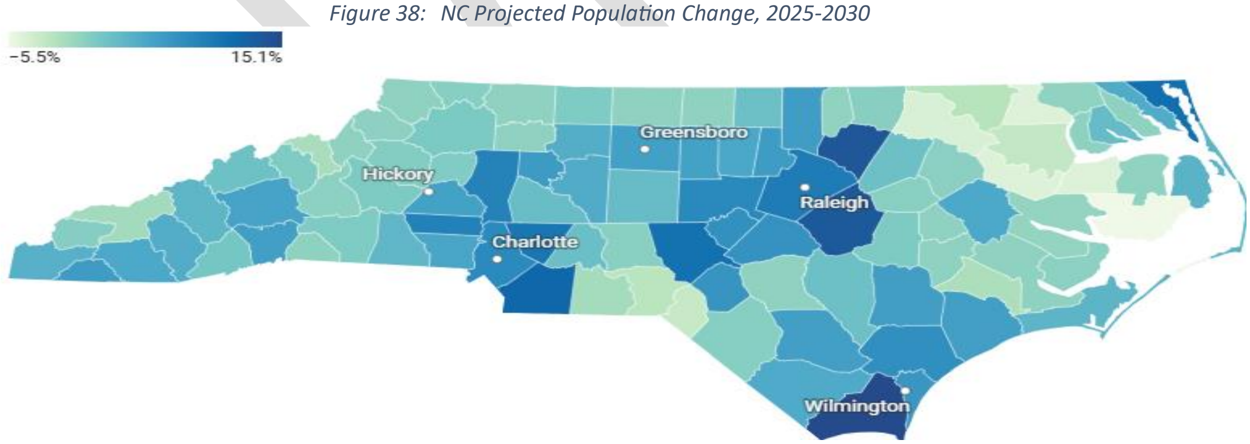
Rising Demand

Increases in NC demand has been driven by a confluence of population growth, the proliferation of AI and data centers, electrification trends, and rising EV sales, all of which collectively challenge the state's ability to maintain reliable and affordable energy.

The state's population increased 9 out of the past 10 years, with its largest year-over-year increase (1.3%) during 2021-2022. Net migration has accounted for over 90% of the state's population growth, and beginning in the 2030s all growth will depend on net migration (Cline, 2025). In 2020, 65% of all North Carolinians (or 6.8 million people) lived within 22 urban or regional center/suburban counties, with the remaining 35% (or 3,649,000 people) living in 78 rural counties (Cline, 2025). Continued rapid growth in the Raleigh-Durham, Charlotte, and Wilmington urban areas will lead to more urban counties increasing population size and density. The high population density in NC's urban areas amplifies the need for expanded generation and transmission infrastructure to deliver reliable power efficiently to these high-usage areas, which is explored more in *Section 8.2: Supply Side Mitigation*.

The figure below shows the forecasted population change by county from 2025-2030, indicating that the urban counties may see a ~10-15% increase in population. The rapid population growth and urbanization in NC threatens energy security by intensifying electricity demand, straining aging infrastructure, and challenging the grid's ability to deliver reliable, affordable power to its growing ~8.4 million electric customers.

Figure 38: NC Projected Population Change, 2025-2030



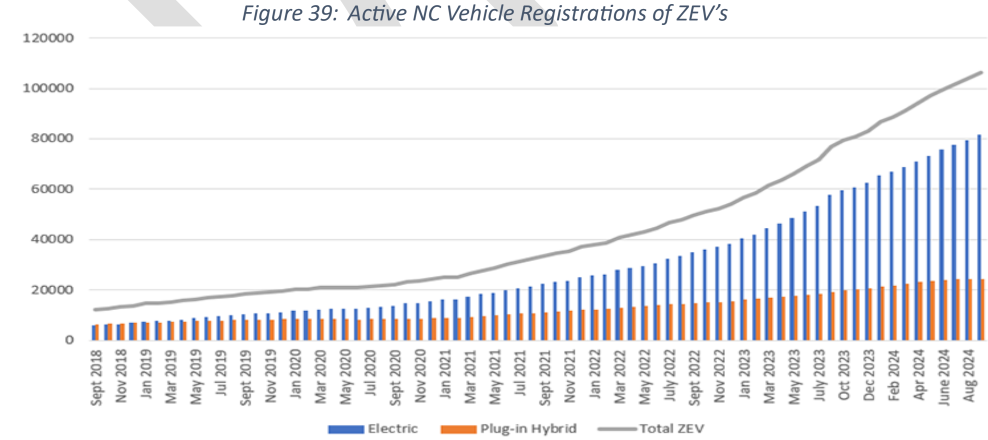
Source: Office of State Budget & Management (OSBM) Standard & Revised Population Estimates

AI is fueling a surge in data center construction in NC due to the immense computational power required for AI model training and deployment. This growth is driven by major tech companies expanding their infrastructure to support AI-driven services, positioning the state as a key hub for data center development. For instance, Apple is set to expand its footprint in North Carolina with a $175 million investment and will be adding a 237,600 sq ft data center on land it already owns in Maiden, Catawba County (Butler, 2025). Microsoft is also developing a campus in Catawba County, having announced plans to spend at least $1 billion on four data centers in the area in 2022. One of those projects is in Maiden, with the company breaking ground in April 2024 (Butler, 2025).

A resurgence of domestic manufacturing has also increased electricity demand across the US. Recent economic development projects in NC include the $5.9 billion Toyota Motor battery production plant in Randolph County and the $5 billion Wolfspeed data processor chip manufacturing site in Chatham County (Mildenberg, 2023). These larger projects will command an electric demand increase ranging from 150 MW to as much as 1 GW, many of which operate more than 90% of the time and require an around-the-clock supply of firm electricity. Data computing needs to support the rapid expansion of infrastructure for cloud, AI computing, and electronic currency production are anticipated to exponentially increase, as are general trends of electrification in the built environment (e.g., air source heat pumps and other electronic appliances).

Legislation advancing the adoption of EVs in NC is helping increase electricity demand as households and businesses install charging infrastructure, adding strain to the grid and boosting peak loads. EO 246, "NC's Transformation to a Clean, Equitable Economy," signed by Governor Roy Cooper in early 2022, increases the state's ambition for total targeted number of registered ZEVs in the state to be at least 1,250,000 by 2030 and aims for 50% of in-state new vehicle sales to be zero-emission by 2030 (NC EV Policy Landscape, 2024). As of 2023, NC ranks third in the Southeast for charging deployment per capita with 811 fast charger ports and 2,601 level 2 ports, a 60% growth in total ports from July 2022. The NC EV manufacturing industry recently had $25.35 billion in private investments, signaling continued growth (NC EV Policy Landscape, 2024). DEP and DEC both forecasted that over 30% of the vehicle fleet within its territories will be comprised of EV's by 2037, comprising of over 3 million EV's, according to the 2023 consolidated Carbon Plan and Integrated Resource Plan (CPIRP) (Electric Load Forecast , 2023). These forecasts translate into 11.8M (MWh/year) of additional load onto the grid, or ~8% of the total system load by 2037. The figure below shows the active vehicle registration of ZEV's within NC, which has now exceeded 100,000 as of August 2024.

Figure 39: Active NC Vehicle Registrations of ZEV's



Source: NC DOT

The forecasted increase in population and data center development are anticipated within the NCUC's 2024 Annual Report Regarding Long Range Needs for Expansion of Electric Generation Facilities for Service in NC. The table below shows the projected annual load growth rates for DEP, DEC, and Dominion Energy North Carolina, inclusive of energy efficiency (EE). The report noted that the DEP and DEC projected load growth is eight times higher than the growth they projected for the 2022 Carbon Plan and is 2GW higher than their 2023 Spring load forecast (NCUC, 2024). For context, historical data shows that utility sales in NC grew at an average annual rate of approximately 1.1% (Electric Load Forecast , 2023).

Figure 40: Forecast Average Annual Growth Rates of IOUs in NC (with EE Included)

Utility	Summer Peak	Winter Peak	Energy Sales
DEP (2024-2038)	1.6%	1.2%	2.4%
DEC (2024-2038)	2.1%	2.0%	2.1%
Dominion Energy NC	4.7%	4.2%	6.0%

Source: NCUC

The rise in demand coupled with an aging generation fleet can create resource adequacy risks which are discussed more in *Section 4.5.2: Technological Threat Impacts*.

Infrastructure Failure: Electric Generation

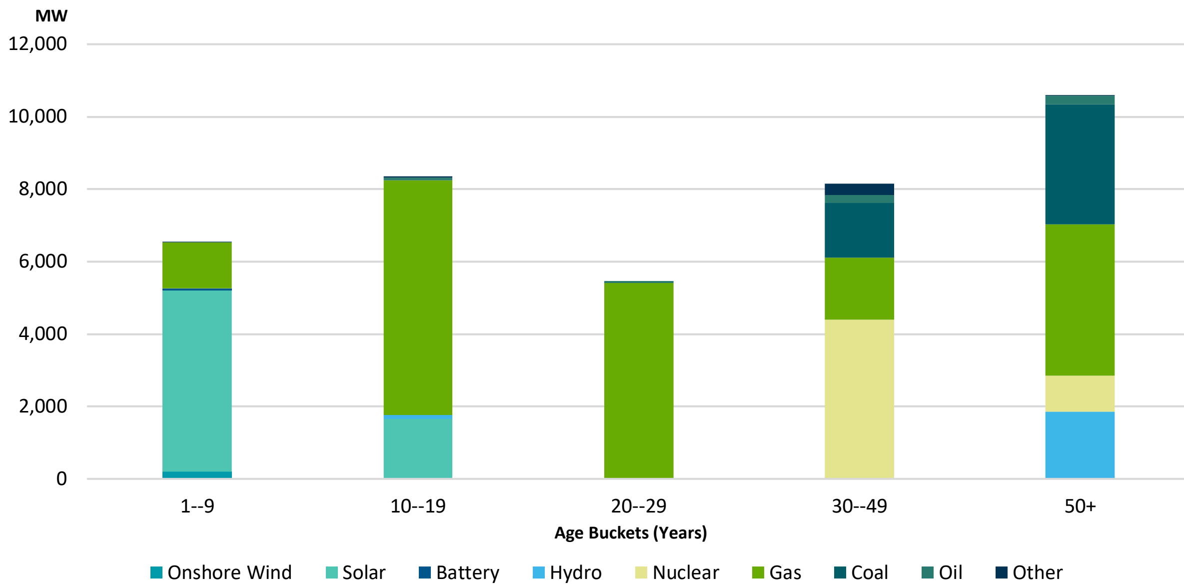
Electric infrastructure failure poses a significant threat to NC, such as aging systems, extreme weather events, and increasing demand strain the grid, risking widespread outages that disrupt daily life, economic activity, and critical services across the state. Generation failure was apparent during Winter Storm Elliot, when NC experienced widespread power outages customers due to equipment failures at several electric generation facilities, exacerbated by extreme cold. The failures primarily occurred at two coal-fired plants (Roxboro No. 3 and Mayo No. 1) and a natural gas plant in Rockingham County, operated by Duke Energy Carolinas and Duke Energy Progress (Sorg, 2023). The key issues impacting the generators included:

- **Frozen Instrumentation Lines**: Critical sensors and control systems froze, impairing plant operations.
- **Insulation Failures:** Inadequate insulation on equipment led to malfunctions in sub-zero temperatures.
- **Reduced Generation Capacity:** The failures caused a shortfall in power supply, triggering rolling blackouts to prevent grid collapse.

Roughly 50% of the installed "baseload" generation capacity in NC is over 30 years old, which is slightly higher than the national average of 42% (EIA 860, 2024). According to the National Electrical Manufacturers Association (NEMA), baseload generation refers to the minimum level of constant power supply that a utility or power grid must produce to meet the continuous and consistent demand for electricity (NEMA, 2024). This demand remains relatively stable over time, typically covering the 24-hour period, and is not significantly influenced by daily fluctuations or seasonal variations. Baseload assets are designed to run continuously and efficiently to meet this steady demand (NEMA, 2024).

The figure below shows the current NC generation fleet by fuel and age buckets. Over 30% of the total gas fleet, 100% of coal and nuclear resources, and more than 95% of the hydro fleet in the baseload fuel resources are over 30 years old. Nearly 80% of the generation that was brought online in the past 10 years was from intermittent renewable (solar, wind) resources.

Figure 41: NC Installed Generation Capacity by Fuel & Age



Source: EIA 860

According to Duke Energy's 2023 CPIRP filing with the NCUC, the company plans to retire all its coal capacity by 2036 (Coal Retirement Analysis, 2023). The coal retirements would remove an additional ~8GW of baseload capacity from the state's grid. Replenishing the lost baseload capacity will be crucial to maintaining a healthy reserve margin. Duke Energy is already taking steps to replenish lost coal capacity, they plan to install a 167 MW/668 MWh battery storage system where the retired Allen Steam Station coal plant is located and has additional generation resources included in their long-term planning processes. The table below shows the details of the future coal retirement plan.

Figure 42: Duke Energy Planned Coal Retirement Dates

Unit	Capacity (Winter MW)	Estimated Retirement Year
Belews Creek 1	1,110	2036
Belews Creek 2	1,110	2036
Cliffside 5	546	2033
Marshall 1	380	2029
Marshall 2	380	2029
Marshall 3	658	2035
Marshall 4	660	2035
Mayo 1	713	2036
Roxboro 1	380	2029
Roxboro 2	673	2029

Roxboro 3	698	2034
Roxboro 4	711	2034
TOTAL MW	**8,019**	

Source: Duke Energy 2023 CPIRP

Nuclear generation plays an integral role in providing the NC electric grid with carbon-free baseload energy. NC has over 5GW of in-state nuclear generation, in which their NRC operational licenses are set to expire at various times from 2036-2046. The retirement of these nuclear units can present an electric reliability risk (given loss of baseload power), and risk of NC not meeting the House Bill (HB) 951 (SL 2021-165) target to achieve a 70% reduction in CO2 emissions from electric public utilities compared to 2005 levels by the year 2030, and to reach carbon neutrality by 2050. For instance, California had to pass legislation to extend the operations at both units of the Diablo Canyon Nuclear Power Plant to stay on track of its clean energy goals, adding $722.6 million in additional ratepayer costs (Symon, 2024). In the CPIRP, NCUC stated its approval to continue working towards the extension of the operating licenses for Duke's existing nuclear fleet, which is a mitigation strategy proposed in *Section 7: Risk Mitigation Assessment*.

The table below shows the installed capacity, in-service date, current NRC license expiration date of the operating nuclear facilities within NC.

Figure 43: NC Nuclear Generator Capacity & Expiration

Unit	Installed Capacity (MW)	In-Service Date	NRC License Expiration Date
Brunswick 1	1,002	Sep. 1976	Sep. 2036
Brunswick 2	1,002	Dec. 1974	Dec. 2034
Harris 1	951	Oct. 1986	Oct. 2046
McGuire 1	1,220	Jun. 1981	Jun. 2041
McGuire 2	1,220	Dec. 1983	Dec. 2043
TOTAL MW	**5,395**		

Source: NRC List of Power Reactor Units

Infrastructure Failure: Transmission/Distribution

Most of the US electric grid infrastructure was built in the 1960s and 1970s, and 70% of transmission lines are over 25 years old and approaching the end of their typical 50–80-year lifecycle (Grid Deployment Office, 2023). Older and faulty infrastructure can lead to power outages, as 21% of NC's outages were a result from faulty equipment from 2008-2017 (NC Energy Risk Profile, 2021).

Signs of aging transmission can be identified from reduced load-carrying capacity (less power being able to be transmitted), lines overheating and/or sagging (Dengler, 2024). This can lead to increased transmission maintenance costs, and fire hazards from faulty and failing equipment. Reduction in transmission load-carrying capacity can also increase the demand put on generation, since higher transmission energy losses equate to additional power needed from the generation source, which in turn could lead to widespread outages.

Signs of aging distribution infrastructure include increased incident of power disruptions, especially at end-of-line (the final stage where electricity is delivered to end-users), which could result in increased frequency and duration of power outages (Dengler, 2024). Distribution infrastructure is highly vulnerable to damage from extreme weather events, which can lead to increased costs to rate payers.

The DOE released a National Transmission Needs Study, noting that nearly all regions in the US would gain improved reliability and resilience from additional transmission/distribution investments (National Transmission Needs Study, 2023). The study noted a few key drivers of additional transmission/distribution needs such as rising congestion prices, and changes in generation mixes and load profiles, which are all apparent within NC. The study also noted that siting and permitting of new transmission infrastructure remains a major challenge to transmission expansion due to disparate state and local siting and permitting processes and varied determinations of project benefits and cost. A statewide analysis of transmission infrastructure and needs to identify areas of high risk for failure or congestion and areas of high growth could help improve grid resiliency for the state. Stakeholder coordination for grid planning, expansion and enhancement efforts (similar to SEO exercises presented *in Section 3: Energy Emergency and Response*) could also help NC improve the efficiency and interconnection of the transmission infrastructure to reduce risk.

Infrastructure Failure: Pipelines

Aging pipelines pose a threat to NC's energy security due to their increased risk of failure, which can disrupt fuel supply, compromise grid reliability, and create environmental and safety hazards, all while straining the state's ability to meet growing energy demands.

The transportation of crude oil and refined product supply within NC is also impacted by aging infrastructure, as 57% of the state's petroleum pipeline systems were constructed prior to 1970 or in an unknown year (NC Energy Risk Profile, 2021). NC does not have any petroleum refineries, but the state does have two major petroleum product pipelines-the Colonial Pipeline and the PPL Pipeline-that deliver refined products at several locations in NC on their way to the Northeast from the Gulf Coast. A third pipeline-the Dixie Pipeline-supplies propane to customers in seven southeastern states, including NC, before terminating in Apex, NC. The reliance on fuel imports through pipelines is a risk to reliable and affordable energy and is one of the major vulnerabilities identified in *Section 5: Vulnerability and Severity Assessment*.

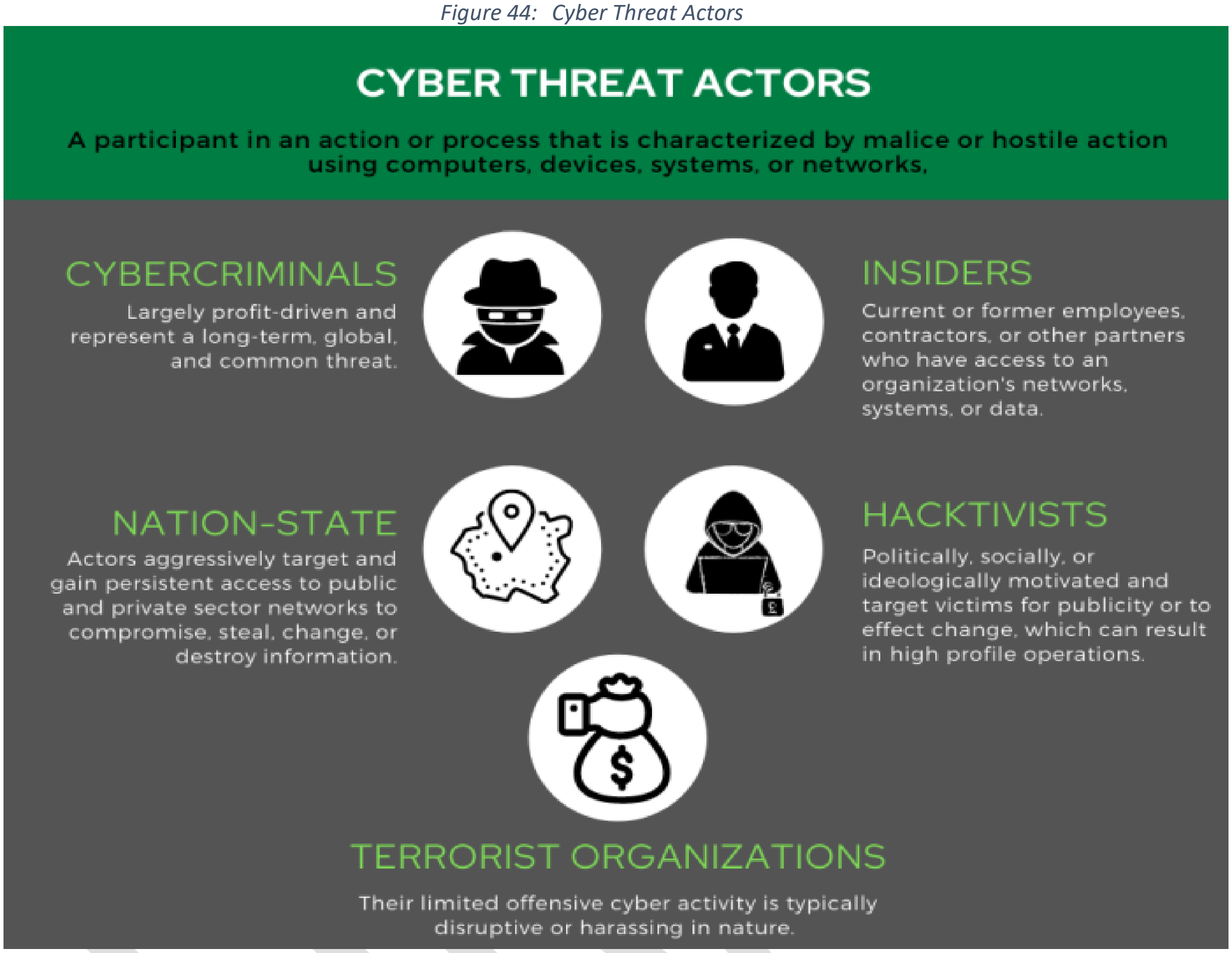
4.3. Human-Caused Threats

This section delves into human-caused threats, encompassing cyber-attacks and physical threats such as deliberate grid/pipeline attacks, excavation damage, political uncertainty, misinformation, and a lack of trained workforce. NC's critical infrastructure is continuously at risk from sophisticated cyber threats and physical disruptions, these challenges jeopardize grid reliability, resilience, and public safety, underscoring the need for strong defenses and a skilled workforce to counter their effects.

Cyber Attacks

The Annual Threat Assessment that the US Office of the Director of National Intelligence (ODNI) released in 2022, emphasizes that cyber threats from nation states remain acute (2022 Annual Threat Assessment of the US Intellegince Community, 2023). ODNI's concerns are focused on Russia, China, Iran, and North Korea, all of whom currently possess the ability to remotely damage infrastructure in the US or compromise supply chains. Both domestic and international adversaries, whether politically, socially, or financially motivated, are targeting the nation's energy infrastructure and the digital supply chain. The figure below illustrates various categories of threat actors, while the subsequent figure depicts different types of cyber-attacks employed by these attackers.

Figure 44: Cyber Threat Actors



Source: DOE

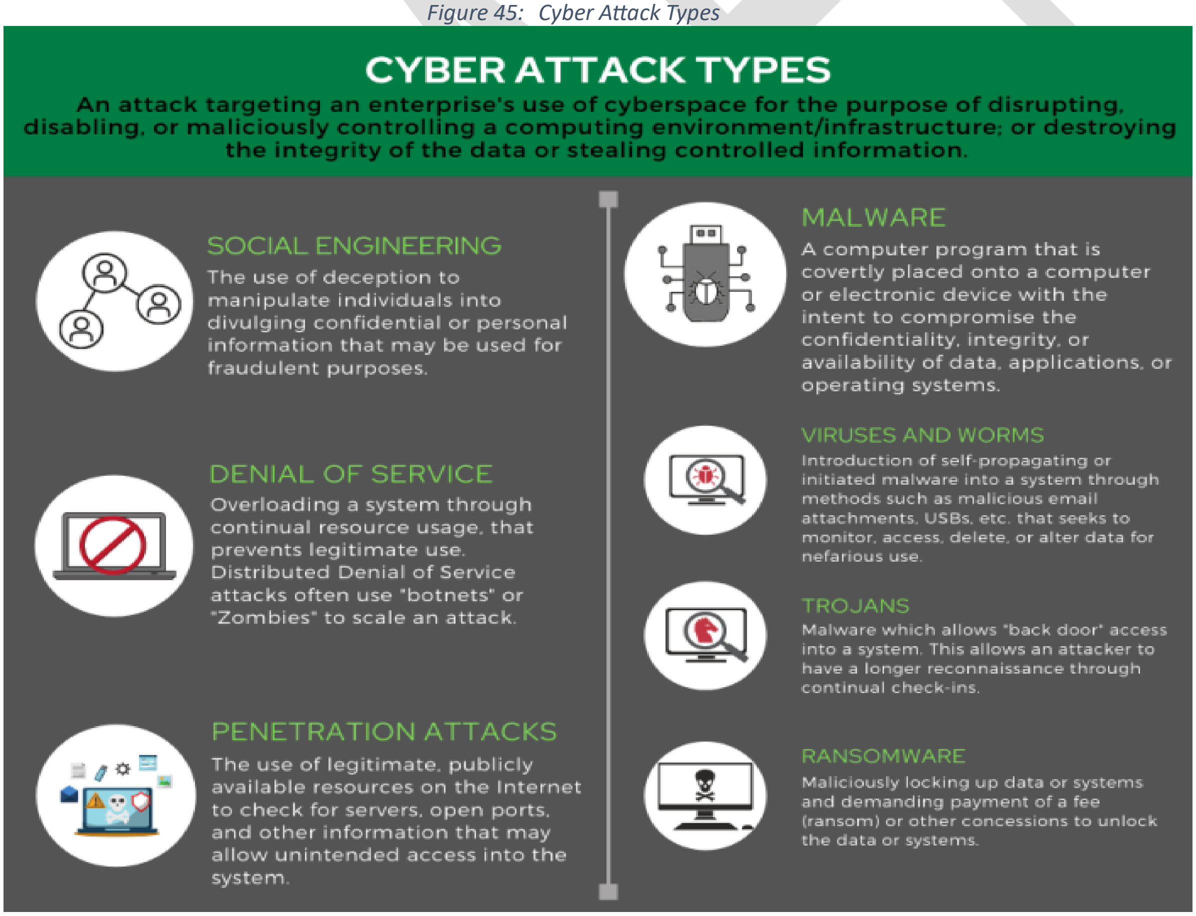
The energy sector is uniquely critical because all other critical infrastructure sectors depend on power and fuel to operate, which makes the state's energy infrastructure an attractive target for cyber-attacks, as an energy infrastructure attack could have a cascading effect on the rest of the state's infrastructure. All energy systems have vulnerabilities to cyber threats, 100% security is not possible, however, many steps can be taken to harden operational technology (OT) systems to mitigate these threats.

Understanding the evolving threat landscape and consequences of a cyber-physical event can help state officials and energy system owners and operators understand risks. Understanding risks can help prioritize investments, such as purchases, staff resources, and training, based on the threats and vulnerabilities posing the highest risks to an organization. Investments should be focused on areas that can mitigate the highest risks. The nation's critical infrastructure is mostly owned and operated by private companies, so both the government and private sector have a common incentive to reduce the risks of disruptions to critical infrastructure. The National Infrastructure Protection Plan (NIPP) recognizes that public-private partnerships are vital to keeping critical infrastructure safe and secure, including from cyber-attacks. These partnerships unite government agencies and private sector entities to manage risks and enhance resilience across 16 critical infrastructure sectors. The NIPP public-private partnerships include:

- InfraGard: Facilitates information sharing on threats like nation-state actors and cybercriminals, with local chapters nationwide collaborating on security strategies.
- Sector Coordinating Councils (SCCs): Each of the 16 sectors (e.g., energy, transportation, water) has an SCC, comprising private sector owners and operators.
- Government Coordinating Councils (GCCs): These pair with SCCs, involving federal and SLTT governments to align policies and resources.
- Critical Infrastructure Partnership Advisory Council (CIPAC): Established under NIPP, CIPAC provides a legal framework for direct collaboration between SCCs and GCCs, exempt from public disclosure requirements to foster candid risk discussions.
- Regional Consortium Coordinating Council: This public-private partnership unites regional stakeholders—private firms, local governments, and utilities—to address cross-jurisdictional risks.

Understanding the different methods those actors may use to compromise important systems, networks, and infrastructure is also pertinent. Common types of cyber-attacks are listed in the figure below (State Energy Security Plan Optional Drop-In: IT/OT and Cyber Threat Overview, 2022).

Figure 45: Cyber Attack Types

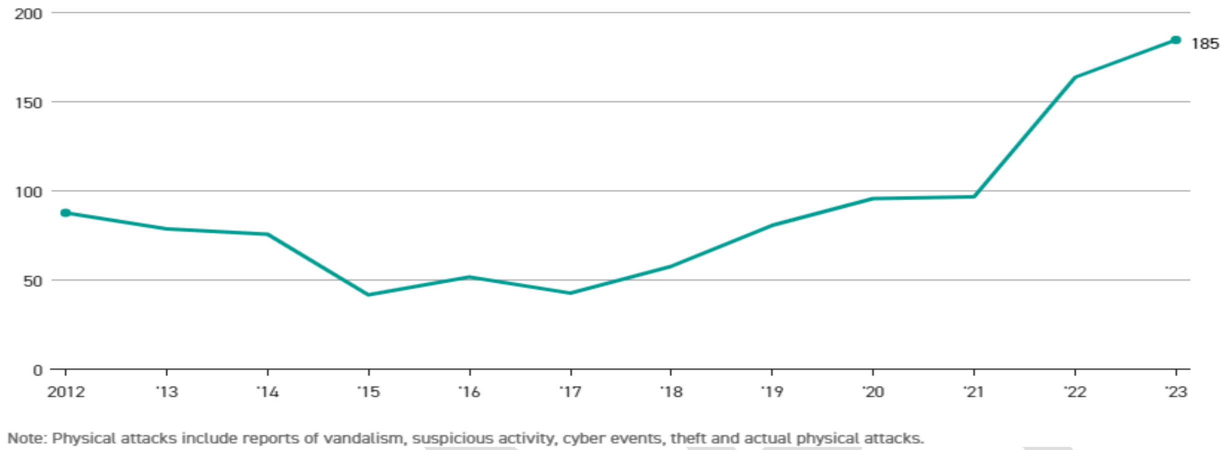


Source: DOE

Physical Threats

Physical threats against the grid have seen a sharp uptick in recent years, as US power providers reported 185 instances of mostly physical attacks or threats against critical grid infrastructure in 2023, beating the previous record number of reports from 2022 and doubling the number of incidents in 2021 (Morehouse, 2024). The figure below shows the increasing nature of physical (and cyber) threats reported by US utilities.

Figure 46: Physical and Cyber-Attacks or Threats Against the Grid Reported by Utilities to the DOE Since 2012



Source: DOE

In 2022, an attack on two electrical distribution substations in Moore County left up to 40,000 customers without power for up to five days. Since the attacks, NC lawmakers unanimously passed the Protect Critical Infrastructure law (G.S. 14-150.2), increasing the punishment for property crimes committed against utilities and energy infrastructure. Details surrounding physical security mitigation strategies can be explored further in *Section 8.5: Physical Attack Protection*.

Physical damage risk is also present for gas and petroleum pipeline infrastructure. Between 1984 and 2019, the state's highest annual average economic loss to natural gas transport came from excavation damage (NC Energy Risk Profile, 2021). The DOE estimated excavation damage to natural gas distribution understructure cost NC roughly $1.2M in annual economic loss from 1984-2019. Excavation damage to gas pipelines refers to physical harm caused to a buried gas pipeline when digging or excavating near it, often resulting from accidental contact with digging equipment, which can lead to leaks, ruptures, and potentially dangerous situations due to the release of natural gas if not properly addressed; it is considered one of the leading causes of pipeline incidents (Fact Sheet: Excavation Damage, 2014).

Intentional physical attacks on pipeline infrastructure are also a threat, as there have been isolated pipeline attack incidents in the US over the past 10 years. On March 20, 2017, the developer of the Dakota Access Pipeline alleged in a court filing that it had experienced "recent coordinated physical attacks along the pipeline", and on October 11, 2016, a coordinated group of domestic environmentalists caused the shutdown of five pipelines in four states transporting crude oil from Canada to the United States (Parfomak, 2017). Previous national security assessments identified pipeline infrastructure as a potential target for terror attacks, and the North American Electric Reliability Corporation (NERC) stated that, due to growing electric and natural gas system interdependency, industry "should evaluate the need for additional assessments of the risks of attacks on midstream or interstate natural gas pipelines" (Parfomak, 2017).

The petroleum transport from trucks or trains are susceptible to physical damage such as derailment, collisions, or rollovers. For example, in 2020, a vehicle collided with a tanker truck carrying 8,500 gallons of fuel on Highway 16 in Lincoln County, causing social and environmental damage. Between 1986 and 2019, the leading cause of economic loss to petroleum transport came from derailment, collisions, or rollovers, which averaged $1.5M in annual loss (NC Energy Risk Profile, 2021). The persistent dependence on petroleum products for transportation and home heating, coupled with the rising frequency of extreme weather, suggests that incidents like these will likely persist or become more common in the future.

Workforce Transition Challenges

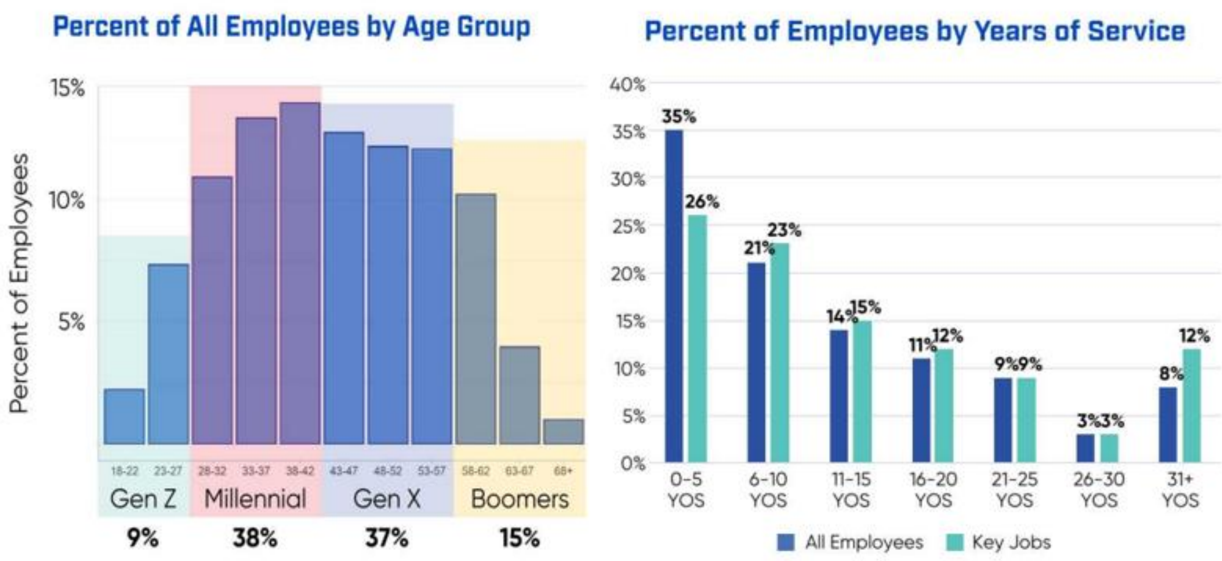
The potential shift in skills within the energy workforce increases the risk of operational errors, delayed maintenance, and inadequate responses to emergencies, potentially compromising the reliability and safety of energy systems.

According to the Center for Energy Workforce Development (CEWD) tenth Energy Workforce Survey[21], a significant portion of skilled workers are nearing retirement, and the energy industry faces a critical shortage of expertise needed to maintain and innovate its infrastructure (2023 Energy Workforce Survey Results, 2023). The analysis of the survey defined key job categories as lineworkers, technicians, plant/field operators, and engineers. The demographic shift not only jeopardizes operational reliability but also hampers the transition to sustainable energy solutions, underscoring the urgent need for strategic investment in training, recruitment, and knowledge transfer to safeguard the future of energy production.

The survey revealed that Millennials constitute the largest generational group in the energy industry workforce, highlighting potential challenges stemming from a higher proportion of younger, less experienced employees in the sector. The survey showed that 56% of workers in key jobs have less than 10 years of service, with engineers and lineworkers being above 60%. The figure below shows the breakdown in the workforce by age group, as well as the percentage of employees by years of service (broken out into key jobs).

[21] Surveyed 41 utility companies regarding the trends in the size of the energy workforce, demographic composition, forecasted retirements, and attrition data to support industry companies with their strategic workforce planning

Figure 47: Energy Workforce by Age and Years of Service



Source: Center for Energy Workforce Development

While the energy industry workforce is getting younger, the changing generation mix and decarbonization trends will likely result in a continued decline in existing fossil-fuel generation jobs. At the same time, the energy transition is expected to require a substantial number of new emerging technology jobs[22], which could potentially offset some of the decline elsewhere.

This transition will require careful management of the workforce changes and a focus on programs to retain and reskill displaced workers to be able to perform new energy jobs (2023 Energy Workforce Survey Results, 2023). Retraining employees will be crucial given the competition for these workers from non-utilities or the potential for broader workforce shortages.

In conclusion, the aging workforce in the energy industry poses a significant threat to its long-term sustainability, as the impending retirement of experienced workers in key job areas could lead to a critical loss of expertise and skills. Addressing this challenge requires proactive measures, such as robust knowledge transfer programs and targeted recruitment efforts, which is highlighted *in Section 8.2.5: New Renewable Generation*.

Misinformation & Disinformation

Misinformation[23] and targeted disinformation[24] can threaten NC's energy security by creating an unstable framework that hampers long-term planning and investment in resilient energy infrastructure. Misinformation is increasingly prevalent and rapidly spreading, particularly through digital platforms,

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[22] Emerging technologies was defined as positions involving generation and distribution of electrical energy generated by renewable means, advanced metering, advanced utility or utility of the future, the development of advanced statistical models, ML models, AI applications, and EV fleet management and maintenance.

[23] **Misinformation** - False content but the person sharing doesn't realize that it is false or misleading. Often a piece of disinformation picked up by someone who doesn't realize it's false and shares it with their networks without the intent to do harm.

[24] **Disinformation** - Content that is intentionally false and designed to cause harm. It is motivated by three distinct factors: to make money; to have political influence, either foreign or domestic; or to cause trouble for the sake of it.

amplifying its impact on public perception and decision-making. According to the Pew Research Center, one in five Americans receive their daily news intake from social media platforms (Disinformation and the public, 2025). In that same survey, 64 percent of adults said, “fake news” caused confusion on basic facts, and 23 percent said they had shared “fake news,” either knowingly or unknowingly (Disinformation and the public, 2025).

Large-scale spread of misinformation, enabled by advanced information manipulation tools and online platforms, is driving new types of information warfare. Access to advanced tools like machine learning, automated bots, and natural language generation allows individuals with limited technical skills to create and spread manipulated information at scale (Combating weaponized misinformation, 2019). This includes social media bots influencing public opinion, false trends from paid reviews, and fake photos and videos. The issue is exacerbated when algorithms derive inaccurate insights from manipulated data, leading to significant decision-making errors. Nation-states, organized crime groups, companies, and disgruntled customers use these tools for malicious purposes, competitive advantage, or mischief (Combating weaponized misinformation, 2019). Misinformation can pose a major risk for the energy sector, as false claims about renewable energy such as alleged health risks of wind turbines or the environmental impacts of solar panels, has led to the delay or cancellation of clean energy projects across the United States, hindering the transition from fossil fuels and threatening efforts to meet climate targets (Liez, 2024).

In NC, misinformation and questionable narratives surrounding energy resource planning, such as claims about the need for additional natural gas or downplaying the feasibility of renewable energy, have complicated energy system planning for the state. Conversely, environmental groups including the Sierra Club and the Southern Environmental Law Center, have pushed back on the need for additional gas plants and related infrastructure contained within the 2023 Duke CPIRP filing, claiming that load growth Duke projects might still be “somewhat speculative” (DiGangi, 2024). Countering this persistent threat of misinformation demands ongoing public engagement and transparent, evidence-based data to ensure a common set of facts that underly energy policies to support sustainable, long-term objectives.

The dissemination of misinformation can also undermine public trust in basic concepts like the formation and causes of natural hazards such as hurricanes. For example, after the devastating impacts from Hurricane Helene, a large amount of disinformation about nonexistent weather manipulation technology spread across the internet, particularly on social media platforms (Fact check: Debunking weather modification claims, 2024). Such disinformation efforts can also erode public confidence in federal and state emergency response efforts, which is covered in *Section 4.5.3: Human-Caused Impacts.* The table below lists a few of the inaccurate claims circulating online, as identified by NOAA, related to weather and climate disinformation.

Figure 48: Weather Modification Claims

Claim	Fact
The government is creating, strengthening and/or steering hurricanes into specific communities.	No technology exists that can create, destroy, modify, strengthen, or steer hurricanes in any way, shape or form. All hurricanes, including Helene and Milton, are natural phenomena that form on their own due to aligning conditions of the ocean and atmosphere.

The government is engaging in activities like cloud seeding to modify the weather.	Cloud seeding is the only common weather modification activity currently practiced in the United States — typically by private companies in western mountain basins in winter to help generate snow in specific locations, or in the desert southwest to replenish water reservoirs in summer.
NEXRAD Doppler radars are being used to steer hurricanes and are targeting specific communities.	Radars are tools for observation and are not able to direct the motion or intensity of air masses or storms. NEXRAD Doppler radars detect precipitation and the motion of the precipitation particles.

Source: NOAA

The pervasive spread of misinformation and disinformation poses a significant threat to NC's energy security by fostering public distrust, delaying critical renewable energy projects, and destabilizing policy frameworks essential for resilient infrastructure. From false claims about hurricane causes to misleading narratives driving legislative setbacks, these distortions undermine evidence-based decision-making and erode confidence in emergency responses, as seen post-Hurricane Helene. To safeguard the state's energy future, NC must prioritize transparent communication, robust public engagement, and proactive measures to counter misinformation (described in *Section 8.4.2: Combatting (Mis)(Dis)-Information*), ensuring policies and infrastructure align with sustainable, long-term goals for a reliable and resilient energy system.

4.4. Threats Likelihood Assessment

This subsection introduces a method for assessing the threat likelihood scores of the state's energy system, evaluating key factors such as historical occurrences and forward-looking probability. Natural threat scores are assigned using a combination of documented natural hazards, climate projections, and professional judgement based on likelihood of occurrence assessed from the quality and consistency of data and the degree of agreement among different sources. Scores for technological and human-caused threats are determined using insights gained from industry research, reflecting the latest understanding of existing conditions. Threat Likelihood scores will be updated on a recurring basis as NC's energy ecosystem evolves, integrating new and emerging threats, and removing any that are no longer pertinent, to maintain a dynamic and accurate risk assessment.

The table below shows the qualitative and quantitative scores and associated threshold descriptions used to assign threat likelihood scores.

Figure 49: NC Threat Likelihood Scoring Description

Threat Likelihood Score		**Threshold Descriptions**
Categorical	**Numerical**	
High	**9**	Threats at this level are almost certain to occur, based on historic and frequent occurrences.
Medium-High	**7**	Threats are more likely to occur than not.
Medium	**5**	Threats may occur.
Medium-Low	**3**	Threats are slightly elevated level of occurrence. Possible, but more likely not to occur.
Low	**1**	Very low probability of occurrence. An event has the potential to occur but is still very rare.

The table below assigns the likelihood scores to the threats previously discussed. The scores were quantified by analyzing the probability of occurrence based on factors such as historical data and forward-looking analysis.

Figure 50: NC Threat Likelihood Scores

Threat Category	Threat	Score
Natural Threats	Storms (hurricanes, tornadoes, thunderstorms)	9
	Flooding / Precipitation	9
	Extreme and Rising Temperatures	9
	Landslides	5
	Wildfires	7
	Drought	7
Technological	Rising Demand	7
	Infrastructure Failure	7
Human-Caused	Cyber Attacks	7
	Physical Attack	3
	Aging Workforce	3
	Misinformation	9

The threat likelihood scores will be incorporated into the risk calculations within *Section 6: Risk Assessment.*

4.5. Impacts Overview

The following subsection examines the NC energy system impacts stemming from natural, technological, and human-caused threats, highlighting how these diverse threats could disrupt power and fuel delivery, escalate costs, and affect public health, safety, and the environment. The identification of impacts associated with each threat is a crucial step in assessing vulnerabilities, which will be discussed in *Section 5: Vulnerability and Severity Assessment*. Every threat could impact the energy system in multiple ways. For example, strong winds from hurricanes could cause transmission poles and lines to fall — resulting in power outages, additional costs for repairs, financial loss due to damaged infrastructure, and cause social harm and displacement.

4.5.1. Natural Threat Impacts

This section explores the impacts of natural threats on NC's energy system, assessing how these events challenge the state's energy security. It examines the consequences of a range of environmental hazards that disrupt critical infrastructure, strain resource availability, and test grid resilience, highlighting their potential to affect power delivery, fuel supply, and overall system stability. From 1980 to 2024, there have been over 120 natural disasters causing at least $1 billion in damage in North Carolina (Billion-Dollar Weather and Climate Disasters, 2025).

High Wind and Lightning (Hurricanes, Tornados, and Severe Thunderstorms)

The impact of severe storms, hurricanes, and tornados on the energy sector can cause direct physical damage through lightning, hail, high winds, and debris carried by the wind striking infrastructure. Heavy precipitation from severe storms and hurricanes can trigger riverine and coastal flooding, creating risks to energy infrastructure. From 2009 to 2019, NC experienced over 15 tornados, 203 severe thunderstorms, and 3 hurricanes causing over $270 million in property damage in an average year (NC Energy Risk Profile, 2021).

Although hurricanes are the least common of the three, they pose the most severe risk. They pose a significant threat to the state's energy system through high winds, flooding, and lightning strikes that can cause energy supply disruptions, particularly during hurricane season from June through November. One recent study estimated with high confidence that hurricanes reduce short-term economic growth (IPCC, 2023). Recently, western NC experienced devastating impacts from Hurricane Helene, which among other damages caused widespread energy service disruptions. The Office of State Budget & Management (OSBM) estimates the total non-farm non-governmental business disruption loss to NC from Hurricane Helene to be $12.4 billion – inclusive of direct and secondary (indirect and induced) effects (Hurricane Helene Recovery , 2024).[25] This is consistent with other studies that estimate the economic impacts of these natural hazards, for example, Super Storm Sandy and Hurricanes Irma and Maria caused billions in damages to electric grids in the Northeast and Puerto Rico. Extensive damages to energy infrastructure are costly and time-consuming to address, which could mean residents are without power and fuel for extended periods of time.

Per DOE Situation Reports regarding Helene, the electricity sector saw a peak of over 1 million customers without power, with 13% of customers in NC (670,224) without power still on September 28, 2024, two days after initial landfall. Over 13,000 customers still had no power on October 15, 2024. Power outages also impacted the liquid fuels, natural gas, and propane supply chains by impacting operations at fuel stations, pipelines, and other infrastructure (Hurricane Helene Situation Reports, 2024). Significant outages caused by hurricanes like Helene, and other severe storms and tornados, indirectly impact human health. Residents who rely on electric powered medical devices are at elevated risk. Additionally, residents may switch to diesel generators to supply power while they await restoration to normal service. These and other risks have been confirmed by several studies, which report elevated risk of CO poisoning, hospitalizations for cardiovascular, respiratory, and renal issues, and elevated risks for those relying on powered medical devices (Casey, Fukurai, Hernandez, Balsari, & Kiang, 2020). The table below details the impacts within the electricity, natural gas, liquid fuels, and propane sectors from severe storms.

Figure 51: Impacts of NC Energy Sectors from Severe Storm

Energy Sector	Severe Thunderstorms	Hurricanes	Tornadoes

[25] Direct effects include lost production and sales to firms resulting from storm-related disruptions (e.g., business closures, reduced access by employees and customers, etc.). Indirect effects include changes to business-to-business purchases and household purchases affected by disruptions and wage losses, all located in primarily disadvantaged communities in the western part of NC.

Electricity	• Hail damage to solar and wind generation. • Disruptions to nuclear power. • Flood related impacts (see flooding section). • Wind and debris. damage to transmission and distribution lines. • Direct damage and triggered shutdowns due to lightning strikes.	• Hail damage to solar and wind generation. • Flood related impacts (see flooding section). • Disruptions to nuclear power. • Wind and debris damage to transmission and distribution structures and lines. • Maximum windspeeds may exceed design limits of wind turbines. • Direct damage and triggered shutdowns due to lightning strikes.	• Disruptions to nuclear power. • Wind and debris damage to transmission and distribution structures and lines. • Maximum windspeeds may exceed design limits of wind turbines.
Natural Gas	• Flood related impacts (see flooding section). • Damage to pipelines from high winds.	• Flood related impacts (see flooding section). • High wind and debris damage to pipelines and other structures.	• High wind and debris damage to pipelines and other structures.
Liquid Fuels	• Flood related impacts (see flooding section). • Reduced ability to transport over the road and rail. • Damage to pipelines from high winds. • Power loss to or destruction of distribution facilities.	• Flood related impacts (see flooding section). • High wind and debris damage to pipelines and other structures. • Reduced ability to transport over the road and rail. • Power loss to or destruction of distribution facilities.	• High wind and debris damage to pipelines and other structures. • Reduced ability to transport over the road and rail. • Power loss to or destruction of distribution facilities.
Propane	• Flood related impacts (see flooding section). • Reduced ability to transport over the road and rail. • Damage to pipelines from high winds. • Power loss to or destruction of distribution facilities.	• Flood related impacts (see flooding section). • High wind and debris damage to pipelines and other structures. • Reduced ability to transport over the road and rail. • Power loss to or destruction of distribution facilities.	• High wind and debris damage to pipelines and other structures. • Reduced ability to transport over the road and rail. • Power loss to or destruction of distribution facilities.

Data Source: DOE, EIA

Flooding and Increased Precipitation

Riverine and coastal flooding damages energy infrastructure through water exposure, physical damage from debris, and saltwater corrosion. Flood events pose extreme danger to human health, cause substantial property damage, and require extensive clean-up in their aftermath. Western NC experienced catastrophic flooding during Tropical Storm Fred in 2021, causing landslides, uprooting trees and destroying homes, buildings roads and bridges. Beyond deaths and injuries directly attributable to flooding, the loss of energy can worsen the human cost of floods, and extensive clean-up activities can delay the restoration of energy services, exacerbating an outage's impact on critical infrastructure and facilities like healthcare facilities. In addition to these human costs, riverine and coastal flooding events cause significant economic damage. From 2009 - 2019, the state experienced an average of 55 floods per year, with property damage costs averaging $124 million per year (NC Energy Risk Profile, 2021). The table below lists the most pertinent flood impacts for the electricity, natural gas, liquid fuels, and propane supply chains within NC.

Figure 52: NC Impacts of Flooding

Energy Supply Chain	Impacts to Flooding
Electricity	• Water exposure to substations, distribution panels, circuit breakers, and transformers. • Buried power lines may be damaged due to the combination of soil changes and debris and saltwater corrosion. • Debris damage to the distribution network, substations, and transformers. • Water exposure and/or debris damage to generation facilities located near waterways. • Hydroelectric dam failure.
Natural Gas	• Aboveground pipelines can be damaged by quick moving debris. • Buried pipelines can be exposed to, and damaged by, debris. • Compressor stations can lose power and be exposed to water damage.
Liquid Fuels	• Aboveground pipelines can be damaged by quick moving debris. • Buried pipelines can be exposed to, and damaged by, debris. • Pumping stations can lose power and be exposed to water damage. • Reduced ability to transport over-the-road and by rail. • Power outages may impact distribution facilities and gas stations.
Propane	• Storage tanks may be swept away by rapidly moving water and damaged by debris. • Aboveground pipelines can be damaged by debris. • Buried pipelines can be exposed to, and damaged by, debris. • Loss of pumping stations can lose power and be exposed to water damage. • Reduced ability to transport over-the-road and by rail. • Power outages may impact distribution facilities.

Data Source: DOE, EIA

Extreme and Rising Temperatures

Extreme temperatures result in service disruptions stemming from peak demands, reduced capacity and efficiency, and equipment failures. These service disruptions can have significant impacts on North Carolinians' health and the economy. Power outages reduce residents access to building cooling and heating, which leaves them vulnerable to exposure-related illness and death. In the case of extreme heat, electricity outages are likely to increase the risk of heat-related illnesses such as dehydration, heat-stroke and heat-related death (Stone, et al., 2023). Those risks may be further exacerbated by other factors such as urban heat islands, socioeconomic status, age, and existing health conditions (NCDPS, 2023, pp. 3-60).

Based on the Centers for Disease Control and Prevention (CDC) data from 2020 to 2023, an average of 14 North Carolinians died from hyperthermia and other heat-related illnesses (Mortality Dashboard, 2024) (Centers for Disease Control and Prevention, National Center for Health Statistics, 2024). Extreme cold can lead to frostbite and hypothermia, given the lack of adequate heating. CDC data from 2018 to 2023 shows that 156 North Carolinians died from hypothermia and exposure to cold temperatures (Mortality Dashboard, 2024) (Centers for Disease Control and Prevention, National Center for Health Statistics, 2024). According to the 2023 State Hazard Mitigation Plan, there were nearly 46,000 heat-related emergency department visits from 2010 through 2021 (NCDPS, 2023, pp. 3-58).[26]

Extreme temperatures cause significant economic impacts, from higher energy prices to account for peak demand, and it is also estimated that heat-related healthcare costs exceed $1 billion each summer (The Mounting Costs of Extreme Heat, 2023). A report in 2020 estimated that economic costs from lost worker productivity related to heatwaves are roughly $100 billion annually (Atlantic Council, 2021). This can have a massive economic impact to the state's economy, as 26% of the workforce is employed in heat-exposed industries (The Mounting Costs of Extreme Heat, 2023). Economic costs related to freezing temperatures are lower, but still significant, with estimates of $800 million in national annual damages from the National Centers for Environmental Information (Billion-Dollar Weather and Climate Disasters, 2025). The table below lists the energy sector impacts from extreme heat and cold temperatures.

Figure 53: Energy Sector Impacts from Extreme Temperatures

Extreme Heat	Extreme Cold
Increased demand for comfort cooling and refrigeration	Increased demand for comfort heating
Increased risk of wildfires and drought	Freezing of water and other liquids in wellheads and natural gas gathering lines
Reduced efficiency of generation facilities (equipment derates) and transmission and distribution equipment[27]	Reduced capacity and efficiency of generation, transmission, and distribution infrastructure due to freezing of mechanical components
Equipment degradation	Activation of peaker generating units
Activation of peaker generating units	Damage to structures and power lines as the result of freezing

Data Source: DOE, EIA

Drought

Droughts can negatively affect a substantial portion of energy infrastructure, particularly electricity generation, by disrupting operations and reducing output. Drought conditions impact existing hydroelectric generation, which, as mentioned in *Section 1.1.1: Electricity Overview*, makes up 3-6% of the state's power generation, through a reduction in water supply in reservoirs. These impacts were observed during an extreme Southeast drought in 2007/2008, when the NC Drought Management Advisory Council had to coordinate releases from reservoirs, hydroelectric power generation, etc. to conserve as much

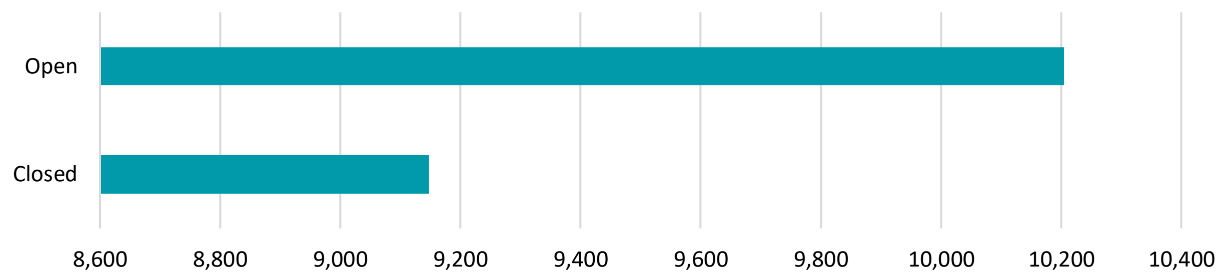
[26] No data is reported for cold exposure.

[27] The efficiency of thermo-electric generation facilities is related to the temperature difference between the steam inlet and the condenser temperature. Extreme affects these facilities in a variety of ways, and can depend on the cooling system of a particular facility (Allen-Dumas, Binita, & Cunliff, 2019).

water as possible and to balance upstream and downstream needs. Similar impacts occurred in California, as hydroelectric generation output fell 59% to drought conditions in 2021 (Impacts, Risks, and Adaptation in the US: Fourth National Climate Assessment, Volume II, 2018).

In addition, thermoelectric power generation facilities, including nuclear generation, are impacted by droughts from reduced water supply. These facilities require water for both spinning steam-driven turbines to generate electricity and for cooling needs. A shortage of available water may lead to reduced generation capacity and shutdowns. For existing thermoelectric generation facilities, the type of cooling system installed in the power plant may exacerbate a drought's impact on a facility. Generation facilities that use once-through ("open") cooling systems are heavily dependent on a reliable source of water, while recirculating closed systems or dry-cooling systems require significantly less water resources to operate. In NC, the majority of summer generation capacity comes from thermoelectric generation facilities that utilize once-through cooling systems. As a result, these generation facilities are especially susceptible to the existing and likely increasing impacts resulting from drought conditions. The figure below illustrates the distribution of open versus cooling systems in NC, emphasizing the risk posed by the considerable number of generation systems dependent on substantial water usage.

Figure 54: NC Open vs Closed Cooling Systems by Summer Capacity (MW)



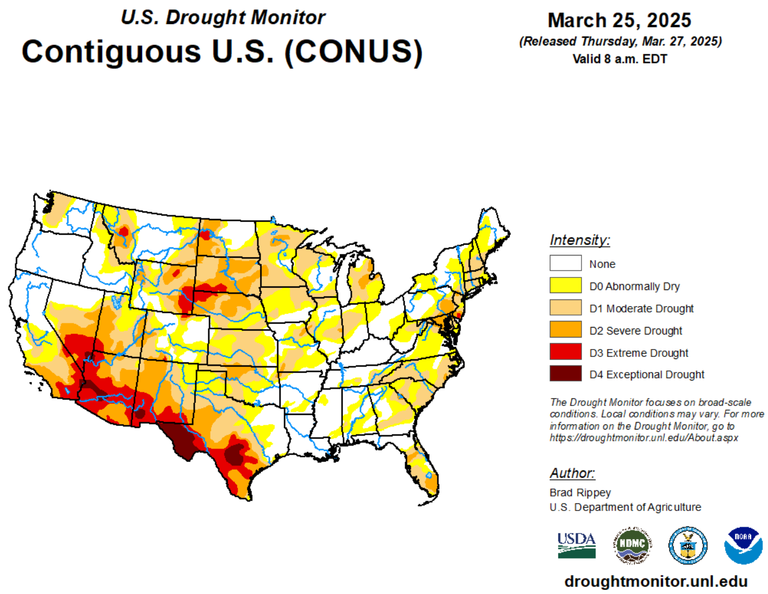
Source: EIA

For natural gas and liquid fuels, the impacts of drought are less pronounced within the state; however, drought conditions can negatively impact infrastructure. *Sections 1.12* and *1.13* detailed that NC does not produce any liquid fuels or natural gas. Instead, natural gas and liquid fuels are predominantly transported to NC via pipeline infrastructure. Droughts can often lead to increased groundwater pumping, which can result in subsidence.[28]

Recent studies have also investigated how shifting ground could lead to pipeline damage creating a safety hazard and endangering the supply of natural gas and liquid fuels in the state (Rutqvist, et al., 2021). Droughts in other parts of the country could threaten NC's natural gas and liquid fuel supply by affecting production and refining processes. Water is essential for hydraulic fracking and refining, which are necessary to produce the refined petroleum products and gas that North Carolina depends on. If water availability in other regions of the country responsible for producing NC's supply becomes scarce, it could force those producers to switch to alternative supplies or shut down operations. The figure below shows the U.S drought monitor (as of March 25, 2025), which is updated daily.

[28] Subsidence is the sinking of the ground, often due to extraction of water, oil, or other resources.

Figure 55: Drought Intensity of the Continental US



Source: US Drought Monitor

Wildfires

Wildfires can cause a range of physical impacts on energy infrastructure. Wildfires can physically damage generation facilities, potentially rendering them inoperable and forcing shutdowns (Fifth National Climate Assessment, 2023). In addition, Wildfires can damage electric transmission and distribution systems through direct damage to support structures and the wires themselves, reduce transmission capacity of a line through exposure to heat, smoke, and particulate matter, and cause efficiency losses and line arcing due to ionized particulate matter in smoke (Allen-Dumas, Binita, & Cunliff, 2019). Liquid fuel and natural gas infrastructure are also vulnerable to physical damage due to extreme temperatures resulting from wildfire. As illustrated in *Section 2: Critical Energy Infrastructure and Cross-Sector Interdependencies*, disruption to electric supply also interrupts the transmission and delivery of both liquid fuels and natural gas, which can cause additional damage to public safety and the NC economy. As discussed in *Section 4.1: Natural Threats*, wildfires are correlated to drought conditions, and droughts are estimated to occur more often in the future. Furthermore, the fire season is expected to lengthen in the Southeast. Beyond the physical damages and other impacts described above, an increase in wildfires may result in risks to affordability for NC consumers through rising insurance costs or reduction or elimination of insurance products for utility infrastructure.[29]

Landslides

In addition to general property damage, landslides can damage any electric, liquid fuels, or natural gas infrastructure nearby. From 2009-2019, NC averaged $1 million annually in property damage resulting from landslides (NC Energy Risk Profile, 2021). According to provisional data from the U.S. Geological Survey, Hurricane Helene caused over 2,000 landslides in the Appalachian Mountains, over 1,000 of which

[29] Pacific Gas & Electric in California recently opted to self-insure for wildfire risk due to rising costs and diminished availability (As Wildfires Losses Mount, Will Commercial Insurers Decline to Cover Utilities, 2024).

caused extensive damage to infrastructure in the region (United States Geological Survey, 2024). The extensive road damage slowed and hindered damage assessments and aid for many of western NC's more isolated communities. The inability to access sites during an emergency is one of the major vulnerabilities addressed in *Section 5: Vulnerability Severity Assessment*. Landslides severed transportation routes, hindering emergency responders' ability to assist the public and isolating residents from external aid and communication (Hurricane Helene Recovery , 2024). Landslides not only destroy existing structures along their path but also jeopardize the land's potential for future development.

Landslides' impacts are difficult to mitigate because they cause damage to buried infrastructure like pipelines or electrical transmission and distribution wires, of which the latter two may be buried to mitigate the risks of other hazards (Fifth National Climate Assessment, 2023; Oruji, Ketabdar, Moon, Tsao, & Ketabdar, 2022). Research indicates that steel natural gas pipelines are resilient, particularly to vertical movement compared to horizontal. However, the magnitude and debris associated with a landslide can heighten the potential damage to pipelines and other energy infrastructure. (Oruji, Ketabdar, Moon, Tsao, & Ketabdar, 2022)

Winter Storms

Winter storms can damage infrastructure and disrupt power delivery across the state, potentially leaving millions without electricity or heat during critical times. These storms, often bringing ice, heavy snow, and high winds, can topple exposed transmission and distribution lines, as exemplified by Winter Storm Elliott in December 2022, which caused over 500,000 outages statewide, including significant disruptions to Duke Energy's NC customers, with restoration efforts hampered by subzero wind chills and fallen trees. These events significantly increase heating demand, strain backup systems, and disrupt fuel transport, thereby challenging grid reliability and affordability. They also reveal vulnerabilities in aging infrastructure and vegetation management, especially in a state susceptible to increasingly severe weather.

Earthquakes

Earthquakes, though less frequent than other natural threats, can damage critical infrastructure and disrupt power and fuel supply. The 5.1-magnitude earthquake near Sparta on August 9, 2020 (the strongest in NC in over a century), demonstrated this threat. Roads, utility lines, and masonry structures were damaged, including the collapse of walls and chimneys and the cracking and shifting of foundations, causing NC's governor to declare a local state of emergency and the NC General Assembly to provide $24M for earthquake recovery (One Year After Sparta Earthquake, Recovery is Well Underway, 2021). Such seismic events could fracture vulnerable infrastructure, interrupt grid operations, and complicate emergency response in a state with limited seismic retrofitting, amplifying reliability risks and economic impacts, especially if coupled with secondary effects like landslides in the western mountains.

Electromagnetic Disturbances

Electromagnetic disturbances, such as geomagnetic storms from solar flares or electromagnetic pulses from high-altitude nuclear events, can potentially disrupt the state's electrical grid and critical infrastructure. These disturbances can induce voltage surges in transmission lines and transformers, as seen in the 1989 Quebec blackout, threatening outages for NC's electric customers and damaging equipment for electric suppliers. With NC's reliance on exposed transmission and distribution lines and aging infrastructure, a severe event could lead to prolonged power losses, disrupt fuel supply chains, and impair communication systems vital for emergency response, amplifying economic and safety impacts in a state already vulnerable to natural disasters like hurricanes.

4.5.2. Technological Threat Impacts

This section investigates the impacts of technological threats, focusing on the consequences of rising demand and infrastructure failures in generation, transmission, and pipeline networks. By detailing these impacts, this section underscores the need for strategic interventions to safeguard energy security and maintain system resilience and affordability across the state.

Rising Demand

Falling Reserve Margins

Rising demand without a subsequent increase in supply could lead to falling "reserve margins" for utilities, which presents a major reliability risk during high demand times.[30] The 2023 Duke CPIRP and the 2024 NERC Long Term Reliability Assessment both forecast a declining reserve margin for the NC region. This trend suggests that demand growth may outpace supply growth in the long term, potentially resulting in major reliability, economic, and health and safety challenges for the state.

Low reserve margins signal an inadequate amount of supply to meet peak demand. When reserve margins drop below recommended levels (minimum 15% per NERC guidelines), the grid becomes more statistically vulnerable to blackouts. An inadequate reserve margin means there is little buffer to handle sudden demand spikes, such as those during heatwaves, or unexpected generation losses, like a power plant going offline. Falling reserve margins can create vulnerabilities for end-use customers, especially at critical infrastructure such as hospitals, which can't afford to endure periods of power supply disruption.

Affordability

Rising demand for electricity can potentially lead to higher energy rates as utilities invest in expanded capacity and grid upgrades. In NC, low-income households face disproportionately high energy burdens[31], spending up to 19.8% of their income on energy costs, with those at 50% of the Federal Poverty Level facing burdens as high as 32.8%, far exceeding the 6% threshold for high energy burden (Williams, 2024). Despite the Southeast's low electricity rates (11.24 cents/kWh in NC vs. 14.12 cents/kWh nationally), factors like energy-inefficient housing, historical inequities, aging infrastructure, and high cooling demands due to the region's climate all drive elevated energy costs (Williams, 2024). Rural and elderly residents are particularly vulnerable, with energy burdens in rural counties ranging from 27.71% to 43.2% for the poorest households (Williams, 2024). These burdens force families to prioritize energy bills over essentials, impacting health, education, and economic stability. Hurricane Helene in September 2024 further exposed energy resilience gaps, underscoring the need for accessible, resilient clean energy infrastructure to address energy insecurity in low-income and disadvantaged communities (Williams, 2024).

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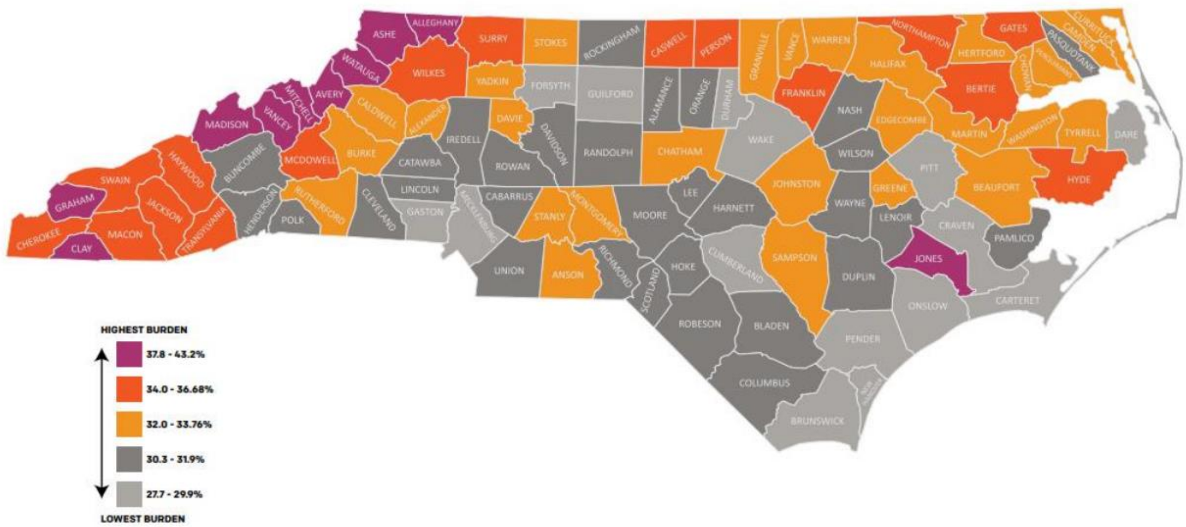
[30] The EIA defines reserve margin as the amount of unused available capability of an electric power system (at peak load for a utility system) as a percentage of total capability. For example, a system with 100 GW of firm capacity and a 75 GW peak load, would therefore have a ~33% reserve margin. Reserve margins are an essential calculation to assess resource adequacy and ensure reliability during peak demand periods.

[31] Energy burden is defined as the percentage of gross household income spent on energy costs. It is calculated by dividing the average housing energy cost by the average annual household income. A household with 6% or greater energy burden is a high energy burden household.

The figure below shows the most energy burdened counties in NC for households at 50% Federal Poverty Level. Rural western counties experience the highest energy burdens across all income brackets, largely due to energy-inefficient housing and the increasing number of cooling and heating degree days driven by climate change (Williams, 2024).

Figure 56: NC County-Level Energy Burden at 50% Federal Poverty Level



Source: NC Clean Energy Fund

Infrastructure Failure: Outages

The aging infrastructure can cause major disruptions such as power outages, vulnerability to cyber-attacks, and emergencies caused by faulty grid infrastructure. NC ranks as the second-highest state in the nation for average electric power service interruptions per customer in total duration, averaging roughly eleven hours annually. This measure is known as the System Average Interruption Duration Index (SAIDI) (Electric Grid Resilience, 2024). Frequent power outages disrupt essential services like hospitals, emergency response systems, and water treatment facilities, and prolonged outages can jeopardize life-saving medical equipment and delay critical treatments (Dengler, 2024). Power disruptions can have a negative economic impact on local business that result in lost revenue, spoiled goods, and damaged equipment, in addition to increased costs of emergency repairs and backup power solutions (Dengler, 2024). Unreliable grid infrastructure often disproportionately impacts disadvantaged communities, and these communities experience more frequent outages and have fewer resources to cope with the consequences, exacerbating existing social and environmental inequities (Foster, 2024).

The Lawrence Berkley Laboratory provides an Interruption Cost Estimate (ICE) Calculator that estimates the economic impacts of localized, short-duration power interruptions as well as widespread, long-duration interruptions. The model inputs incorporate the state, number of non-residential and residential customers, System Average Interruption Duration Index (SAIFI) per customer, and the SAIDI in minutes. The ICE Calculator example below utilizes the EIA 2023 estimated state-level reliability metrics, including the SAIFI and SAIDI, along with the actual outage statistics from the physical attack on a substation located in Moore County (discussed in greater detail below).

The table below shows the NC state-specific outage inputs into the ICE Calculator model, and the figure below shows the calculated costs of said outage, which was estimated to be $3.6M (2016$) (ICE Calculator, n.d.). Given that NC is the second-highest state in the nation for average electric power service interruptions per customer in total duration, power service interruptions can become an extremely high annual cost for the state. High power outage rates may deter companies from siting data centers within NC, as the data centers and the businesses they support cannot afford the business disruptions caused by outages or power spikes.

Figure 57: ICE Calculator Inputs

# Of Non-Residential Customers	# Of Residential Customers	SAIFI	SAIDI
1,000	45,000	1.506	252

Source: Lawrence Berkeley National Laboratory ICE Calculator & EIA Form EIA-861, Annual Electric Power Industry Report.

Figure 58: ICE Calculator Outputs

Sector	# of Customers	Cost Per Event (2016$)	Cost Per Average kW (2016$)	Cost Per Unserved kWh (2016$)	Total Cost (2016$)
Residential	45,000	$8.79	$5.92	$2.12	$595,363.58
Small C&I	950	$1,411.91	$461.51	$165.51	$2,020,022.62
Medium and Large C&I	50	$13,979.57	$67.48	$24.20	$1,052,661.82
All Customers	**46,000**	**$52.95**	**$30.43**	**$10.91**	**$3,668,048.02**

Source: Lawrence Berkeley National Laboratory ICE Calculator

Infrastructure Failure: Pipeline Disruptions

Aging pipelines can result in costly leaks, which pose economic, social, and environmental consequences. Between 1986 and 2019, the most frequent impacts on the state's petroleum supply were caused by corrosion and equipment failure. Corrosion has been the costliest annualized economic loss for the state. The DOE estimates refined product pipeline corrosion cost $225,000 in annual losses from 1986-2019 (NC Energy Risk Profile, 2021).

The 2020 Colonial Pipeline spill in NC, near Huntersville, released approximately 2 million gallons of gasoline into the Oehler Nature Preserve, marking the largest onshore fuel spill in US history. For NC, the consequences were multifaceted. Environmentally, it contaminated soil and groundwater with hazardous chemicals like benzene and PFAS, affecting the preserve and necessitating a massive cleanup. Economically, the cleanup of Huntersville was estimated to cost over $55 million, with potential long-term ecological damage imposing further financial burdens. Socially, the spill eroded local trust as 22 nearby drinking wells were tested, and the delayed detection heightened safety concerns among residents. The incident exposed vulnerabilities in aging pipeline infrastructure, spurring legal action and calls for stricter oversight in NC.

Pipeline failures weaken grid resilience, heightening vulnerability to environmental damage and safety incidents that challenge the state's ability to maintain a reliable and affordable energy supply amidst growing demand and frequent weather threats.

4.5.3. Human-Caused Threat Impacts

This section explores the impacts of the human-caused threats identified in the previous section. These impacts can lead to prolonged outages, compromised safety, and economic losses for NC's energy customers and businesses. The impacts identified highlight the critical need for enhanced security measures and workforce development to protect the state's energy security and resilience.

Cyber Security

The energy sector has become technology driven, and these changes have resulted in many benefits including improvements to efficiency, resiliency, and flexibility. However, cybersecurity vulnerabilities and the capabilities of malicious actors have also evolved over the past 20 years. Cyber threats are not limited to personally motivated individuals but can also come from criminal and nation-state groups focused on profit, political gain, or power. The aptitude of these groups to compromise internet-connected, internet-adjacent, or even traditional incident command system (ICS) assets that were never designed to connect to the internet continues to grow. Example consequences of an attack on IT and OT systems are described in the table below.

Figure 59: Potential Impacts of a Cyber-Attack on Energy Infrastructure

	IT	OT
Impacts	• Loss of personally identifiable information. • Loss of business data. • Customer/supplier payment issues. • Brand damage/loss of confidence in company.	• Health, safety, and economic impacts. • Disruption to basic daily activities – loss of power or access to fuel. • Impacts from prolonged disruptions can cascade into larger consequences. • Operator loses visibility into operations. • Supply fails to meet demand. • Operator forced to switch to manual operations mode.

Source: CISA

A cyber-physical event can cause loss of power or access to fuel, initiate prolonged cascading impacts, create potential risks to health and safety, and result in economic impacts to companies and the people and businesses that rely on that energy. The table below includes several notable examples of cyber-attacks on energy infrastructure perpetrated by various threat actors, including Colonial Pipeline ransomware attack that impacted NC among several other states. For cybersecurity best practices for industrial control systems, CISA and DOE created an infographic outlining key areas of consideration.

Figure 60: Industrial Control System Cyber-Attack Examples

Attack Name	Physical Target	Method	Impact/Implication
Stuxnet (2010)	Nuclear facilities (Iran)	Stuxnet was the first publicly known malware to specifically target control systems with the intent to damage physical infrastructure. The malware was especially notable due to its covert nature, presenting fake data to operators while hiding operations underway.	Proof that hardware is an equal threat vector and that ICS systems are targets.

BLACKENERGY 3 (2015)	Regional electricity distribution company (Ukraine)	The attackers likely spent an extended period of time doing reconnaissance before executing their final attack. Attackers used spear phishing emails, multiple variants of malware, and manipulation of documents as part of a broad campaign. After gaining initial access, they captured valid credentials and leveraged those credentials to access electric power Supervisory Control and Data Acquisition (SCADA) systems. Successful penetration of the OT systems enabled them to shut down and disable portions of the distribution power grid	Approximately 225,000 Ukrainian power customers lost power. Manual black start required.
CRASHOVERRIDE (2016)	Electrical substation (Ukraine)	Leveraged previous successful ICS attacks such as Stuxnet, Havex, and BLACKENERGY 3, as learning mechanisms to develop industrial system malware that could work on multiple infrastructures without a human operator (unlike BLACKENERGY 3).	Kiev, Ukraine experienced a one-hour power disruption. The attack failed to accomplish apparent goals, but it was a demonstration of the attacker's ability to accomplish automated cyber-attacks on critical infrastructure.
Triton / Trisis (2017)	Petrochemical facility (Saudi Arabia)	The first publicly known attack on a Safety Instrumented System (SIS), a system of last resort intended to protect lives by triggering emergency shutdowns of industrial processes if unsafe conditions are reached. Attacker gained access and deployed malware directly onto the SIS to gain full access to the SIS without plant operator knowledge. The malware installation triggered a failsafe that activated the SIS.	Shut down plant operations at a petrochemical facility, triggering a full investigation. Preventing safety mechanisms from performing their intended function can result in physical consequences.
Unnamed Attack (2019)	US electric grid	A cyber-attack temporarily created blind spots between a control center and a number of remote generation sites in the western US by exploiting a vulnerability in a technology vendor's firewall.	Denied reliable communications between a control center and the power generation controlled.

EKANS / Snake (2020)	ICS operations (Enel and Honda)	Ekans/Snake utilized popular ransomware attack methodology, but targeted control system processes instead of more common targets. This malware contains static lists to automatically kill known processes run by ICS.	First known ransomware that targeted ICS/OT. Manufacturing operations disrupted on 3 continents after victims decided to suspend ICS/OT operations.
Colonial Pipeline Ransomware Attack (2021)	US petroleum pipeline	The cyberattack targeted Colonial Pipeline's IT network using Darkside Ransomware, prompting the company to proactively shut down pipeline operations as a precaution.	Fuel stopped flowing, affecting Southeast and MidAtlantic states who are heavily dependent on the Colonial Pipeline for their fuel. Limited alternatives to the pipeline. Consumer panic buying, further limited supply which was also exacerbated by tanker truck driver shortage.
Volt Typhoon (2024)	Electric Utilities	The US government and its Five Eyes intelligence partners issued a warning about Volt Typhoon, a Chinese state-sponsored hacker group, targeted critical infrastructure, such as energy, transportation, and water systems, by exploiting vulnerabilities in internet-connected devices.	The group operates like a traditional botnet, compromising thousands of devices worldwide to mask its attacks, complicating detection and raising the risk of unintended retaliation against innocent third parties caught in its network.

Source: CISA

Physical Attacks

Physical attacks on the power grid can lead to sudden power disruption that can jeopardize the operations of critical infrastructure such as hospitals. Power disruptions in hospitals can significantly impact patient safety by causing critical medical equipment to malfunction, hindering life-saving procedures, disrupting vital monitoring systems, and potentially leading to complications or even death for patients reliant on electricity for their care, especially those in intensive care units; this includes issues with ventilation, medication delivery, and imaging capabilities, all while compromising the overall ability to provide quality healthcare during an outage. The Moore County attack caused outages at FirstHealth Moore Regional Hospital in Pinehurst. However, the hospital was fortunately able to quickly restore power from backup generators, limiting the potential adverse safety impacts to patients.

Physical attacks on the natural gas or liquid fuel infrastructure can halt the flow of fuel, leading to shortages in regions dependent on that supply. This can affect industries, transportation, and households, potentially causing economic ripple effects. Ruptures or leaks from liquid fuel pipelines (e.g., oil or gasoline) or other importation methods can spill hazardous materials into soil, rivers, or groundwater, causing long-term ecological harm. Breaches to gas pipelines or at LNG storage facilities may release methane, a potent greenhouse gas, exacerbating climate issues.

Misinformation & Disinformation, and Policy Uncertainty

Misinformation and disinformation pose a growing threat to NC's energy security by undermining public trust, delaying critical infrastructure projects, and skewing policy decisions (Countering False Information on Social Media in Disasters and Emergencies, 2018). False narratives, such as exaggerated claims about renewable energy risks or unfounded allegations of government mismanagement during crises like Hurricane Helene, can erode confidence in state and federal responses, hinder the adoption of sustainable energy solutions, and exacerbate vulnerabilities in the energy system, making it harder to ensure a reliable, affordable, and resilient energy future for the state.

Major impacts of misinformation and disinformation to NC can include:

- **Erosion of Public Trust in Government, Energy Institutions, and Emergency Responses:** Reduced trust weakens the collaboration needed for resilient energy infrastructure, increasing risks during future crises.
- **Economic and Environmental Opportunity Costs:** Missed opportunities caused by mis/disinformation may slow NC's economic growth and exacerbate climate impacts, as the state could struggle to meet federal and state climate targets.
- **Polarization of Public Opinion:** Misinformation can deepen divides among communities, hindering consensus on energy policies and obstructing unified action towards energy security or disaster recovery.

Disinformation surrounding Hurricane Helene's aftermath in NC has significantly eroded public trust in federal and state response efforts, sowing confusion and fear among affected communities. False claims, such as allegations that FEMA is withholding aid or, seizing property, or that the government engineered the storm to manipulate elections, have been amplified online, creating a pervasive atmosphere of distrust. These baseless narratives, which gained millions of views on social media platforms, led some residents to hesitate in seeking government assistance, fearing land seizures or inadequate support, while diverting critical resources from recovery as officials are forced to debunk rumors (Disinformation and conspiracy theories cloud Helene recovery efforts in hard-hit areas, 2024). This erosion of trust not only delays aid delivery but also hampers the unified, fact-based response needed to rebuild devastated communities, highlighting the dangerous impact of disinformation during crises.

The far-reaching impacts of misinformation and disinformation, which include eroding public trust, incurring economic and environmental costs and polarizing communities, can create a complex web of challenges that undermine NC's ability to build a secure and sustainable energy future. These effects not only disrupt public support for critical energy initiatives but also complicate the policymaking process, as false narratives infiltrate regulatory debates and influence decision-making at both state and federal levels. Addressing these challenges requires a clear understanding of how misinformation shapes energy policy and public perception, paving the way for targeted strategies to counteract its influence and strengthen the state's energy resilience.

Policy Uncertainty

Policy uncertainty poses a significant threat to North Carolina's energy security. Both at the State and Federal level, energy and energy security funding and policy have seen drastic variation in recent years. Policy changes that favor or restrict energy generation sources continue to change, revisions to the permitting process for infrastructure continue to be debated, disaster response and rebuilding policies fluctuate, and both energy funding and related environmental regulations seesaw as political environments change. The volatility this creates makes a challenging environment for achieving long-term energy security, it deters long-term investment, disrupts planning, and slows the transition to a more reliable, affordable, and sustainable energy system.

In conclusion, misinformation and disinformation and policy uncertainty can undermine NC's energy security by eroding public trust, delaying vital energy projects, and enable uncertainty that deters long-term investment and hinders the state's transition to a sustainable energy future. The nature of online information makes it difficult to effectively curb misinformation and disinformation. This undermines proactive measures, leaving systems vulnerable to perpetuating cycles of misinformation. These distortions, amplified by social media and potentially influenced by malicious actors, create distrust that can delay recovery efforts, divert crucial resources, and deprive communities of economic and environmental benefits. To combat this persistent threat, NC must prioritize transparent, evidence-based communication and robust public engagement to counter misinformation (described in *Section 8.4.2: Combatting (Mis)(Dis)-Information*), ensuring a resilient, affordable, and sustainable energy system that supports long-term prosperity and resilience objectives.

4.5.4. Conclusion

In summary, the impact of natural, technological, and human-caused threats poses significant energy security challenges for NC. These threats can increase the severity of the major vulnerabilities within NC, underscoring the critical need for comprehensive strategies to bolster the resilience and reliability of the state's energy systems. The following section will go into further detail regarding the State's vulnerabilities, and the correlation between threats and vulnerabilities.

5. Vulnerability and Severity Assessment

In addition to the threats described in *Section 4: Energy Sector Threats and Impacts*, the state's energy system faces a diverse array of vulnerabilities that threaten its reliability, affordability, and resilience, each carrying the potential for significant statewide impacts. Taking a proactive approach to understand the vulnerabilities facing energy infrastructure enables NC's energy stakeholders to minimize or eliminate the threat impacts and improve energy security for the state.

Vulnerabilities may occur within the infrastructure (e.g., generation, transmission, distribution, pipelines, etc.) or system processes (e.g., operations, workforce, planning, financial, etc.) as illustrated in the table below. Infrastructure vulnerabilities are often easy to address but tend to be expensive, while process vulnerabilities tend to be difficult to address but usually require relatively inexpensive fixes (Sherry Stout, 2019).

Figure 61: NC Energy System Vulnerabilities

Vulnerability Categories	NC Specific Vulnerabilities

Infrastructure	• Aging Infrastructure (generation assets, transmission/distribution, liquid fuel and natural gas pipelines). • Reliance on fuel/electricity imports. • Supply interdependency (reliance natural gas and nuclear generation). • Lack of backup system for critical facilities. • Exposed transmission and distribution lines. • Cooling water supply. • Location prone to storms, flooding, fire, etc. • Overgrown vegetation (over transmission lines).
Process/ Planning	• Increasing rates for customers (affordability). • Transmission and generation siting/permitting delays. • Future under supply of generation assets (falling reserve margins). • Inaccurate demand growth forecasts (stranded asset risk). • Insufficient capital for system upgrades. • Lack of coordination between stakeholders. • Policy and regulatory uncertainty.
Operations	• Lack of cybersecurity defenses, malware, and potential for stolen data.
Workforce	• Lack of trained professionals. • Inability to access site during emergency.

Evaluating the NC energy system vulnerabilities will help determine the potential severity of a threat being realized. The assessment below determines the severity score of each vulnerability through a scoring system, ranking the severity (magnitude of consequence) on the energy system from low to high. These scores are combined with the threat likelihood scores (see *Section 4: Energy Sector Threats and Impacts*) to determine the total risk to the energy system, which will be examined in *Section 6: Risk Assessment*. A review of documents and studies (e.g., natural hazard studies, NC climate risk assessments, utility IRPs, historical outages, EIA energy data, DOE state risk profile, emergency operation plans) were considered for the scoring evaluation of the state's vulnerabilities.

The table below shows the qualitative and quantitative scores and associated threshold descriptions used to assign the vulnerability scores. The score represents the degree to which an affected process, system, or population could be adversely affected because of a disruptive event (e.g., flooding, a large storm, attack, etc.) (Sherry Stout, 2019). Vulnerability Severity scores will be updated on a recurring basis as NC's energy infrastructure, workforce, technology, and processes evolves, incorporating new and emerging vulnerabilities, and removing any that are no longer pertinent. Dynamic updates will help NC maintain a comprehensive and current assessment of the state's energy infrastructure risks.

In scoring each vulnerability, the following categories are considered:

- **Effect on delivery of power or fuel:** the percentage of service disrupted, effects on power quality, fuel disruptions, etc.
- **Effects of capital and operating costs:** additional costs for the reliable operation of the energy system.

- **Extent of health and safety impacts on the population**: number of people and severity of potential impact on the health and safety of the population.

Figure 62: Vulnerability Assessment Scoring Description

Vulnerability Likelihood Score		Threshold Descriptions
Categorical	Numerical	
High	9	Severe economic and social consequences with widespread, immediate impact. Risks at this level could halt critical energy infrastructure, cause significant price spikes, displace/harm large populations, cause massive ecological damage.
Medium-High	7	Substantial impacts with notable economic or social strain but more contained than High. These risks might disrupt key systems, lead to moderate cost increases, or affect smaller regions.
Medium	5	Moderate impacts with manageable economic or social effects. Risks here could involve temporary, modest cost rises, or localized disruptions.
Medium-Low	3	Limited impacts with minimal economic or social disruption. These risks might cause brief service interruptions, slight cost increases, or affect small, isolated groups.
Low	1	Negligible economic or social consequences. Risks at this level have little to no effect on energy availability, costs, or communities.

The table below evaluates the severity of the NC specific vulnerabilities, measuring their potential impact on the state's energy system based on factors like service disruption, cost implications, health and safety risks, and environmental consequences to support a comprehensive risk evaluation.

Figure 63: Vulnerability Severity Scores

Threat Category	Vulnerability	Potential Vulnerability Impact	Score
Physical	Aging Infrastructure	The state's outdated energy infrastructure struggles to meet modern demands, potentially leading to widespread outages and inefficiencies.	9
	Reliance on Fuel/Electricity Imports	The state's dependence on imported fuel and electricity increases vulnerability to external supply disruptions, risking energy shortages across sectors.	7
	Supply Interdependency	Reliance on natural gas and nuclear generation can pose a major risk if an element of the gas/nuclear fuel supply chain is disrupted.	7
	Lack of Backup System and Supplies	Insufficient reserves or backup systems leave the state exposed to prolonged disruptions during emergencies.	7
Natural	Location prone to storms, flooding, fire, etc.	The state's geographic exposure to frequent storms, flooding, and wildfires increases the risk of widespread damage to energy infrastructure, potentially disrupting power, and fuel supply across the state.	9

	Overgrown Vegetation	Unmanaged vegetation near power lines heightens the risk of outages or fires, potentially affecting large areas of the grid.	9
Technological	Increasing Rates for Customers (Affordability)	Rising energy costs could strain affordability, limiting access and economic stability for residents and businesses.	5
Human-Caused	Transmission & Generation Siting/Permitting Delays	Slow approval processes for new energy projects may hinder system expansion, delaying critical upgrades or capacity increases.	5
	Falling Reserve Margins	Declining excess power capacity could lead to blackouts during peak demand, impacting reliability statewide.	7
Process/Planning	Varying Demand Growth Forecasts (Stranded Asset Risk)	Inaccurate demand predictions might result in underused or obsolete investments, wasting resources and reducing system flexibility.	3
	Insufficient Capital for System Upgrades	Limited funding for improvements could stall modernization efforts, leaving the energy system less resilient.	5
	Lack of Coordination Between Stakeholders	Poor collaboration among energy providers and regulators may slow response times, amplifying the scale of disruptions.	5
	Policy & Regulatory Uncertainty	Political uncertainty can hamper the ability to plan for and finance grid modernization efforts and slow the deployment of resilient technologies needed to address escalating risks.	9
Hardware/Software	Lack of Cybersecurity Defenses	Weak digital protections expose the grid to cyberattacks, potentially crippling operations across regions.	9
Workforce	Lack of Trained Professionals	A shortage of skilled workers could delay maintenance and repairs, prolonging recovery from system failures.	1
	Inability to Access Site During Emergency	Restricted access to critical sites during crises might hinder repairs, extending outages and economic losses.	3

5.1.1. Conclusion

NC's energy system faces a wide range of vulnerabilities that threaten its reliability, affordability, and resilience, including aging infrastructure, reliance on imported fuel, and exposure to natural disasters, each assessed for severity based on their potential to disrupt power delivery, increase costs, and impact public health and safety. By proactively evaluating these vulnerabilities, stakeholders can prioritize risks and streamline mitigation strategies, which are detailed in the following two sections (*Section 6: Risk Assessment* and *Section 7: Risk Mitigation Assessment*).

6. Risk Assessment

Building on the threat and vulnerability analysis, this section evaluates the risk within the state's energy system. By linking the threat likelihood scores to the applicable vulnerability severity scores, a total risk score can be derived to highlight the most pressing concerns. This methodical approach enables the prioritized mitigation strategies presented in *Section 7: Risk Mitigation Assessment*, guiding policymakers and stakeholders in targeting resources and interventions to mitigate the greatest risks to the state's energy stability and security.

Not every vulnerability is directly impacted by each threat. Thus, the first step is to determine which vulnerabilities correspond to specific threats. The matrix below illustrates the connections between the previously identified vulnerabilities and threats. A "yes" signifies a correlation between a vulnerability and a threat (e.g., overgrown vegetation can worsen the impact of a high wind event), whereas a "no" denotes no relationship (e.g., a lack of cybersecurity defenses is unaffected by extreme temperatures).

Figure 64: Threats & Vulnerability Relationship Matrix

		THREATS														
		Hurricanes	High Wind Events	Lightning	Extreme Precip. (Flooding)	Increasing Avg. Temps	Extreme Temperature	Landslides	Wildfires	Drought	Rising Demand	Infrastructure Failure	Cyber Security	Physical Attack	Aging Workforce	Misinformation
Vulnerabilities	Aging Infrastructure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
	Reliance on Fuel/Electricity Imports	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
	Supply Interdependency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Lack of Backup Systems for Critical Infrastructure	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	Exposed Transmission and Distribution Lines	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes
	Location prone to storms, flooding, fire, etc.	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No
	Cooling Water Supply	No	No	No	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No
	Overgrown Vegetation	Yes	Yes	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No
	Increasing Rates for Customers (Affordability)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
	Transmission & Generation Siting/Permitting Delays	No	No	No	No	No	No	No	No	No	Yes	Yes	No	No	Yes	Yes

	Falling Reserve Margins	No	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No
	Varying Demand Growth Forecasts (Stranded Asset Risk)	No	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No
	Insufficient Capital for System Upgrades	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Lack of Coordination Between Stakeholders	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Political and Regulatory Uncertainty	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No	No	Yes
	Lack of Cybersecurity Defenses	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	No	No
	Lack of Trained Professionals	No	No	No	No	No	No	No	No	No	No	No	Yes	No	Yes	No
	Inability to Access Site During Emergency	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No	No	Yes	No

If a vulnerability/threat pairing is identified, then the severity score for each vulnerability is multiplied by the threat likelihood score to create a risk score for each specific vulnerability-threat combination (shown in the risk formula below). Risk scores are scaled from 1 to 100, with higher scores corresponding to higher risks.

The risk formula is: $\boldsymbol{Risk\ Score\ =\ Threat\ Likelihood\ Score\ X\ Vulnerability\ Severity\ Score}$

Creating a risk matrix offers a structured approach to integrate scores, aiding in the analysis and prioritization of risks for effective mitigation planning. The heat map figure below portrays high-risk scores as red cells and low-risk scores as orange or yellow values, and blank cells showing no link between specific vulnerability-threat pairs. This matrix reveals the relative importance of various risks, highlighting potential triggers and weaknesses associated with disruptive incidents. It also enables decision-makers to identify tailored resilience strategies for specific vulnerability-threat combinations. For instance, a decision-maker could assess specific vulnerabilities alongside the probability of various threats, enabling targeted allocation of resources to critical areas. The calculated risk scores inform the prioritization of risk mitigation strategies detailed in *Section 7: Risk Mitigation Assessment*.

Figure 65: NC Risk Matrix

Vulnerability Severity Score	Score	Hurricanes	High Wind Events	Lightning	Extreme Precip. (Flooding)	Increasing Avg Temps	Extreme Temperatures	Landslides	Wildfires	Drought	Rising Demand	Infrastructure Failure	Cyber Attacks	Physical Attack	Aging Workforce	Misinformation
Threat Likelihood Score		9	9	9	9	9	9	5	7	5	7	7	7	3	5	9
Aging Infrastructure	9	81	81	81	81	81	81	45	63	45	63	63	63			
Reliance on Fuel/Electricity Imports	7	63	63	63	63	63	63	35	49	35	49	49	49			
Supply Interdependency	7	63	63	63	63	63	63	35	49	35	49	49	49	21	35	
Lack of Backup Systems for Critical Infrastructure	7	63	63	63	63		63	35	49	35	49	49	49	21		
Exposed Transmission and Distribution Lines	7	63	63	63	63	63	63	35	49	35		49		21		
Location prone to storms, flooding, fire, etc.	9	81	81	81	81		81	45	63	45		63				
Cooling Water Supply	5					45	45		35	25						
Overgrown Vegetation	7	63	63						49	35						
Increasing Rates for Customers (Affordability)	5	45	45		45	45	45	25	35	25	35	35	35			45
Transmission & Generation Siting/Permitting Delays	5										35	35			25	45
Falling Reserve Margins	7					63	63			35	49	49				63
Varying Demand Growth Forecasts (Stranded Asset Risk)	3											21				
Insufficient Capital for System Upgrades	5	45	45	45	45	45	45	25	35	25	35	35	35	15	25	45
Lack of Coordination Between Stakeholders	5	45	45	45	45		45	25	35	25	35	35	35	15		45
Lack of Cybersecurity Defenses	9											63	63	27		
Policy and Regulatory Uncertainty	9															81
Lack of Trained Professionals	3												21		15	
Inability to Access Site During Emergency	5	45	45	45	45			25	35			35			25	

6.1.1. Conclusion

The risk assessment section illuminates the critical intersections of threats and vulnerabilities within NC's energy system, leveraging a structured risk matrix and heat map to pinpoint the highest-priority concerns—such as natural disasters and cybersecurity—that jeopardize reliability, resilience, and public safety. By quantifying these risks scores, the analysis provides a clear framework for understanding the state's most pressing energy challenges and their compounding effects, offering a solid foundation for strategic planning and resource allocation that can be updated in the future as NC specific risks evolve.

With these risks clearly defined, the next section outlines targeted mitigation strategies and actionable steps to address these risks, enhancing the state's energy security and preparedness for future disruptions.

PART THREE: Risk Mitigation and Coordination

7. Risk Mitigation Assessment

This section outlines risk mitigations and security improvements that will reduce, prevent, and manage risks in the state's energy sector. Risk mitigation solutions often include some combination of resource or technological diversity, redundancy, decentralization, transparency, collaboration, flexibility, and foresight considerations. A mix of solutions should be considered because no single intervention will address all threats and/or vulnerabilities.

The table below presents a concise overview of NC's top vulnerability and threat pairing related to energy security, alongside the primary mitigation strategies proposed to address these risks. Detailed explanations and case studies can be found in *Section 8: Risk Mitigation Descriptions and Case Studies*. Highlighted by a comprehensive risk matrix, the primary risks—such as natural threats like hurricanes and flooding coupled with infrastructure vulnerabilities—constitute the state's most urgent challenges. Corresponding mitigation strategies, including elevating infrastructure above flood levels, deploying microgrids for enhanced resilience, and constructing new transmission and generation facilities, are specifically tailored to address these high-priority risks and should be prioritized in implementation plans. Each strategy is designed to reduce exposure to disruptions and enhance energy reliability, with a corresponding feasibility analysis (below) elaborating on implementation time, costs, and expected risk reduction specific to NC's energy landscape. The prioritized risk mitigation solutions will evolve by regularly updating Threat Likelihood and Vulnerability Severity scores to reflect NC's changing energy ecosystem, ensuring mitigation strategies remain relevant, current, and effective.

Figure 66: Priority Risk Mitigation Solutions

Vulnerability Category	Aligned Threat Category	Risk Rank	Proposed Mitigation Solutions
Infrastructure	Natural (i.e. severe storms)	1	**Preventative** • LIDAR scans for vegetation management. • Utility pole replacement. • Elevate substation equipment. • Install flood walls around substations. • Bury transmission lines in high-wind prone areas. • Increase propane fuel stock in rural areas. **Supply Side** • Build microgrids at critical infrastructure facilities. • Install backup generation at critical facilities (i.e. solar plus storage or diesel).

Hardware / Software	Human-Caused (i.e. cyber-attacks)	2	**Cyber** • Active monitoring of announcements from Information Sharing and Analysis Centers. • Robust information sharing practices and procedures. • Enhance cybersecurity personnel, practices, and response coordination.
Process / Planning	Technological (i.e. extreme and rising demand, falling reserve margins)	3	**Supply Side** • Build new utility scale renewable generation. • Upgrade or build new transmission capacity. • Implement dynamic line ratings (DLRs). • Install backup generation at critical infrastructure facilities. • Obtain subsequent nuclear re-license for existing fleet. • Build new baseload generation (i.e. small-scale nuclear). **Demand Side** • Utility demand flexibility strategies (EE, DR, Time of Use). • Implement virtual power plants. • Residential EE expansion.
Workforce	Human-Caused (i.e. lack of trained professionals)	4	**Stakeholder Coordination** • Workforce development. • Communication coordination.

The figure below displays a feasibility mitigation matrix ranking system for the identified risk mitigation measures. The mitigation feasibility matrix ranking system evaluates energy system solutions based on their input (costs and time/effort required), and output (the degree of risk reduction achieved). This framework helps prioritize strategies to safeguard electricity, natural gas, and liquid fuel infrastructure. High Input solutions involve significant resources (e.g., millions of dollars, years), while Low Input options are cost-effective and quick (e.g., thousands, months). High Output reflects substantial protection against economic and social risks, like widespread outages, whereas Low Output offers limited impact. Tailored to the state's vulnerabilities, such as flooding and aging infrastructure, this matrix balances investment against resilience to optimize energy system stability.

The assumptions made for the risk mitigation feasibility matrix can be found below.

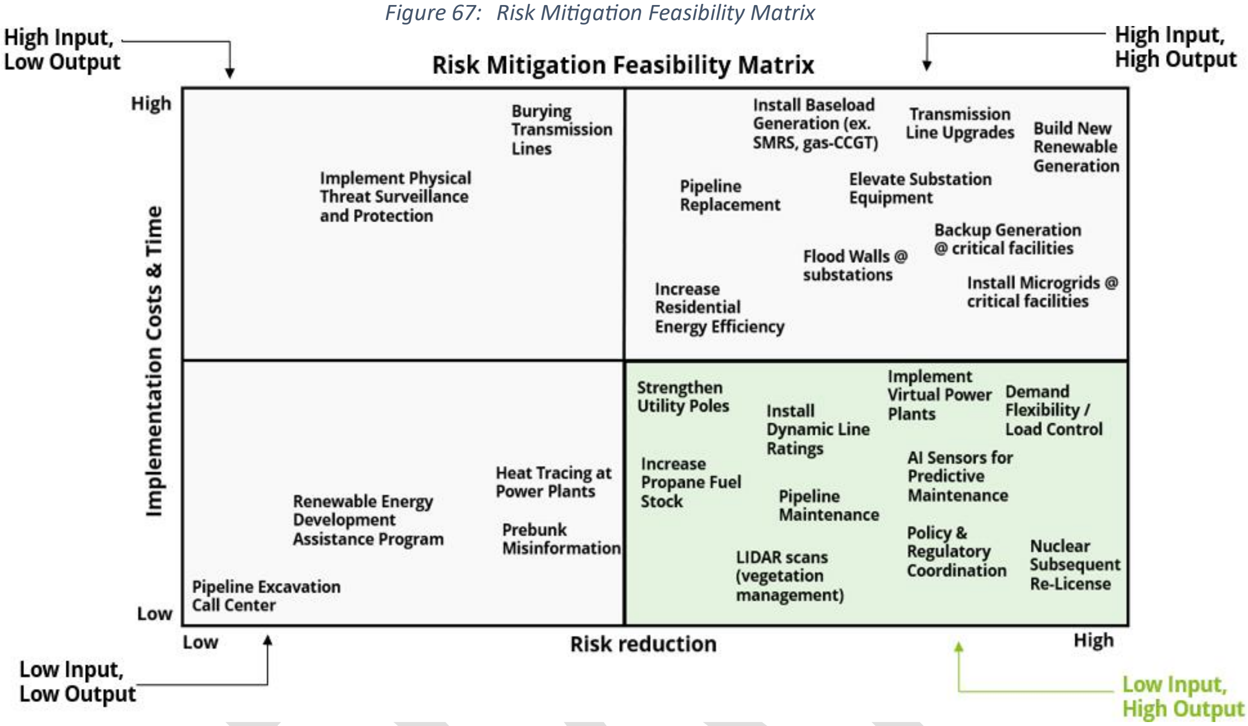
High Input-High Output (upper right quadrant): Significant costs and time/effort with substantial risk reduction. These solutions demand large investments (e.g., millions of dollars, multi-year projects) and extensive labor but deliver major protection against critical risks. Example: Elevating coastal substations to prevent flooding.

High Input-Low Output (upper left quadrant): High costs and time/effort with limited risk reduction. These require substantial resources but yield marginal benefits relative to the investment, often due to narrow scope or inefficiencies. Example: Installing a small modular nuclear reactor requires significant financial investment and time for development and regulatory approval, yet it may only provide a modest increase in energy capacity and resilience relative to the resources expended.

Low Input-High Output (lower left quadrant): Minimal costs and time/effort with significant risk reduction. These are cost-effective, quick wins (e.g., thousands of dollars, weeks to months) mitigate key vulnerabilities. This quadrant is highlighted in **green**, as it showcases attainable solutions that deliver low-cost and high-risk reduction benefits. Example: LIDAR scans for vegetation management.

Low Input-Low Output: Low costs and time/effort with minimal risk reduction. These are inexpensive and fast to implement but offer limited impact, often addressing minor or already-managed risks. Example: Excavation call-center that prevents pipeline excavation damage when digging.

Figure 67: Risk Mitigation Feasibility Matrix



By strategically aligning resources with the most effective outcomes, the risk mitigation feasibility matrix aligns NC's energy security measures to be both cost-efficient and impactful. This approach not only fortifies the state's energy infrastructure against potential threats but also addresses critical economic and social vulnerabilities. By prioritizing high-output strategies that deliver substantial risk reduction and align with state goals, and managing the costs and time associated with implementation, NC can enhance energy security in the face of increasing demand and environmental uncertainty.

7.1.1. Conclusion

The risk mitigation section establishes a strategic framework for addressing NC's most critical energy security risks, pairing top vulnerabilities and threats, with tailored mitigation strategies. By integrating a feasibility matrix that balances input costs and time against risk reduction outputs, this section provides a practical guide for prioritizing solutions that enhance the resilience of the state's electricity, natural gas, and liquid fuel systems, ensuring both economic and social stability in the face of disruptions.

To further illustrate these proposed solutions in action, the next section dives into detailed explanations and real-world applications, highlighting how these risk mitigations can be effectively implemented to safeguard NC's energy future.

8. Risk Mitigation Descriptions and Case Studies

This section delves into detailed descriptions of risk mitigation strategies and presents relevant case studies to illustrate their practical applications. Building on the risk mitigation feasibility matrix analysis, this section aims to provide actionable insights and proven solutions. The case studies highlight successful implementations of these strategies, offering valuable lessons and best practices that can be adapted to enhance the resilience, reliability, and sustainability of the state's energy infrastructure. Through this comprehensive analysis, stakeholders can better understand the effectiveness of various mitigation approaches and make informed decisions to safeguard NC's energy future.

8.1. Proactive Preventative Mitigation Measures

This subsection examines a suite of risk mitigation strategies and real-world case studies to proactively protect NC's energy infrastructure, which is at high risk area due to its vulnerability to severe weather and aging components. By highlighting successful implementations and tailored strategies, this subsection offers actionable insights to enhance the state's energy security, ensuring a resilient and reliable energy future for all North Carolinians.

8.1.1. Severe Weather Mitigation

Investing in severe weather mitigation strategies—such as reinforcing utility poles, burying transmission lines, implementing flood protection, and weatherization—is essential for energy stakeholders to enhance reliability and resilience, thereby reducing service interruptions during adverse weather conditions. These investments lead to long-term cost savings by reducing repair and maintenance expenses, improving safety by minimizing the risk of accidents, and help utilities comply with regulatory requirements. Additionally, they boost customer satisfaction through reliable service, protect the environment by preventing damage, and support economic stability by maintaining essential services during severe weather events. The National Institute of Building Sciences 'Natural Hazard Mitigation Saves: 2017 Interim Report' found that federally funded mitigation grants, on average, can save the nation $6 in future disaster costs for every $1 spent on hazard mitigation. The table below provides an overview of the mitigation measures pertinent to NC.

Figure 68: 1Severe Weather Mitigation Measures

Vulnerability	Potential Vulnerability Impact	Sector
Stronger utility poles	This can involve reinforcing wood poles, replacing wood poles with concrete ones, or replacing wood cross-arms with fiberglass ones.	Electricity
Undergrounding Power Lines	Placing transmission lines underground protects them against external threats, including high winds and falling branches, wildfires, extreme heat or cold, icing, dirt/dust/salt accumulation, and animals. Buried lines may be more vulnerable to flooding if located in low-lying areas and may be more difficult and expensive to maintain and repair.	Electricity
Elevate Equipment	Elevating equipment located in low-lying areas can protect it from flooding that would otherwise damage or destroy it.	NG, Liquid Fuels, Electricity
Flood walls/gates	Installing flood walls, gates, and/or barriers can protect essential equipment in flood prone areas from water intrusion and avoid restoration delays after major storms and floods.	NG, Liquid Fuels, Electricity
Heat Tracing	Electric cable runs alongside delivery pipes and equipment to protect them against extreme cold temperatures. Heat trace is designed to prevent freezing from occurring inside water or steam lines, which could rupture and disrupt plant operations.	NG, Liquid Fuels, Electricity

Data Source: DOE

Case Study: EnergyUnited Grid-Enhancing Investments

EnergyUnited is the largest energy cooperative in NC and the 16th largest electric cooperative in the US. EnergyUnited serves nearly 130,000 metering points in parts of 19 NC counties, and EnergyUnited Propane provides products and services to more than 25,000 residential, commercial, and industrial customers in 74 counties across North and South Carolina.

The 2025-2028 Construction Work Plan is designed to make strategic enhancements to the grid while meeting the growing energy demands of our communities. Over the next four years, EnergyUnited is investing more than $216 million in several projects that will help deliver reliable power to its customers. This includes a ~$30 million investment to build six new substations and upgrade eight others. These projects will address the rapid growth in energy demand across our entire service territory. The Construction Work Plan also includes 14 miles of new transmission lines and upgrading 37 miles of existing lines to improve resiliency and reduce outages.

Grid reliability is a major focus, replacing aging poles and copper lines, installing modern equipment, and upgrading transformers, EnergyUnited is ensuring the grid is ready to handle severe weather and other challenges. This also includes investments in newer technologies such as SCADA systems and data analytics to reinforce reliability, while supporting the continued growth of solar energy throughout its service area. EnergyUnited is planning to stay ahead of the anticipated demand growth, with plans to add more than 200 miles of underground lines and 60 miles of overhead lines to serve new members.

Source: EnergyUnited (January 2025 Letter from the Chief Executive Officer, Thomas Golden)

8.1.2. Natural Gas and Liquid Fuel Weatherization

Weatherization of natural gas and liquid fuel infrastructure includes measures to prevent freeze-offs, protect equipment, and bolsters the reliable operation of facilities. While the state's climate is generally milder than northern states, ice storms, cold snaps, and elevation-related temperature drops pose challenges to gas and propane infrastructure, especially in the western mountains and northern regions of the state. Major winter storms have challenged the fuel infrastructure of various U.S. states, including Texas during Winter Storm Uri in 2021 and several Northeastern states during Winter Storm Elliot.

The 2021 Winter Storm Uri crippled the Texas gas infrastructure, where frozen pipelines slashed gas supply by 27%, and caused widespread power outages which resulted in the death of 246 people. The Railroad Commission (RRC) of Texas mandated weatherization for critical gas facilities, including pipelines, under Senate Bill 3 (2021). Oklahoma followed suit with the 2021 Energy Assurance Act, requiring weatherization audits and upgrades for gas infrastructure, including pipelines, after similar freeze-offs.

The below describes the best industry practices for weatherization of fuel infrastructure:

- **Insulation**: Adding thermal insulation to pipes, valves, and wellheads to prevent freezing, a common failure point during Uri.
- **Heat Tracing:** Installing electric heat tracing systems on pipelines and equipment to maintain temperatures above freezing.
- **Methanol Injection:** Using chemical injections at wellheads and along pipelines to prevent hydrate formation in cold conditions.

- **Windbreaks:** Erecting physical barriers around exposed equipment to shield from wind chill, particularly in open field operations.
- **Drainage Systems:** Upgrading to prevent water accumulation that could freeze and block pipelines or equipment.
- **Monitoring Systems**: Deploying sensors to detect temperature drops or pressure anomalies early, allowing preemptive action.

Source: RRC

Federal responses are also underway to address the challenges posed by extreme cold weather events. NERC developed the EOP-012 Reliability Standard to ensure generator owners prepare their facilities for extreme cold conditions (Perotti, 2025). The proposed Reliability Standard EOP-012-3 aims to enhance the existing standard by providing clearer criteria for generator cold weather constraints, requiring timely validation and review of these constraints, and setting stricter deadlines for corrective actions (Perotti, 2025). These improvements are intended to increase the reliability and efficiency of power markets during future cold weather events, aligning with directives from the June 2024 Order.

Expanding weatherization efforts into critical natural gas and liquid fuel supply infrastructure can help NC mitigate fuel reliability during extreme demand events.

8.1.3. Vegetation Management

Vegetation, in combination with severe weather conditions, is the leading cause of outages in electric power systems in the US, resulting in millions of people without power and billions of dollars in economic damage (Rethinking Vegetation Management, n.d.). The 2021 DOE NC Energy Risk Profile Report confirms that weather and falling trees are the lead cause of electric utility-reported outages from 2008-2017 (NC Energy Risk Profile, 2021). Vegetation inspections and forecasting are crucial for effectively mitigating these complex risks. Electric utilities consider different vegetation encroachment risks on and around the right-of-way (ROW) for transmission and distribution lines. Two primary categories of encroachment that occur on and adjacent to power lines' ROW are grow-in and fall-in (Rethinking Vegetation Management, n.d.):

- **Grow-in** refers to vegetation growing into a power line. Regulation often prescribes which vegetation species are allowed in proximity to power lines. Fast-growing species may end up in or around the utility corridor, posing a grow-in risk.
- **Fall-in** refers to trees falling onto the power line. Fall-in can happen in severe weather conditions, such as instances of heavy winds. The risk of falling trees is amplified when trees are sick, or soil conditions are weak.

Proper vegetation management includes understanding grow-in and fall-in risks for every mile. Identification and prioritization of high-risk areas help correctly plan and evaluate vegetation maintenance and investigate where and when encroachments might occur in the coming month, season, and year.

Case Study: Vegetation Management

Given that vegetation related incidents are the single largest cause of service outages in th**e US**, a large utility provider that operates in a region prone to outages due to vegetation related incidents needed to reduce the potential for such hazards. To respond accordingly, the utility provider turned to Deloitte to leverage advanced technology to build a scalable solution that helps reduce the impact of vegetation growth with preventive maintenance, including identifying and removing at-risk vegetation.

Conventional grid monitoring techniques typically involve on-foot visual inspections, which are expensive, time-consuming, labor-intensive, and dangerous for workers. To improve this process, Deloitte helped the utility implement remote and automated monitoring – using drones, cameras, and alert tools – to detect objects close to high-voltage wires or in hard-to-reach areas, minimizing the risk of vegetation affecting power transmission.

The utility and Deloitte team implemented Salesforce Service and Field Service Cloud, which allows **users to plan, s**chedule work orders, and generate reports. It integrates with a GIS for robust maps and data layers that can be pushed out to the field in real time. Deloitte helped the utility launch a fully operational aerial remote-sensing program to monitor the grid at scale. The program included unmanned aircraft systems, also known as drones, helicopters, map-based views, and ML for image processing—all of which have significantly enhanced efforts to strengthen the grid and reduce vegetation related incidents.

The overarching improvements were:

- Improved productivity, performance, and efficiency with a field workforce centric user experience.
- Empowered field users to work offline to allow for inspections in remote areas.
- Established cross-program coordination via a single app to schedule work and track metrics.
- Improved compliance using real-time reporting capabilities for speed and accuracy.
- Implemented a 360-degree view of asset data that includes asset details, pictures, geo-spatial context, and work order history for more efficient resource allocation.

Source: Deloitte

8.1.4. Pipeline Maintenance

Fuel pipeline spills, such as the Colonial Pipeline leak in North Carolina in August 2020, can discharge millions of gallons of gasoline into ecosystems, contaminating soil and groundwater with benzene levels up to 700 times above federal safety limits. Each major incident can cost an estimated $10 million in cleanup and cause significant ecological damage. During the event, an estimated 2.0 million gallons leaked from a crack in a 1970s-era section of the pipe. The spill was caused by corrosion in a Type A sleeve repair patch installed in 2004, prompting a mix of immediate fixes and longer-term efforts to prevent similar failures. According to the company's settlement with PHMSA, the pipeline's leak detection system never caught the spill. By November 2021, they were ordered to map every Type A sleeve in the state, evaluate their condition, and replace or reinforce them with modern alternatives if needed.

Pipeline companies deploy a range of solutions to mitigate corrosion and leaks, blending preventative measures, real-time monitoring, and repair techniques to keep aging infrastructure functional and safe. These approaches are driven by the need to protect steel pipes, most common in fuel transport, from rust, cracks, and breaches caused by environmental factors, wear, or design flaws.

- **Cathodic Protection**: Technique that uses electrical current to prevent corrosion of metal surfaces. The US has over 400,000 miles of liquid pipelines, and federal regs from PHMSA mandate cathodic protection for most buried steel lines.
- **Protective Coatings:** Pipes get wrapped in layers like epoxy, polyethylene, or fusion-bonded coatings before burial to shield them from moisture, soil acids, and oxygen. Older pipelines might have coal tar or asphalt, but modern ones favor multi-layer plastics. Over time, coatings degrade, cracking under soil stress or ultraviolet exposure before burial, so companies often pair them with cathodic protection.
- **Inline Inspection Tools (Smart Pigs):** Electronic devices that travel through pipelines to inspect for defects, using magnetic or ultrasonic sensors to spot corrosion, dents, or thinning walls. Magnetic flux leakage pigs detect metal loss from rust, while ultrasonic gauges measure pipe thickness.
- **Leak Detection Systems:** Pressure sensors and flow meters track anomalies, and sudden drops signal a breach. Computational pipeline monitoring software compares real-time data to expected patterns, flagging leaks within minutes if tuned.
- **Corrosion Inhibitors:** Chemicals get injected into the pipeline flow to neutralize corrosive elements like water or sulfur compounds in crude oil. These inhibitors form a protective film on the pipe's interior, cutting rust rates.
- **Pipe Replacement or Sleeving:** Companies replace pipeline sections outright with new steel, often pre-coated and thicker walled (Schedule 40 or 80 pipe). Type B sleeves (pressure containing patches) can be used for spot fixes over corroded areas.

Pipeline Excavation Damage

The primary tool for avoiding damage to underground facilities is timely communication between excavators and the owners of the facilities. One of the greatest challenges to safe pipeline operations is accidental damage to the pipe or its coating that is caused by someone inadvertently digging into a buried pipeline. Pipeline markers only show the general location of a pipeline or pipeline ROW. Markers do not show the precise pipeline location or depth of burial and therefore should not be solely relied upon to show where it is safe to dig (Fact Sheet: Excavation Damage, 2014). State One-Call Centers are established to help ensure that excavation is performed safely and to prevent damage by or to underground facilities and serve as a central communication point for anyone planning to excavate (Fact Sheet: Excavation Damage, 2014). One-Call Centers alert affected underground facility operators of excavation plans and the location of the proposed excavation. Facility operators are then responsible to locate their facilities and visibly mark their locations so that the person(s) doing the excavation will be able to dig safely over and around these buried facilities (Fact Sheet: Excavation Damage, 2014). **811** is the national call-before-you-dig number for professional excavators and homeowners.

The National Conference of State Legislatures lists nine elements for comprehensive and effective damage prevention programs:

- Enhanced communication between operators and excavators.
- Fostering support and partnership of all stakeholders.
- Operator's use of performance measures for locators.
- Partnership in employee training.
- Partnership in public education.
- Enforcement agencies' role to help resolve issues.

- Fair and consistent enforcement of the law.
- Use of technology to improve the locating process.
- Data analysis to continually improve program effectiveness.

8.1.5. Predictive Maintenance

"Predictive maintenance" is a proactive equipment management strategy that uses real-time monitoring and data analytics to forecast failures, replacing reactive and scheduled maintenance approaches. It is used in the energy industry to improve efficiency, reduce waste, and prevent costly breakdowns. The use of AI analysis can augment the abilities of subject matter experts and transform the way utility companies approach predictive maintenance by enabling more accurate, efficient, and proactive management of their assets. AI technologies facilitate the early detection of potential issues, enabling utility companies to address them proactively before they result in equipment failures, thereby enhancing the reliability of the power supply. AI and Machine Learning (ML) algorithms analyze this sensor data to identify patterns and predict potential failures.

Duke Energy uses predictive maintenance to optimize its maintenance schedule for transformers. By analyzing data from smart grid devices, the company can identify transformers that are at risk of failure and schedule maintenance visits to prevent issues before they occur (Clou, 2023). Duke Energy's data analytics system processes over 85 billion data points annually from their grid sensors, enabling precise maintenance scheduling. Pacific Gas & Electric employs ML models to forecast equipment failures by analyzing historical performance data alongside real-time sensor readings, reducing unplanned downtime by 30% (Predictive Maintenance in Utility Services: Sensor Data for ML, 2025).

NC energy stakeholders can utilize these technologies in practical applications:

- **Grid operators** use IoT sensors and ML to predict transformer health.
- **Water utilities** employ pressure sensors and AI to detect pipe leaks before they occur.
- **Gas companies** utilize thermal sensors and predictive analytics to identify potential pipeline issues.
- **Power distribution companies** combine weather data with grid sensor information to predict storm-related outages.

The table below outlines four major energy infrastructure types and their predictive maintenance frameworks. Each category (Power Plants, Power Grids, Wind Farms, and Solar Plants) is analyzed across four dimensions: monitoring parameters, technology implementation, operational benefits, and ROI metrics (Predictive Maintenance in Utility Services: Sensor Data for ML, 2025).

Figure 69: 2 Predictive Maintenance Applications in Energy Infrastructure

Infrastructure Type	Key Monitoring Parameters	Technologies Uses	Benefits	ROI
Power Plants	• Turbine Vibration. • Boiler Temperature. • Generator Output. • Cooling system flow.	• Vibration sensors. • Thermal cameras. • Performance analytics. • IoT devices.	• Reduced downtime. • Extended equipment life. • Optimized maintenance.	• 30% maintenance cost reduction. • 40% fewer forced outages.

				• 25% longer equipment life.
Power Grid	• Transformer oil quality. • Line integrity. • Voltage stability. • Load patterns.	• Oil analyzers. • Drone inspection. • Smart meters. • ML algorithms.	• Better reliability. • Faster fault detection. • Improved load balance.	• 35% fewer outages. • 50% faster repairs. • 20% better grid efficiency.
Wind Farms	• Blade condition. • Gearbox health. • Wind patterns. • Temperature.	• Acoustic monitors. • Vibration sensors. • Weather stations. • AI analytics.	• Optimal performance. • Reduced failures. • Weather-adapted maintenance.	• 25% less downtime. • 30% maintenance savings. • 5% higher output.
Solar Plants	• Panel efficiency. • Inverter status. • Temperature variations. • Dust levels.	• Thermal imaging. • Current sensors. • Performance monitoring. • ML models.	• Maximum efficiency. • Optimal cleaning cycles. • Better power output.	• 20% efficiency gain. • 35% maintenance savings. • 45% fewer failures.

Source: DataForest

Case Study: ENGIE Predictive Maintenance

ENGIE Digital, the software arm of the ENGIE Group, partnered with Amazon Web Services (AWS) to develop two predictive maintenance platforms: Robin Analytics (for ENGIE's thermal power plants) and Agathe (for business-to-business customers). These platforms aim to optimize maintenance, reduce costs, and prevent equipment failures by leveraging ML on AWS infrastructure, including Amazon S3, SageMaker, Glue, and Lambda.

The initiative supports ENGIE's shift toward renewable energy and carbon neutrality by improving operational efficiency and adapting thermal plant equipment use to intermittent renewable production. Nearly 10,000 pieces of equipment will eventually be connected—8,000 via Agathe within five years and over 1,000 via Robin Analytics by 2023—each with multiple predictive models, saving an estimated €800,000 annually. The AWS architecture ensures scalability, cost control, and innovation, enabling early anomaly detection, equipment health monitoring, and optimized maintenance schedules, with plans to explore additional services like Amazon Timestream and SageMaker Studio.

Source: EnergyUnited (January 2025 Letter from the Chief Executive Officer, Thomas Golden)

8.2. Supply Side Mitigation

This subsection focuses on a targeted set of risk mitigation strategies and case studies designed to strengthen NC's energy supply infrastructure, a critical area of concern given its exposure to supply chain disruptions, extreme weather, and rising demand. This section explores recommendations for enhancing reliability and resilience, including the deployment of microgrids, backup generation systems, transmission and distribution upgrades, and the integration of new renewable energy sources. By showcasing practical applications and innovative solutions, this subsection provides a roadmap for fortifying the state's supply-side energy framework, ensuring a secure and adaptable energy system capable of meeting current and future challenges.

8.2.1. Microgrid Deployment

A microgrid is a group of interconnected loads and distributed energy resources (DERs) that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to operate as grid-connected or "island" itself during outages, ensuring uninterrupted power (Prabakar, 2024). Microgrids can improve customer reliability and offer resilience from disturbances to the grid. A microgrid can significantly enhance the security and resilience of critical infrastructure in NC by providing a localized, reliable, and flexible energy system that operates independently or in coordination with the main power grid. Microgrids can be highly beneficial for critical infrastructure (e.g., hospitals, communication infrastructure, and defense facilities) that have damaging effects on public safety and health when power supply is disrupted.

NC has implemented numerous microgrid solutions across the state. For instance, NC's electric cooperatives have five active microgrids (Eagle Chase, Butler Farms, Rose Acre Farms, Ocracoke, and Herons Nest), while Duke Energy has implemented microgrids at Camp Lejeune and Fort Bragg, and implemented the Duke Energy + Electrada Fleet Mobility Microgrid in Mount Holly, a first-of-its-kind electrification center for commercial and public electric fleet vehicles. The project is the first of its kind in the country to offer a zero-emission, carbon-free microgrid option for fleet charging.

Other microgrid projects in North Carolina include Duke Energy's Hot Springs, which uses Wärtsilä's GEMS Digital Energy Platform and successfully maintained power to the town center for 143.5 hours following Hurricane Helene (Handley, 2025). Additionally, the Fayetteville Public Works Commission and Bloom Energy are developing a waste-to-electricity project near the Hoffer Water Treatment Facility. Siemens is planning an interactive Customer Experience Center and an on-site microgrid at its Wendell County headquarters. Appalachian State University is also working on a zero-carbon energy system at its Boone campus. These innovative projects collectively demonstrate NC's commitment to advancing sustainable energy solutions and enhancing grid resilience through cutting-edge technology and strategic partnerships.

Below are the benefits microgrids offer:

- **Resilience Against Outages**: NC is prone to natural disasters like hurricanes, flooding, and ice storms, which can disrupt the grid. For example, Hurricane Helene in 2024 caused widespread power outages across the Southeast. A microgrid can support critical facilities, such as hospitals in Raleigh or EOCs in Charlotte, stay powered even when the broader grid fails.
- **Energy Independence:** Microgrids often generate and store its own power, reducing reliance on vulnerable transmission lines.
- **Enhanced Security:** Critical infrastructure faces risks from cyberattacks targeting the centralized grid. A microgrid, especially one with minimal reliance on external networks, is harder to access and compromise. It can operate autonomously, protecting facilities like water treatment plants or communication hubs from cascading failures.

- **Customizable and Scalable Design:** Microgrids can be tailored to the needs of specific infrastructure. A data center in Durham might pair solar power with backup generators, while a rural fire station could rely on a smaller system with batteries and a microturbine. This flexibility helps consistent performance under varying conditions.
- **Integration of Renewables:** NC has growing renewable energy potential (e.g., solar in the eastern plains and wind along the coast). Microgrids can harness these local resources, reducing fuel dependency and costs while supporting sustainability goals, which are important for state, local and educational facilities under pressure to meet environmental standards.
- **Rapid Response and Recovery:** During disasters, microgrids can prioritize power to essential services, such as powering ventilators in a hospital or pumps at a flood-control station. Post-event, they can help restore grid stability by providing a stable power source as the main grid comes back online.

Case Study: Ocracoke Island Microgrid

NC Electric Cooperatives and Tideland EMC installed a microgrid and in-home energy conservation controls on Ocracoke Island in 2017. Ocracoke's microgrid project features a solar array, diesel power generation and a utility-scale battery storage system. These items supply energy resources year-round to support grid resilience. The system contributes electricity during periods of high demand and can provide power when the main grid is disconnected.

The cooperatives also installed over 230 smart thermostats and 40 water heater controls in the homes of Tideland EMC consumer-members on the island. The cooperatives can activate the thermostats and water-heater controls to reduce total load when electricity use is high (NC Electric Cooperatives, n.d.).

The microgrid and the conservation tools improve Ocracoke Island's resilience to power outages when the mainland grid connection fails. The project also increases the capacity of the island's electrical distribution during peak tourism season when demand is abnormally high.

Hurricane Dorian in 2019 was the microgrid's first major test. Both the main grid and microgrid were forced to shut down due to severe wind and significant floodwater. However, once the floodwaters subsided, the microgrid's diesel generator restored power one day before the main grid was reconnected.

Source: NC Resiliency Exchange

8.2.2. Transmission, Distribution, and Communications Improvements

A modernized energy grid will evolve through active engagement across distribution companies, power retailers, transmission companies, generation companies, regulatory agencies, state legislators, grid and market operators, and consumers (Dengler, 2024). Grid-enhancing technologies such as advanced power flow, dynamic line ratings (DLRs), phasor measuring units, two-way communication, and overall improved grid information sharing will allow NC to get more from its existing infrastructure through improvements (Dengler, 2024). Transmission and distribution physical upgrades such as line upgrades including hardening, advanced reconductoring, and infrastructure expansion, and can enhance grid reliability.

Transmission:

Enhancing the NC transmission system will help the state face challenges posed by the changing climate and the increasing share of variable renewable generation in the energy mix. NC can utilize government funding to rebuild or enhance its current transmission infrastructure, or work with other states and regions to utilize a broader range of resources. For instance, the Utility System Planning and Investment Memo released by NCDEQ recommended that NC create a stakeholder engaged electric resource, grid, and system planning process, which is transparent and consistent (Utility System Planning and Investment Memo, n.d.). Conducting a consistently scheduled and regulated transmission planning process fosters confidence and predictability for the state's utilities, stakeholders, and energy security objectives.

The ability for NC to tap into a distant region's transmission system could provide an opportunity to import a lower-cost (possibly carbon-free) power supply. A National Transmission Planning (NTP) Study created from the National Renewable Energy Laboratory determined expanded investments in interregional transmission capability show the greatest potential to meet national imperatives for reliability, resilience, and reduction in greenhouse gas emissions at the lowest cost and deliver a wide range of system benefits (Rose, 2024). The NTP study highlighted the benefits of transporting low-cost wind generation from Kansas into highly populated areas such as Charlotte. The study highlighted an estimated $626M in energy cost savings for Charlotte (based on actual local energy costs in 2022), with a 2.15 benefit/cost ratio[32] of energy savings.

NC is taking steps to enhance the reliability and capacity of its inter-state transmission system. The state is utilizing the Grid Resilience and Innovation Partnerships (GRIP) Program, established by the Bipartisan Infrastructure Law, which improves the resilience of the power system against extreme weather, and ensures American communities have access to affordable, reliable, electricity when and where they need it. The DOE Grid Deployment Office (GDO) administers GRIP funding. The NC Innovative Transmission Rebuild project was selected through the second round of GRIP funding and will receive $57 million in Federal funds. Duke Energy provides the same amount in match funds, making the projects total $114 million.

Case Study: NC Innovative Transmission Rebuild

The NCDEQ SEO, in partnership with Duke Energy, will implement advanced transmission technology to meet growing electricity demand in eastern NC and improve reliability. The NC Innovative Transmission Rebuild project will reconstruct the Lee-Milburnie 230 kV transmission line, incorporating high temperature, low-sag advanced conductors and monopole steel structures that will enhance resilience and reliability within the existing ROW. It will help retool a key transmission line between Wake and Wayne counties, replacing wood poles with steel and adding more power capacity.

Anticipated Benefits:

- **Reduced Customer Interruptions:** 14,000 utility customers, who live in an area susceptible to the impacts of hurricanes and strong storms, will see an estimated 10% reduction in the length of service interruptions.
- **Preparing for Growth:** Increased line capacity will support 1,600 MW of solar and 260 MW of energy storage, readying the grid for the anticipated load growth in the area. The support structures will also be designed to accommodate another line, paving the way for even more capacity in the future.
- **Optimized ROW:** Rebuilding the transmission line in place— utilizing the existing ROW—will minimize the impact to communities during construction and will cost less than a new greenfield transmission line.

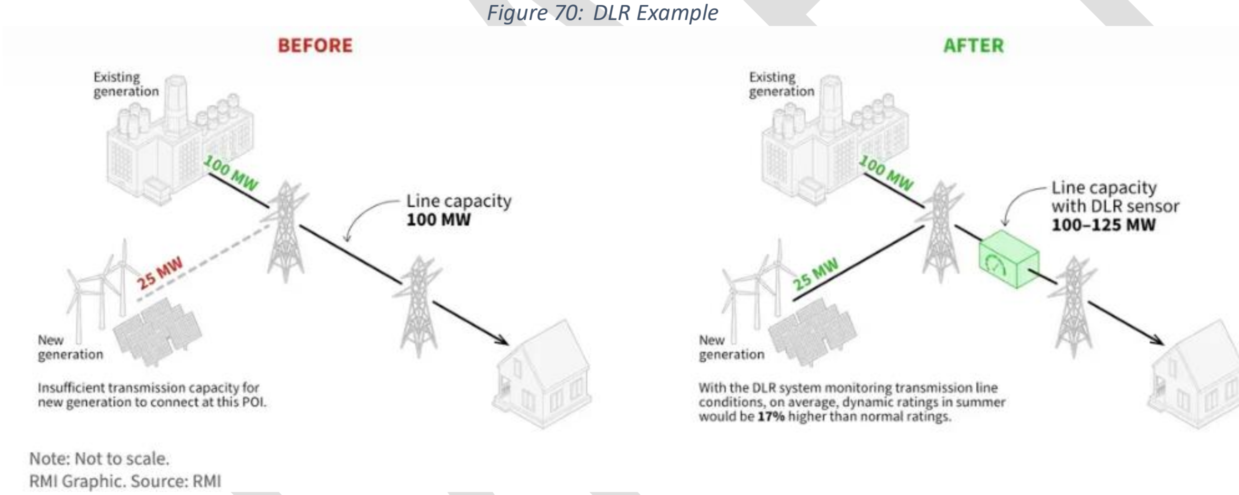
[32] A cost/benefit ratio of 2.15 indicates that for every dollar spent, there is a return or benefit of $2.15. This ratio suggests that the benefits significantly outweigh the costs, making the investment or project economically advantageous.

- **New Jobs and Workforce Training:** The project will create 550 new positions that can be filled through partnerships with Historically Black Colleges and Universities and local community colleges. The project also dedicates more than $3 million to workforce development and training.

Source: NCDEQ DOE Grip Fact Sheet

Companies could also adopt newer technologies such as DLRs, which adjust transmission line ratings based on local conditions rather than relying on static assumptions, thereby providing additional ampacity— the maximum current a wire or cable can safely carry—to transmission lines (DLR, 2024). Grid transmission lines are given static ratings based on maximum ampacity and temperature limits, and the weather conditions used by regulators in these methods are typically constant values year-round or with seasonal patterns and are set using conservative assumptions for the conditions. By not accounting for additional cooling during periods of high wind or low ambient temperature, many transmission lines likely have additional ampacity capacity available (DLR, 2024). The DOE has identified DLR as a transmission and distribution infrastructure solution to defer upgrades, support line outages and increase yields of distributed power, meaning NC can increase transmission (and power supply) capacity with minimal disruption to the current power supply. The figure below shows an example of how a DLR would increase capacity on a transmission and distribution system.

Figure 70: DLR Example



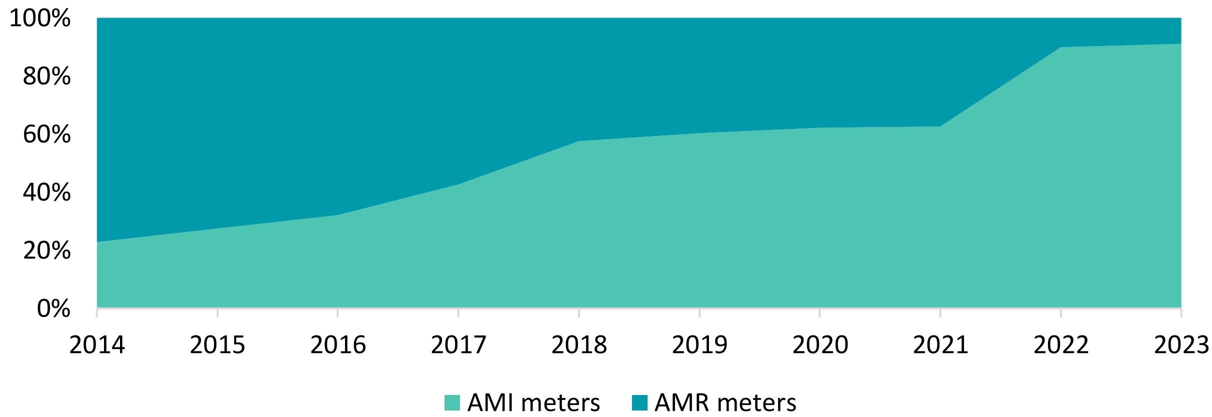
Source: RMI

Distribution and Communications:

Outdated one-way communication and monitoring systems in NC's energy grid could fail to adapt to extreme weather, equipment breakdowns, or sudden demand surges, resulting in more frequent and prolonged power outages across the state. Deploying advanced metering infrastructure (AMI) with real-time monitoring and two-way communication, alongside consumer education, enhances energy security by leveraging precise data and analytics to optimize grid reliability, swiftly detect outages, and improve response times to disruptions (Dengler, 2024). This smart system enables automated, seamless interaction between utilities and smart meters, strengthening resilience and operational efficiency across NC's energy network. AMI manage a wide range of energy data, including kWh usage, peak kW demand, load profiles, voltage information, outage logs, tamper alerts, and more. This information is essential to understanding usage and grid dynamics. Electric metering endpoints contribute to data collection and analysis, offering insights into consumption, grid performance, and customer behavior. Municipal utilities, like the City of Albemarle Public Utilities Department, are using smart meters to provide daily usage data via a customer portal to encourage conservation measures, like running dishwashers during off-peak times (Advanced Meter Infrastructure, n.d.). They've also piloted load control programs for water heaters, remotely cycling them off during peaks, which reduced MW off summer peak demand in 2023 (Advanced Meter Infrastructure, n.d.).

According to EIA data, AMI meters represent over 90% of the total electric meter infrastructure within NC. The figure below shows the transition from Automated Meter Reading (AMR) to AMI over the past 10 years. The AMI gives NC utilities an opportunity to utilize demand side management (DSM) strategies.

Figure 71: NC AMR vs AMI Deployment



Data Source: EIA

8.2.3. Backup Generation

NC can leverage backup generation at critical infrastructure such as hospitals, EOCs, water treatment plants, and communication hubs, by strategically integrating reliable, resilient, and scalable power solutions to support continuity during severe storms, grid outages, or other disruptions. Siting and sizing backup generation, like black start units or strategically placed emergency power systems, for critical infrastructure in NC is crucial because it directly determines how quickly and effectively essential services can recover from outages, maintain operations during disruptions, and support grid stability.

Examples of backup generation solutions include:

- Solar + Storage
  - Implement solar photovoltaic systems paired with battery storage at critical facilities to provide a reliable, renewable source of backup power. These systems can store excess solar energy generated during the day for use during outages or peak demand periods, ensuring continuous operation of essential services and reducing reliance on fossil fuel-based generators. Solar + Storage solutions are particularly effective in enhancing energy resilience and sustainability for both urban and rural areas.
- Long Duration Energy Storage
  - LDES' are battery systems designed to store electricity for extended periods, typically lasting 10 hours or more, allowing it to deliver power over a significantly longer timeframe compared to standard battery storage systems. These types of systems are useful for

avoiding curtailment of DERs, managing fluctuations in renewable energy generation, or providing backup power during extended outages. These systems can involve several emerging technology types including solid state or lithium batteries, thermal storage, fuel cells, electrolyzers, or other innovative solutions.
    - While not frequently thought of as energy storage, liquid fuel storage (either in geologic formations, in pipelines, or in storage facilities) is a form of LDES. Oversight of LNG and other liquid fuel supply capacity can help ensure shortages or outages do not occur.
- Diesel/Linear Generators
    - Install high-capacity diesel or natural gas generators at key facilities, sized to handle full or priority loads (e.g., HVAC, medical equipment).
    - Newer technologies such as Mainsprings **linear generator** efficiently produces electricity using a low-temperature reaction of air and fuel, can scale from a few hundred kW to 10 MW, tracks energy use, ramps up quickly, uses various fuels including clean options, and produces fewer emissions, presenting a valuable solution for resilient infrastructure with lower environmental impact (Penrod, 2024).
- Leverage Propane Generators in Rural Areas
    - Install propane-fueled generators at remote critical sites, like rural clinics or water pumps, where natural gas pipelines do not reach.
- Mobile Backup Units
    - Maintain a fleet of portable generators (e.g., 50 kW to 1 MW) and/or storage technologies that can be deployed to critical sites as needed, managed by utilities or the state.
- Prioritize Critical Loads with Smart Controls
    - Use advanced load management systems to direct power to essential equipment (e.g., emergency lighting, pumps) rather than entire facilities.

Case Study: Cape Fear Valley Medical Center (CFVMC) Backup Generation

Located in Fayetteville, NC, CFVMC provides acute care and emergency services to approximately 500,000 patients per year. Due to proximity to the coast, hurricanes are often a concern, with power outages ranging from several hours to days.

To prepare against power outages, Dewberry engineering helped CFVMC develop a plan to upgrade their aging emergency power system, without disrupting operations to the 1.3-million-square-foot hospital. The new 10-MW, 7,000-square-foot emergency power plant contains four 2.5-MW diesel generators (with the ability to add one more) and delivers nearly four times the amount of emergency power than before, using only two-and-a-half times the amount of fuel. The new SCADA control system provides a completely automated system for transferring power.

The new emergency power plant delivers 100 percent of the power required to run the entire campus, making CFVMC one of the few US hospitals fully operational by using only the onsite generator plant.

Source: Dewberry; CFVMC, Emergency Generator Plant

8.2.4. Nuclear Technology

Nuclear power is a vital component of the state's energy security given its role in providing stable, low-carbon power. This section highlights recommendations for pursuing subsequent re-licensing of existing nuclear plants to extend their operational life, alongside the adoption of Advanced Small Modular Reactors (SMRs) to diversify and modernize the nuclear fleet.

License Extension - Each of the operating nuclear facilities within NC are currently under the NRC "renewed license" period. The renewed license is typically valid for a 20-year extension period, extending the facilities' life from 40 to 60 years. The current expiration dates of the NC nuclear fleet renewed licenses range from 2036 – 2043. However, the NRC has recently implemented a Subsequent License Renewal (SLR), which provides an operating extension of an additional ~20 years (80-year total operational period). Pursuing the SLR for the existing NC nuclear generators would extend the ~5 GW of carbon-free baseload power through 2056.

The Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report is the NRC staff's generic evaluation of plant aging management programs and provides guidance for SLR applicants. The GALL-SLR Report establishes the technical basis for the adequacy of applicant aging management programs that are found to be consistent with its guidance (Status of Subsequent License Renewal Applications, 2025).

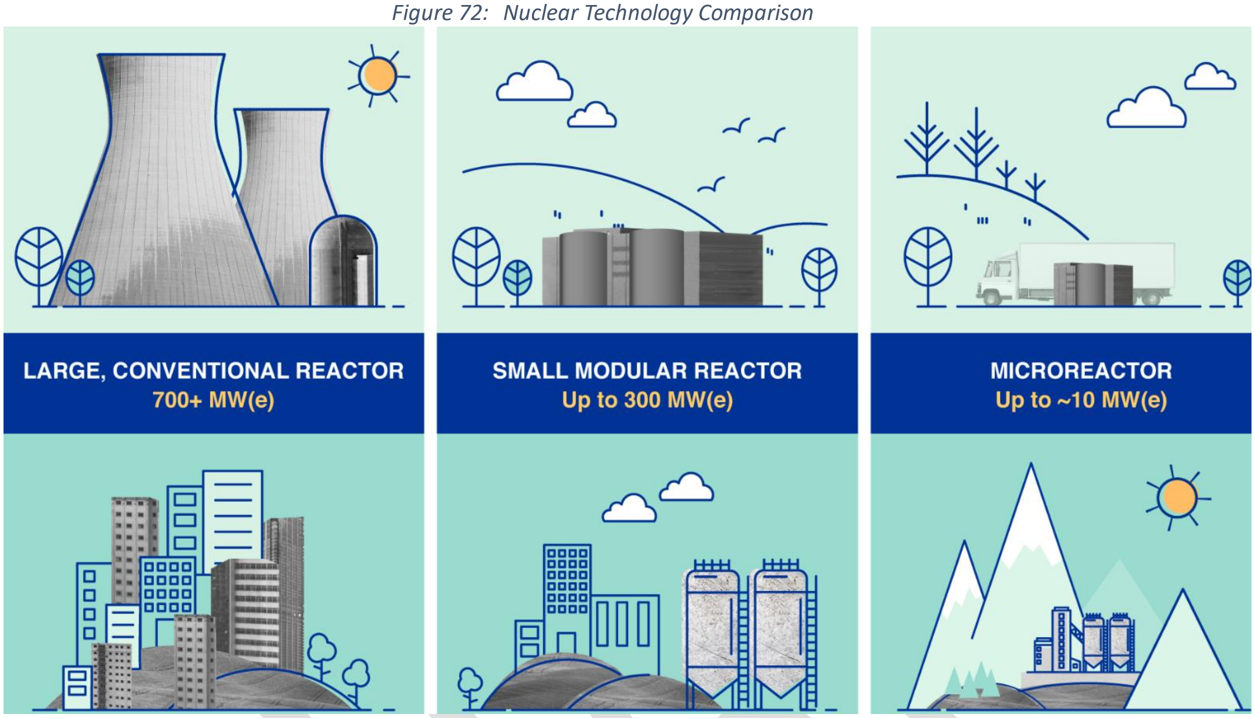
The Standard Review Plan for Review of Subsequent License Renewal Applications for Nuclear Power Plants (SRP-SLR) provides guidance to NRC staff reviewers in the review of a subsequent license renewal application (SLRA). The SRP-SLR assists reviewers in verifying that the applicant has met the requirements of Title 10 of the Code of Federal Regulations (10 CFR) Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." The SRP-SLR ensures the quality and uniformity of NRC staff reviews and establishes a well-defined base from which to evaluate applicant programs and activities for the subsequent period of extended operation (Status of Subsequent License Renewal Applications, 2025). The NRC states that pursuing the SLR typically takes 22 to 30 months, but recent workforce reductions at the NRC and DOE could extend these timelines.

New Nuclear Technology - The US Secretary of Energy Chris Wright signed his first Secretarial Order in February 2025, which listed nine priorities to "unleash American Energy in accordance with President Trump's EOs." One priority was to "Unleash Commercial Nuclear Power in the US" and stated that the DOE will work diligently and creatively to enable the rapid deployment and export of next-generation nuclear technology (WRIGHT, 2025).

SMRs are in alignment of the DOE's goal to develop safe, clean, and affordable nuclear power options. The advanced SMRs currently under development in the US represent a variety of sizes, technology options, capabilities, and deployment scenarios. These advanced reactors, designed to range in size from tens to hundreds of MW, can be utilized for power generation, process heat, desalination, and various other industrial applications (Advanced Small Modular Reactors (SMRs), 2024). SMRs have a power capacity of up to 300 MW(e) per unit, which is about one-third of the generating capacity of traditional nuclear power reactors. SMR designs may employ light water as a coolant or other non-light water coolants such as gas, liquid metal, or molten salt.

Given their smaller footprint, SMRs can be sited on locations not suitable for larger nuclear power plants. In areas lacking sufficient lines of transmission and grid capacity, SMRs can be installed into an existing grid or remotely off-grid, as a function of its smaller electrical output, providing low-carbon power for industry and the population (Liou, 2023). These locations are applicable to microreactors, which are a subset of SMRs designed to generate electrical power typically up to 10 MW(e). Microreactors have smaller footprints than other SMRs and will be better suited for regions inaccessible to clean, reliable, and affordable energy. Microreactors could serve as a backup power supply in emergency situations or replace power generators that are often fueled by diesel, for example, in rural communities or remote businesses (Liou, 2023). The figure below shows the difference between a large conventional nuclear power reactor, compared to an SMR or microreactor.

Figure 72: Nuclear Technology Comparison



Source: IAEA Office of Public Information and Communication

The Gateway for Accelerated Innovation in Nuclear (GAIN) initiative is a public-private partnership established by the DOE, which facilitates access to the technical, regulatory and financial support needed to accelerate the commercialization of advanced nuclear technologies (Gateway for Accelerated Innovation in Nuclear, 2025). GAIN is also evolving to support organizations (states, utilities, communities) who are new to nuclear and interested in learning more. GAIN provides competitively awarded access to DOE national labs for US businesses to tap into the intellectual and technical resources needed to overcome critical technology challenges for their advanced energy products and gain a global competitive advantage (Gateway for Accelerated Innovation in Nuclear, 2025). Awarded funds are sent directly to a national laboratory to perform work on behalf of an awardee.

While the benefits of SMRs are promising, there is potential for delays in their deployment. The uncertainty surrounding the permitting of SMRs poses significant challenges to their timely deployment, primarily due to the novel nature of the technology and stringent regulatory processes. The absence of standardized designs further complicates safety and reliability assessments, contributing to market uncertainty and potential delays. These hurdles, combined with the need for extensive environmental reviews and site-specific regulations, could push commercial deployment timelines beyond the anticipated early-2030s, hindering SMRs' role in meeting urgent clean energy goals.

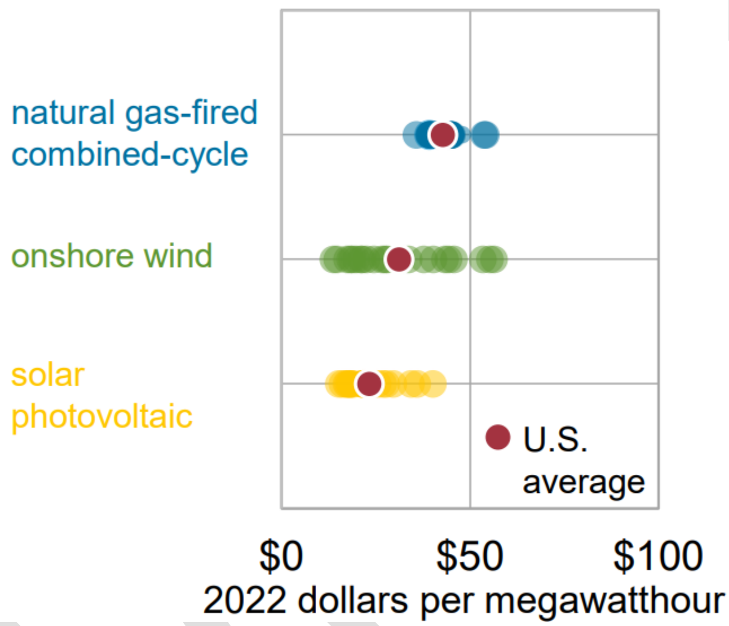
8.2.5. New Renewable Generation

Building new renewable energy generation will add supply onto the grid and increase the diversity of the state's generation portfolio, mitigating supply (natural gas) interdependency risk. Given the intermittency of solar/wind generation, pairing those technologies with battery storage will increase the firm capacity accreditation of the resource.[33] Increasing the firm capacity accreditation of resources will help boost the available supply during peak periods, increasing the reserve margin and decreasing the potential need to curtail excess generation.

Renewable energy has become an increasingly attractive investment due to its rapidly declining costs. The cost of renewable generation has dropped significantly, according to the International Renewable Energy Agency (IRENA). The cost of solar power generation has dropped by around 89% since 2010, while wind power generation costs have decreased by approximately 55% during the same period, making renewable energy highly cost-competitive with fossil fuels.

The figure below shows that solar and wind generation have gained cost competitiveness with the levelized cost of energy of conventional generation such as a natural gas combined-cycle plant.[34]

Figure 73: EIA Regional and US Average Levelized Cost of Electricity



Source: EIA AEO 2023

NC remains a leader in installed solar capacity, and further expanding renewable resources will be crucial for achieving resource diversity and meeting the targets set by HB 951. Plans are in place to continue expanding renewable resources. For example, the NCUC CPIRP includes a plan to build additional capacity:

- Solar: 6,000 MW by 2031
- Standalone Storage: 1,100 MW by 2031
- Onshore Wind: 1,200 MW by 2033
- Advanced Nuclear Generation: 600 MW by 2035

[33] Firm capacity accreditation is a method that measures how well a resource can provide reliable electricity during periods of high demand.

[34] The levelized costs are calculated based on a 30-year cost recovery period, using an after-tax weighted average cost of capital (WACC) of 6.54% for the 2028 online year.

New renewable generation can also be built at “repurposed energy sites”, which include closed landfills, closed coal mines, closed or closing fossil fuel-fired power plants, contaminated lands in rural or urban areas known as “brownfields,” and marginal farmland (Klass, 2024). Federal funding is available for this effort, and the DOE Loan Programs Office is charged under the IRA with administering $250 billion in funds to finance electric utility projects that result in the “remediation, repurposing, and redevelopment of eligible energy infrastructure sites,” including retiring existing fossil fuel energy infrastructure, and replacing it with clean energy generation. For instance, Duke Energy is replacing the lost generation capacity from the shuttered coal-fired Allen Steam Coal Station and will construct a grid BESS on a small piece of the 943-acre property along the Catawba River, fewer than 20 miles west of Charlotte (Ellis, 2024). The battery will be able to supply about 50,000 homes with electricity for four hours. A second, 167-MW, four-hour battery storage system is also expected to be built and ready by late 2027 and will be more than five times larger than Duke’s current largest battery system (Ellis, 2024). The 167 MW match the production level of the last of five coal-fired generation units at the Allen plant, which allows Duke to repurpose the plant’s existing transmission infrastructure. The batteries at both sites will store solar and nuclear energy generated elsewhere, which Duke can use to offset peak demands.

Renewable Energy Development Assistance

Expanding the outreach and knowledge regarding renewable energy expansion within NC is key to getting as many stakeholders involved in pursuit of the State’s carbon reduction goals. According to a Berkley Lab 2023 survey, the top three leading causes of project cancelations for both wind and solar were local ordinances or zoning, grid interconnection, and community opposition (Robi Nilson, 2024). The survey described how developers believe that community engagement addresses community concerns and decreases opposition. Most agree that increased engagement results in fewer project cancelations (75%) and local concerns being adequately addressed before project construction (66%). The Carolinas Renewable Energy Development Assistance and Siting Hub is aiming to engage renewable energy developers and offer fact-based insights into the fundamentals of development, siting, and the technical aspects of solar and wind energy technologies. By providing accurate information and educational resources, local stakeholders will be able to then engage in the development process effectively, particularly as the scale and number of projects in the region expand (Carolinas Renewable Energy Development Assistance and Siting Hub is Now Available, 2025).

In March 2024, six state-based projects were selected to receive funding in the first of three rounds of awards under the Renewable Energy Siting through Technical Engagement and Planning (R-STEP) program funded by the DOE. The R-STEP program aims to provide fact-based siting processes for renewable energy developers and permitting authorities when looking to develop large-scale renewable energy and energy storage projects. The NC Clean Energy Technology Center (NCCETC) was awarded $2 million in funding over three years to lead a project under the R-STEP program, titled the Carolinas Renewable Energy Development Assistance and Siting Hub (C-DASH), that encompasses both NC and South Carolina, the only multistate project in the R-STEP Program (Carolinas Renewable Energy Development Assistance and Siting Hub is Now Available, 2025).

The main hub will be launching in June 2025 and will provide a comprehensive overview of the program, a complete resource library that is regularly updated, a database of renewable energy ordinances in NC and South Carolina, upcoming events, a form for technical assistance requests, and an FAQ section. The resource library will feature updated white papers, model ordinances, and other useful information (Carolinas Renewable Energy Development Assistance and Siting Hub is Now Available, 2025). NCCETC has been holding local meetings in counties across NC to inform residents about large-scale renewable energy developments and to gather feedback about local perspectives.

The Center will also collaborate with project partners to plan education sessions and offer technical assistance to local governments throughout the region. NCCETC aims to launch the fully developed online siting hub and provide citizens and local government officials throughout the Carolinas with accessible, fact-based resources that will serve to educate and advise future siting and permitting processes.

Such collaboration and communication will help reduce misinformation, ensuring that all parties clearly understand the benefits and challenges of renewable energy projects. By fostering transparency and trust, these efforts can lead to more informed decision-making and smoother project implementations. This increased collaboration and knowledge-sharing strengthens energy security by building a more resilient, decentralized, and more diverse grid.

8.3. Demand Side Mitigation

Energy management solutions are available to engage the public in addressing the increasing consumer demand. These solutions can be applied to residential, commercial, and industrial customers looking to reduce their energy consumption, reduce their carbon footprint, and lower their energy bills. Consumer solutions such as demand response (DR), EE, and DERs such as behind-the-meter solar and storage, offer a customary demand management strategy, especially during peak consumption periods. NC has implemented several energy DSM techniques to optimize electricity use, enhance grid reliability, and reduce customer bills. These efforts focus on shifting or reducing consumer demand, especially during peak times, and are driven by utilities, state policies, and customer participation.

8.3.1. Residential and Commercial Building Solutions

Residential and commercial building solutions such as EE, weatherization, and rooftop solar mitigate growing demand by reducing strain on the grid. Efficiency upgrades like insulation, efficient HVAC, and LED lighting cut energy use, lowering peak demand. Rooftop solar generates power onsite, reducing reliance on utility-scale generation (e.g., a 5 kW solar system can offset 6,000–8,000 kWh/year). Together, they shrink overall consumption and peak loads, delaying costly grid upgrades and stabilizing supply as demand rises from electrification and population growth.

Here are some of the current programs within NC that provide incentives for building efficiency and rooftop solar.

EE Programs

- **Weatherization Assistance Program (WAP):** The NCDEQ runs the WAP program, which installs energy conservation measures in the homes of income-eligible persons, especially homes occupied by the elderly, persons with disabilities, and children. Funds are applied to the most cost-effective conservation measures, which are determined by conducting an on-site energy audit. Energy conservation measures funded through the program may range from air sealing and insulating single-family homes to replacing heating systems, windows, and doors.
- **Low Income Home Energy Assistance Program (LIHEAP):** LIHEAP is a federal program; the State Energy Office has signed a Memorandum of Understanding with the NC Department of Health and Human Services to manage LIHEAP. The LIHEAP program includes the Low-Income Energy Assistance Program (LIEAP), the Crisis Intervention Program (CIP), and the Heating and Air Replacement Program (HARP).

  - **The Low Income Energy Assistance Program (LIEAP):** Under LIEAP, persons aged 60 or older, disabled persons receiving services through the NC Division of Aging and Adult Services, or households meeting certain income thresholds are eligible to sign up for financial assistance for utility bills. Assistance levels are based on household size and income levels in relation to the Federal Poverty Level.
  - **Crisis Intervention Program (CIP):** The CIP serves individuals and families who are experiencing or in danger of experiencing a heating or cooling-related crisis.
  - **Heating and Air Repair or Replacement Program:** is a program funded under LIHEAP (described below) that enables eligible households to have heating and air conditioning systems inspected, tuned, repaired, or replaced, when needed. Selection is based on a state-mandated priority system.
- **Energy Saver NC (Home Energy Rebate Programs):** includes more than $208 million dollars for federally funded rebates for income-eligible households. Energy Saver NC includes two distinct, but complementary DOE programs:
  - Homeowner Managing Efficiency Savings: Rebates for whole-home energy upgrades (e.g., insulation, efficient HVAC based on energy savings and income eligibility.
  - Home Electrification and Appliance Rebates: Rebates for electrifying appliances (e.g., heat pumps, electric stoves) for income-eligible households.
- **Duke Energy Smart $aver:** Offers incentives for installing EE heating/cooling systems, attic insulation, duct sealing, and heat pump water heaters. Amounts vary by equipment.
- **Commercial Property Assessed Capital Expenditure (C-PACE)** financing: NC Session Law 2024-44 authorizes the Department of Commerce to provide commercial building owners with low interest private capital financing for improvements for energy efficiency measures, increase resilience, install renewable energy sources, or conserve or improve water quality.

Solar Programs

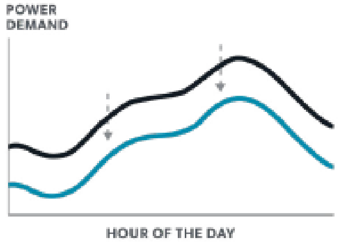
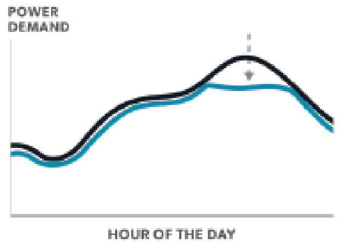
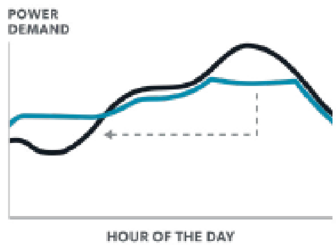
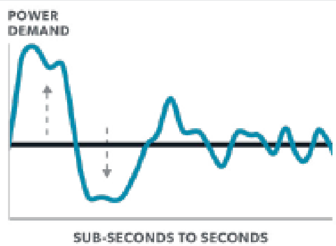
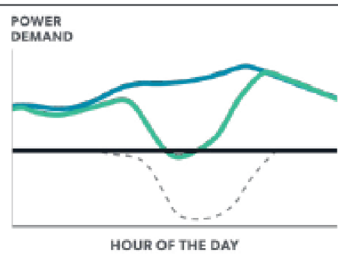
- **Duke Energy PowerPair Program:** A one-time rebate up to $9,000 for Duke Energy customers installing solar + battery storage.
- **Piedmont Electric Solar Loan Program:** Solar energy financing program to help with the cost of buying and installing solar panels and water heaters. Authorized customers can borrow up to $15,000 at a fixed 5% interest rate for 7 years.
- **EnergizeNC Solar for All:** A $156 million EPA-funded program to deploy rooftop solar for low-income homes, on April 22, 2024, the EPA awarded the EnergizeNC coalition (led by NCDEQ) with a $156,120,000 Solar for All grant. The EnergizeNC coalition plans to design programs that have the greatest impact with a focus on reducing greenhouse gas emissions, lessening energy burdens, and improving quality of life. Specifically, the coalition will focus on four goals:
  - Goal #1: Create a comprehensive project management approach over a one-year planning period to include input from low-income and disadvantaged communities.
  - Goal #2: Reduce greenhouse gas emissions, lower energy costs, and foster environmental justice through the installation of rooftop solar at low-income single-family and multifamily units across NC, including community solar access.
  - Goal #3: Foster and develop a trained workforce to deploy solar in all regions of the state, especially in minority and tribal communities, while working to ensure transparent ethical and business practices that protect consumers from potential market abuses.

- Goal #4: Provide robust community engagement to ensure that project benefits flow to disadvantaged communities and individuals.

8.3.2. Demand Flexibility (DF)/Load Control:

DF is the capability provided by DERs to "reduce, shed, shift, modulate, or generate electricity" (DOE's National Roadmap for Grid-interactive Efficient Buildings, 2021). DF tools enable end-use customers to respond to price signals, or to direct signals from the grid, which provides benefits to both the customer and the grid operator through more efficient balancing of supply and demand. A robust DF program can reduce the need for costly investments in generation, transmission, and distribution capacity. Many DERs that can be harnessed by a DF program are already in the market and are cost-effective, including rooftop solar, battery storage, back-up generators, smart thermostats, and smart electric water heaters. Other innovative DF-enabling technologies are currently in development, such as the ability to leverage EV batteries for grid services using vehicle-to-grid technology. The figure below shows examples of EE & DF, and their effects on power demand.

Figure 74: Examples of EE & DF Effects on Power Demand

	LOAD IMPACT	EXAMPLE MEASURE	EXAMPLE BENEFIT
Efficiency		Building has an insulated, tight envelope and an efficient HVAC system to reduce heating/cooling energy needs	Reduced costs of burning fuel to satisfy energy demand, and reduced emissions associated with lower fuel use
Shed Load		Building dims lighting system by a preset amount in response to grid signals while maintaining occupant visual comfort levels	Reduced investment in generation and transmission capacity due to lower peak demand
Shift Load		Connected water heaters pre-heat water during off-peak periods in response to grid signals	Reduced energy costs due to shifting consumption to cheaper hours of the day; avoided curtailment of renewables during off-peak periods
Modulate		Batteries and inverters autonomously modulate power draw to help maintain grid frequency or control system voltage	Reduced ancillary services costs, improved integration of variable generation resources (e.g., wind, solar)
Generate		Rooftop solar PV exports electricity to the grid	Reduced T&D losses due to on-site consumption; avoided need for grid-scale generation

Source: DOE Grid Interactive Efficient Buildings Report

DF, especially when combined with EE, represents a significant opportunity for NC to improve reliability of the grid and avoid power systems costs associated with recent estimates of high growth in power demand. The DSM cost savings can be passed on to end-use customers as direct incentives to improve affordability. Market potential analyses in other states demonstrate significant potential benefits and imply that similar benefits may be realized in NC (Peters, 2025).

Case Study: Market Potential of Demand Flexibility in New York

A recent market potential study conducted by The Brattle Group and commissioned by the New York Public Service Commission focused on dispatchable, behind-the-meter solutions to meet the state's clean energy goals while maintaining reliability and managing costs. The study found that the cost-effective potential for flexibility in 2030 is 3.0 GW, representing 11% of New York Independent System Operator's (NYISO) summer peak demand forecast. The study also estimates that this potential rises to 8.5 GW by 2040, which represents 21% of forecasted NYISO winter peak demand (it is estimated that, due to electrification of building heating, New York will become a winter-peaking system by the mid-2030s).

If New York were to achieve 8.5 GW of flexibility potential by 2040, the study estimates that the state would **avoid $2.9 billion in annual power system costs**, including $111 million in avoided transmission capacity, $2.03 billion in avoided generation capacity, $408 million in avoided distribution capacity, and $384 million in avoided energy costs. Of the $2.9 billion in avoided costs**, $2.4 billion could be returned to end-use customers** in the form of participant incentives. Overall, this study demonstrates the opportunity for New York and other states like NC to harness DERs to enhance reliability and provide benefits to end-use customers.

Source: The Brattle Group

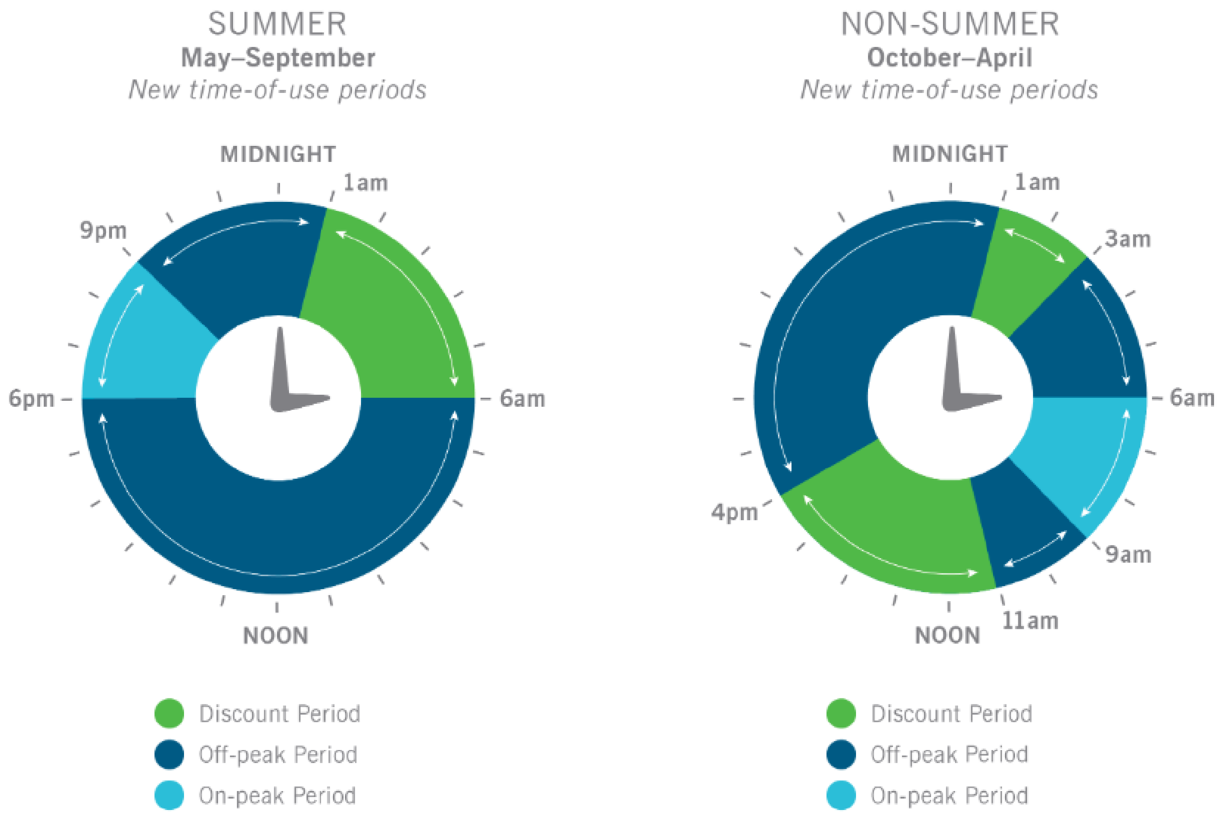
EE and Time-of-Use Pricing

Energy Efficiency means using less energy to perform the same task or achieve the same output, thereby reducing waste and minimizing environmental impact. The projected rise in demand and push for electrification makes EE paramount for NC. NC utilities have been implementing EE solutions to meet climate goals. For example, a recent EE measure is Duke Energy's tariffed on-bill EE program. Initially rolled out in 2024 across sections of its NC service areas and soon-to-be state-wide, the program lets customers upgrade to efficient appliances, like heat pumps, HVAC systems, or better insulation, without upfront costs. Customers pay through a charge on their utility bill, sized so the energy savings offset the expense. It's one of the first IOU programs of its kind in the US, targeting residential and small business customers to cut peak demand and total usage. Roanoke Electric Cooperative launched its Upgrade to $ave program in 2016, targeting EE improvements for its roughly 14,000 members across five counties. This program uses smart devices to track and manage energy use, helping lower monthly bills while ensuring comfort. Connected devices also automatically adjust energy consumption during peak demand times, which reduces costs for both member-owners and the Co-op, keeping electricity rates more affordable for all customers. Promptly updating North Carolina's building codes to the most recent standards would increase and expedite use of EE technologies while driving its technological costs down. Updated building codes would also reduce energy consumption for the life of each new structure built, helping North Carolina meet future energy demand. Property owners may request a builder construct a dwelling or commercial property to energy efficiency standards above current code at their discretion.

Time-of-use (TOU) pricing refers to an electricity billing system where the price you pay for electricity varies depending on the time-of-day customers consume it, with higher rates during peak demand hours (usually mornings, or afternoons and evenings) and lower rates during off-peak hours (likely overnight) to incentivize customers to shift their energy usage to less congested periods on the grid. Duke Energy offers optional TOU rates where electricity costs less during off-peak hours and more during peak windows.

Customers with smart meters (nearly all of Duke's NC customers) can shift usage, like charging EVs or running appliances at night. The figure below shows the different Duke Energy TOU periods that customers can participate and reduce their energy bills. Given the seasonality of demand, the "summer" and "non-summer" periods have different on-peak, off-peak, and discount periods.

Figure 75: Duke Energy Time-of-Use Program



Source: Duke Energy

Demand-Response

DR is a change in electricity demand by end-use customers in response to a short, peak demand period. DR, which is one of many tools that are within the scope of DF, reduces strain on the grid and the need to activate expensive and higher-emitting peak generation capacity. Participants in DR programs are offered a financial incentive for responding to a DR event. These incentives reflect the value of end-use customers, lowering their power consumption during times of high wholesale market prices or when system reliability is threatened by peak demand. DR programs have been in the present in the market for several years. In NC, some utilities currently offer DR programs to their customers, some of which recently saw increases in incentives. Duke Energy's PowerShare® program provides large business $5/kW reduced during an event, and their EnergyWise Business programs offers smaller business customers $50/kW per kW reduced. In addition, DEP offers commercial, industrial, and governmental customers with the potential to shed 50kW the opportunity to participate in their Demand Response Automation (DRA) program.

DR programs have been present in the market for several years, but there is potential to enhance their value proposition as part of a wider DF portfolio in NC. Increasing the value of DR in NC may be achieved through expansion of existing programs, for example Duke Energy's Power Manager® and EnergyWise

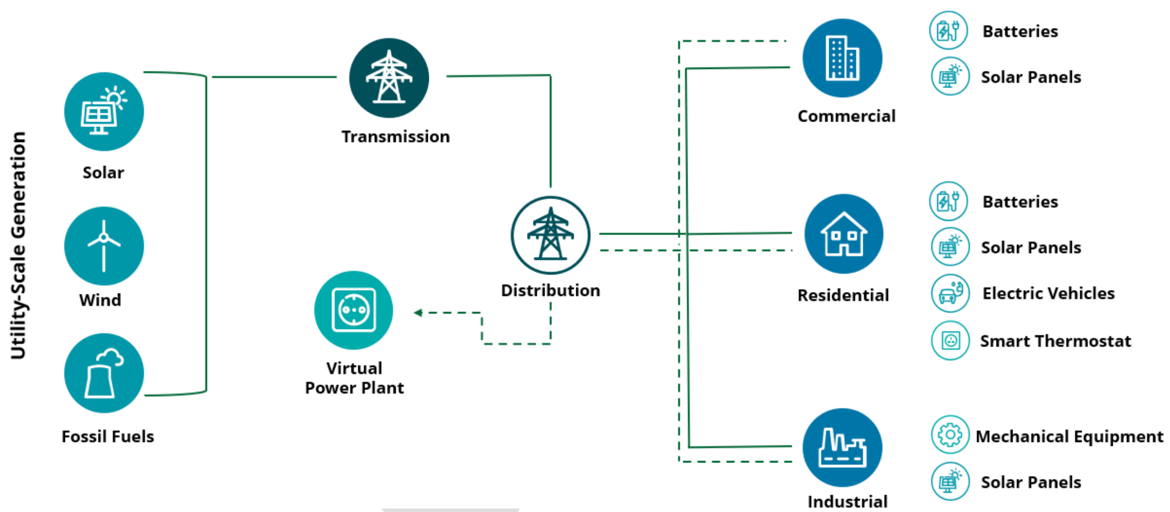
Home® programs and harnessing both commercially available technologies and new technologies as they become available.

Virtual Power Plants

Duke Energy has unveiled the PowerPair® incentive-based pilot program, which incentivizes home solar generation with BESS installation in its DEC and DEP service areas (PowerPair, 2024). The one-time incentive-based program, designed to help make a home solar plus battery system more affordable for customers, offers up to $9,000 in incentives for residential customers who install a solar plus battery storage system.

This program can provide the building blocks into creating virtual power plants (VPP), which are a network of small-scale energy resources (such as a residential solar system with storage that can supply power back to the grid when needed) that work together to balance the supply and demand of electricity. VPPs have progressed in regions operated by third-party aggregators who bid into wholesale energy markets, but it is still a nascent concept for vertical integrated utilities. VPPs can unlock deeper integration of renewables and DF, along with energy demand and cost savings for residential, commercial, and industrial customers. The figure below shows an example of the VPP communication network, and how the on-site solutions for residential, commercial, and industrial customers feed into the VPP distribution. VPPs reduce peak demand by using energy supplies from DERs; engage customers; reduce the carbon footprint; and advance the communication between consumer and utility. The potential of VPPs has been demonstrated elsewhere; for example, in California a 2024 study estimated significant benefits to the grid and customers in the state (Hledik, 2024). The value proposition of VPPs in NC is likely to be similarly attractive.

Figure 76: Virtual Power Plant Communication Network



Case Study: Market Potential of Virtual Power Plants in California
A market potential study conducted by the Brattle Group in California estimates that more than 7,500 MW of cost-effective VPP capacity could be leveraged by 2035. This capacity comes solely from conservative estimates of adoption of already commercially available technologies such as smart thermostats, behind-the-meter storage, EV chargers, and smart water heaters, and DR. If California reaches that potential, it could translate to $755 million in annual avoided traditional power system

costs, of which $504 million could be returned to end-use customers in the form of incentive payments.

Source: The Brattle Group

8.4. Human-Caused Mitigation Solutions

This section focuses on human-caused mitigation areas such as cybersecurity, combating misinformation and disinformation, addressing policy and regulatory uncertainty, and enhancing communication coordination. By proactively addressing these challenges, NC can ensure a resilient and secure energy future, minimizing vulnerabilities and fostering trust among stakeholders.

8.4.1. Cybersecurity

Cybersecurity is an emerging and constantly evolving risk to the energy sector. Sophisticated attacks carried out by threat actors can cripple IT and OT systems with the potential for severe service disruptions to customers and significant economic harm to communities nationwide. Given the risk to national security, many efforts to confront cybersecurity risks to critical infrastructure happen at the federal level. Energy stakeholders in NC must actively engage in safeguarding against cyber-attacks and develop comprehensive response plans.

To bolster cyber-attack and response planning account for a threat lifecycle in its entirety, a holistic approach is employed. This consists of 1) identifying threats, 2) analyzing threats, and 3) mitigating threats. Organizations in the energy sector should take steps to ensure they are investing in cybersecurity personnel and resources to enable this robust approach. Energy sector firms should implement policies and procedures to support "cyber hygiene", conduct periodic self-assessments, participate in information sharing, and practice responses to cyber-attacks using exercises. Several resources are available for organizations to assess their cyber maturity and coordinate cyber efforts. The DOE, American Public Power Association, National Rural Electric Cooperative Association, and National Association of Regulatory Utility Commissioners have created self-assessments that are available to IOUs, rural electric cooperatives, and municipal utilities. In addition, the Edison Electric Institute created the Electricity SCC to enable coordination between federal partners and electric companies in response to both cyber and physical threats. Practicing responses to cyber threats is another valuable tool to sharpen an organization's ability to identify, analyze, and mitigate cyber-attacks. Red teaming, for example, is an exercise where participants act as hypothetical threat actors to simulate a cyber-attack, giving energy infrastructure owners and operators the opportunity to test and refine response procedures.[35] Lastly, organizations should prioritize staying updated on the latest guidance and resources from cybersecurity industry leaders, information sharing resources, state and local law enforcement, and federal entities like CISA, DOE CESER, and other federal agencies. Investing in cybersecurity resources, implementing best practices, sharing information, and practicing responses reduces an energy organization's risk to IT and OT attacks from would be threat actors by preparing for the entire threat lifecycle.

Cybersecurity information sharing is vital, and ideally, bi-directional. This includes sharing cybersecurity best practices, guidance, and trends; information on emerging cyber threats and vulnerabilities affecting energy sector stakeholders; and real-time information sharing during the response and recovery stages following a cyber event. Robust, timely, and actionable information is crucial to all partners involved. Each

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[35] Additional information regarding cyber hygiene practices, including examples, can be found on the web site of CISA.

partner has a unique role to play in protecting critical infrastructure against cybersecurity threats as well as participating in a coordinated response should a cyber incident occur. NC engages in information sharing through the NCISAAC, which is operated by SBI. NCISAAC works with local, state, and federal law enforcement agencies to counter cyber threats via robust information sharing. Examples of how energy sector organizations prepare for cyber threats, include, but are not limited to the following:

- Actively monitoring announcements and alerts from ISACs like NCISAAC.
- Well-defined information-sharing processes.
- Testing information-sharing mechanisms through exercises like those mentioned in *Section 3.*
- Facilitating or attending threat briefings (unclassified or classified).
- Staffing cybersecurity personnel to keep current on cybersecurity news, relay high priority information to leadership, and enhance the security of the organization itself.
- Working with the NCUC and other stakeholders to discuss cybersecurity topics, such as strategies, plans, and challenges.
- State facilitates informal energy CISO or industry group calls to share cybersecurity updates, trends, and questions.
- Distribution of actionable indicators or detection signatures of malicious activity, vulnerability information, courses of action (to proactively defend or to stop and remediate an attack), and cyber threat intelligence.
- Incentivizes industry participation in federal cyber information sharing programs.

There are multiple organizations to support information sharing between stakeholders in the energy sector, such as the Electricity ISAC and the Downstream Natural Gas ISAC. The NC ISAC is a valuable resource connecting federal, state, and local law enforcement and partners for information sharing on cyber threats as well. Robust information sharing allows energy stakeholders to share information on identified threats, including threat analyses and threat mitigation tactics to protect all North Carolinians from malevolent cyber threat actors.

Energy stakeholders can better prepare for cyber threats through practices like red teaming. Individual organizations should periodically conduct red team exercises leveraging reputable resources like the MITRE ATT&CK® model.[36] Conducting these exercises provides many benefits, including experience identifying and analyzing threats, develop threat identification analytics, and mitigating real cyber threats. Another valuable resource for responding to cyber-attacks, is a TTX.[37] TTXs are role-playing activities that present scenarios to "players" to practice responses to threats and can provide highly valuable experience to energy stakeholders and State and Local officials in the event of a cyber-attack that disrupts service to NC. Successful threat mitigation relies on robust identification and analysis capabilities and sufficient resources and experience to respond to threats in a way that minimizes harm to energy consumers.

To protect North Carolinians and prevent severe economic consequences resulting from cyber-attacks, energy sector stakeholders and state and local law enforcement must work together. The first step for all utilities and energy sector organizations is to implement best practices for cybersecurity in their respective

[36] MITRE ATT&CK® is a knowledge base of adversarial tactics and techniques employed by cyber threat actors and based on real-world observations. It can be leveraged as a foundation for the development of threat-specific models.
[37] There are several resources for additional information regarding TTXs, including DOE Clear Path and the Electricity ISAC's GridEx.

organizations, which would provide an immediate baseline of resilience to identifying and responding to cyber-attacks. Second, if all energy sector participants engage in robust information sharing practices, this would result in improved threat identification, analysis, and mitigation across all organizations. This can help boost cybersecurity hygiene at organizations with fewer cyber resources, which in turn supports reliable service to end-use consumers within their service territory. For example, NC can host a cybersecurity summit for the energy sector and state and local emergency response officials, as has been done in other states. This would also be an excellent opportunity to conduct TTX that would help NC prepare for future cyber-attacks, since there will not be time to prepare when an actual attack occurs. All these actions together, better position NC to mitigate the potentially severe economic harm and potentially life-threatening effects of major energy service disruptions brought on by an attack to IT or OT systems by preparing relevant stakeholders for ever-evolving cyber threats, and by providing valuable input into emergency response plans.

Case Study: Related Efforts in Other States

Tennessee Department of Environment & Conservation Office of Energy Programs (TDEC OEP)

- TDEC OEP, in collaboration with the Tennessee Emergency Management Agency and NASEO, has hosted multiple workshops that included TTX with representation from non-governmental, state, regional, and federal energy stakeholders to discuss energy security topics like cybersecurity. TTX included scenarios involving cyber-attacks, severe weather, and fuel supply shortages. The results of these exercises were summarized in an After-Action Report that helped inform a Situational Manual.

Mississippi Development Authority (MDA) Energy and Natural Resources Division (ENRD)

- MDA ENRD is hosting an energy security summit in early 2025 that seeks to bring together utilities, emergency management personnel, and other energy and cybersecurity professionals with the goal of addressing energy security in Mississippi.

Source: TDEC

8.4.2. Combatting (Mis)(Dis)-Information

This section outlines proactive measures designed to identify, counteract, and prevent the spread of misinformation. By fostering transparency, enhancing communication channels, and leveraging technology, NC aims to safeguard its energy infrastructure and support stakeholders in gaining access to accurate and reliable information. Through these efforts, the state is committed to maintaining public confidence and supporting the successful implementation of its energy security objectives.

Strategic Recommendations

To effectively combat misinformation for NC's energy security, particularly during crises like Hurricane Helene, stakeholders should consider the following recommendations from the American Psychological association are structured to build resilience, limit spread, and correct falsehoods in alignment with the misinformation lifecycle (8 recommendations for countering misinformation, 2024).

- **Prebunk Misinformation for Susceptible Audiences:** Begin by implementing prebunking strategies to build public resilience before misinformation exposure. Develop media literacy programs and tools (e.g., short videos, quizzes) in schools and communities to teach residents how to identify false energy-related claims, such as inaccurate power restoration timelines. Regular campaigns via trusted channels like NC 211 or local media can maintain resilience, ensuring long-term preparedness.
- **Fund Basic and Translational Research into Misinformation Psychology:** Invest in research to understand effective interventions for energy-related misinformation. Fund studies to test which strategies work best for specific issues (e.g., outage rumors) in real-world settings, collaborating with universities and psychological science experts. This foundational knowledge will inform tailored, evidence-based approaches for subsequent actions.
- **Demand Data Access and Transparency from Social Media Companies:** Advocate for access to social media data to quantify misinformation spread and test interventions. Engage policymakers to push for responsible data-sharing frameworks, enabling researchers to analyze platform algorithms and user exposure to energy misinformation. This step supports informed strategies to curb spread.
- **Collaborate with Social Media Companies to Reduce Harmful Misinformation:** Partner with platforms to leverage their incentive structures, targeting "superspreaders" and echo chambers amplifying energy misinformation. Implement measures like fact-check labels or downranking false posts about energy outages, reducing their visibility and credibility during crises.
- **Leverage Trusted Sources to Counter Misinformation:** Deploy trusted community, religious, or political leaders to disseminate accurate energy information through channels like radio, town halls, or NCDPS websites. Their credibility enhances acceptance of correct information, countering false narratives aligned with social or political identities.
- **Use Misinformation Correction Strategies with Proven Tools:** Combine misinformation corrections with evidence-based behavioral strategies (e.g., social norms, incentives) to promote accurate energy-related actions, such as following official restoration updates. Ensure corrections are clear and paired with tools that encourage trust in reliable sources, addressing the gap between knowledge and behavior.
- **Debunk Misinformation Often and Repeatedly Using Evidence-Based Methods:** Actively debunk false energy claims post-exposure through trusted channels with detailed, evidence-based corrections. Repeat debunking efforts regularly, ensuring accurate information overshadows misinformation, and provide clear guidance on true facts.
- **Avoid Repeating Misinformation Without Correction:** When addressing false energy claims, minimize repeating misinformation to avoid the illusory truth effect. If repetition is necessary for debunking, ensure the falsehood is brief and the correction is prominent, delivered via trusted platforms like the NCDEQ website or local radio.

By implementing these strategies, from prebunking and research to targeted debunking and careful correction, NC can effectively combat misinformation, ensuring robust communication during energy crises. This approach will bolster public trust and enhance the state's energy security, safeguarding communities against future disruptions.

Hierarchical Framework Approach

Researchers at the Alan Turing Institute[38] developed a new hierarchical framework for understanding interventions against misinformation online. This framework identifies three stages for tackling online misinformation (Pica Johansson, 2023):

- **Prepare:** Interventions aimed to reduce susceptibility to misinformation by cognitively preparing people for possible exposure.
- **Curb:** Interventions aimed to limit people's exposure to misinformation by reducing its creation and spread.
- **Respond:** Interventions aimed to correct false beliefs induced as a result of exposure to misinformation

These strategies collectively aim to reduce misinformation's impact across its lifecycle. The table below shows where each intervention type is placed within the framework and provides a brief definition of each (Pica Johansson, 2023).

Intervention Stage	Level and Definition	Type and Definition
Prepare	**Educate Users:** Teach people strategies to recognize misinformation well before exposure.	**Media Literacy Courses:** equip people with the skills necessary to critically evaluate content, recognize content that may be misinformation, and reduce susceptibility to believing and sharing such content. **Educational Games:** designed to reduce people's susceptibility through 'prebunking' - showing people common signs of misinformation through short games.
	Prime Users: Remind people to be alert to recognizing misinformation nearer to the point of exposure.	**General Warnings:** messages reminding people of the dangers of misinformation and encouraging users to actively scrutinize content. **Public Awareness Campaigns:** raise public awareness about the prevalence of misinformation and the harm that believing and sharing such content can cause.
Curb	**Contextualize Content:** platforms provide people with additional context about pieces of content, aiming to help them make informed assessments about content veracity.	**Fact Check Labels:** warn users that claims made in the content have been disputed, sometimes offering users links to more information. **Tiplines and Self-help Resources:** allow individuals to investigate the veracity of a claim or gather additional context, through social media tiplines, bots and fact-check databases. **Prompts:** encourage people to pause before liking or sharing content to consider its veracity, for example by asking people if they would like to read a full article before sharing a headline. **Provenance Cues:** provide information about the source and edit history of audio-visual online content (its metadata), to help people understand if something is presented out of context or is a deepfake.
	Slow Content: platforms make content classed as misinformation less visible and de-incentivize the creation and sharing of such content. The aim is to limit people's exposure to misinformation.	**Demonetization:** publishers of misinformation cannot make money from it, for example by generating an ad-revenue. **Algorithmic Downranking:** limits a piece of content's amplification on the platform or service. The content may appear less frequently, be shown to fewer users, or

[38] The Alan Turing Institute is the United Kingdom's national institute for data science and artificial intelligence.

		will appear further down a 'feed' or list of recommendations. **Delisting:** content does not appear in results when using terms or hashtags, but the content remains accessible on the service.
	Remove Users or Content: platforms remove content or creators of content that is classed as misinformation. The aim is to prevent exposure to misinformation entirely.	**Early Stage Moderation:** blocking content at the point of upload to prevent certain content from ever appearing on the platform. The aim is to prevent exposure completely. **Deplatforming:** g removes a user, channel or forum from a platform when they post content classed as misinformation. The aim is to prevent generation of further misinformation from the same source.
Respond	**Correct Claims Post Hoc:** interventions providing corrections about claims made in content classed as misinformation, often aiming to prevent harmful behaviors arising because of exposure, and limiting further spread.	**Debunking:** correct false beliefs brought about as a result of misinformation exposure by countering claims made in misinformation with detailed **Counterspeech:** comprises user-generated rebuttals which aim to challenge claims made in misinformation, for example in comments under pieces of content.

Source: The Alan Turing Institute

Narrative Responses

In addition to the frameworks discussed above, narrative interventions to prevent and combat misinformation are gaining increased attention. Ensuring factual information, pre-bunking, debunking, and infographics are available to the public have become standard methods of reducing the spread of misinformation. However, these methods work primarily on audiences who have not yet personally identified with misinformation narratives (Slater, 2003). The addition of carefully designed narratives to misinformation communication plans enables prevention of misinformation spread and often is more effective at reaching audiences who already personally identify with misinformation narratives (Ophir, 2020) (Lee, 2022).

The creation of strong, positive narratives with ties to community values from the beginning of a campaign can reduce the likelihood of misinformation spreading on or offline in local communities. Careful crafting of narrative responses to misinformation can also redirect information-seeking behavior, community resilience, and trust in public officials (Sangalang, 2019). While these techniques are commonly used to respond to health misinformation (Krishna, 2022), they have also been successfully applied to renewable energy projects and community resilience planning (Greguska, 2021). Advancing narratives early to encourage community buy-in and fostering personal narratives to allow residents to identify with the values, goals, and benefits of projects are successful tactics that prevent misinformation from taking hold (see The American Resilience Project for examples). Narrative responses are an effective addition to the tools listed above and have the potential to both prevent and respond to misinformation online and offline.

Case Study: NCDPS Ground Truth - The Facts of the Helene Response

In response to misinformation and disinformation regarding the NC and Federal response to Hurricane Helene Aid, the NCDPS created a resource to ground truths against rumors/falsehoods. NCDPS stated that the public should get information about storm response and impacts from trusted sources like the State Emergency Response Team, National Weather Service, and other federal, state, county and local government sites. Be aware that Artificial Intelligence or AI-generated images are being circulated on social media that do not depict conditions on the ground.

NCDPS recommended stopping the spread of rumors by doing three easy things:

- Find trusted sources of information.
- Share information from trusted sources.
- Discourage others from sharing information from unverified sources and question where information is coming from.

NCDPS also created a "Fact vs. Rumor" list for the Hurricane Helene response efforts, which included responses such as:

FACT: The NC State Emergency Response Team, which includes local, state, federal and military partners, along with power and cell phone agencies, private businesses and volunteer organizations, is working around the clock to save lives and provide humanitarian relief to Western North Carolina residents. This is a coordinated effort aimed at saving lives and to speed recovery for residents, businesses and municipalities in the impacted areas.

RUMOR: The state and federal government are doing nothing to respond to the ongoing disaster in Western North Carolina.

FACT: The state is encouraging financial donations to the North Carolina Disaster Relief Fund at www.nc.gov/donate, or to a NC Volunteer Organization Active in Disaster. A list of these organizations can be found at www.ncvoad.org/members. The state is working with these organizations to stand up logistical operations to coordinate the collection and distribution of countless physical donations from across the state and country. Donations are not being confiscated by state and federal officials.

RUMOR: The state is discouraging donations in the wake of Hurricane Helene. Physical donations are being confiscated by state and federal officials.

Source: NCDPS

8.4.3. Policy and Regulatory Coordination

Effective policy and regulatory coordination are a cornerstone of enhancing NC's energy security, ensuring a resilient and sustainable energy ecosystem. By aligning state and federal policies, streamlining regulatory frameworks, and fostering collaboration among stakeholders, NC can mitigate risks associated with energy supply disruptions, price volatility, and infrastructure vulnerabilities. This approach strengthens the state's ability to integrate diverse energy resources, including renewables and natural gas, while addressing emerging challenges such as extreme weather and cybersecurity threats. Coordinated policies also attract investment in critical infrastructure, support equitable access to reliable energy, and position NC to adapt and benefit from evolving federal mandates, such as those under the IIJA, thereby safeguarding energy security for its residents and industries.

To effectively meet NC's ambitious energy goals while ensuring affordability and reliability, it is imperative to align policy frameworks with these objectives and embrace the innovative solutions outlined in *Sections 8.2 and 8.3*. NC has demonstrated its commitment to leading the nation in clean energy by enacting HB 951, which mandates the NCUC to take all reasonable steps to reduce carbon emissions by 70% from 2005 levels by 2030 and to achieve carbon neutrality by 2050. To achieve this transformative vision for a cleaner energy system that benefits both the environment and residents, it is essential to streamline policies that enable an efficient transition. For instance, the Mountain Ridge Protection Act of 1983[39], which effectively prohibits wind energy projects in western NC, a region with substantial wind energy potential, poses a significant barrier of clean energy growth. Such restrictive policies hinder progress and should be reconsidered to determine if there is a way to protect mountain views while still supporting a comprehensive, all-inclusive strategy for achieving NC's energy objectives.

Effective policy coordination is also crucial for managing energy emergencies and ensuring swift, reliable responses. In times of crisis, such as natural disasters or unexpected disruptions to energy supply, a well-coordinated policy framework enables rapid mobilization of resources and minimizes the impact on communities and businesses. By harmonizing policies across local, state, and federal levels, NC can enhance its preparedness and resilience against energy emergencies. This coordination helps stakeholders, including government agencies, energy providers, and emergency services, to work collaboratively and implement contingency plans that restore services efficiently. Integrating innovative technologies and data-driven approaches into emergency response strategies can significantly improve situational awareness and decision-making. Understanding and communicating timelines for restoration of natural gas services, for example, can help with planning to ensure the prompt and safe return to service to help restore economic activity and help save lives. By prioritizing policy alignment and coordination, NC can safeguard its energy infrastructure and protect its residents, maintaining stability and security in the face of unforeseen challenges.

By aligning policies and regulations across various governmental and private sector entities, NC can create a unified and efficient response to energy threats and disruptions. Proper coordination can streamline recovery efforts, minimize regulatory conflicts, and provide clear guidelines for all stakeholders involved. Ultimately, coordinated policies and regulations strengthen NC's ability to prevent, respond to, and recover from energy-related incidents, thereby safeguarding the state's energy security and the well-being of its residents.

Case Study: NC Flood Resiliency Blueprint (EO No. 266)

NCDEQ is developing the NC Flood Resiliency Blueprint, which will form the backbone of a state flood planning process to increase community resilience to flooding throughout NC's River basins. The Blueprint is a first-of-its-kind program in NC and represents the largest statewide flood mitigation investment in state history. An online decision support tool and associated planning will drive state, regional and community decision-making and guide the legislature in making funding decisions.

[39] Codified in Chapter 113A, Article 14 of the North Carolina General Statutes

Working with local stakeholders, interagency partners, academics, and technical experts, DEQ's Division of Mitigation Services plans a comprehensive approach to identify problems, address barriers, and prioritize solutions.

The Blueprint's early investments resulted in the implementation of 54 projects worth over $40 million for $22 million in costs to the Blueprint program. To date, the Blueprint has committed an additional $56 million in flood resilience investments.

The Blueprint continues to advance several initiatives, including:

- Building upon and enhancing the effectiveness of existing flood modeling tools, which will provide more accurate estimates of current flood risks and project future flood risk to support long-term strategic planning.
- Developing a decision support tool that'll empower state agencies, local governments, and flood resiliency partners to make informed flood resilience decisions. Collaborators and stakeholders have actively engaged in testing the Blueprint tool, with the inaugural public release in Spring 2025.
- Developing River Basin Action Strategies for all six priority basins (Cape Fear, Lumber, Neuse, Tar-Pamlico, White Oak, and French Broad) that are supported by the best available data and information.

As the Blueprint progresses, its goal is to develop a statewide program that covers all 17 river basins in the state.

Source: NCDEQ

8.4.4. Communication Coordination

Reliable communication is fundamental to energy security, serving as the backbone for coordinating energy infrastructure operations, responding to disruptions, and ensuring public safety during crises. Seamless communication networks enable real-time monitoring of power systems, rapid deployment of resources for restoration, and effective dissemination of critical information to stakeholders and communities. In the face of disasters like hurricanes or cyberattacks, robust communication systems help utilities, emergency responders, and policymakers maintain grid stability, address outages, and deliver energy reliably, safeguarding economic stability and public welfare.

For example, Hurricane Helene's unprecedented impact on Western NC in September 2024 exposed severe communication vulnerabilities, particularly in the rugged, rural Mitchell County and surrounding areas, where ground-based systems were knocked offline (Rosson, 2025). The NC SERT and NCDPS, alongside the Texas Division of Emergency Management (TDEM) responders, implemented innovative solutions to restore connectivity (Rosson, 2025). These included offline Google Maps for navigation, QR-coded incident action plans for responder coordination, Starlink satellite internet kits deployed across 24 counties, and the resilient Voice Interoperability Plan for Emergency Responders (VIPER) radio system, supported by SHP efforts to deliver fuel and radios (Rosson, 2025). Public communication was bolstered through town hall meetings, AM radio broadcasts (1470 WTOE), printed newsletters, a dedicated Hurricane Helene website, and NC 211 call centers, despite challenges like misinformation and overwhelmed 911 systems (Rosson, 2025). These efforts mitigated disruptions but revealed gaps, such as unlisted satellite terminal locations and the need for non-internet-based public outreach, emphasizing the critical role of communication in disaster response and energy security.

To enhance energy security and mitigate future communication disruptions, NC can adopt targeted strategies informed by Helene's lessons. Implementing backup satellite communication systems for critical infrastructure would boost reliable connectivity when terrestrial networks fail supporting energy facilities and emergency operations (Hemphill, 2024). Integrating maps of satellite terminal locations into daily incident action plans and creating cloud-based servers for QR-coded data access would streamline responder coordination, maintaining energy restoration efforts (Hemphill, 2024). For public communication, NC should develop robust non-internet plans, leveraging local radio, TV broadcasters, and printed materials, as seen in Mitchell County, to keep communities informed about energy availability and safety (Hemphill, 2024). Coordinating with the DOE's CESER to pre-position responders and resources, as well as incorporating offline map downloads into response checklists, would further bolster preparedness (Response & Recovery, n.d.). By aligning these measures with state energy policies, NC can strengthen grid resilience and bolster uninterrupted communication, safeguarding energy security during future disasters.

8.5. Physical Attack Protection

The first step in determining whether to adopt or implement any protective measures is to conduct a threat and vulnerability assessment (TVA) unique to each substation and in compliance with local and federal regulations (CISA, 2023). Protective measures should only be implemented based on a tailored threat assessment for each substation. A 'boilerplate' TVA approach, wherein the same TVA is applied to all substations, is highly discouraged and unlikely to adequately address specific threats for each unique substation (CISA, 2023). Electricity Substation Physical Security increases awareness of available options that can enhance the physical security of electrical substations, establishes a means and path forward toward protected and resilient substations, and helps mitigate the inherent risks of owning and operating an electrical substation (CISA, 2023).

The table below provides examples of security measures that harden electric substations from physical attack.

Figure 77: 3 Physical Security Risk Mitigation Measures

Measure	Description
Perimeter Security	Installation of perimeter fencing or other physical barriers to prevent or delay attackers from entering the facility. Installation of ballistic shielding or obscuring of the line of sight to protect critical components from being targeted from a distance. Providing sufficient lighting for human or technological recognition of intrusion into facility perimeter or critical areas. Use of penetration resistant physical barriers, such as concrete jersey-style barriers or other barriers can mitigate the use of vehicle as a weapon.
Physical Security Control	Physical access can be controlled, monitored, and logged to prevent unauthorized access. Methods can include controlling, physical access via card keys, special locks, or other authentication devices; monitoring physical access via alarm systems or human observation of access points; and logging physical access via computerized logging, video recording, or manual logging.
Security Monitoring	Infrastructure owners can ensure security, operations, or maintenance personnel check facilities on a regular basis, and possibly on a varied timetable, so that attackers cannot take advantage of a predictable schedule. Regular site visits, along with a generally well-maintained substation site (both inside and outside the fence line), are important deterrents.

Personnel Training	Infrastructure operators can provide security awareness briefings, including insider threat mitigation, to all personnel upon hiring and refresher training at regular intervals.
Intrusion Monitoring and Detection	Deploying video surveillance, motion detectors, glass break sensors, or other systems that detect intruders attempting to pass through exterior access points, like fences, checkpoints, and access control gates can enable quick response times and limit potential damages. Intrusion detection systems may be designed to automatically alert response authorities or to engage intrusion prevention measures when an intrusion has been detected. Video surveillance should be recorded to enable better post-incidence forensics.
Intrusion Prevention	Critical infrastructure is equipped with systems designed to automatically shut down security breaches when detected (e.g., doorway entry system with lockdown capabilities).
Physical Security Assessment	Periodic review and inspection of physical security measures, by the infrastructure owner/operator, to evaluate their effectiveness. This will be useful in post-incident forensics, along with the development of written procedures to ensure security equipment is in functioning order with deficiencies addressed promptly.
Local Responder Coordination	Conducting outreach with local first responders to ensure they are aware of each facility's criticality/significance and which facilities are the most important. Attending periodic security drills or exercises (conducted by critical facilities) in coordination with emergency responders.

Source: DOE CESER

CISA also provides a layered security approach to physical security, involving the following concepts:

- **Deter**: Install physical security measures to dissuade potential attackers.
- **Assess**: Develop a process to evaluate the legitimacy of an alarm and the procedural seps required to respond.
- **Communicate**: Utilize communication systems to send and receive alarm/video signals and voice and data information. Include a documented process to communicate and report detected intrusions.
- **Respond:** Develop measures to immediately assess, interrupt, or apprehend an intruder.
- **Intelligence Analysis**: Design measures to collect, process, analyze, evaluate, and interpret information on potential threats.
- **Audit**: Periodically review and inspect physical security measures to evaluate their effectiveness. This will be useful in post-incident forensics.

8.5.1. Conclusion

NC's pursuit of a resilient, reliable, and sustainable energy future hinges on the strategic implementation of risk mitigation strategies and innovative solutions outlined in *Sections 8.1 through 8.5*. By integrating proactive measures such as severe weather mitigation, predictive maintenance, supply and demand-side innovations, NC can fortify its energy infrastructure against diverse threats, including extreme weather, rising demand, cyberattacks, and physical attacks. Effective policy coordination, as highlighted in *Section 8.4.3*, is crucial not only for achieving HB 951's ambitious carbon reduction goals but also for ensuring rapid and cohesive responses to energy emergencies. Case studies, such as EnergyUnited's grid enhancements and the NC Flood Resiliency Blueprint, demonstrate the tangible benefits of these approaches, offering scalable models for stakeholders. Through the alignment of policies, fostering collaboration, and leveraging cutting-edge technologies, NC can safeguard its energy security, maintain affordability, and provide a cleaner, more resilient energy system that benefits all North Carolinians now and in the future.

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