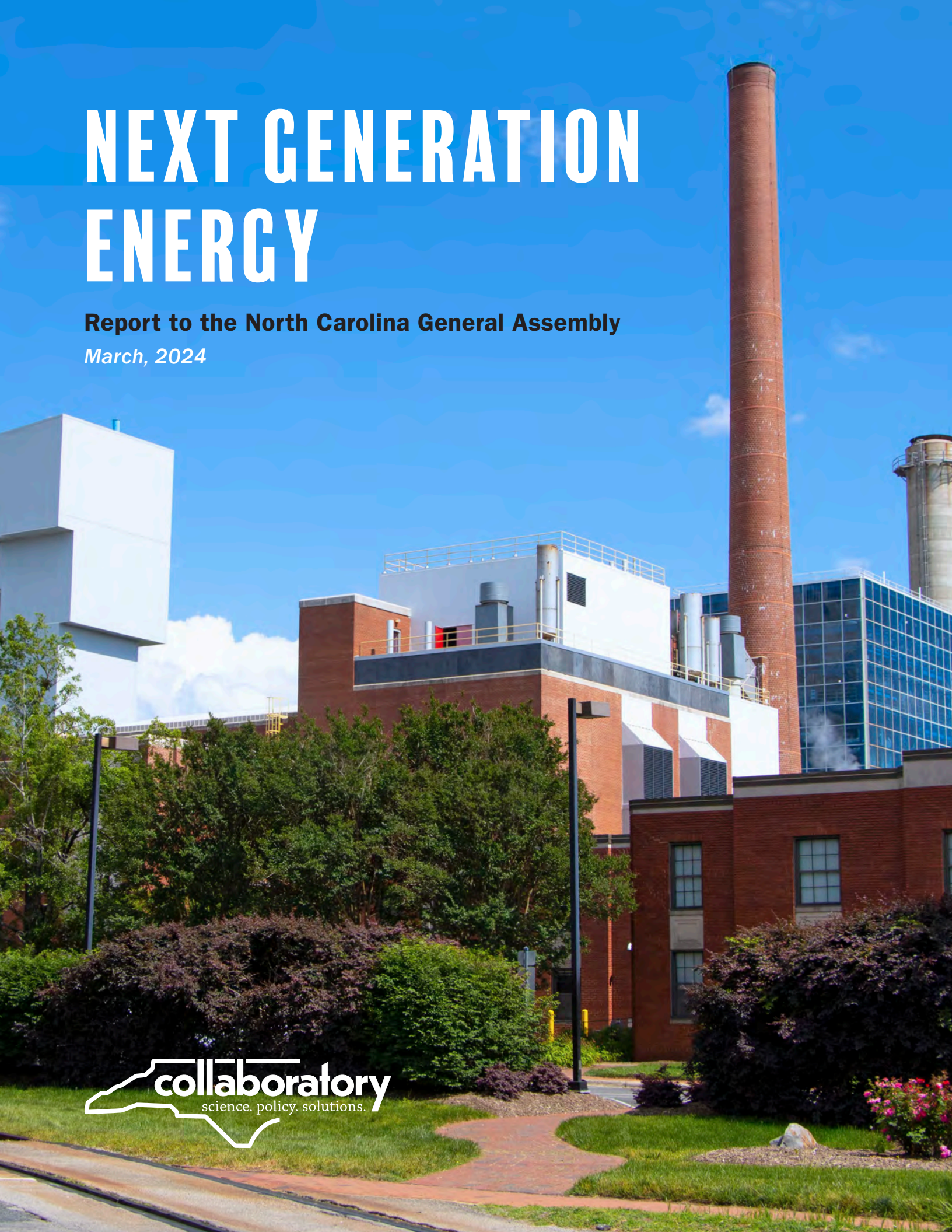
NEXT GENERATION ENERGY

Report to the North Carolina General Assembly

March, 2024



collaboratory
science. policy. solutions.

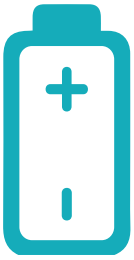
TABLE OF CONTENTS

By the Numbers	**3**
Introduction	**4**
Background	**5**
UNC Cleantech Summit	**6**
Legislative Charge	**7**
Economic Impacts of Mineral Mining	**8**
Ongoing Projects	**9**
Exploration of Lithium Potential in North Carolina	**9**
Working to Make Lithium Extraction More Efficient	**10**
Looking Ahead	**11**
Conclusion	**12**

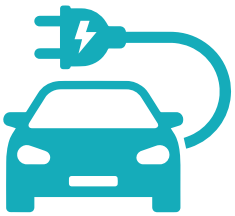
BY THE NUMBERS

25
miles of mineral ores in the Carolina Tin-Spodumene Belt

43
potential automotive sector projects in NC as of August 2022



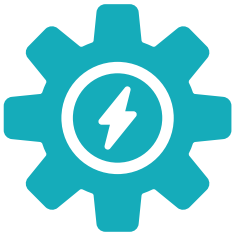
$200M
lithium research center opening in Charlotte's University area



5,000
jobs expected to be created from the Toyota battery facility in Liberty, NC

$4B
expected to be generated in the first six years of Piedmont Lithium's operations

$3B
Dr. Walden's estimate of NC's mineral deposits' economic impact



$88,440
expected annual salary of Kempower's jobs by the third year of their manufacturing facility in Durham

$15M
allocated to the Collaboratory for Next-Generation Energy and Research Development

INTRODUCTION

North Carolina's energy sector is in a transition phase for power generation and for vehicle transportation. This transition presents many challenges in the development of new technologies and policy changes, but just as importantly represents a major opportunity for the state to plan its energy future.

The North Carolina Collaboratory has been supporting research in the energy field over the last several years, including a ground-breaking energy storage study, efforts to make the grid more resilient, and helping catalyze the emerging electric vehicle battery industry within the state.

In the 2023 state budget (Session Law 2023-134) the North Carolina General Assembly invested $15 million for Next-Generation Energy research. The intent of these funds is to identify and execute research that will assist industry efforts in the energy transition as well as take advantage of the economic development opportunities that come with this transition.

This report is designed to provide a brief update on the Collaboratory's current activities related to energy issues and outline some future plans to spur on innovation in the energy industry in North Carolina.

BACKGROUND

The clean energy industry in North Carolina has been vastly expanding and bringing new economic activity to the state in the last few years. Specifically, the electric vehicle battery supply chain has developed in the state and brought with it numerous companies and jobs. One part of the supply chain that makes North Carolina attractive is the availability of raw materials.

Electric vehicles require lithium-ion batteries, making lithium a crucial commodity for this industry. It turns out that North Carolina holds the country's largest hard rock deposit of lithium. The Carolina Tin-Spodumene Belt is a 25-mile-long belt of ore that stretches from the northern to the southern state line. An alternative to the lithium-ion battery is the lithium-phosphate battery, making phosphate another key mineral for batteries. Beaufort County happens to have the largest integrated phosphate mine in the world.

North Carolina's abundance of lucrative minerals has brought many companies focusing on electric vehicle battery production to the state. After relocating its headquarters to Charlotte in 2015, Albemarle Corporation is looking to reopen its lithium mine in Kings Mountain to supply battery makers and is opening a $200M lithium research center in Charlotte's University area. The company predicted that the research center would create 200 jobs, averaging $94,000/year salaries, which is $20,000 greater than Mecklenburg County's average annual pay. About $12.7 million in state and local grants have been offered to Albemarle, but most of the money is contingent on the company meeting their hiring goals.

Piedmont Lithium is also in the permitting process to open a mine in Gaston County. A study by UNC-Charlotte Finance Professor, John Connaughton, estimated their operations to create more than 1,000 jobs and generate almost $4 billion in its first 6 years. Piedmont Lithium has a deal to supply batteries to large corporations including Tesla.

PIEDMONT LITHIUM

The Collaboratory is working closely with industry partners, such as Piedmont Lithium, to identify research needs that will support industry.

Toyota is building their first North American electric vehicle battery facility in Randolph County, which is expected to be operational in 2025. The company has already invested approximately $14 million and expects job creation to be over 5,000 jobs. Toyota is planning on using 100% renewable energy at this facility.

VinFast is another automotive company coming to the state, establishing its electric vehicle manufacturing plant in Chatham County, which is expected to create 7,500 jobs there. Kempower Inc., a manufacturer of charging stations for electric vehicles, is headquartered in Finland and is opening a new manufacturing facility in Durham. They are investing $41.2 million into the new facility and plan to create 300 jobs, with average annual salaries of $88,440 by the third year of the project.

Forza X1 is manufacturing electric boats in Marion, NC, and Boom Supersonic is manufacturing clean-fueled airplanes in Greensboro for major airlines like United and the US Air Force. It's clear that North Carolina is becoming a hub for the electric vehicle battery supply chain as countless companies involved in both mining and manufacturing are bringing their operations here. According to the Economic Development Partnership of North Carolina, as of August 2022, there were 43 potential automotive sector projects in NC, with the majority of projects being related to the electric vehicle supply chain.

While recent fluctuations in the lithium markets have caused announcements in the early months of 2024 for some of these companies to modify projections, the opportunities for growth in this sector remain strong based on continued investment and plans by companies locating in NC.

UNC CLEANTECH SUMMIT

Every year, UNC's Institute for the Environment and Ackerman Center for Excellence in Sustainability host the Cleantech Summit. This event brings together industry leaders, government officials, and academics from the Southeast and the world. During the 2023 Summit the North Carolina Collaboratory's Executive Director, Jeff Warren, moderated two panels on the electric vehicle battery supply chain in North Carolina. The first was titled, "Building a Complete Battery Supply Chain in North Carolina," and featured employees from Piedmont Lithium, Ford, and Soelect, a Greensboro-based provider of a new lithium technology called dendrite-resistant LiX (Lithium-X) Anode.

The panel had a compelling combination of speakers, from the mining industry to manufacturing to a technology provider. While all of the panelists come from different backgrounds, they each agreed that the demand for lithium is going to rapidly increase as electric vehicles become more popular and the Inflation Reduction Act incentivizes them. They also talked about the permitting process being one of the largest roadblocks to their development.

The second panel on mineral mining was titled, "Battery materials and Supply Chains" and featured The United States Geographical Survey (USGS), Panasonic, Nth Cycle, and The Metals Company. The USGS studies the landscape of the United States, more specifically the natural resources within it and the potential natural hazards that may threaten our landscape. The panel discussed potential hazards that could arise due to mining minerals here in NC.

Panasonic currently has a lithium EV battery plant in Sparks, Nevada and is expanding to De Soto, Kansas. Company representatives discussed the challenges that came with opening their first EV battery plant. Nth Cycle is a metals processing technology company that aims to reuse critical metals from batteries and mining ores. They help improve supply chain efficiency of critical minerals for the battery industry. The fourth company present at the panel, The Metals Company, similarly seeks to produce metal that can be reused repeatedly and focus on EV battery production through nodule technology.

These two panels at the Clean Tech Summit represent the potential growth of this sector both across the country and specifically here in North Carolina.

Dr. Jeff Warren moderating a panel with employees of Ford, Piedmont Lithium, and Soelect; Warren is holding a rock containing spodumene ore, a source of lithium.

LEGISLATIVE CHARGE

In the 2023 legislative session, House Bill 259 (Session Law 2023-134) allocated $15 million to the Collaboratory for "Next-Generation Energy and Research Development." The Collaboratory is tasked with leveraging its academic research partnerships with NC businesses to research technologies including lithium batteries, computer chip manufacturing, small modular- or micro-nuclear technologies, hydrogen storage, production, and transportation, and grid modeling for power generation, storage, and distribution.

The legislation requires the Collaboratory to report on its progress by March 15, 2024, and annually thereafter while funds remain to the Joint Legislative Education Oversight Committee. The submittal of this written report is intended to meet that statutory requirement.

ECONOMIC IMPACTS OF MINERAL MINING

While the Collaboratory has been following the latest news on certain clean energy developments in NC, the recent funding from the state also builds on ongoing research the Collaboratory has been supporting, such as a study on the economic impacts of mineral mining for batteries in NC, research on improved methods of lithium exploration below Earth's surface, and the development of a new ultra-efficient lithium extraction method.

In March of 2023, Dr. Michael Walden, an economics professor at North Carolina State University, published his study titled, "The Future of Mineral Mining in North Carolina: Impacts, Issues, and Solutions." The Collaboratory funded this study to look into the previously mentioned spike in automotive projects coming to NC that rely on the state's mineral deposits for battery production.

The minerals that Dr. Walden focused on were high-purity quartz, lithium, and phosphate. The mines in Mitchell County produce the largest quantity of high-purity quartz in the world, having an annual economic impact of $700 million for the state as estimated by Walden (considering direct and indirect impacts). Quartz is a crucial input to manufacture computer chips and semiconductors, which are both experiencing rising demand. Walden explains how lithium's demand will also spike as consumers switch to electric vehicles powered by lithium-ion batteries. Considering the proposed mines by Piedmont Lithium and Albemarle, the study estimates a potential economic impact of almost $2 billion annually, nearly 5000 jobs created, and important state and local tax revenues.

Lastly, phosphate is used in an alternative electric vehicle battery called the lithium iron phosphate battery. Beaufort County has the largest integrated phosphate mining and chemical plant in the world and its mine is estimated to have a total annual economic value of $600 million and 2850 jobs. Figure 1 shows the locations of the various mining operations mentioned within NC. Dr. Walden found that the annual total impact of all of the state's mineral deposits could be over $3 billion. However, these operations do have some local opposition due to environmental and noise pollution. Walden listed several mitigation options to address these concerns, including a severance tax on the mining companies to pay back the affected communities.

The key takeaway from Dr. Walden's study is that the development of the electric vehicle battery supply chain in North Carolina will have large economic benefits for the state and that there are options to mitigate local environmental concerns.

Locations of Proposed Lithium Mines and of the Existing Silica Quartz Mine and Phosphate Mine in North Carolina

Map from Dr. Walden's report.

EXPLORATION OF LITHIUM POTENTIAL IN NORTH CAROLINA

The Collaboratory is supporting an innovative and ground-breaking project that involves UNC-Chapel Hill and NC State University. Faculty from these institutions are collaborating in partnership with industry to identify the potential lithium resources here in North Carolina.

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

NC STATE UNIVERSITY

Dr. Drew Coleman from the University of North Carolina at Chapel Hill is researching improved methods of lithium exploration. In June of 2023, Dr. Coleman and his lab achieved preliminary results that worked at determining high-precision age patterns of lithium rock in the Caroline Tin-Spodumene belt. Only certain ages of lithium rock are suitable for mining, so knowing what ages of lithium rock NC has is crucial to improving lithium exploration. Coleman mentioned the renewed interest in NC's lithium due to its use in energy storage batteries. His group partnered with Piedmont Lithium to observe their mineral cores and property. Coleman wrote that maintaining cooperation with Piedmont will be necessary for progress on this research.

Coleman's lab also demonstrated the utility of using a new extraction technology, a hand-held laser analyzer, for predicting where lithium-bearing rocks are below Earth's surface. This new technology (Laser-Induced Breakdown Spectroscopy or LIBS) is now being used broadly across the mining industry in part thanks to Dr. Coleman's research. He identified room for improvement with developing the LIBS for exploration, a potential next step for his research group. He also pointed out that related research in recycling, improvement of battery efficiency, and charging would be highly beneficial to lithium exploration in North Carolina. Dr. Coleman's research group made substantial findings pertaining to the geochemistry of lithium in North Carolina, created partnerships with relevant companies like Piedmont Lithium, and recommended opportunities for future research on the topic.

In short, Coleman's research shows that North Carolina can make efficiency improvements in mining for lithium either by funding additional research or using new technologies like LIBS.

Professor Adam Curry and his team identified critical mineral indicators such as muscovite, K-feldspar, and quartz, employing geochemical indices to differentiate between lithium-rich and lithium-poor pegmatites. Through comprehensive analyses of trace elements within pegmatites in comparison to Cherryville Granite, the project shed light on various hypotheses surrounding their formation and evolution.

A significant project focus was the development of an exploration technique utilizing a calibrated handheld laser-induced breakdown spectroscopy (LIBS) analyzer. This innovative approach enables real-time, on-site quantitative geochemical analysis, significantly enhancing the efficiency and precision of assessing ore quality and quantity. Recommendations for future initiatives include sustained exploration efforts, continued investment in lithium research, and bolstering academic resources to support the lithium industry in North Carolina. In summary, this project advances the understanding of lithium exploration and utilization and better positions North Carolina to lead the transition to a low-carbon energy economy.

WORKING TO MAKE LITHIUM EXTRACTION MORE EFFICIENT

Another energy-related project that the Collaboratory funded was a project at the University of North Carolina at Greensboro that developed a new form of lithium extraction. Dr. Hemali Rathnayake and her lab developed and tested the new Nano Mosaic solid-phase extraction (SPE) technology that can extract lithium with extremely high efficiency (upwards of 87%). It can cut down the extraction time of lithium from two years to less than 48 hours.

Efficient extraction methods will be crucial to ensure that supply matches demand with the growth of the lithium market for EV batteries. Dr. Rathnayake pointed out that "the lithium-ion battery market is projected to reach $94.4 billion by 2025, thus outpacing the rate at which the lithium is currently mined from primary resources".

The lab found that their Nano Mosaic SPE technology could translate into a viable commercial product by their next phase of the project. The technology can be incorporated into existing brine operations as an extremely efficient and cost-effective lithium extraction technology.

The current price for battery grade LCE is about $65,000 per ton, while this new technology can extract high purity lithium at less than $5,000 per ton. In order for this technology to be used to its full potential, Dr. Rathnayake urged North Carolina to continue working with lithium mining companies to complete the supply chain and unlock the state's potential to lead the nation's lithium industry.

The key takeaways from Rathnayake's research are that there's a new ultra-efficient technology for lithium extraction which could be commercially viable shortly and that this advancement, paired with North Carolina's abundance of lithium deposits, positions the state to have a leading supply chain if it successfully opens up proposed lithium mines.

LOOKING AHEAD: PLANS FOR NEXT-GENERATION FUNDING

Much of this report has focused on the growing potential of North Carolina's role as a leader in the battery supply chain sector. Although that industry is of critical importance and will be a focus of the Collaboratory's work over the next several years, there are also a number of other topics mandated by the legislature for the Collaboratory to provide research and support to the energy sector.

Electricity Grid

Developments in recent years, including unexpected growth in the state's electricity usage, the emergence of renewables, blackouts during December of 2022 and Duke Energy's Carbon Plan, have all illustrated the importance of strengthening the power grid.

The Collaboratory will be working with researchers at UNC-Charlotte's Energy Production and Infrastructure Center (EPIC) to support modeling work for the grid. As Duke Energy's portfolio of energy sources changes in the coming years and decades it will be critical to assess what improvements to the grid are needed to accommodate those changes. The Collaboratory will also continue to build on its previous work related to studying the grid's vulnerability to flooding and major storm events.

Small Modular Nuclear

Small Modular Nuclear Reactors (SMRs), are an emerging energy technology that has gained much ground in the last decade. SMRs are small scale advanced variations of the traditional nuclear fission reactor meaning they can produce a fraction of the energy that a full size power plant can produce yet still produce the same clean energy. Also referred to as light water reactors (LWRs) due to their use of light water as a coolant for the fission process, SMR's can be used in power generation, process heat, desalination, and many other industrial applications.

Despite SMRs being a relatively new technology, they share many of the same benefits and drawbacks that accompany conventional nuclear. SMR technology, however, is seen as the next step in nuclear energy generation because its smaller and safer design further advances the advantages while also compensating for and eliminating the drawbacks of a traditional nuclear power plant. SMRs can be linked with other energy sources such as renewables to ensure grid stability while still decarbonizing electricity producers' energy portfolios as well as bringing a variety of advantages independently.

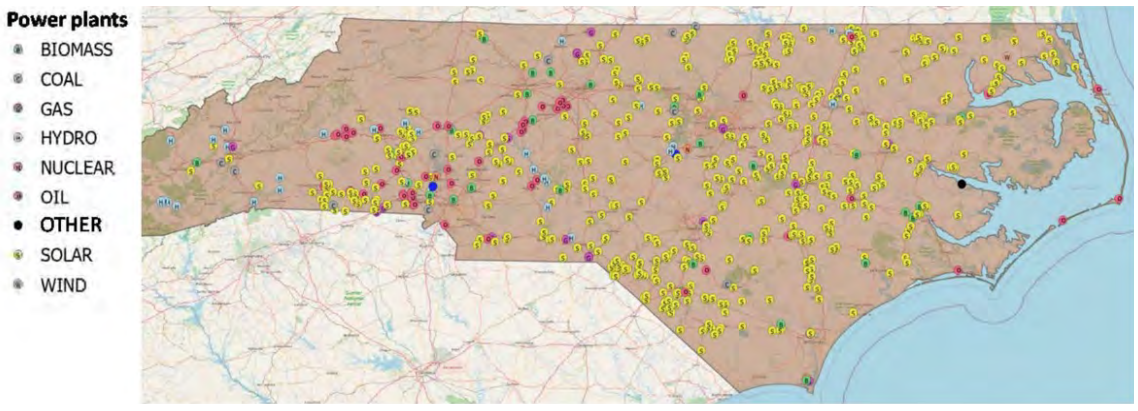
The Collaboratory will be working with academic experts and industry leaders to advance the knowledge base around SMRs and what they might mean for the state's energy future.

Energy Storage

Since the Collaboratory's assessment of current and future presence of and potential for energy storage in 2018, energy storage capacity in the United States has increased significantly. While most of this presence is observed in California and Texas, Duke Energy has initiated several battery storage projects in North Carolina. As the nation and our state continue with an energy transition the need for a reliable energy grid system is paramount to ensuring that transition results in a reliable and affordable electricity sector.

As innovative progress continues to expand opportunities for energy storage throughout the country, it is time to reexamine what options North Carolina has to advance its energy storage technologies. Further research on this topic will include the current market for grid-scale and distributed storage, including relevant policies already effective in North Carolina. This will include an analysis of energy storage development in recent years.

Location of electric supply generators in North Carolina as of 2018 (U.S. EPA)



CONCLUSION

North Carolina is in the early stages of an energy transition as the state, along with the nation, continues to move away from fossil fuels to renewable resources. As part of that transition there are a multitude of technological developments and policy challenges facing industry and state policy-makers.

The expectation is that the work and research carried out over the next several years as part of the Collaboratory's Next-Gen Energy portfolio will catalyze industry projects, support new technological innovation and provide current analysis to state leaders as they continue to chart a course for our state's energy sector.

The North Carolina Collaboratory is a funding agency that partners with academic institutions and state agencies to transform research into practical information for use by State and local government. Initially focused on natural resources and environmental issues, the Collaboratory has since broadened its portfolio to include research on some of the State's most pressing challenges, including within the public health, education, clean energy, economic recovery, and technology sectors.

Since its authorization in 2016 by the North Carolina General Assembly the Collaboratory has stewarded $225 million in appropriations from the legislature, investing in over 500 research projects across all 17 University of North Carolina System campuses and numerous NC-based private colleges and universities. The Collaboratory is committed to developing innovative, evidence-based solutions that serve the State and its constituents.

More information about the Collaboratory can be found at:
collaboratory.unc.edu

collaboratory
science. policy. solutions.

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

NEXT GENERATION ENERGY
March, 2024
collaboratory.unc.edu