Strategic Energy Action Plan+

A Roadmap for Sustainability

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Acknowledgments

The Strategic Energy Action Plan+ (SEAP+) is the product of our goals to make Charlotte a more sustainable city. This work would not have been possible without a dedicated team, many partners, and many supporters.

The plan was developed by the City of Charlotte's Office of Sustainability and Resilience (OSR), led by Sarah Hazel, Dr. Robyn Byers, Heather Bolick, and Aaron Tauber. The team was supported by EY US and public engagement specialists Civility Localized.

Many different groups, organizations, and entities, including departments within the City of Charlotte, local nonprofit organizations, local businesses, Duke Energy, and more, provided valuable input into the SEAP+'s goals, strategies, and actions (see the list below for more details).

Most importantly, this plan exists thanks to the people of Charlotte. The accomplishments, concerns, and goals voiced throughout months of public engagement are what make the SEAP+ a reflection of the Charlotte community. Charlotte has made great strides toward its previous goals, and with continued support, will be able to achieve our vision to become a global leader in environmental sustainability, balancing economic growth with preserving our natural resources.

OSR would like to thank the following contributors to the SEAP+:

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SEAP+ Operations Team

Duke Energy and Piedmont Natural Gas

Centralina Regional Council

Mecklenburg County Solid Waste Services

Mecklenburg County Air Quality

The Innovation Barn

The SEAP+ is also dedicated to the memory of our neighbor, friend, and advocate, John Holmes III, who was instrumental in developing the plan through amplifying and spotlighting the voices of Charlotte's residents. His passion for the city and his character inspire us to continue the work of making Charlotte a more sustainable city for all.

1. Foundation and Context

Background

Since 2015, Charlotte has been committed to climate leadership through its participation in the Global Covenant of Mayors for Climate and Energy. This dedication led to the creation of the city's first Strategic Energy Action Plan (SEAP) in 2018, a comprehensive framework designed to guide Charlotte toward a low carbon future. With ambitious goals set for 2030 and 2050, the SEAP laid the foundation for transformative change, focusing on reducing greenhouse gas emissions (GHG) and promoting resilience.

Today, with the SEAP+, an update to the 2018 SEAP, the City of Charlotte reaffirms its commitment to sustainability, reflects on progress made, and charts a course for continued innovation and collaboration toward a net-zero carbon future.


HYATT house

Five Stages to Zero Carbon

In 2018, Charlotte developed the SEAP by leveraging the Five Stage Approach to Zero Carbon Energy. This approach also informed the updated SEAP+ as a framework for meeting our energy goals.

By following this approach, the City of Charlotte and its citizens are able to identify cost-effective and realistic paths to delivering GHG reductions. It is a continuous approach and consists of the following five iterative stages:

Shift Energy Demand

The biggest challenge to energy planning is ensuring peak demand is met, which becomes more complex with higher levels of intermittent renewables generating electricity. This stage's goal is to shift when energy is demanded so that the energy profile is much less dynamic.

Reduce Energy Consumption

Reducing the amount of energy consumed is nearly always the most efficient way to meet a zero carbon target. This is because the less energy required on the demand side, the less zero carbon energy is required on the production side.

Change the Energy Consumed

The types of energy we consume dictate emissions. Therefore, changing the type of energy consumed can lower emissions. This step does not have to be immediate; for example, the transition away from fossil fuel-based vehicles to electric vehicles can be started now and extend over many years.

Generate Energy On-Site

The generation of energy on-site includes heating, cooling, and electricity which may come from sources like geothermal heat pumps, solar and wind, all of which may be supplemented by storage opportunities. These options each reduce reliance on the grid, which may not be carbon free in Charlotte until 2050.

Purchase the Remainder

When steps have been taken on each of the above stages, the remaining energy can be purchased from zero carbon sources — for example from a utility. This is meant to be a last resort when the other four options are not sufficient.


Shift Energy Demand
Gaining control of when energy is consumed (energy demand) is a crucial step in gaining control of your energy use. With better control of energy demand opportunities for zero carbon energy increase.
Reduce Energy Consumption
Reducing the amount of energy consumed means there is less zero carbon energy that must be procured. When considered as part of a package of energy reduction options, reducing energy consumption offers revenue potential that can be used to finance wider energy investment.
Change the Energy Consumed
This stage requires changing the type of energy consumed. This means moving from fossil fuels to zero carbon energy. This may be bioenergy or electricity / hydrogen. If electricity, it does not need to be zero carbon, yet.
Generate Energy On-Site
The energy needs may be met entirely or partially onsite. This generation may be for heat (e.g. solar thermal, heat pump or CHP), cooling (using an absorption chiller) and/or electricity (eg solar PV, wind, CHP).
Purchase the Remainder
Any zero carbon energy that cannot be produced onsite will need to be procured. Negotiating energy contracts is not a straight forward process. It is made easier and cheaper with better knowledge of your energy usage. The other steps will help in this process.
5
Stages to Zero Carbon Energy
carbon captured

As centers of talent and innovation, cities are uniquely equipped to take climate action while enhancing the health, economy, and quality of life for their residents.

This belief has fueled Charlotte's sustainability journey to date. And now Charlotte is at a key moment in its sustainability journey.

Over the past five years, the city has made progress in generating renewable energy, improving building efficiency, and investing in clean transportation. However, the impacts of climate change persist, bringing challenges like heavier rainfall and extreme heat, and demanding continued urgency to reduce emissions and strengthen resilience.

The city began this journey by publishing the original SEAP in 2018, and this update, the SEAP+, builds on that plan, incorporating the latest science, technology, and lessons learned. The SEAP+ is grounded in the empirical basis of a greenhouse gas (GHG) inventory and a climate risk assessment and is informed by a robust public engagement process. The plan itself has four focus areas: buildings, energy generation, transportation, and cross-sectional; each focus area is composed of a number of strategies and implementation actions.

In the SEAP+, the core focus remains on the largest emitting sectors. This update places an intentional emphasis on alignment with citywide policies and clarified focus, ensuring that all communities can benefit from Charlotte's transition to a low carbon future. It is clear that a thriving economy is key to long-term sustainability, and this plan promotes job growth, workforce development, and economic opportunities that support both environmental and financial resilience for all.

Collaboration is crucial to making this vision a reality. The SEAP+ sets forth a path for strengthened partnerships with community organizations, businesses, utilities, and educational institutions. Investing in sustainability not only protects the environment but also creates economic benefits, attracts new industries, and lowers energy costs. As the city moves toward a low carbon future, success will depend on both resources and community support. This plan provides a roadmap for action, reinforcing Charlotte's commitment to lead. By working together, the city and its residents can create a cleaner, stronger, and more sustainable future for generations to come.

"Charlotte will lead, as a global city, by continuously improving, protecting, and preserving the environment, its community, and economy, while ensuring equity and resilience **- for today's and future generations."**

The City of Charlotte extends its gratitude to the community for its continued engagement and support. Together, through bold actions and enduring partnerships, we will create a future that is not only sustainable but also equitable and resilient for generations to come.

What is the + in the SEAP+?

The “plus” in SEAP+ highlights the new addition of a climate risk assessment, creating a stronger link between energy transitions and climate challenges. Shifting from fossil fuels to renewable energy helps cities reduce emissions. Traditional energy systems are vulnerable to disruptions, but renewable and decentralized systems provide reliable power during disasters, keeping critical infrastructure running and aiding recovery. They provide an array of additional benefits, including:

- Lowering emissions and energy use not only supports an energy transition, but also reduces costs for residents.
- Energy-efficient technology and renewables stabilize costs, making energy more affordable.
- Sustainable energy solutions can also drive equitable economic growth through programs like community solar and green job training, ensuring everyone can benefit from the clean energy transition.

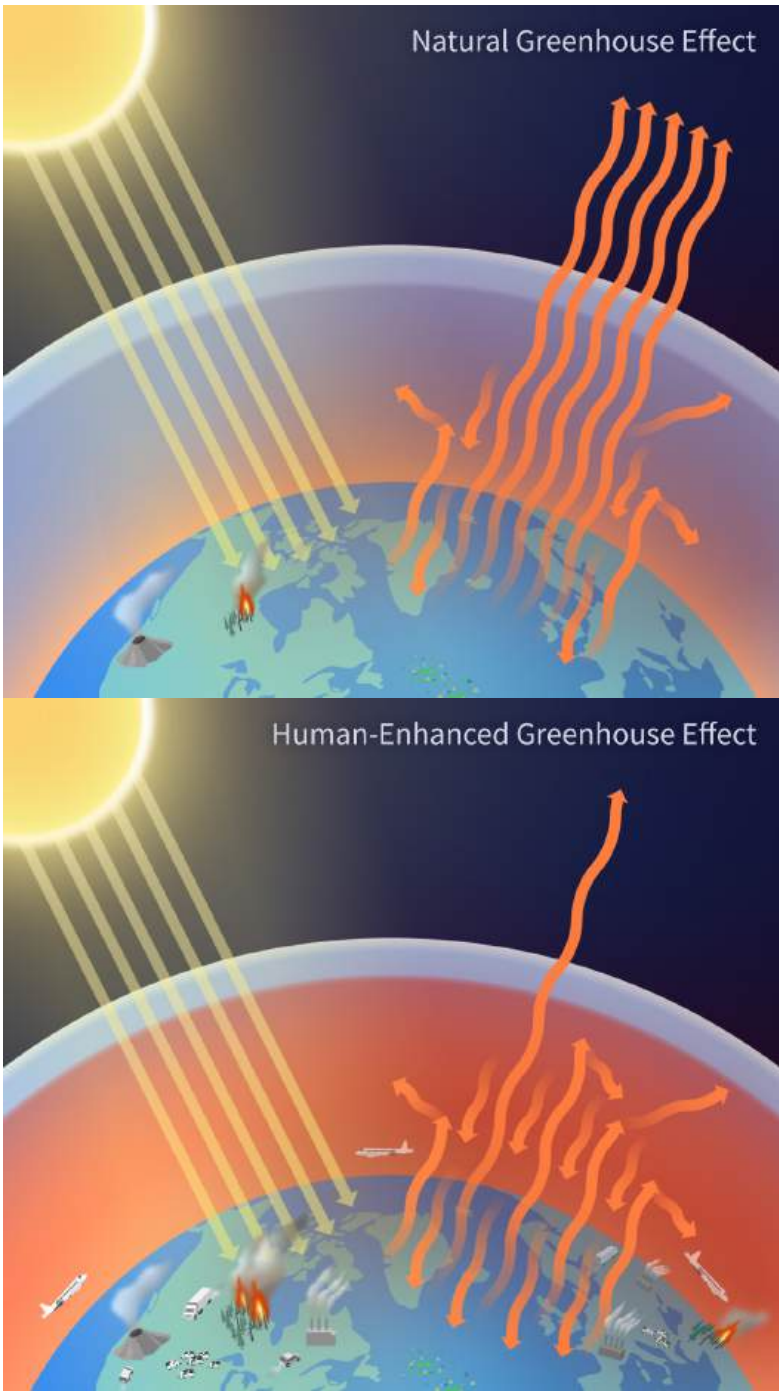
Climate Change

Background on climate change

Climate change refers to long-term shifts in the Earth's weather patterns.[1] Some changes happen naturally, like volcanic eruptions, changes in the sun's energy, or events like El Niño and La Niña, which affect short-term weather.

However, since the Industrial Revolution in the 1800s, human activities have amplified climate change. Burning fossil fuels like coal, oil, and gas releases greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the air. These gases trap heat from the sun, making the Earth warmer.[2] While the greenhouse effect is a natural process that keeps the planet habitable, excessive greenhouse gases are causing temperatures to rise, leading to the climate change impacts we see today.

We are now experiencing the early impacts of climate change: 2024 was the warmest year on record[3] since recordkeeping began in 1880. The last 10 years were the 10 hottest years on record.[4]



The top panel shows the greenhouse effect, where heat is trapped near Earth's surface by naturally occurring greenhouse gases. The right bottom shows how humans are intensifying the greenhouse effect through processes that release greenhouse gases into the atmosphere, mainly burning fossil fuels for energy and transportation.

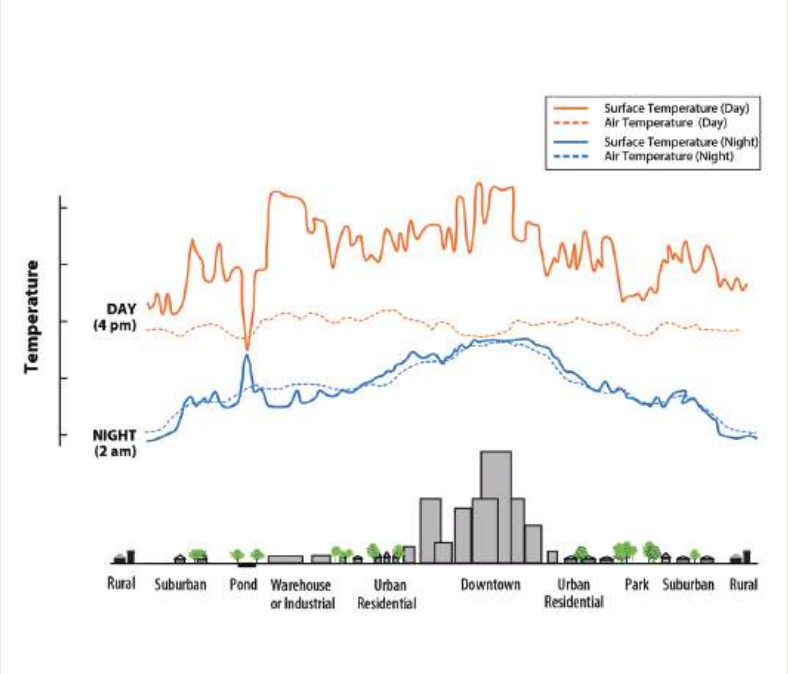
Source: https://www.epa.gov/climatechange-science/basics-climate-change

Climate change's risks and impacts

Climate change brings many risks. Heat waves are becoming more common, lasting longer, and getting stronger.[5] Heavy rainstorms are happening more often, leading to flooding.[6] The oceans are getting warmer[7] and more acidic,[8] causing ice to melt, sea levels to rise, and harming animals and plants, with over 40% of species at risk of extinction.[9]

These changes matter because they affect our daily lives. Heat waves can cause serious health problems, including illness and death. Flooding can pollute drinking water with bacteria and chemicals. Poor air quality can worsen asthma and lung diseases. Severe storms like hurricanes and tornadoes can destroy homes, injure people, and force families to evacuate.

Not everyone experiences these dangers equally. Outdoor workers have more exposure to extreme heat and polluted air and people with disabilities may need extra help during disasters. Older adults[10] are more at risk due to health problems and mobility challenges.



The Urban Heat Island Effect

The above graph depicts the phenomenon known as the urban heat island effect where developed areas experience higher temperatures due to the trapping of heat in surfaces like concrete and asphalt. More developed areas, like city centers, will experience higher average temperatures when compared to more suburban or rural areas that have higher concentrations of greenspace.

Charlotte is already feeling the effects of climate change. The number of extremely hot days (days above 95°F) has tripled since the 1960s and will continue to rise. Annual rainfall is increasing, leading to more flooding. Since 1980, North Carolina has faced 120 $1-billion-dollar-plus disasters, mostly from hurricanes like Hurricane Helene in 2024, which grew past the historic extent of hurricanes in the region. Beyond risks to health and property, these disasters also divert taxpayer funds to expensive recovery efforts. For more information on climate risks, please see Charlotte's full climate risk assessment.

Charlotte's Sustainability Leadership

In the global challenge to combat climate change, cities, like Charlotte, play an especially central role: today, about 56% of the world's population, responsible for 80% of global GDP, live in cities and may be responsible for 70% of global CO_2 emissions. Charlotte has led by example. The various initiatives Charlotte has undertaken in pursuit of climate leadership include:

City-wide

- In 2015, Charlotte joined the Global Covenant of Mayors for Climate & Energy (GCOM),[14] the largest global alliance for city climate leadership, reaffirming its commitment in 2018.
- In 2018, the Charlotte City Council unanimously passed the Sustainable and Resilient Charlotte by 2050 Resolution and directed Charlotte to develop the SEAP,[15] an aggressive plan to deliver a low carbon and resilient Charlotte.
- Selected as one of 25 cities for the America Cities Climate Challenge by Bloomberg Philanthropies in December of 2018.
- Awarded the Centralina Region of Excellence Clean Cities Award in 2020.
- Received an A- from the CDP, a nonprofit that runs the global disclosure system for investors, companies, cities, states, and regions, in 2022 and 2023.
- Selected as one of 10 cities to receive technical support from the Smart Surfaces Coalition in 2023.
- Ranked 25th in the 2024 American Council for an Energy-Efficient Economy (ACEEE) Clean Energy Scorecard, up 17 positions from its previous ranking.
- Selected by Bloomberg Philanthropies in 2024 as one of 25 American Sustainable Cities, focusing on the intersection of Black wealth and climate.
- Became a LEED Gold rated city.

Buildings and Energy Generation

- Updated the Sustainable Facilities Policy in 2021 and again in 2024[16] to align with SEAP goals, focusing on reducing energy consumption in municipal buildings, electrifying future buildings, and formalizing building energy performance benchmarking.
- Earned the 2021 US Green Building Council (USGBC) Carolinas Leadership Award for exceptional achievements and significance in the green building industry for Charlotte-Mecklenburg Police Department South.
- Transitioned to CitySET (sustainable energy transition), a partnership with Duke Energy that serves as a blueprint for utilities and cities working together toward a sustainable future.
- Council approval of the Duke Energy Green Source Advantage Bridge program to bring online an 80 MW solar farm.
- Charlotte developed programs like Power Down the Crown[17] to encourage building owners to increase their buildings' energy efficiency and to highlight successful practices in that space.
- Won a 2024 Local Government Impact Award from the Research Triangle Cleantech Cluster for Beneficial Electrification in the updated Sustainable Facilities Policy.

Transportation

- Updated development standards to include EV charging requirements and bonuses for additional EV charging, High Performance Construction bonuses to increase energy efficient buildings and renewable energy, and enhanced safety and accessibility of transit, bike lanes, and sidewalks to promote micromobility.
- Ranked as 6th Greenest Fleet by the NAFA Fleet Management Association

Highlights...

This update marks a pivotal milestone for the City of Charlotte since 2018 SEAP was published. Five years in, the city has made significant progress towards the goals that were outlined in the original plan.

Buildings

- 55% of benchmarked municipal buildings reduced their energy use intensity 2022-2023.
- Power Down the Crown has 13 partners covering 26 buildings.
- 146 homes received deep energy retrofits in the Duke Energy & City of Charlotte High Energy Usage Reduction Assistance program.
- 17 certified green municipal buildings.

Energy Generation

- 28 MW Solar PV capacity community-wide.
- 1.8 MW Solar PV capacity municipally funded.
- Municipal Solar PV systems include 22 in operation, 5 under construction, and 3 in design for a total of 30 systems.
- 1 MW combined heat and power (CHP) at Charlotte Water McAlpine Creek wastewater facility.

Transportation

- 200+ EVs in Charlotte's Fleet.
- 950+ EV charging ports communitywide.
- 330 municipally-installed EV charging ports (30%+ of all EV charging ports), including four (4) solar-powered public EV chargers.
- 11,560 EVs, 21,206 hybrids, and 3,207 plug-in hybrids were registered in Mecklenburg County as of the end of 2023.

Workforce

- CATS eSERVE Academy program provides training for Battery Electric Bus (BEB) maintenance professionals.
- The Renewable Energy & Efficiency Workforce (RENEW) training program has trained 178 individuals focused on the HVAC sector.
- Anticipate approximately 800 jobs from the investment in the GSA 80 MW project.


FIRE
C-341

SEAP+ Connectivity to Related Plans and Policies

Local Plans

Charlotte Future 2040 Comprehensive Plan[18]

A key component of the SEAP+ is its integration with other local plans and policies, including the Charlotte Future 2040 Comprehensive Plan. The Comprehensive Plan was adopted in 2021 and is a living document that provides a policy framework to guide the city's decision-making and investment in both the near- and long-term.

The SEAP+ supports the Comprehensive Plan's vision to be Inclusive & Diverse, Livable & Connected, Healthy & Sustainable, Prosperous & Innovative, and Regional. It does so through its strategies and actions to address climate justice and focus on equity, adaptation and resilience, conservation, public health, multi-modal transportation, and collaboration with a wide range of stakeholders.

Tree Canopy Action Plan[19]

The Tree Canopy Action Plan (TCAP), completed in January 2021, is a plan to protect and grow Charlotte's tree canopy because trees make the city healthier, cooler, and more connected. Trees help clean the air, reduce extreme heat, support wildlife, and make neighborhoods more enjoyable. This plan gives recommendations for improving tree policies, updating city rules, and making sure there are enough resources to care for trees. It also works with the Charlotte Future 2040 Comprehensive Plan to guide how the city grows while protecting nature.

Strategic Mobility Plan[20]

The SEAP+ is also closely tied to the Charlotte Strategy Mobility Plan (SMP), adopted in June 2022. The plan established a mobility vision for the city:

Charlotte will provide safe and equitable mobility options for all travelers regardless of age, income, ability, race, gender, where they live, or how they choose to travel. An integrated system of transit and tree-shaded bikeways, sidewalks, shared use paths, and streets will support a sustainable, connected, prosperous, and innovative network that connects all Charlotteans to each other, jobs, housing, amenities, goods, services, and the region.

To support its vision, the SMP established a goal that, *as a community, half of our commute trips will be made by means other than a single-occupancy vehicle, through walking, biking, and taking transit.* This goal is reflected directly in the SEAP+ transportation focus area as it will help Charlotte realize its mobility vision while simultaneously reducing community-wide emissions.

Corridors of Opportunity

The Charlotte Corridors of Opportunity Program is an initiative focused on revitalizing six historically underinvested areas in the city to create thriving, equitable communities where families and businesses can grow. These corridors serve as important connections, linking residents to jobs, transportation, and essential services. Since the program began, over $147 million has been invested, including $72+ million from the city and $75+ million from corporate partners, funding 75+ projects with 20+ partners. In 2023, the program secured over $20 million in federal funding, supporting projects like the Sugar Creek Mobility Corridor, new affordable housing, and small business development. Investments have also improved public safety, infrastructure, and access to technology. The program is deeply connected to Charlotte's long-term growth plans, ensuring that economic opportunities, racial equity, and sustainability remain at the center of development. Through strong partnerships and community involvement, Corridors of Opportunity is transforming neighborhoods and creating lasting change for residents and

businesses alike.

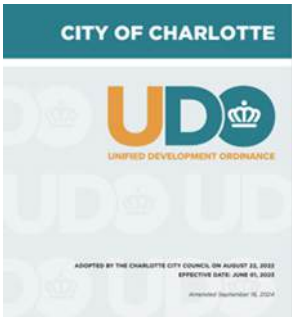
- **GreenPrints**

  The GreenPrints project is co-led by the City of Charlotte Office of Sustainability and Resilience, the Charlotte Corridors of Opportunity, CleanAIRE NC, and SolNation. The project is designed to address environmental justice and climate inequities in six historically disadvantaged corridors in Charlotte. By aligning with the Corridors of Opportunity program, GreenPrints will develop community-informed strategies to tackle issues like unequal tree canopy distribution, urban heat islands, energy burden, and legacy pollution. These action plans will be created with and for the communities most affected, ensuring that residents, local leaders, and organizations play a key role in shaping solutions.

Bloomberg American Sustainable City

In 2024, the City of Charlotte was selected by Bloomberg Philanthropies as a Bloomberg American Sustainable City. With an innovation team supporting these efforts and partnerships providing technical expertise, the city is committed to redesigning neighborhoods where all residents can thrive. By 2040, Charlotte aims to be a model for equitable, inclusive, and sustainable urban growth—where every voice is valued, and every community flourishes.

Unified Development Ordinance (UDO)[21]



The City of Charlotte has adopted several strategic changes to its rules for land development in the city's UDO that better position the city to adapt, mitigate, and prepare for a more sustainable and resilient future. The drafting and adoption of the city's UDO updated and consolidated Charlotte's development regulations into a unified document with clear and predictable development rules that would enact the vision of the Charlotte Future 2040 Comprehensive Plan.

Among the changes that were adopted with the goal of supporting the city's sustainability and resilience goals, Charlotte City Council approved a Unified Development Ordinance that:

- Contains Transit-Oriented Development standards that allow the greatest amount of population density around existing or planned transit network (Article 13);
- Requires 15% green area for all development types. This was a 5% increase in the amount of tree protection area for residential (Neighborhood 1) subdivisions (Section 20.15.C);
- Added protection for "heritage trees" which includes all native trees above 30 inches diameter (Section 20.14);
- Included green roofs as an option for compliance with tree protection standards (Table 20-5 Green Area Credits within Section 20.15.D);
- Set parking maximums that limit the amount of parking provided (Table 19-1 in Section 19.2);

- Added requirements for electric vehicle charging spaces and infrastructure in development of new multifamily, mixed-use, hotel, and parking lot (as a principal use) (Section 19.3);
- Allows wind turbines and solar panels as accessory structures (Section 17.2.L);
- Includes several height bonuses that allow increased building height for new development above the base zoning district allowances in exchange for sustainability benefits including:
    - Affordable Housing Equitable Clean Energy Projects Fee Program;
    - Electric Vehicle (EV) Charging Stations (above the base requirements);
    - High Performance Construction (includes four different tiers of performance);
    - Electronic Micromobility Lockers. (Section 16.3);
- Improves resilience against larger storm events by:
    - Adding new site drainage standards that expanded the stormwater review authority for the city over smaller development projects (i.e. tear-down/rebuild single family development) Article 24;
    - Lowering the review threshold for Post-Construction Stormwater compliance – the city's strongest stormwater controls which detains and treats stormwater before it goes back into streams and the groundwater (Section 25.2).

Mecklenburg County

On March 16, 2021, the Mecklenburg Board of County Commissioners resolved to adopt a revised and updated Environmental Leadership Policy:[22]

“In order that County government may operate in a manner that conserves and protects our natural resources; models environmental stewardship for local government, business and industry in our region; and uses the County’s assets, both existing and future, wisely for the benefit of its residents.”

The Board further resolved to align operations in support of current and future pollution reduction, resource conservation, and climate preparedness initiatives.

The resolution includes a goal to “Transition County facilities and fleet to net-zero carbon energy sources by 2035.”

The strategies and actions set forth in the SEAP+ are aligned with the strategies developed by Mecklenburg County and the City of Charlotte.

Duke Energy and Piedmont Natural Gas

The City of Charlotte is reliant upon Duke Energy for its supply of electricity and Piedmont Natural Gas (PNG, a subsidiary of Duke Energy) for its supply of natural gas, both critical energy sources for the city.

Charlotte and Duke Energy have recognized the value of collaborating with each other in pursuit of their joint efforts toward long-term sustainability and signed a memorandum of understanding[23] in 2019 to memorialize their partnership.

Duke Energy's goal[24] is to reduce carbon emissions from electricity generation 50% by 2030, 80% by 2040, and achieve net-zero by 2050. Duke Energy has already reduced carbon emissions more than 40% since 2005, largely through the retirement of coal plants and their replacement with natural gas, nuclear, and renewable energy. The City of Charlotte recognizes Duke's goals as a key component of its energy generation focus area.

PNG has additionally set a goal to reduce methane emissions to net-zero by 2030.[25] This entails improvements to reduce emissions throughout delivery systems, new technologies to measure and monitor emission and pinpoint leaks, and implementing satellite detection of escaped methane gas.

Charlotte residents participate in SEAP+ community launch event at the Innovation Barn.

Public Engagement

Objectives and overview

Public engagement is essential in sustainability work because it ensures that decisions are informed by the needs and perspectives of the community, leading to more effective and lasting solutions. According to the International Association for Public Participation (IAP2)[28], meaningful engagement builds trust, increases transparency, and encourages collaboration between governments, organizations, and residents. When people have a voice in sustainability policies and projects, they are more likely to support and participate in sustainable actions. By involving the community early and often, cities can create stronger, more equitable climate strategies that benefit everyone.

Public engagement for the SEAP+ provided information and transparency on the update process, incorporated public feedback into the plan, and built understanding and support for sustainability across the city.

> "The SEAP should more explicitly address resiliency, livability, heat, drought, and storm impacts."
>
> **-Charlotte resident, SEAP+ public survey**

The overall objectives of the SEAP+ public engagement framework were to:

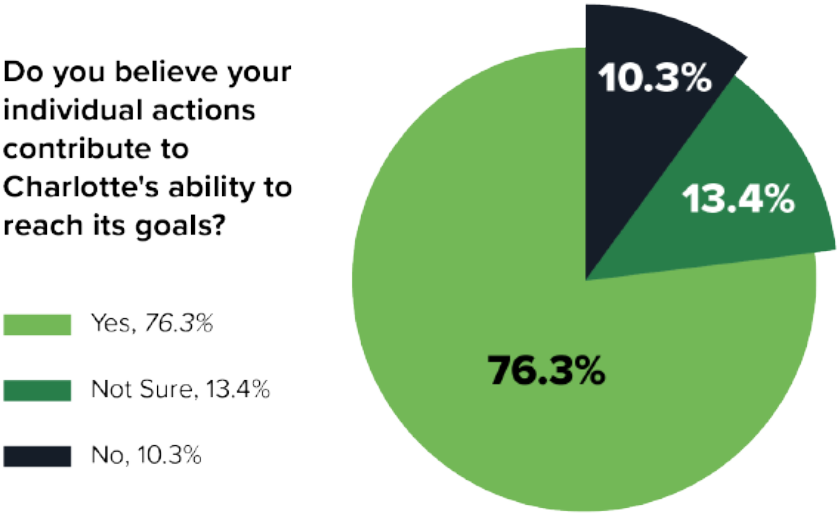
- Provide stakeholders with information about the current SEAP, relevant technical information, and key trends;
- Explain the overall SEAP update process, roles, and expectations, including how stakeholders can shape decisions;
- Reach out to and meaningfully engage stakeholders for this project;
- Gather input from key stakeholders on goals, actions, indicators of success, barriers and tradeoffs;
- Build understanding and support for the community's essential role in successfully advancing this plan; and
- Explain how stakeholder input and feedback is shaping the plan.

What we heard

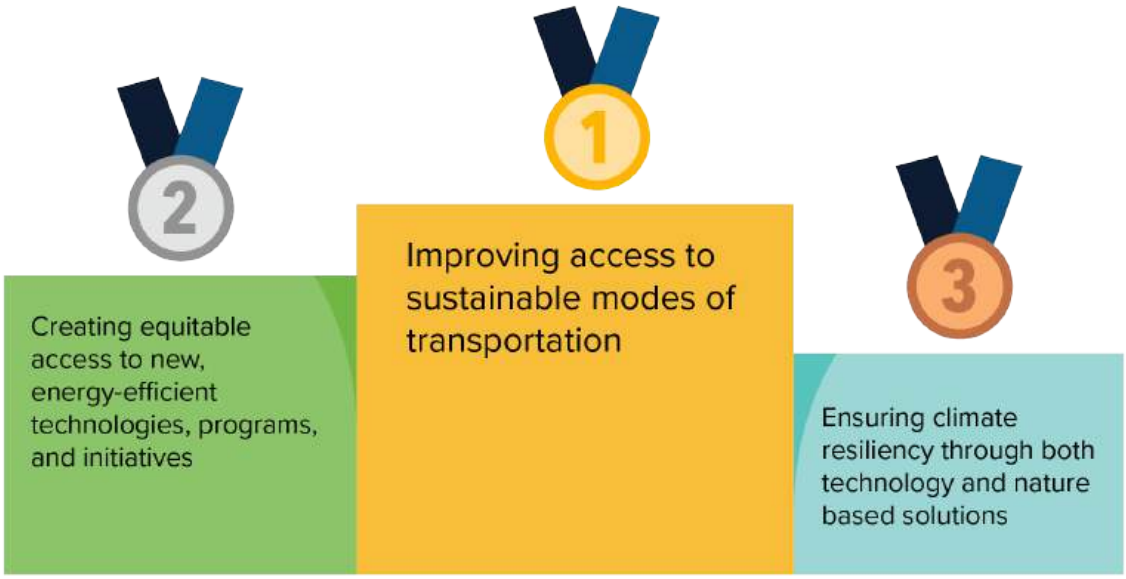
The public survey was an important vehicle for collection and summarization of public feedback on the SEAP+. It consisted of 22 questions asking Charlotte residents about a variety of topics including their familiarity with the SEAP and its focus areas, the actions they take at home or in their daily lives to promote sustainability, their concerns around climate change and extreme weather, and how they view the city's role in tackling challenges related to climate and sustainability.

Charlotte residents across generations (ranging in age from 18 to 65+) responded to the survey, as did residents of various backgrounds, with 31% minority community representation.

Do you believe your individual actions contribute to Charlotte's ability to reach its goals?



Which of these areas do you think the city should prioritize when considering revising action areas for a SEAP update?



Over 90% of respondents strongly agreed or agreed that the City of Charlotte has a role to play to promote sustainability for all residents.

67.3%
Strong Agree

23.7%
Agree

SEAP+ PUBLIC ENGAGEMENT

TIMELI

Oct 4, 2024
Buildings & Energy Generation TAC

Oct 4, 2024
Newsletter

Oct 5, 2024
Hola Festival & Unearthed Env. Justice Community Festival

Oct 21, 2024
Environmental Justice Town Hall

Oct 27, 2024
Biketoberfest

Nov 1, 2024
Newsletter

Sept 6, 2024
Buildings TAC

October – December 2024 | Public Survey
353 Respondents • 11,629 Responses • 464 Comments

Oct 8, 2024
Civic Leadership Academy

Oct 18, 2024
Transportation TAC

Nov 2, 2024
Meckleburg County Park and Recreation Fall Festival

10.28.24
SEAP Operations meeting with Charlotte Departments

NE

Technical Advisory Committee Meetings

Community Events

Newsletters

Public Events

SEAP Operations Team Meetings

Dec 6, 2024
Newsletter

Dec 10, 2024
Charlotte Mecklenburg Climate Leaders

Nov 21, 2024
SEAP Community Launch

Jan 13, 2025
SEAP Operations meeting with Charlotte Gov. Departments

Mar 6, 2025
SEAP Public Review Event

Nov 22, 2024
Goal Setting TAC

Dec 17, 2024
Newsletter

Feb 28, 2025
Review draft strategies TAC

Nov 8, 2024
Workforce Development and Climate Justice TAC

Dec 17, 2024
SEAP Virtual Workshop

II. Analysis and Goal Setting

Charlotte's GHG Inventory: Overview and Trends

In 2023, Charlotte produced 7,928,540 metric tons of CO_2e (greenhouse gas emissions), or about 8.7 metric tons per person.

These emissions come from energy used to power buildings, fuel burned in vehicles, and waste originating from the community. Tracking emissions helps Charlotte understand problem areas, set goals, and create plans to reduce pollution.

The city follows a global standard for measuring emissions, developed by experts in climate leadership. Charlotte calculated its GHG inventory using the Global Protocol for Community Scale Greenhouse Gas Emissions (GPC),[29] a leading framework for public sector GHG inventories, developed by the World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI Local Governments for Sustainability.

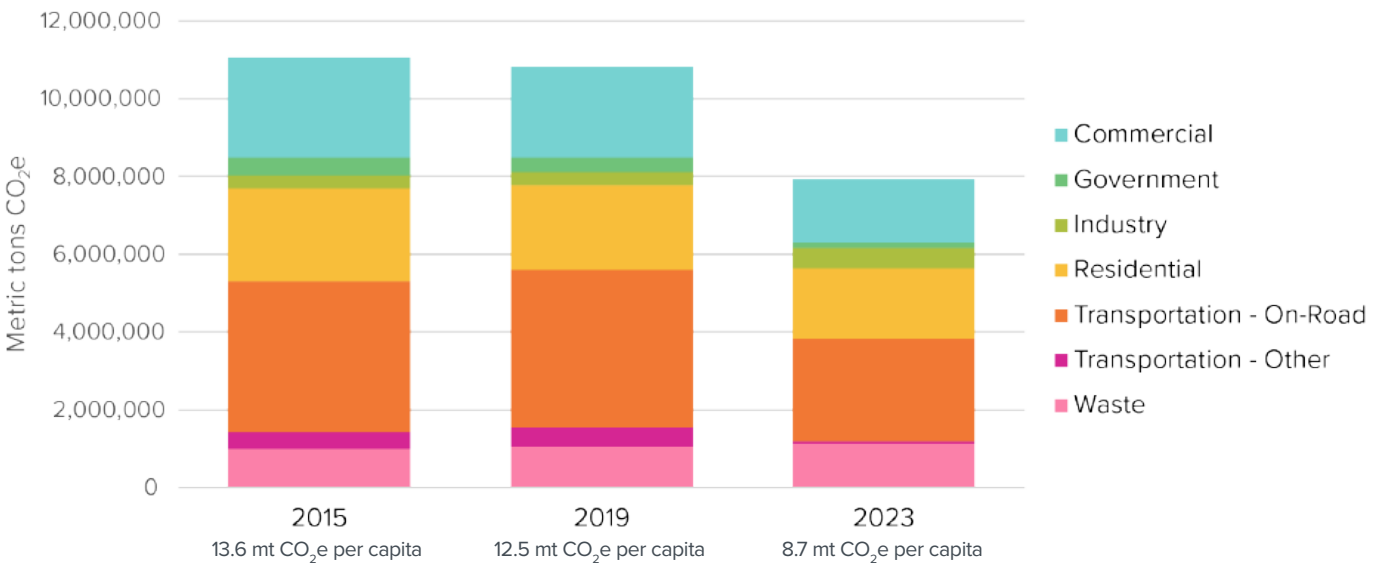
Transportation (on-road) is the largest emitting category, making up 33.3% of emissions, mostly from cars and trucks. Buildings are another major source, with homes contributing 22.7%, commercial buildings 20.5%, industry 6.8%, and government buildings 1.7%. Most building emissions come from using electricity and natural gas. Emissions from waste, including wastewater, makes up the remaining 14.4%.

Charlotte's GHG inventory is an important step toward emissions quantification and reduction. By first identifying emissions sources, the city can then target those areas with reduction measures and monitor progress over time, enabling better planning and more impactful strategies. In addition, an accurate GHG inventory is necessary to set a science-based goal.

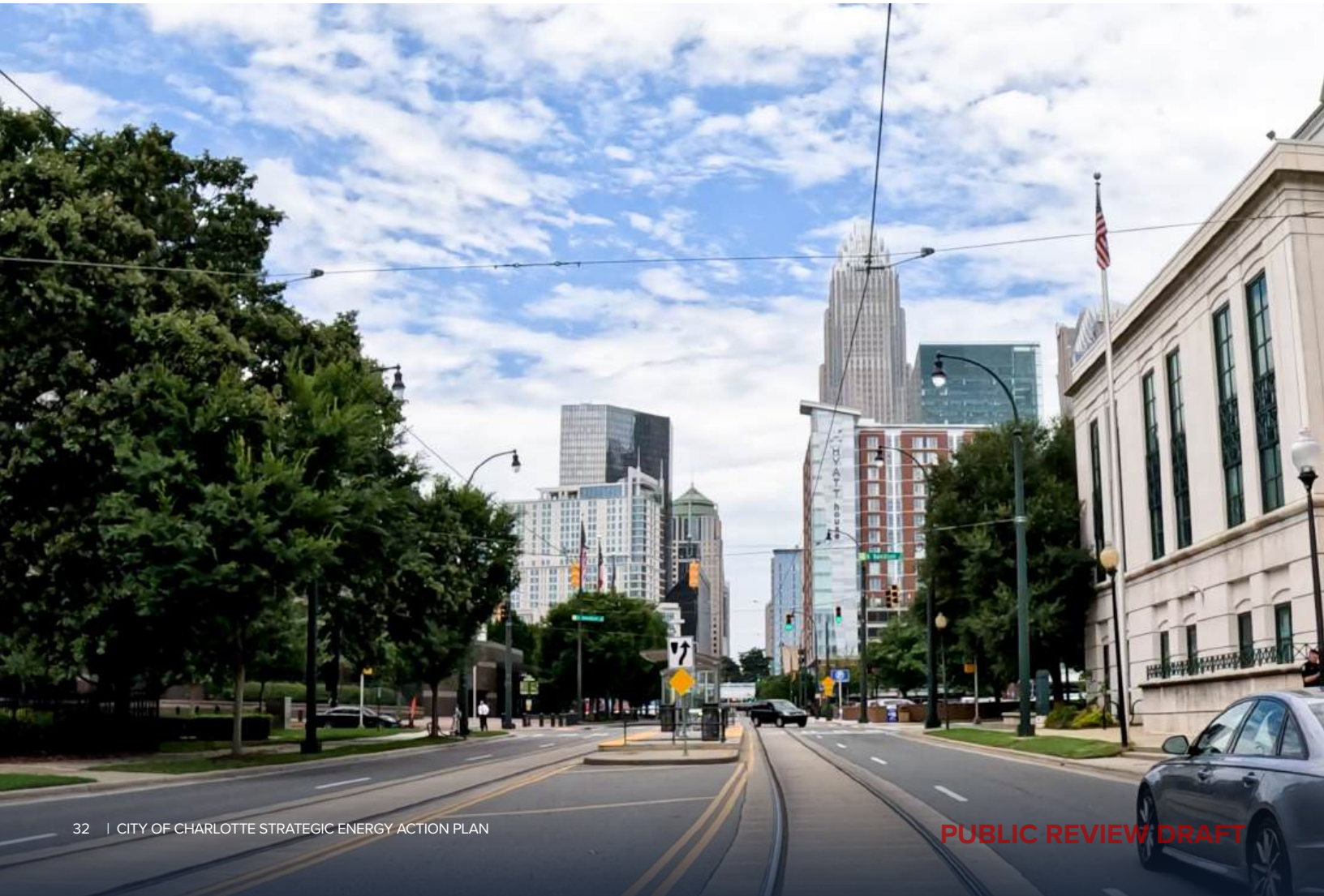
- This inventory is aligned to the Global Protocol for Community-Scale emissions and includes stationary energy, transportation, and waste.
- Per Capita GHG Emissions dropped by 30% 2019-2023.
- In 2023, Charlotte's emissions per person are lower than peer cities such as Raleigh, Nashville, Columbus, and Jacksonville.
- This reduction is in part attributable to improved methodologies across multiple sectors and a focus on using more accurate, complete, and local data.
- Other reasons for the decrease include a cleaner electric grid, energy efficiency initiatives like Power Down the Crown, more EV and hybrid vehicles, and more efficient vehicles overall.

If Charlotte and its residents continue to reduce emissions at this rate, Charlotte is on track to meet its science-based target by 2050 while still growing its population and economy.

Charlotte's 2023 emissions by reporting category



This chart shows Charlotte's community-wide emissions in 2015, 2019, and 2023. 2023 emissions decreased 26.7% from 2019 and 28.4% from 2015.



Climate Risk Assessment

Executive summary

This climate risk assessment serves as a blueprint for understanding and preparing for the climate challenges that may lie ahead for the City of Charlotte. Charlotte is expected to continue to grow as people move away from areas with more severe climate risks.[31]

This assessment explores new and existing climate-related challenges for Charlotte and identifies risks and, by examining these risks and their varied impacts across different areas in Charlotte, presents an opportunity to bolster the city's resilience and protect diverse communities from the unfolding realities of climate change.

For the full assessment, please see the appendix.

"I've lived in North Carolina for most of my life. I was in Charlotte during Hurricane Hugo. I feel like climate events are getting worse, not better. We've experienced two occasions last fall where we lost everything in our fridge and freezer during 8+ hour power outages cause by extreme thunderstorms. Our homeowner's insurance is good, but the loss of food was not covered and it happened twice that season."

- Charlotte resident

"The SEAP is an investment in our community, our residents, and our children. Thank you for acknowledging the impact of climate change on Charlotte and working to mitigate those risks in the future. We're counting on you and we believe in you."

- Charlotte resident

The SEAP+ climate risk assessment groups climate risks into three types: acute, chronic, and transition.

- Acute risks are sudden and severe events, like major storms, that can cause immediate harm.
- Chronic risks develop slowly over time and continue for years, such as rising average temperatures.
- Transition risks come from the challenges in moving toward a more sustainable, low carbon future. These challenges are influenced by new policies, market demands, and technology.

To understand possible future climate impacts, the assessment looks at two different scenarios—one with high warming and one with lower warming—based on current and future emissions levels.

Low Carbon Future	High Carbon Future
• Aligns with UN scenarios SSP1-RCP2.6 • Approximately 1.8°C (~3.2°F) of warming • Envisions a global transition toward sustainable development and reduced greenhouse gas emissions	• Aligns with UN scenarios SSP5-RCP8.5 • Approximately 4.3°C (~7.7°F) of warming • Reflects a continued reliance on carbon-emitting fuels and delayed climate action

Scenarios utilized for the climate risk assessment

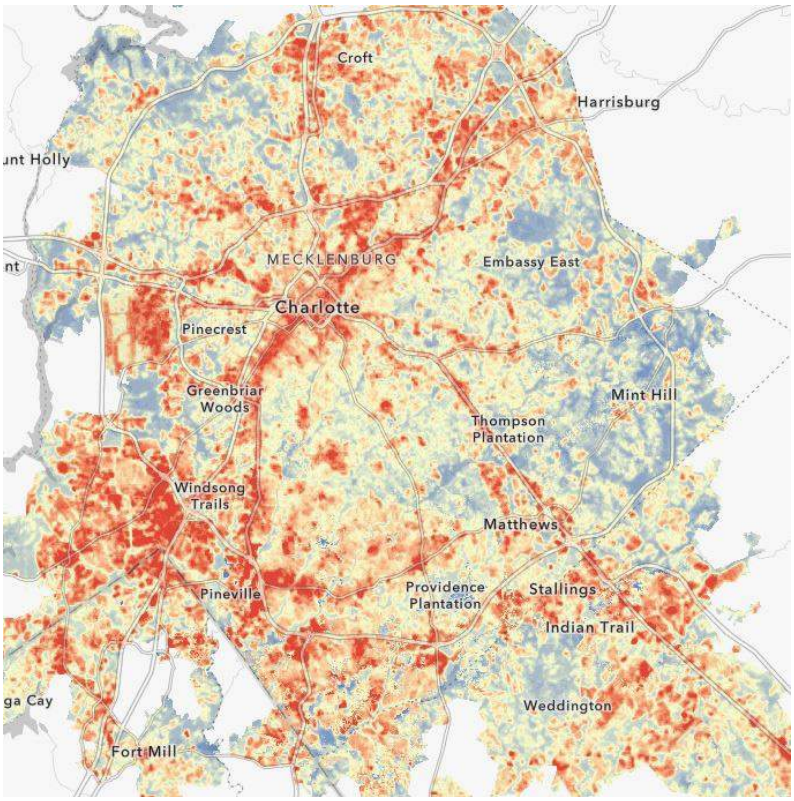
For Charlotte, the assessment identified four acute physical risks and four chronic physical risks and analyzed their potential impacts in both a low carbon and high carbon future.

Climate risk assessment results

Acute risks ("shocks")		Risk rating
Severe thunderstorms	In the past 5 years, North Carolina has seen a near doubling in the annual number of $1+ billion-dollar severe storm events and severe storms are projected to increase in both frequency and intensity.	***
Hurricanes/tropical cyclones	Since 2016, North Carolina has seen at least one, $1-billion-plus tropical cyclone event annually, with 2020 bringing four events.	**
Urban flooding	Charlotte is projected to see an increase between 10% and 20% in annual financial loss from flooding, including costs associated with damage to buildings, infrastructure, and residential homes by 2050.[31]	**
Wildfires	Though less of an immediate risk to Charlotte, wildfires in other regions of the state present potential indirect impacts such as air quality degradation and respiratory illness.	*
Chronic risks ("stressors")		
Extreme heat	By 2050, Charlotte is projected to see up to 48 days of extreme heat, or days above 95°F, which is more than double the current number of extreme heat days the city faces.	***
Drought	Currently, Charlotte has a low risk of drought,[32] but that is expected to increase in the future as the number of dry days increases by up to 1.7% by 2050.	**
Water stress	Based on the current data, water stress in Charlotte is projected to reach extremely high levels regardless of scenario by 2050.	***
Precipitation	Total annual precipitation is projected to increase by 4–5% in either of the potential future scenarios by 2050.	**

*Low; **Moderate; ***High

The Urban Heat Island Effect: Average Land Surface Temperature (°F) across Charlotte 2021 – 2023



The map depicts the urban heat island effect across the City of Charlotte. The urban heat island effect describes the phenomenon where developed areas experience higher temperatures due to the trapping of heat in surfaces like concrete and asphalt. More developed areas, like city centers, will experience higher average temperatures when compared to more suburban or rural areas that have higher concentrations of greenspace.

Summary of Results

Climate hazards often connect, like how a lack of rainfall can make ongoing water shortages worse. The analysis shows that extreme heat and severe thunderstorms are the biggest risks for Charlotte. These hazards will be even worse in a future with high global carbon emissions compared to one with lower global emissions.

Charlotte studied two major transition risks—economy and transportation—and found that fairness and accessibility must be part of future sustainability plans. As jobs shift toward clean energy, workers will need new skills, and their health and safety must be protected. In transportation, Charlotte aims to reduce dependence on single-passenger cars by improving public transit and promoting other ways to get around. Expanding electric vehicle (EV) use is also a priority, requiring more charging stations to meet state goals. These changes require early planning and investment to ensure a smooth and fair transition.

Climate change will affect residents differently based on where they live. Urban areas with lots of buildings and pavement will struggle with extreme heat, while parks and forests, which make up 47% of Charlotte's tree cover, help cool the city, reduce flooding, and protect the land. Each area needs its own strategies to help Charlotte prepare for climate change. For more detailed analysis, please see the Climate Risk Assessment Appendix.

This inaugural climate risk assessment is one decisive step closer to ensuring that Charlotte not only endures but thrives in the face of an uncertain future. The results of the analysis help the city to pinpoint specific risks, place types, and vulnerable populations that require attention for adaptation and mitigation efforts, laying the groundwork for a more sustainable and equitable future.

Charlotte's Goals

Charlotte has made significant progress in its transition to clean energy and sustainability. From expanding electric vehicle (EV) infrastructure to increasing solar capacity and improving energy efficiency programs, these efforts demonstrate the city's commitment to a more sustainable future. With over 200 EVs in the city fleet, nearly 1,000 charging ports available communitywide, and investments in renewable energy and efficiency programs, Charlotte is taking important steps toward reducing emissions and building resilience. As we look ahead, setting clear goals will help guide the next phase of action, ensuring continued progress toward a cleaner, more equitable, and climate-ready city.

The goal-setting process began with an analysis of data from the Greenhouse Gas (GHG) Emissions Inventory to track progress and assess the trajectory toward the original 2050 targets. A Climate Risk Assessment was conducted to ensure that emissions goals were grounded in the context of a changing climate and its local impacts. Input from the Office of Sustainability and Resilience, city leadership and subject matter experts, the Technical Advisory Committee, SEAP Ambassadors, and public feedback played a key role in determining priorities. Using methodology from the Science Based Targets initiative (SBTi), along with guidance from global GHG reporting organizations, peer cities, Duke Energy, and the Charlotte business community, helped shape goals that are both ambitious and achievable. Rather than setting goals first, a detailed analysis was conducted, allowing the goals to be developed step by step based on the findings.

Charlotte set its climate goals using well-respected global standards and processes:

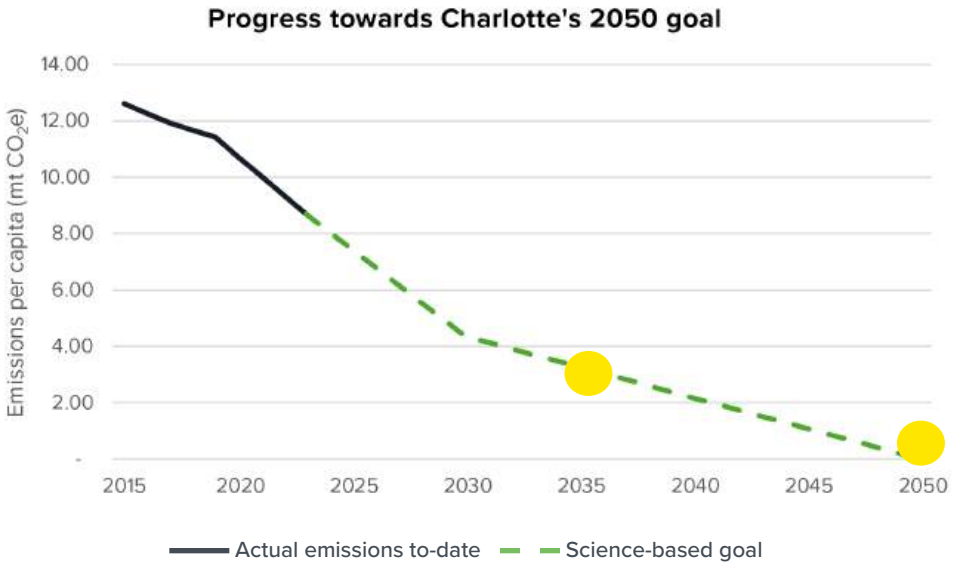
- The city followed guidance from organizations like CDP and the Global Covenant of Mayors for Climate and Energy, ensuring its goals align with international best practices.
- Charlotte used the WWF's One Planet City Challenge methodology, which has been used by 900 cities across 70 countries and is one of three methods accepted by CDP. This approach helps Charlotte aim for the highest "A" rating from CDP.
- The goals are science-based, meaning they align with the global target to limit warming to 1.5°C. To do this, emissions need to drop by about 50% by 2030 and reach net-zero by 2050.
- The targets are also fair, considering historical contributions and socioeconomic factors, and they include all major emission sources city-wide.
- By setting a science-based goal, Charlotte aligns its efforts with peer cities, Duke Energy, the North Carolina Utilities Commission (NCUC), North Carolina, the U.S., and the local business community.

Community-wide goals

A community-wide goal means that it applies to all of Charlotte – all of the energy, transportation, and waste emissions generated by all of its residents.

Charlotte's original community-wide carbon goal, set in the Sustainable and Resilient Charlotte by 2050[33] Resolution, was an ambitious goal to lower per capita emissions to below 2 tons of CO_2e per capita by 2050.

To align with the latest climate science, and to support its vision to lead as a global city, Charlotte has updated its original carbon goal to a more ambitious science-based goal:



This line graph shows Charlotte's GHG emissions to date and the projected change in annual emissions in order to reach the city's community-wide science-based goal. This projection maintains the city's current pace of emissions reduction through 2030, then takes a more conservative reduction approach to 2050.

Charlotte will reduce community-wide greenhouse gas emissions 72% by 2035 and achieve net-zero emissions by 2050.

Charlotte's climate goal had to meet strict standards to be recognized as science-based,[34] holding the city to a higher level of accountability. This means it follows the latest climate science, is fair by considering historical emissions and economic factors, and is comprehensive by including emissions from multiple sources. Charlotte's short-term target helps track progress toward net-zero by 2050.

Many peer cities have also set similar goals, making Charlotte's goal both ambitious and achievable while staying aligned with the science.

Peer cities' community-wide carbon goals

Peer city	Goals
Austin	Net-zero community-wide greenhouse gas emissions by 2040
Columbus	45% GHG reductions by 2030, 100% by 2050
Nashville	Reduce emissions (community-wide and Metro government) by 80% by 2050 compared to a 2014 baseline

In addition to the community-wide science-based goal, Charlotte has set a goal to increase distributed renewable energy throughout the city. This is an important additional driver toward reduced emissions which complements Duke Energy's goals.

600 MW of distributed renewable energy will be installed in Charlotte by 2035.

Municipal goals

Charlotte is working to lead by example by setting municipal goals, applicable to city government operations, to reduce emissions from its own buildings and vehicles. In 2018, the city set a goal to use 100% clean energy for its buildings and fleet by 2030. Since then, Charlotte has made progress by improving energy efficiency and switching to cleaner energy sources.

The city's Sustainable Facilities Policy helps lower energy use by requiring LEED certification, geothermal heat pumps, beneficial electrification, renewable energy, and upgrading the least efficient buildings.

Meanwhile, Charlotte is also making its fleet more eco-friendly. The Sustainable and Resilient Fleet Policy requires city departments to buy the lowest-emission vehicles available, which has helped increase the number of electric vehicles (EVs) in the fleet by 25% since 2022. In 2023 alone, Charlotte's fleet avoided 1,551 metric tons of CO_2 emissions – 43% more than the previous year.

The city is also using cleaner fuel options, such as compressed natural gas (CNG) trucks for waste collection and electric buses and light rail for public transit.

As the city reflects on successes and challenges, municipal goals have been updated to remain ambitious, while recognizing the changing landscape of this work:

The city will source 100% of its electricity use in municipal buildings from zero carbon sources by 2030 and reach net-zero emissions in municipal buildings by 2050.

The city will reach net-zero emissions in its light-duty fleet by 2035 and in its entire fleet by 2050.

III. Strategies and Implementation

SEAP+ Focus Areas

The City of Charlotte has identified four focus areas to organize initiatives in the SEAP+: buildings, energy generation, transportation, and cross-sectional. These focus areas touch on all of the city's material sources of emissions, as well as new information from the climate-risk assessment, and are based in large part upon the structure of the 2018 SEAP. Each of the four focus areas is composed of strategies that outline the broader objectives the city is working toward in each focus area. Each strategy, in turn, is composed of more detailed actions that describe specifically what the city plans on implementing to achieve its goals. The four focus areas are informed and supported by equity and workforce development, which are both key in evaluating implementation actions.

How to read this section

The SEAP+ is divided into four focus areas: buildings, energy generation, transportation, and cross-sectional, which address Charlotte's largest sources of emissions. Each focus area is composed of several overarching strategies, each of which contain more granular actions to help achieve the SEAP+'s goals.

Actions

The actions are the building blocks of the SEAP+. Each action describes an initiative that Charlotte will strive to implement in support of its associated strategy and focus area.

Co-benefits

In order to comprehensively assess the anticipated impacts of implementing the SEAP+, every action is evaluated on the following four co-benefits:

Emissions reduction potential: Does the action help lower or control emissions in a specific area or in the community?

Resilience and adaptation: Does the action help protect the community from extreme weather or reduce the negative effects of climate change, like power outages or property damage?

Workforce development: Does the action help grow the economy, create jobs, or support new industries?

Climate justice and equity: Does the action help reduce the unfair impacts of climate change?

Ratings

The actions are rated low, moderate, or high on each of the above four co-benefits based on the anticipated impact that action will have.

- High: The action directly helps achieve the co-benefit.
- Moderate: The action supports the co-benefit in an indirect way.
- Low: The action may not have a direct or indirection alignment with the co-benefit, but still helps the city's overall goals and mission.

The rationale for the ratings is provided in the Alignment column

Action					Alignment
Support and incentivize new non-residential buildings to be built to net-zero carbon standards					Improved building standards can significantly limit emissions over the entire life cycle of a building, reducing emissions from a major source in the city. These standards also bring resiliency and equity improvements for those who use the building and provide workforce opportunities through construction and maintenance.

Example action-evaluated (low, medium, high) across the four main categories of emissions reduction potential, resilience and adaptation, workforce development, and climate justice and equity.

Focus Area: Buildings

Buildings in Charlotte

Buildings in Charlotte—including homes, businesses, government offices, and industrial facilities—account for 51.7% of the city's total emissions:

- Residential buildings: 22.7%
- Commercial buildings: 20.5%
- Industrial buildings: 6.8%
- Government buildings: 1.7%

How Buildings Create Emissions

Buildings release emissions in two main ways:

- Direct emissions – Including burning fossil fuels like natural gas for heating, hot water, and cooking.
- Indirect emissions – Including using electricity, which is generated in part by burning fossil fuels.

Progress in Charlotte

Since 2019, building-related emissions have decreased by 21.5%, partly due to better data and tracking methods and also the implementation of sustainability measures citywide. Charlotte has already started taking steps to lower emissions through the 2018 Strategic Energy Action Plan (SEAP), including the following suite of measures:

- Retrofitting programs such as the High Energy Use Pilot program with Duke Energy;
- Outreach and accessibility programs to encourage progress, such as Power Down the Crown;
- New incentives in the Unified Development Ordinance (UDO) for private development;
- New building standards for city facilities through the Sustainable Facilities Policy, and
- Working with the NCUC and Duke Energy to lower the carbon intensity of the generation mix.

Buildings Strategies and Actions

Charlotte will pursue the following strategies and actions to reduce the impact of buildings:

Strategy 1:	**Source 100% of electricity use in municipal buildings from zero carbon sources by 2030 and reach net-zero emissions by 2050.**
Actions:	
1.1	Continue implementation of the Sustainable Facilities Policy and revise as needed to accomplish the SEAP+'s goals.
1.2	Continue to identify specific buildings to target for action.
1.3	Continue annual benchmarking of city facilities and rehabilitation for those buildings in the bottom quartile.
1.4	Continue to demonstrate leadership by seeking opportunities to innovate toward net-zero buildings.
Strategy 2:	**Transition residential buildings to be zero carbon by 2050.**
Actions:	
2.1	Develop an ongoing educational program on residential zero carbon opportunities.
2.2	Develop deep retrofitting demonstration sites illustrating net-zero energy levels.
2.3	Expand weatherization and efficiency programs for residential buildings.
2.4	Promote beneficial electrification of high-emissions appliances.
2.5	Influence the energy requirements of new residential buildings to be zero carbon.
2.6	Facilitate the development of a workforce pipeline of qualified workers trained in deep energy retrofits.
2.7	Support and promote utility, other governmental, nonprofit, and/or community-based organization programs that provide energy efficiency and renewable energy assistance, particularly for income qualified customers.
2.8	Support implementation of Sustainable Housing projects identified through the GreenPrints program.
Strategy 3:	**Transition non-residential (commercial & industrial) buildings to be zero carbon by 2050.**
Actions:	
3.1	Support and incentivize new non-residential buildings to be built to net-zero carbon standards.
3.2	Incorporate best energy practices, including financing options for energy efficiency and renewable energy projects, into developer outreach and communication.
3.3	Expand and incentivize the voluntary Power Down the Crown benchmarking program.
3.4	Support or incentivize the installation of renewables on commercial and industrial buildings.
3.5	Enable fast tracking of development projects that include clean energy measures, especially alongside affordable housing.
3.6	Facilitate the use of renewables and alternative fuels as sources for backup energy generation.
3.7	Support and promote utility, other governmental, nonprofit, and/or community-based organization programs that provide energy efficiency and renewable energy assistance.

Strategy 1: Source 100% of electricity use in municipal buildings from zero carbon sources by 2030 and reach net-zero emissions by 2050

Overview:

Charlotte's updated aspirational municipal buildings goal states that the city will source 100% of its electricity use in municipal buildings from zero carbon sources by 2030 and reach net-zero emissions by 2050. This strategy will reduce GHG emissions from the consumption of electricity and natural gas in municipal government buildings operated by the City of Charlotte.

Municipal buildings-related initiatives have included an outreach program to facility managers and staff on energy awareness and savings, professional energy management training, and continuous benchmarking of government buildings.

As part of ongoing SEAP+ implementation, the Sustainable Facilities Policy (SFP) is periodically reviewed to incorporate new technology, lessons learned, and to ensure alignment with SEAP goals. Last updated in 2024, the SFP focuses on the way the city constructs new buildings, completes major renovations, and operates and maintains city buildings. The most notable change in the 2024 SFP update is in the area of building decarbonization which includes requiring all new buildings to be powered exclusively by electricity (no direct combustion of carbon-emitting fuels). Since a previous policy revision in 2021, the city has added solar photovoltaics at 16 facilities and received LEED certification for an additional nine buildings. The city stands as an example to the community in helping to accelerate the transition to building electrification by identifying challenges and collaborative solutions.

Strategy 1 potential impacts

Emissions Reduction Potential: The City of Charlotte's municipal government buildings are responsible for a relatively small percentage of total community-wide emissions. However, the city has greater control to directly reduce government emissions, offering an opportunity to demonstrate leadership and effectively use resources.

Resilience and Adaptation: While the overall government building stock is small compared to residential and commercial buildings, updating government buildings to use zero carbon energy sources can provide resilience benefits of energy independence in some instances like installing rooftop solar and battery storage, allowing these facilities to operate even if the grid is down, and potentially offering places of refuge to citizens during extreme climate events.

Workforce Development: By setting an aggressive target of 2030, Charlotte is signaling demand for the workforce skills required for implementing zero carbon buildings and investment in sustainability across the government that may provide opportunities for skilled work and new training.

Climate Justice & Equity: Improvements to government buildings are not expected to materially impact climate justice and equity, but they support the overall goals and mission of the city.

The following actions support Strategy 1: Source 100% of electricity use in municipal buildings from zero carbon sources by 2030 and reach net-zero emissions by 2050.

Action					Alignment
1.1 Continue implementation of the Sustainable Facilities Policy and revise as needed to accomplish the SEAP+'s goals.					The Sustainable Facilities Policy targets municipal buildings, making them more resilient to climate-related events and driving down emissions. The policy is not expected to drive major workforce or equity opportunities.
1.2 Continue to identify specific building targets for action.					This ongoing process targets the lowest-performing municipal buildings, helping to maximize emissions reductions and resiliency improvements while also providing workforce opportunities. As with Strategy 1 overall, the equity benefits are limited for government buildings.
1.3 Continue annual benchmarking of city facilities and rehabilitation for those buildings in the bottom quartile.					Benchmarking allows for targeted emissions reduction work opportunities, which often has resiliency benefits as well. Since it specifically benchmarks municipal facilities, this action does not have major equity implications.
1.4 Continue to demonstrate leadership by seeking opportunities to innovate toward net-zero buildings.					Net-zero buildings would produce no emissions, representing a major emissions reduction opportunity and indirect resiliency improvements. New construction would also bring workforce opportunities. This municipal construction would not likely impact climate jutice and equity.

Low
Med
High

Strategy 2: Transition residential buildings to be zero carbon by 2050

Overview:

In 2023, Charlotte's homes and apartment buildings made up about 23% (1,801,284 metric tons of CO_2e) of the city's total emissions because they use natural gas and electricity.

There are several ways to lower these emissions:

Upgrading buildings: Older buildings can be retrofitted to use less energy. This might include air sealing, adding insulation, better windows, or other improvements. However, making these changes in older buildings is usually harder and more expensive than doing so in new buildings. It also means working with many different people like homeowners, landlords, and business owners, and the work can affect people who live or work there.

Electrification: This means changing systems like heating, water heaters, and appliances to run on electricity instead of natural gas. This can help reduce pollution, but it only works well if the electricity itself is made in a cleaner way.

Charlotte is working to reduce pollution with programs like GreenPrints, an environmental justice focused action plan for the Corridors of Opportunity, and the High Energy Usage Assistance program (in partnership with Duke Energy). These programs teach people how to save energy and help make home improvements more affordable, especially in households where energy costs are disproportionately high.

For new buildings, changes in policies—like offering incentives for clean energy projects—can also help lower emissions. For example, Charlotte's Unified Development Ordinance encourages clean energy projects in affordable housing.

Strategy 2 potential impacts

Emissions Reduction Potential: Residential buildings made up 22.7% of the 2023 GHG inventory, a major component of Charlotte's total emissions. Established strategies, such as retrofitting and electrification, and new policies can make large reductions in residential buildings which in turn can have a sizable impact on community-wide GHG emissions.

Resilience and Adaptation: Strategies like weatherization, energy retrofits and beneficial electrification for residential buildings may improve resilience to extreme weather and climate events, due to reduced energy costs for heating/cooling and appliance usage, building materials that hold in heat/air as needed, and materials that hold up better to severe thunderstorms.

Workforce Development: With Charlotte's population expected to grow through 2050, there is a large volume of building work (examples identified in the action areas below) that would benefit from a variety of skill sets.

Climate Justice & Equity: Weatherization and retrofit programs target existing building stock and often prioritize older residential buildings. These programs can improve resilience, decrease energy burden, and provide healthier living circumstances for disadvantaged communities and can make the benefits of these programs more equitable and widespread across the city. While residential building decarbonization can have a profound and positive impact on climate justice and equity, the city must ensure that safeguards are in place so that people can readily access these programs and are not turned away due to cost.

The following actions support Strategy 2: Transition residential buildings to be zero carbon by 2050.

Action					Alignment
2.1 Develop an ongoing educational program on residential zero carbon opportunities.					Spreading awareness of projects, such as the Duke High Energy Usage Assistance Program, highlights employment opportunities in the associated workforce, as well as supporting improvements for income-qualified housing, leading to reductions in energy burden. While emissions reductions, resiliency, and climate justice are not direct co-benefits, they will all benefit by sharing information broadly and supporting growth in this emerging sector.
2.2 Develop deep retrofitting demonstration sites illustrating net-zero energy levels.					Demonstration sites offer the ability for the public and industry specialists to see what is possible, directly affecting emissions reductions and improving resiliency of buildings. Showcasing this indirectly supports the desire for these skills in our area and could lead to new standards of building throughout Charlotte, including affordable housing sites.
2.3 Expand weatherization and efficiency programs for residential buildings.					Weatherization and efficiency programs can make buildings more resistant to climate hazards and provide an ongoing stream of work. In addition, they can drive down emissions from buildings, which are a major emissions source, and can benefit city residents equitably.
2.4 Promote beneficial electrification of high-emissions equipment.					Electrifying high-emissions appliances can reduce dependence on fossil fuel. This work requires trained technicians, providing workforce development opportunities.
2.5 Influence the energy requirements of new residential buildings to be zero carbon.					By collaborating with policymakers and developers, Charlotte can help influence the energy standards of new buildings reducing their lifetime emissions. New construction standards can also drive resiliency and equity opportunities such as efficient appliances while also providing workforce opportunities across the city.
2.6 Facilitate the development of a workforce pipeline of qualified workers trained in deep energy retrofits.					Retrofitting can benefit much of Charlotte's existing building stock, necessitating a larger workforce trained in energy retrofits to implement the program broadly, enhancing sustainability and resilience in the process.
2.7 Support and promote utility, other governmental, nonprofit, and/or community-based organization programs that provide energy efficiency and renewable energy assistance, particularly for income qualified customers.					This action specifically targets income qualified customers and emphasizes equity. The content of these programs can support emissions reductions and climate resiliency through education and assistance. These programs also bring some workforce opportunities for outreach and technical professionals.
2.8 Support implementation of Sustainable Housing projects identified through the Corridors of Opportunity GreenPrints initiative.					Sustainable housing projects can reduce emissions from electricity and fuel consumption while also being built to withstand future climate events. Construction projects can be tailored to support workforce development.

Low
Med
High

Strategy 3: Transition non-residential (commercial & industrial) buildings to be zero carbon by 2050

Overview:

Emissions from commercial and industrial buildings, like offices, stores, factories, and power plants, make up almost 27% of Charlotte's total emissions. To reduce emissions, both old and new buildings need to be improved. Many commercial and industrial buildings have different owners, so it's important for business leaders to take charge. Building emissions can be reduced by making the buildings more energy-efficient, switching to electricity for heating and cooling, and using renewable energy on-site.

Over time, emissions from electricity use are expected to drop as Duke Energy, the city's electricity provider, moves to cleaner energy sources.

New building policies encourage energy efficiency and renewable energy. For example, the Unified Development Ordinance (UDO) includes incentives for sustainable practices in new construction. Reducing emissions in commercial and industrial buildings is important for these buildings' resilience, as they can benefit from upgrades that make them less affected by climate risks. It can also create job opportunities in the city. However, it's important that everyone, including small and lower-income business owners, benefits from these changes.

Just as with houses, both old and new commercial buildings need improvements to lower emissions. Because many different people own these buildings, it's important for businesses and property owners to work together. Some ways to reduce pollution include:

- Stricter Building Standards: New buildings can be built to use less energy, and old buildings can be updated (or "retrofitted") to be more efficient.
- Electrification: Switching systems like heating and cooling to run on electricity can help, especially as our power company moves toward cleaner energy.
- On-Site Renewable Energy: Adding things like solar panels on the building can generate clean energy.

Strategy 3 potential impacts

Emissions Reduction Potential: Charlotte's commercial and industrial buildings together made up 27.3% of the 2023 GHG inventory, representing a large opportunity for Charlotte to target and reduce emissions.

Resilience and Adaptation: While residential buildings and essential services are often the highest priorities for resilience and adaptation improvements, commercial and industrial buildings can benefit from these improvements as well, strengthening services and businesses and Charlotte's economy at large. For instance, more resilient water and energy utilities are better able to serve communities despite climate risks.

Workforce Development: Charlotte has a large base of commercial and industrial buildings that could provide work opportunities for sustainable improvements.

Climate Justice & Equity: Transitioning C&I buildings with intention can ensure benefits are equitably distributed among all business owners.

The following actions support Strategy 3: Transition non-residential (commercial & industrial) buildings to be zero carbon by 2050.

Action					Alignment
3.1 Support and incentivize new non-residential buildings to be built to net-zero carbon standards.					Improved building standards can significantly limit emissions over the entire life cycle of a building, reducing emissions from a major source in the city. These standards also bring resiliency and equity improvements for those who use the building and provide workforce opportunities through construction and maintenance.
3.2 Incorporate best energy practices, including financing options for energy efficiency and renewable energy projects, into developer outreach and communication.					By working with developers, Charlotte can influence existing and new construction to drive down emissions over time and create new work opportunities. Energy efficiency and related projects can make buildings more resilient to climate-related disruptions and drive down energy costs, supporting the city's equity focus.
3.3 Expand and incentivize the voluntary Power Down the Crown benchmarking program.					Benchmarking is proven to lower emissions in commercial and industrial buildings, which also brings resiliency improvements. This work indirectly necessitates some workforce opportunities and benefits any populations that use the participating buildings.
3.4 Support or incentivize the installation of renewables on commercial and industrial buildings.					Besides lowering emissions, renewables provide a variety of benefits including enhanced resilience and reliability for commercial and industrial buildings across the city. Installing renewables also provides workforce opportunities.
3.5 Enable fast tracking of development projects that include clean energy measures, especially alongside affordable housing.					Incentivizing buildings to align with sustainable standards can help drive work related to emissions reduction and resiliency improvements, while making sustainable improvements more accessible for commercial and industrial building owners.
3.6 Facilitate the use of renewables and alternative fuels as sources for backup energy generation.					Using renewables or alternative fuels as backup fuel sources in case of supply disruptions or emergencies would strengthen Charlotte's climate resilience. This work would drive emissions reduction and workforce opportunities indirectly.
3.7 Support and promote utility, other governmental, nonprofit, and/or community-based organization programs that provide energy efficiency and renewable energy assistance.					These programs are designed specifically to reduce emissions and improve resiliency through improvements to energy efficiency and renewables installation. This provides work opportunities and, due to the breadth of the action and the programs it supports, can benefit a wide variety of commercial and industrial buildings.

Low
Med
High

Focus Area: Energy Generation

Energy generation in Charlotte

The energy consumed across Charlotte by buildings or public services is primarily generated and distributed by the city's utilities and consumed as either electricity or natural gas. Approximately 66% of the city's energy emissions comes from electricity, and approximately 34% comes from natural gas. The energy generation focus area is closely tied to the buildings focus area, where most of this energy is consumed. While the buildings focus area covers topics such as efficiency and retrofits, the energy generation focus area targets the city's energy infrastructure to support generation improvements or the development of new energy sources such as renewable energy.

Charlotte is working to reduce carbon emissions from the energy used in homes, businesses, and public services like street lighting by also looking at how energy is generated. The city aims for net-zero carbon emissions from electricity by 2050, aligning with Duke Energy's goals. By 2035, Charlotte aims to have 600 MW of local renewable energy installed communitywide, like solar panels on homes, businesses, and city buildings, to cut emissions and promote clean energy investment.

Most of Charlotte's electricity comes from Duke Energy, which generates power from coal, oil, natural gas, nuclear, and renewable sources like solar and hydro. To reach net-zero, fossil fuels will need to be replaced with zero carbon options such as nuclear and renewable energy sources. Piedmont Natural Gas (PNG) supplies natural gas, and is working to achieve net-zero methane emissions by 2030 by reducing leaks.

The city, as an organization, is working with Duke Energy, the North Carolina Utilities Commission, and PNG to accelerate clean energy, including solar panels, community solar projects, and energy storage. These efforts will help Charlotte meet its sustainability goals and reduce emissions from energy use.

In 2023, Charlotte had 3,900 residential solar photovoltac (PV) systems and 114 commercial solar PV systems which totals approximately 37 MW of solar photovoltaic capacity. This represents major progress in distributed energy generation in Charlotte.

Energy Generation Strategies and Actions

Charlotte will pursue the following strategies and actions to reduce emissions from energy generation:

Strategy 4:	**Reach net-zero emissions from electricity generation by 2050.**
Actions: 4.1 Support renewable energy opportunities for different customer types and levels of renewable integration. 4.2 Implement Green Source Advantage or other large scale renewable utility program(s). 4.3 Develop approaches to using biogas from landfills and wastewater. 4.4 Support other carbon free forms of energy generation in Charlotte. 4.5 Continue working with Duke Energy, the NC Utilities Commission, and other regional partners to support the timely transition to net-zero carbon electricity generation.	
Strategy 5:	**Strive toward 600 MW of distributed renewable energy generation in Charlotte.**
Actions: 5.1 Incentivize residential and commercial solar. 5.2 Continue to integrate renewables at all municipal buildings in alignment with the Sustainable Facilities Policy. 5.3 Identify new zero carbon energy technologies/processes/opportunities.	
Strategy 6:	**Develop a suite of educational tools.**
Actions: 6.1 Develop tools for residents and businesses to understand carbon emissions resulting from their utility use. 6.2 Work to educate the public on when electricity is cleaner and the benefits of shifting use to when CO_2 is lower. 6.3 Connect to resources, and encourage training, on demand-side management. 6.4 Create demonstration site(s). 6.5 Provide and support training and events on alternative technologies. 6.6 Facilitate the development of a workforce pipeline of qualified workers trained in distributed renewables installation. 6.7 Work to develop a suite of educational tools for commercial and industrial properties on the financial benefits of renewable energy.	

Strategy 4: Reach net-zero emissions from electricity generation by 2050

Overview:

Charlotte is aligned with state and utility sustainability targets, including:

- Duke Energy's goals[35] to reach net-zero carbon emissions from electricity generation by 2050, with interim goals of 50% reduction by 2030 and 80% reduction by 2040, from a 2005 baseline
- North Carolina and the North Carolina Utility Commission's (NCUC) statewide goals, laid out in HB951[36] and the Carbon Plan,[37] to achieve a 70% reduction in emissions of carbon dioxide (CO_2) emitted in the State from electric generating facilities owned or operated by electric public utilities from 2005 levels by the year 2030 and carbon neutrality by the year 2050

Charlotte supports these goals and aims to do its part through the actions and strategies in the SEAP+.

Charlotte's electricity generation emissions are reliant to a large degree on Duke Energy, the sole electric utility provider in the city. Charlotte and Duke Energy have signed a Memorandum of Understanding[38] affirming their shared commitment to the city's emissions goal. As of 2023, Duke Energy has achieved a 48% reduction[39] by reducing oil and coal in the generation mix and replacing it with lower emissions fuels such as natural gas and zero carbon energy sources such as nuclear and renewables such as solar. Today, Charlotte's electricity is almost 60% carbon-free.

A 48% reduction in emissions is an impactful and major step toward achieving their interim goal of 50% emissions reductions by 2030, however, Duke Energy's continued actions to transform its energy mix is essential to reach net-zero emissions from electricity generation. This is a long-term process and depends on continuous progress: Duke Energy plans to retire coal generation by 2035[40] and continue introducing new generation resources such as wind, solar, hydrogen, renewable natural gas, and advanced nuclear technologies.

One action established – and ongoing – from the 2018 SEAP is advancing renewable energy opportunities. The Green Source Advantage (GSA) program was established in 2017 and provides the opportunity for large industrial and commercial customers, including the City of Charlotte, to procure renewable energy. This type of program helps Duke Energy to gradually transition its electricity supply while also providing greater consumer choice.

This overarching strategy is especially important for Charlotte because, as an expanding city, electricity demand is expected to grow. By reducing the emissions of the generation mix of grid-supplied electricity, Charlotte can continue to grow its population and economy while achieving its sustainability goals. Charlotte will continue to partner with Duke Energy to monitor progress toward its goals.

Strategy 4 potential impacts

Emissions Reduction Potential: Electricity generation impacts all grid-supplied electricity in Charlotte, including electricity use in buildings and transportation. Electricity consumption in buildings makes up 33.9% of total community-wide emissions, making it a major priority for emissions reductions.

Resilience and Adaptation: Investing in additional renewable energy generation capacity may help to strengthen the region's resilience towards supply chain disruptions and extreme climate events.

Workforce Development: North Carolina's clean energy workforce[41] grew at a faster pace (4.2%) than the state's overall employment (2.5%) in 2023, and Mecklenburg County is one of the top 30 counties for clean jobs in the country. Further investment by government and businesses is expected to strengthen these opportunities for workforce development, creating well paying and reliable jobs for Charlotteans.

Climate Justice & Equity: Transforming Charlotte's electric grid is expected to make clean energy more accessible to all Charlotteans, including those who cannot afford or are unable to install their own distributed energy resources. A cleaner electricity grid can also have positive public health implications. The energy transition can alleviate and decrease the energy burden.

The following actions support Strategy 4: Reach net-zero emissions from electricity generation by 2050.

Action					Alignment
4.1 Support renewable energy opportunities for different customer types and levels of renewable integration.					Providing more visibility and choice for Charlotteans in their energy supply could help drive down emissions without impacting prices for all consumers. Increased interest in and adoption of renewable energy, which can include resiliency benefits, would also create more job opportunities.
4.2 Implement Green Source Advantage or other large scale renewable utility program(s).					Municipal energy tariffs can demonstrate leadership and drive down regional emissions. Direct workforce and equity benefits are limited given this is a targeted policy change.
4.3 Develop approaches to using biogas from landfills and wastewater.					Leveraging biogas allows Charlotte to generate energy without increased dependence on fossil fuels. This can enhance resilience and self-sufficiency while making a sustainable and affordable energy source available.
4.4 Support other carbon free forms of energy generation in Charlotte.					Carbon-free energy such as distributed renewables can be a reliable source of emissions in the face of climate hazards and, at scale, can provide significant workforce opportunities and energy output. It also could remove a major source of emissions and make energy more accessible for all populations.
4.5 Continue working with Duke Energy, the NC Utilities Commission, and other regional partners to support the timely transition to net-zero carbon electricity generation.					The transition to net-zero electricity has major implications for emissions reduction and climate resiliency, and the transition and maintenance of the utilities infrastructure will bring significant workforce implications. This action stands to benefit all Charlotteans.

Low
Med
High

Strategy 5: Strive toward 600 MW of distributed renewable energy generation in Charlotte

Overview:

Charlotte has set a goal to reach 600 MW of distributed renewable energy by 2035, of which a major portion is expected to be rooftop solar.

Renewable energy can come in different forms, and Charlotte has evaluated and invested in multiple approaches. For instance, the city has invested in alternative energy sources such as biogas generated from wastewater at the McAlpine Creek wastewater treatment plant. By capturing and combusting this biogas, the city can generate heat and energy from a sustainable source. Solar arrays can be installed on rooftops of buildings and community solar arrays can provide power to larger communities.

Charlotte has demonstrated success[42] expanding its solar capacity, seeing a 225% increase in community-wide solar PV capacity from when the SEAP was adopted in 2018 to 2023, and a 59% increase just from 2022 to 2023 alone. This includes municipally-owned solar systems[43] and residential and commercial solar PV systems, which together can lower long-term energy costs, reduce emissions, and demonstrate sustainable leadership.

Strategy 5 potential impacts

Emissions Reduction Potential: Renewable energy is zero carbon, so replacing grid-supplied energy or other types of energy generation with renewables stands to make a major difference. A large portion of Charlotte's emissions in 2023 came from buildings, and these could be driven down significantly with additional distributed renewable energy installations.

Resilience and Adaptation: Distributed renewable energy resources can make energy generation and access more reliable in the face of disruptions or climate events. For instance, rooftop solar and battery storage can support electricity generation even when the larger electric grid is disrupted.

Workforce Development: Building new sites for energy generation, retrofitting existing buildings or developing new construction to function with renewables, and managing these new installations are all major opportunities for workforce development in Charlotte.

Climate Justice & Equity: Certain actions under this strategy focuses on Corridors of Opportunity to provide benefits to disadvantaged groups. Co-benefits from renewable energy can also include public health impacts, such as improved respiratory health due to reduced air pollution from fuel combustion, benefiting those living in areas with low air quality. While there are potential financial impacts like decreased utility bills, barriers such as high upfront capital costs and unsuitable roofs will need to be proactively addressed – for example through policy or grant funding – to ensure that all Charlotteans can access the benefits of distributed renewable energy.

The following actions support Strategy 5: Strive toward 600 MW of distributed renewable energy generation in Charlotte.

Action					Alignment
5.1 Incentivize residential and commercial solar.	High	Med	High	Med	Installing more solar PV systems across Charlotte will significantly offset emissions from energy generation and provide more sustainable and resilient energy to homes and businesses, especially with incentives offsetting costs. Further investment will provide additional workforce opportunities.
5.2 Continue to integrate renewables at all municipal buildings in alignment with the Sustainable Facilities Policy.	High	Med	High	Low	Solar installations can significantly reduce emissions from energy use in municipal buildings and provide job opportunities in the process. These installations may also have resiliency benefits, though they do not specifically address climate justice and equity.
5.3 Identify new zero carbon energy technologies/ processes/opportunities.	Med	Med	Med	High	New projects will provide work opportunities and can benefit disadvantaged areas specifically. Several projects have been identified, including solar-powered charging stations, and modular energy storage, which have emissions reduction and resiliency components.

Low
Med
High

Strategy 6: Develop a suite of educational tools

Overview:

As Charlotte pursues cleaner energy generation, the city will also support outreach to the community to help residents and businesses to make informed energy choices. Energy generation can seem invisible to the average consumer, who uses energy in the course of their day but does not see how that energy is generated. The 2018 SEAP, and this update, include several actions to improve understanding and accessibility.

This strategy includes actions developing tools to help residents and businesses understand the carbon emissions resulting from their utility use and educating the public on when electricity is cleaner. These actions may individually be small, but they serve to bring energy generation to the forefront of Charlotteans' minds. Charlotte has also promoted more tangible opportunities for education, for instance, the Innovation Barn,[44] located on Seigle Ave., is designed to showcase circular practices.

Besides its bearing on Charlotte's sustainability goals, energy generation has important economic implications for residents and businesses, making it an important topic for the public to be aware of. These educational tools can help residents better understand and control their energy and foster a community-wide culture of environmental stewardship.

Strategy 6 potential impacts

Emissions Reduction Potential: Educational tools can indirectly impact emissions reductions and are expected to drive further interest in renewables and advocacy.

Resilience and Adaptation: Education and outreach is not expected to directly impact resilience but may lead participants to investing in energy generation and resilience improvements.

Workforce Development: These actions are designed to inform the public and could contribute to broader energy generation training programs. In addition, each action could necessitate additional work and possibly jobs in the fields of public outreach, education, and data management.

Climate Justice & Equity: Charlotte's outreach will target all regions of the city, including direct and intentional outreach.

The following actions support Strategy 6: Develop a suite of educational tools.

Action					Alignment
6.1 Develop tools for residents and businesses to understand carbon emissions resulting from their utility use.					Improving visibility and understanding around sustainability may help households and businesses to drive down emissions, especially in areas with outdated infrastructure. This may indirectly bring resiliency or workforce development opportunities.
6.2 Work to educate the public on when electricity is cleaner and the benefits of shifting use to when CO_2e is lower.					Educational programs can help to drive down emissions by reducing or shifting energy usage, especially in areas with outdated infrastructure. This work may support workforce opportunities and overall climate resiliency.
6.3 Connect to resources, and encourage training, on demand-side management.					Demand side management can have significant impacts on energy costs while also supporting emission reduction and resilience. Increased demand for these programs may bring about additional job opportunities.
6.4 Create demonstration site(s).					Demonstration sites are strong educational tools and provide workforce opportunities. They can expose residents to emissions reduction and resilience topics, indirectly helping address these priorities.
6.5 Provide and support training and events on alternative technologies.					Training and events can help to lower the barrier to entry for new technologies, making renewables, monitoring tools, or other technology more accessible and impactful while creating workforce opportunities. Residents can then apply this knowledge to make emissions reduction and resilience improvements.
6.6 Facilitate the development of a workforce pipeline of qualified workers trained in distributed renewables installation.					Workforce expertise can be a bottleneck when transitioning to more renewables, providing an opportunity for workforce upskilling and expansion and further investment in renewables.
6.7 Work to develop a suite of educational tools for commercial and industrial properties on the financial benefits of renewable energy.					Educational tools can support commercial and industrial building owners, especially those with limited resources such as local small businesses, to understand and install renewable energy. These improvements can drive emissions reduction and resilience and create workforce development opportunities in installation and maintenance.

Low
Med
High

Focus Area: Transportation

Transportation in Charlotte

Transportation GHG emissions are produced directly by the use of fuel or indirectly by the use of grid-supplied electricity. Charlotte is working to reduce transportation emissions, which accounted for 2,689,440 mt CO_2e, or 33.9% of the city's emissions total, and include off-road, rail, and air occurring within the city.

- 75% of transportation emissions are from internal combustion passenger cars and light-duty trucks.
- 22% of transportation emissions are from medium- and heavy-duty trucks.
- Railways, hybrid passenger cars, off-road transportation, and motorcycles account for the remaining 3%.

Since 2019, on-road transportation emissions have dropped by 35%, partly due to more electric and fuel-efficient vehicles.

Progress in Charlotte

Electrification & Clean Energy

Charlotte is gradually electrifying its municipal fleet and has funded 330 EV charging ports across the city. The goal is to have net-zero emissions in the municipal light-duty fleet by 2035 and the entire fleet by 2050. To date, the city has 207 light-duty EVs, 67 hybrids, and 43 compressed natural gas vehicles, along with its first electric semi-truck in service. Charlotte was also recognized as the 6th Greenest Fleet by the National Association of Fleet Administrators (NAFA). The city is leading by example with projects like an all-electric fire station including its first electric fire truck. However EVs are only part of the solution for a growing city because they indirectly contribute to emissions through electricity generation. It is also important to consider the impact of the extraction of resources during this transition. That's why Charlotte is also partnering with Duke Energy and the NCUC to increase zero-carbon energy sources.

Expanding Transportation Options

Reducing emissions also means shifting away from single-occupancy vehicles (SOVs) and making public transit, biking, and walking more accessible. In 2022, 76.6% of Charlotteans drove alone to work. The city's Strategic Mobility Plan (SMP) sets a 2040 aspiration so that "as a community, half of our commute trips will be made by means other than a single-occupancy vehicle, through walking, biking, and taking transit." As Charlotte's commuting population is expected to exceed 1 million by 2045, these shifts will help ease traffic congestion and lower transportation costs.

Efforts to accelerate Strategic Investment Areas and transit projects focused on sustainable modes of transportation are a key component to address the overall landscape. The city is also investing in Transit-Oriented Development (TOD), improving zero carbon mobility options, and increasing charging access to encourage cleaner transportation. These initiatives align with Charlotte's 2040 Comprehensive Plan and SEAP+ update, ensuring a safe, connected, and sustainable transportation network for the future.

Transportation Strategies and Actions

Charlotte will pursue the following strategies and actions to reduce the environmental impact from transportation:

Strategy 7:	**Reach net-zero emissions in municipal light-duty fleet by 2035 and in the entire fleet by 2050.**
Actions: 7.1 Continue implementing and updating the Sustainable & Resilient Fleet Policy to align with the goals of the SEAP+. 7.2 Develop a decision matrix to inform right-sizing and typing of the fleet. 7.3 Complete installation of a standardized telematics system across the city's entire vehicle fleet. 7.4 Educate and train staff on new technology and eco-driving. 7.5 Develop a Fleet Transition Plan. 7.6 Seek to pilot zero carbon vehicles when new technologies become available.	
Strategy 8:	**Support reaching a 50-50 mode share by 2040, per the Strategic Mobility Plan (SMP).**
Actions: 8.1 Support implementation of the SMP at the intersection of sustainability, mobility, and other critical areas like affordable housing. 8.2 Continue to implement Place Type policies that support sustainable modes of transportation. 8.3 Develop a platform for one-step purchase of tickets for all modes of shared mobility available in Charlotte. 8.4 Support campaigns to promote the use of public transit. 8.5 Advance sustainable, accessible and equitable mobility options. 8.6 Support continued communication and engagement on mutual goals of the Strategic Mobility Plan and SEAP+ and communicate emissions reduction benefits of actions that impact health and wellbeing.	

Strategy 9:	Facilitate rapid uptake of zero carbon mobility options

Actions:

9.1 Continue promotion and awareness around zero carbon modes of transportation.
9.2 Support development of a clean fueling plan for Charlotte, including different ways of fueling (e.g., EV charging, renewable fuel sources).
9.3 Identify resilience opportunities to ensure access to zero carbon charging and fueling including the potential for on-site energy generation.
9.4 Support the development of a workforce pipeline of qualified workers trained in zero carbon mobility infrastructure.
9.5 Advance mobility planning and infrastructure design that increases multi-modal and zero carbon mobility options, minimizes vehicle miles traveled and strengthens the sustainability of our infrastructure.
9.6 Expand efforts to provide car, scooter, bike share and other micromobility options.
9.7 Support and promote utility, other governmental, nonprofit, and/or community-based organizations that provide assistance for residents to install zero carbon transportation infrastructure (e.g. Duke's EV Charger Prep Credit).
9.8 Support implementation of transportation projects identified through the GreenPrints program.

Strategy 7: Reach net-zero emissions in municipal light-duty fleet by 2035 and in the entire fleet by 2050

Overview:

The city's fleet of vehicles provides a notable opportunity for the city to set a precedent for sustainable transformation in the transportation sector. While the city does not have control over transitioning privately owned vehicles, it does exert this level of control over its own fleet which is active and visible throughout the community. Exemplifying the transition from internal combustion engine (ICE) vehicles to EVs or alternative fuel vehicles (AFVs, such as hydrogen fuel cell or renewable natural gas) can bolster interest and investment and accelerate transportation decarbonization across Charlotte.

The transition away from ICE vehicles requires the development and expansion of critical supporting infrastructure, like EV chargers. The City of Charlotte has funded a total of 330 EV charging ports across the community, which make up over one third of the city-wide total and support the city's fleet, which has seen a 24% increase in the number of EVs since 2022. Many of the municipally-funded chargers are also available to the public and as of the most recent update, over 2,876 unique drivers have utilized these city-funded chargers, further bolstering the community's transition away from ICE vehicles at large.

Outside of supporting infrastructure, the city has invested time and resources in other initiatives to encourage the shift from ICE to EV or AFVs, including education, training, and updates to policy. Since the publication of the 2018 SEAP, the city has launched employee Ride and Drive events to promote awareness and acceptance of electric vehicles in the city's fleet, partnering with organizations like the Centralina Clean Fuels Coalition and the Environmental Defense Fund along the way.

To advance these efforts, the city has implemented the Sustainable and Resilient Fleet Policy (SRFP). The SRFP directs city departments to procure sustainable vehicles and meet SEAP goals by focusing on reducing energy consumption and changing the energy that city operations consume away from fossil fuels. Within the SRFP are four key components: strategies for fleet-wide carbon reductions, vehicle replacement process, carbon reduction strategies for legacy internal combustion engine vehicles, and reporting. The four components broadly instruct the city to prioritize the "purchase of the lowest-emitting vehicles depending on vehicle class, usage, and available technology" and supports fleet right-sizing and idle reduction.

Strategy 7 potential impacts

Emissions Reduction Potential: Decarbonizing the city's fleet provides an opportunity to lead by example and bolster interest in EVs and AFVs in the community.

Resilience and Adaptation: Transitioning the city's fleet from ICE vehicles to zero carbon vehicles encourages the development of resilient infrastructure, such as community-wide charging stations, and promotes technological innovation as the city strives to grow and develop more sustainably; in an emergency, the batteries in EVs can provide backup power. A fleet that utilizes diverse energy sources is also resilient to the loss of any one specific fuel.

Workforce Development: The fleet transition opens opportunities for new employment pathways to assist in the transition toward zero carbon vehicles.

Climate Justice & Equity: Transitioning the city's fleet from ICE to zero carbon can create economic opportunities and foster economic inclusion by prioritizing city investment in charging infrastructure in underserved areas. These areas often are located in high traffic corridors where a transition to zero carbon vehicles can provide public health benefits from reduced air pollution.

The following actions support Strategy 7: Reach net-zero emissions in municipal light-duty fleet by 2035 and in the entire fleet by 2050.

Action					Alignment
7.1 Continue implementing and updating the SMP to align with the goals of the SEAP+.					Alignment of the Strategic Mobility Plan to the SEAP+ enables fast-tracking of progress on transportation initiatives that have the potential to reduce city-wide emissions through decreasing reliance on single-occupancy vehicles and increase resilience to climate disasters by expanding different modes of transportation. Thoughtful transportation planning also supports expanding access to different forms of transportation to historically underserved communities.
7.2 Develop a decision matrix to inform right-sizing and typing of the fleet.					Identifying opportunities to reduce fleet size or vehicle size can reduce the city's fleet emissions by reducing the overall demand for fossil fuel. Vehicle right-sizing and typing also supports the transition to zero carbon mobility options and reduce the city's exposure to potential disruption from climate disasters by reducing reliance on fossil fuel.
7.3 Complete installation of a standardized telematics system across the city's entire vehicle fleet.					Telematics provide the city with relevant data to track fleet utilization and maintenance needs. The data helps the city to identify opportunities to optimize fleet use which helps to reduce fleet emissions. The introduction of new technology to support the city's fleet may generate new workforce opportunities.
7.4 Educate and train staff on new technology and eco-driving.					Training staff on eco-driving can reduce vehicle emissions from idling. Additionally, offering training supports climate resilience and equity by providing transferable skills that employees can share with the community to expand the impact of eco-driving. New employee trainings may require the support of outside counsel creating workforce opportunities.
7.5 Develop a Fleet Transition Plan.					A fleet transition plan enables the city to proactively and comprehensively approach the transition from fossil fuel vehicles to zero carbon vehicles and reduce fleet emissions. The plan allows the city to proactively address climate resilience in the transition away from fossil fuels and may require the support of experienced mechanics and other community partners in the transition.
7.6 Seek to pilot zero carbon vehicles when new technologies become available.					Piloting new technologies introduces new opportunities to further reduce emissions or electricity demand across the city's fleet or identify ways to improve fuel efficiency. Additionally, new technologies can introduce innovative ways for the city's fleet to become more resilient to disruption from climate disasters and introduce collaboration with community partners or industry.

Low
Med
High

Strategy 8: Support reaching a 50-50 mode share by 2040, per the Strategic Mobility Plan (SMP)

Overview:

The city's 50-50 mode share goal is a guiding target of the recently published SMP, and the strategies and actions outlined by the SEAP+ are designed to integrate with and advance those outlined in the plan. Within the SMP, the city states that it is "committed to achieving a greater distribution of travel across a more diverse spectrum of travel choices" while acknowledging that current mode share in Charlotte relies heavily on car travel, which directly impacts "current travel times, travel experience, and transportation cost."

Single-occupancy vehicles (SOVs) are a critical contributing factor to transportation emissions and vehicle miles traveled (VMT) in and around Charlotte, contributing to the roughly 75% of the sector's emissions that are attributable to ICE vehicles. Notably, "more than 76% of Charlotteans commuted to work by driving alone" before the COVID-19 pandemic and, at the time, only 24% of residents used other methods of travel. To that end, the city is working diligently to encourage mode shift, or the reduction of single-occupancy trips in favor of other forms of transportation, to reduce traffic congestion, emissions, and the environmental impact of transportation in Charlotte.

Charlotte is advancing progress on mode shift through policy updates, education and awareness, and integration of technological solutions. In doing so, the city has collaborated with Duke Energy, Centralina Regional Council, and Sustain Charlotte among others. Decreasing the number of SOV trips in Charlotte will require investments in supporting infrastructure such as transit route expansion, last mile modes of transit, sidewalks, bike paths, and shared use paths to create a more integrated system of transportation across the city.

Strategy 8 potential impacts

Emissions Reduction Potential: Reducing the number of SOV trips could substantially reduce transportation sector emissions in conjunction with increased utilization of other modes of transportation including walking, biking, and public transit.

Resilience and Adaptation: Reducing reliance on a single mode of transport helps to diversify the transportation system and reduce congestion while ensuring that Charlotte has access to multiple alternative modes of transportation during disruptions, such as extreme weather events.

Workforce Development: Charlotte's rapid growth and development presents opportunities for the city to prioritize sustainable city planning and Transit Oriented Development (TOD) which could provide new job opportunities while expanding mobility options can improve equitable access to both new and existing jobs.

Climate Justice & Equity: Diversifying Charlotte's transportation mix can reduce transportation costs and improve infrastructure and access to essential services and opportunities. This will require the city to be intentional about investments in Corridors of Opportunity to meet the demand in communities of historical underinvestment. Mode shift also can also improve public safety city-wide.

The following actions support Strategy 8: Support reaching a 50-50 mode share by 2040, per the Strategic Mobility Plan (SMP).

Action					Alignment
8.1 Support implementation of the SMP at the intersection of sustainability, mobility, and other critical areas like affordable housing.					This action indirectly supports the efforts of the city across all four co-benefits by providing an administrative framework for organizations to work together to achieve the City's goals.
8.2 Continue to implement Place Type policies that support sustainable modes of transportation.					Place Types allow the city to tailor solutions to the needs of various communities and built environments across Charlotte. Implementing policies with consideration to Charlotte's Place Types can increase the overall effectiveness of emissions reduction strategies and identify specific ways to increase resilience from climate disasters.
8.3 Develop a platform for one-step purchase of tickets for all modes of shared mobility available in Charlotte.					An accessible one-stop-shop for transportation tickets increases climate resilience and equity in Charlotte by increasing access to various modes of transportation that can keep Charlotteans moving from place to place in case of disruption.
8.4 Support campaigns to promote the use of public transit.					Public transit reduces reliance on single occupancy vehicles and can improve Charlotte's climate resilience by offering multiple ways to get from place to place. Promotional campaigns may introduce workforce opportunities to community partners for community engagement work.
8.5 Advance sustainable, accessible and equitable mobility options.					Expanding access to mass and alternative forms of transportation reduces Charlotte's reliance on single occupancy vehicles and reduces fossil fuel emissions. Expansion of access also creates multiple ways for communities across Charlotte to get from place to place in case of disruption.
8.6 Support continued communication and engagement on mutual goals of the Strategic Mobility Plan and SEAP+ and communicate emissions reduction benefits of actions that impact health and wellbeing.					Integration between the SEAP+ and the SMP strengthens messaging and partnerships with the community to directly address identified needs and gaps.

Low
Med
High

Strategy 9: Facilitate rapid uptake of zero-carbon mobility options

Overview:

Of the various transportation options available in Charlotte, ICE vehicles including passenger cars and light-duty trucks made up the largest source of emissions in the Transportation sector, roughly 75% or 2,016,271 mt CO_2e.

Increasing the uptake of zero-carbon mobility options like EVs and AFVs are critical to reducing Charlotte's transportation emissions from fuel combustion. There are numerous challenges in the transition from ICE to EV, primarily the demand for charging, accessibility, and public perception of EV reliability. Addressing these challenges is critical to Charlotte's transition to a net-zero carbon future, especially as 55% of residents who responded to the public survey noted that improving access to sustainable modes of transportation should be prioritized. The city has identified actions that support the community's transition to zero-carbon mobility options including education and awareness as well as infrastructure investments to improve charging accessibility.

Over the past year, Charlotte has held or participated in, on average, one event per month dedicated to education around and promotion of electric vehicles. These events, both city-sponsored and otherwise, include the Charlotte Auto Show, National Drive Electric Week (NDEW) events, and co-sponsored events with Centralina Clean Fuels Coalition, invigorating the conversation and interest around the EV transition. To increase access to these vehicles, Charlotte has partnered with FORTH mobility on a grant to launch an EV car share program at or near affordable housing sites beginning in early 2025. The interest and investment in EVs has spurred a steady increase in EV and AFV vehicle adoption rates in Mecklenburg County. At the time of writing, the state of North Carolina had already reached the goal of 80,000 zero emission vehicles on the roads by 2025, signaling that there is significant interest in EV adoption.

As the number of EV registrations grow in Charlotte, so will the demand for EV charging. Currently, Charlotte has a total of 960 public and private charging ports with 330 of those charging ports being municipally-funded. The SMP identifies electric vehicle infrastructure as a policy priority as the city prepares and plans for a more connected mobility environment, noting that infrastructure investments and partnerships will play a key role.

The city has been proactive in addressing the challenges associated with the transition to EVs. Efforts, which are closely aligned to the priorities identified in the SMP, include expanding the network of public charging stations and the number of ports, mapping of existing charging ports, data collection, and collaborating with community partners to enhance charging infrastructure and improve resilience to power disruption. These measures aim to alleviate concerns about charging accessibility and reliability, making it easier for residents to make the switch to zero-carbon mobility options.

Strategy 9 potential impacts

Emissions Reduction Potential: ICE passenger cars and light-duty trucks are responsible for 90% of the total vehicle miles traveled (VMT) by road in the city and make up a significant portion of the transportation sector's emissions. Due to the large contribution of this sector, reductions here can have a significant impact to community-wide emissions.

Resilience and Adaptation: As Charlotte's economy transitions toward a low carbon economy, Introducing more zero carbon mobility options can make Charlotte's transportation systems more adaptable to changing conditions and less susceptible to disruptions.

Workforce Development: Charlotte is a rapidly growing city that is actively planning for a more integrated and connected transportation system, which could provide ample work opportunities in public transit as well as in the larger EV space, including batteries, charging, and infrastructure.

Climate Justice & Equity: With intentionality to ensure access, increased uptake of zero-carbon mobility options can help to mitigate the health disparities related to air pollution and greenhouse gas emissions

The following actions support Strategy 9: Facilitate rapid uptake of zero carbon mobility options.

Action					Alignment
9.1 Continue promotion and awareness around zero carbon modes of transportation.					Spreading awareness of projects highlights potential employment opportunities in the transportation workforce. While emissions reductions is not a direct co-benefit, increased uptake of zero carbon modes of transportation improves Charlotte's climate resilience by reducing the demand for fossil-fuels and increased awareness provides equitable opportunities to learn about and potentially adopt new technologies.
9.2 Support development of a clean fueling plan for Charlotte, including different ways of fueling (e.g., EV charging, renewable fuel sources).					As Charlotte continues to see increased uptake of electric and alternative fuel vehicles, there will be increased demand for access to alternative fuels and charging which broadly reduce emissions from fossil fuel combustion. Planning for expanded charging and fueling infrastructure provides an opportunity for the city to make sure all communities have access. Increased uptake of these vehicles will also increase demand for specialized vehicles maintenance.
9.3 Identify resilience opportunities to ensure access to zero carbon charging and fueling, including the potential for on-site energy generation.					Identifying opportunities to improve resilience and access to zero carbon charging and fueling will make sure that all communities can participate in the transition to lower carbon transportation options and increase Charlotte's climate resilience by reducing demand for fossil fuels.
9.4 Support the development of a workforce pipeline of qualified workers trained in zero carbon mobility infrastructure.					As new technologies in transportation are introduced across Charlotte, there will be an increased demand for qualified workers that understand the design, maintenance, and care of the new technologies and the supporting infrastructure. Although this does not directly impact the other three co-benefits, it is a critical piece of advancing the transportation transformation.
9.5 Advance mobility planning and infrastructure design that increases multi-modal and zero carbon mobility options, minimizes vehicle miles traveled and strengthens the sustainability of our infrastructure.					This action is broad in scope and directly impacts all four criteria through its implementation. Increasing multi-modal transportation options addresses both climate resilience and equity because there is an opportunity to expand options equitably across Charlotte's communities and provide multiple alternatives to single occupancy vehicle travel. As the need for updated infrastructure materializes, there will be employment opportunities to support expansion and adaptation efforts. In turn, increased access to multi-modal options can reduce Charlotte's transportation emissions as residents shift away from single occupancy vehicle transportation.

Action					Alignment
9.6 Expand efforts to provide car, scooter, bike share and other micromobility options.					Expanding shared transportation options directly impacts both climate resilience and equity because car, bike, and scooter share can provide another set of alternatives to single occupancy vehicle transport and there are opportunities to make sure these programs are accessible equally across Charlotte communities.
9.7 Support and promote utility, other governmental, nonprofit, and/or community-based organizations that provide assistance for customers to install zero carbon transportation infrastructure (e.g., Duke's EV Charger Prep Credit).					Promoting options for assistance to adapt and install zero carbon transportation infrastructure has a direct impact on both climate resilience and equity. Additional sources of assistance and funding provides an additional path to participate in the transportation transformation, especially for historically underserved communities in Charlotte. Adaptation to these new technologies can support resiliency by reducing reliance on single occupancy vehicles.
9.8 Support implementation of transportation projects identified through the GreenPrints program.					Transportation projects directly address a large emissions source and can be implemented with resilience considerations for future climate events. These projects can support workforce developments and, as they are identified through Corridors of Opportunity GreenPrints.

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Focus Area: Cross-sectional

Overview

Charlotte is working toward a cleaner, greener, and more sustainable future. To make progress, strategies are needed that address key environmental challenges while also improving the overall quality of life for residents. The cross-sectional focus area highlights critical areas—waste reduction, tree canopy protection, climate resilience, and water conservation—based on community priorities and data-driven insights.

Other strategies and actions have an indirect impact on emissions but are crucial to supporting and implementing other elements of the SEAP+'s mission to be net-zero by 2050. These include providing more accurate and regular data and partnering to amplify change.

*Innovation Barn

Waste Reduction and Diversion

Reducing waste and increasing recycling and composting are top of mind for Charlotte residents. Community feedback shows that people are interested in reducing waste, improving recycling, and better communicating sustainability efforts. Charlotte's waste sector emissions total 1,143,676 metric tons of CO_2e, making up 14.4% of the city's total emissions. These emissions come from solid waste disposal, wastewater treatment, and other waste-related processes. By increasing waste diversion from landfills and using new technologies, Charlotte can lower emissions, reduce pollution, and create a more sustainable waste system.

Tree Canopy Protection and Expansion

Trees play a huge role in Charlotte's environmental health. Our 2023 tree canopy analysis found that Charlotte's trees remove 6.9 million pounds of air pollution annually and sequester 138,600 tons of carbon each year. The tree canopy also stores 3.28 million tons of carbon, helping to reduce the effects of climate change. Supporting tree canopy preservation efforts is essential for improving air quality, reducing heat, and making neighborhoods healthier and more beautiful.

Climate Resilience and Extreme Heat

Extreme heat is a major concern for Charlotte residents. In the SEAP Awareness Survey, 48% of participants identified extreme heat as the top climate risk concern. Many people also emphasized the need to improve quality of life and ensure climate resilience through both technology and nature-based solutions. To address this, Charlotte is working to measure urban heat more accurately, plant trees in areas that need more shade, and implement green infrastructure to make communities more livable and resilient.

Water Conservation and Efficiency

Water is one of Charlotte's most valuable resources. As the city grows, ensuring a clean and reliable water supply is critical. By supporting efforts to optimize water usage, Charlotte can protect this resource, reduce costs, and improve resilience to climate-related challenges like drought.

Innovation Barn: Helping Advance Charlotte's SEAP Goals

The Innovation Barn is a key stakeholder of Charlotte's Strategic Energy Action Plan+ (SEAP+), tackling organic waste and reducing greenhouse gas emissions. By fostering key partnerships and innovative programs, the Innovation Barn is helping to accelerate the city's shift to a circular economy, delivering both environmental and economic benefits.

How the Innovation Barn Supports SEAP:

- Reducing landfill waste – Diverted over 1.28 million pounds of organic waste in 2024
- Cutting emissions – Composting and food rescue reduce greenhouse gas emissions
- Strengthening local food systems – Food waste reduction efforts provide fresh, affordable food to communities in need
- Creating jobs – The expansion of the composting and food rescue sectors drives new employment opportunities.

Cross-sectional Strategies and Actions

Charlotte will pursue the following cross-sectional strategies and actions to directly and indirectly support achieving Charlotte's goals and the implementation of the SEAP+:

Strategy 10:	**Continue to develop a smart data approach.**
Actions: 10.1 Monitor and submit environmental data annually to recognized reporting agencies (e.g., CDP). 10.2 Continue to build out SEAP Dashboards to measure and communicate progress of SEAP+. 10.3 Share information and data with residents through a newsletter.	
Strategy 11:	**Promote waste reduction and diversion throughout Charlotte.**
Actions: 11.1 Reduce waste generation and increase waste diverted from landfills (e.g., recycling, composting) from municipal facilities. 11.2 Reduce waste generation and increase waste diverted from landfills (e.g., recycling, composting, reusing) across the community. 11.3 Implement new technologies, as appropriate, to aid with education and waste diversion (e.g., cameras on collection vehicles to identify non-acceptable materials).	
Strategy 12:	**Establish public-private-plus partnerships.**
Actions: 12.1 Identify, build, and formalize relevant partnerships.	
Strategy 13:	**Coordinate and support Tree Canopy Action Plan.**
Actions: 13.1 Support a healthy Charlotte tree canopy. 13.2 Align efforts to support a 'right tree, right place' concept, emphasizing tree shade for impervious surfaces to help combat urban heat. 13.3 Ensure equitable street tree planting with systematic tree care. 13.4 Support implementation of Shade Tree Strategy projects identified through the GreenPrints program.	
Strategy 14:	**Promote climate resilience throughout Charlotte.**
Actions: 14.1 To better measure and monitor environmental justice impacts, update the Equitable Growth Framework to include Land Surface Temperature as the sixth measure of the Environmental Justice metric representing urban heat. 14.2 Collaborate with partners to support heat action planning. 14.3 Develop a promotion and awareness campaign around the eco-benefits of planted areas to combat urban heat (e.g., urban meadows, pollinator gardens, trees). 14.4 Evaluate and align efforts to use green infrastructure to support resilience.	
Strategy 15:	**Support efforts to optimize water usage.**
Actions: 15.1 Support the development of a plan to increase water use efficiency. 15.2 Coordinate and support an educational campaign on water conservation measures including information on the water-energy nexus and the benefits of water conservation. 15.3 Support existing programs to incentivize water conservation and explore additional program opportunities. 15.4 Support implementation of technologies to better maximize water resource efficiency. 15.5 Support expansion of reclaimed water system and usage.	

Strategy 10: Continue to develop a smart data approach

Charlotte is committed to using data to track environmental progress and make informed decisions. By monitoring and submitting environmental data to agencies like CDP, the city can measure its sustainability efforts and identify areas for improvement. Expanding the SEAP Dashboards will help communicate progress more clearly, allowing residents and decision-makers to see how Charlotte is reducing emissions, increasing resilience, and improving quality of life. A strong data-driven approach ensures that sustainability efforts remain effective, transparent, and adaptable.

Action					Alignment
10.1 Monitor and submit environmental data annually to recognized reporting agencies (e.g., CDP).					Monitoring and submitting data on Charlotte's environmental goals to reporting agencies helps to consistently track and verify progress against stated goals. This supports advancement of Charlotte's emissions reduction goals and resilience as the city transitions to a low carbon economy. This action does not directly support workforce or equity, but is a foundational task for the city's overall progress.
10.2 Continue to build out SEAP Dashboards to measure and communicate progress of SEAP+.					The SEAP Dashboards make information about the city's progress against goals more readily accessible to the community as a free, public tool to obtain up-to-date information on the city's major initiatives. Public information around progress advances both resilience and equity as the dashboards are a tool for community engagement to advance the city's work.
10.3 Share information and data with residents through a newsletter.					While the quarterly newsletter will not lead to direct reductions, it can help residents implement ideas in their daily lives. It can make residents aware of programs and opportunities that can help them be more sustainable, resilient, or save on energy.

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Strategy 11: Promote waste reduction and diversion throughout Charlotte

Waste reduction is a major priority for Charlotte residents. For the 2023 GHG Emissions Inventory, waste was expanded from residential waste collection to include commercial waste as well. Waste-specific missions come from landfill waste, wastewater treatment, and other disposal methods. By supporting overall waste diversion, Charlotte can cut emissions and reduce the amount of waste going to landfills. The city is also exploring new technologies, like cameras on waste collection vehicles, to help identify non-recyclable materials and improve overall waste management.

Action					Alignment
11.1 Reduce waste generation and increase waste diverted from landfills (e.g., recycling, composting) from municipal facilities.					Reducing waste generation and diverting waste from landfills has a direct alignment to reducing emissions from municipal facilities and increases the city's resilience to future climate disasters through emissions reduction. As the need for alternative methods of disposal at scale increase, workforce opportunities in the industry may increase as well. Siting of new waste disposal, recycling, or composting facilities will need to equitably consider the surrounding communities and their needs.
11.2 Reduce waste generation and increase waste diverted from landfills (e.g., recycling, composting, reusing) across the community.					Reducing waste generation and diverting waste from landfills has a direct alignment to reducing emissions across Charlotte and increases Charlotte's resilience to future climate disasters through emissions reduction. As the need for alternative methods of disposal at scale increase, workforce opportunities in the industry may increase as well. Siting of new waste disposal, recycling, or composting facilities will need to equitably consider the surrounding communities and their needs.
11.3 Implement new technologies, as appropriate, to aid with education and waste diversion (e.g., cameras on collection vehicles to identify non-acceptable materials).					Implementation of new technologies supports and increases the efficiency of waste reduction and waste diversion measures which drive emissions reductions. Introduction of new technology and education programs may introduce workforce growth opportunities and opportunities for local and industry partnerships.

Strategy 12: Establish public-private-plus partnerships

Sustainability efforts are stronger when different groups work together. By forming partnerships between the city, businesses, nonprofits, and community members, Charlotte can take bigger steps toward reducing emissions, conserving resources, and improving the environment. These partnerships help create innovative solutions, fund important projects, and ensure that sustainability efforts benefit everyone. Working together will make it easier to tackle these big challenges.

Action					Alignment
12.1 Identify, build, and formalize relevant partnerships.					Although not directly aligned with emissions reductions, resilience, or equity, community partnerships are an integral component of advancing the initiatives of the SEAP+ and can provide new workforce opportunities.

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Strategy 13: Coordinate and support Tree Canopy Action Plan

Charlotte's tree canopy plays a vital role in reducing air pollution, absorbing carbon, and cooling the city. Planting trees in the right places, especially in areas with little to no existing shade, helps combat extreme heat and create healthier neighborhoods. The city will continue working to ensure that tree planting and maintenance efforts are fair and effective, so every community can enjoy the benefits of a strong tree canopy.

Action					Alignment
13.1 Support a healthy Charlotte tree canopy.					Trees support emissions reduction through the removal of carbon dioxide, a greenhouse gas, from the atmosphere. Care and maintenance for a healthy tree canopy also helps reduce tree damange. Equitable distribution of tree canopy across Charlotte can boost the city's resilience to climate disasters.
13.2 Align efforts to support a 'right tree, right place' concept, emphasizing tree shade for impervious surfaces to help combat urban heat.					Identifying the right trees for planting across Charlotte support emissions reduction through the increased removal of carbon dioxide from the atmosphere. Trees also help to alleviate the impacts of extreme heat and flooding by providing natural cooling, shade, and water absorption through their roots. Equitable distribution of tree canopy across Charlotte can boost the city's resilience to climate disasters.

Action					Alignment
13.3 Ensure equitable street tree planting with systematic tree care.					Currently, not all communities have equitable access to tree canopy; ensuring equitable planting will support increasing access to tree canopy in communities that previously did not have much access. Planting trees in these communities supports climate resilience and emissions reduction efforts as trees absorb carbon dioxide, alleviate heat, and reduce flooding.
13.4 Support implementation of Shade Tree Strategy projects identified through the GreenPrints program.					A healthy tree canopy can reduce emissions through the sequestration of carbon from the atmosphere and can support resilience through providing relief against climate impacts like extreme heat. Identified projects can support workforce development in their implementation, and as they are identified through the GreenPrints program, address climate justice and equity through tree planting in places that have historically had fewer trees and green spaces.

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Strategy 14: Promote climate resilience throughout Charlotte

The city looks to use both technology and nature-based solutions to address climate concerns. The city supports continued heat action planning, the connections between various city services and resiliency, promoting the benefits of green spaces like urban meadows and pollinator gardens, and using green infrastructure to improve overall resilience. These efforts will help make Charlotte more livable and protect vulnerable communities.

Action					Alignment
14.1 To better measure and monitor environmental justice impacts, update the Equitable Growth Framework to include Land Surface Temperature as the sixth measure of the Environmental Justice metric representing urban heat.					Although not directly aligned to emissions reduction, resilience, or workforce, including Land Surface Temperature as a measure of environmental justice and urban heat is a fundamental step in identifying solutions to mitigate the impacts of urban heat in an equitable manner across all of Charlotte's communities.
14.2 Collaborate with partners to support heat action planning.					Heat action planning improves Charlotte's resilience by identifying strategies to mitigate and adapt to the impacts of extreme heat as temperatures increase. Planning with community partners may provide new workforce opportunities and an opportunity to make sure all communities are considered in the plan and proposed solutions.
14.3 Develop a promotion and awareness campaign around the eco-benefits of planted areas to combat urban heat (e.g., urban meadows, pollinator gardens, trees).					Although not directly aligned to emissions reduction and equity, providing education and increasing awareness around the benefits of planted areas provides more information to Charlotte residents on how they can increase climate resilience of their properties and neighborhoods. It may also provide workforce opportunities to support development and implementation of the campaign.
14.4 Evaluate and align efforts to use green infrastructure to support resilience.					Green infrastructure may not directly align to emissions reduction, but green infrastructure can support community resilience by mitigating the impacts of extreme heat. The growth of green infrastructure may introduce new workforce opportunities to support implementation or adaptation.

Strategy 15: Support efforts to optimize water usage

Water conservation is important for Charlotte's sustainability efforts. As the city grows, managing water resources wisely will help ensure a reliable supply for residents and businesses. Planning for water efficiency, expanding the use of reclaimed water, and improving public awareness about the link between water use and energy consumption are ways to connect the efforts of Charlotte Water to overall sustainability.

Action					Alignment
15.1 Support the development of a plan to increase water use efficiency.					Increasing water use efficiency can reduce demand on water treatment systems which contribute to the Charlotte's overall emissions. It can also help Charlotte build resilience and prepare for a future where the city may experience longer drought periods or periods of water stress.
15.2 Coordinate and support an educational campaign on water conservation measures including information on the water-energy nexus and the benefits of water conservation.					An educational campaign on water conservation may support progress in increased water use efficiency and, in turn, reduce Charlotte's emissions. Educating on the importance of water conservation can advance climate resilience in Charlotte as the city may face more drought and water stress in the future. Also, the development and implementation of the campaign may introduce new workforce opportunities for community partners
15.3 Support existing programs to incentivize water conservation and explore additional program opportunities.					Supporting existing water conservation programs may accelerate progress in increased water use efficiency and, in turn, reduce Charlotte's emissions. Educating on the importance of water conservation can advance climate resilience in Charlotte as the city may face more drought and water stress in the future. Exploration of additional program opportunities may also open the door for workforce and equity opportunities.
15.4 Support implementation of technologies to better maximize water resource efficiency.					New technologies that support improvements in water resource efficiency support emissions reductions from wastewater treatment in Charlotte. Water efficiency fosters increased climate resilience in Charlotte as the city may see more drought and water stress in the future making conservation and efficiency important. As new technologies are developed and implemented, there may be additional workforce opportunities to support implementation. There is an opportunity to support equity and climate justice by making sure new technologies are widely available to all Charlotte residents.
15.5 Support expansion of reclaimed water system and usage.					The expansion of reclaimed water systems supports the reduction of emissions from wastewater treatment. Utilizing reclaimed water improves water system efficiency and fosters climate resilience in Charlotte as the city may see more drought and water stress in the future. The implementation of these reclaimed water systems may generate new workforce opportunities.

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Next Steps and Implementation

The Strategic Energy Action Plan (SEAP+) is a long-range policy document designed to guide the city's strategic energy initiatives over the coming decades. Developed through a collaborative process, the SEAP+ has undergone extensive review by both internal city departments and the public, ensuring it reflects community priorities and operational feasibility.

Following the plan's adoption, city departments will work together over the next year to develop an Implementation Plan. This plan will outline specific steps necessary to transform SEAP+ strategies into impactful initiatives, providing a structured approach to achieving the city's energy and sustainability goals.

During this implementation planning period, the city will continue advancing existing projects and programs. These ongoing efforts will maintain momentum toward the city's strategic energy objectives while laying the foundation for future initiatives outlined in the SEAP+. By aligning departmental efforts and fostering collaboration, the city is committed to translating the SEAP+ vision into tangible progress, ensuring a more sustainable and resilient future. The City of Charlotte would like to thank you for helping us to strive for a more sustainable community.

IV. Appendix

Acronym List

Acronym	Definition
AAWT	Average Annual Weekday Traffic
C40	C40 Cities Climate Leadership Group
CATS	Charlotte Area Transit System
CDOT	Charlotte Department of Transportation
CDR	Charlotte Douglas International Airport
CFD	Charlotte Fire Department
CH_4	Methane
CIRIS	City Inventory Reporting and Information System
CMPD	Charlotte Metropolitan Police Department
CMSWS	Charlotte-Mecklenburg Storm Water Services
CNG	Compressed natural gas
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EPA	United States Environmental Protection Agency
EV	Electric vehicle
GCOM	Global Covenant of Mayors
GHG	Greenhouse gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emissions
IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
kWh	Kilowatt-hour
MSW	Municipal solid waste
MWh	Megawatt-hour
N_2O	Nitrous oxide

Acronym	Definition
PNG	Piedmont Natural Gas
RCP	Representative Concentration Pathways (climate change scenario)
SEAP	Strategic Energy Action Plan
SSP	Shared Socioeconomic Pathways (climate change scenario)
VMT	Vehicle miles traveled
WWTP	Wastewater treatment plant

Glossary

Term	Definition
Acute physical risk	Refers to sudden and severe physical climate events that can be immediately dangerous to health and safety (e.g., severe storms).
Base year	A historical datum (e.g., year) against which a city's emissions are tracked over time. (GPC)
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases (GHGs), consisting of a single carbon atom and two oxygen atoms, and providing the reference point for the global warming potential (GWP) of other gases. (ICLEI)
Carbon neutrality	A state where annual GHG emissions are completely cancelled out or removed through offsetting or carbon dioxide removal (CDR) or emissions removal measures. (GPC)
Chronic physical risk	Refers to physical risks that develop slowly over time and last for a long period (e.g., extreme heat).
City	Used throughout the GPC to refer to geographically discernable subnational entities, such as communities, townships, cities, and neighborhoods. (GPC) In the context of this SEAP, the city of Charlotte, North Carolina.
Climate risk	The potential for negative consequences for the environment, ecosystems, and society from the effects of climate change.
Climate justice	Connects the climate crisis to the social, racial and environmental issues in which it is deeply entangled.
CO_2 equivalent (CO_2e)	The universal unit for comparing emissions of different GHGs expressed in terms of the GWP of one unit of carbon dioxide. (ICLEI)
Emission	The release of GHGs into the atmosphere. (GPC)
Fossil fuel	A fuel such as coal, oil, or natural gas, produced by the decomposition of ancient (fossilized) plants and animals. (ICLEI)
Geographic boundary	A geographic boundary that identifies the spatial dimensions of the inventory's assessment boundary. This geographic boundary defines the physical perimeter separating in-boundary emissions from out-of-boundary and transboundary emissions. (GPC)
Greenhouse effect	A natural process by which greenhouse gases trap heat in Earth's atmosphere, making it habitable by maintaining a temperature suitable for life. However, human activities that increase greenhouse gas levels intensify the greenhouse effect, leading to temperature rise and climate change.
Greenhouse gas inventory	A quantified list of a city's GHG emissions and sources. (GPC)
Greenhouse gas (GHG)	For the purposes of the GPC, GHGs are the seven gases covered by the United Nations Framework Convention on Climate Change: carbon dioxide (CO2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF6); and nitrogen trifluoride (NF3). (GPC)
High carbon future	A potential future state scenario where delayed action on climate change and continued dependence on fossil fuels leads to higher global emissions and corresponds with about 4.3°C of warming by 2100.
Low carbon future	A potential future state scenario defined by significant progress toward current global climate goals, such as those related to reducing emissions and shifting away from fossil fuels, and corresponds to about 1.8°C of warming by 2100.

Term	Definition
Methane (CH_4)	One of the six primary GHGs, consisting of a single carbon atom and four hydrogen atoms, possessing a GWP of 21, and produced through the anaerobic decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. (ICLEI)
Metric ton	Common international measurement for the quantity of GHG emissions, equivalent to about 2,204.6 pounds or 1.1 short tons. (ICLEI)
Natural gas	A naturally occurring mixture of hydrocarbons (e.g., methane, ethane, or propane) produced in geological formations beneath the earth's surface that maintains a gaseous state at standard atmospheric temperature and pressure under ordinary conditions. (ICLEI)
Nitrous oxide	One of the six primary GHGs, consisting of two nitrogen atoms and a single oxygen atom, possessing a GWP of 310, and typically generated as a result of soil cultivation practices, particularly the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning. (ICLEI)
Physical risk	Risks that manifest in the physical environment and include changes in weather and climate due to the concentration of greenhouse gases in the atmosphere.
Place type	Help to articulate desired physical characteristics with context-sensitive application across the city and describe a place more holistically and at a larger scale, incorporating guidance for land use, transportation, layout, and design
Reporting year	The year for which emissions are reported. (GPC)
Scope 1 (territorial) emissions	GHG emissions from sources located within the city boundary. (GPC)
Scope 2 emissions	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary. (GPC)
Scope 3 emissions	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary. (GPC)
Transition risk	The potential financial and economic challenges that could arise because of the shift from a fossil-fuel based economy to one that is more sustainable and reliant on renewable energy.
Wildland urban interface (WUI)	the zone of transition between unoccupied land and human development. It is the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. (U.S. Fire Administration)

GHG Emissions Inventory Appendix

GHG Inventory Emissions Inventory

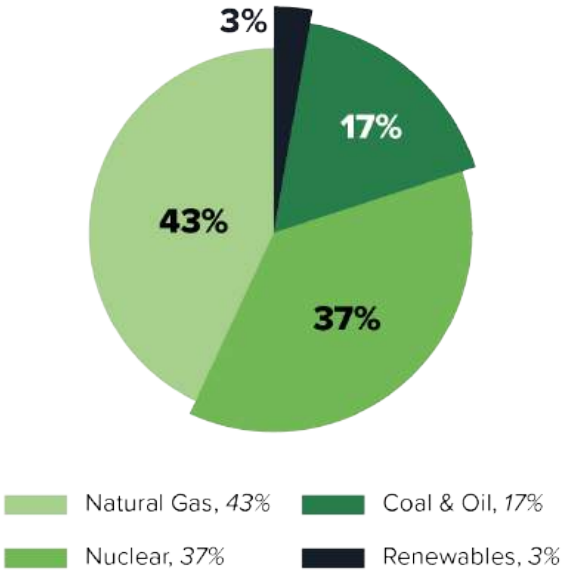
Commercial, Government, Industry, and Residential Buildings

City-wide emissions from buildings in these categories totaled 4,095,424 mt CO_2e and comprised 51.7% of Charlotte's GHG footprint in 2023. These primarily occur due to the consumption of energy – largely electricity and natural gas.

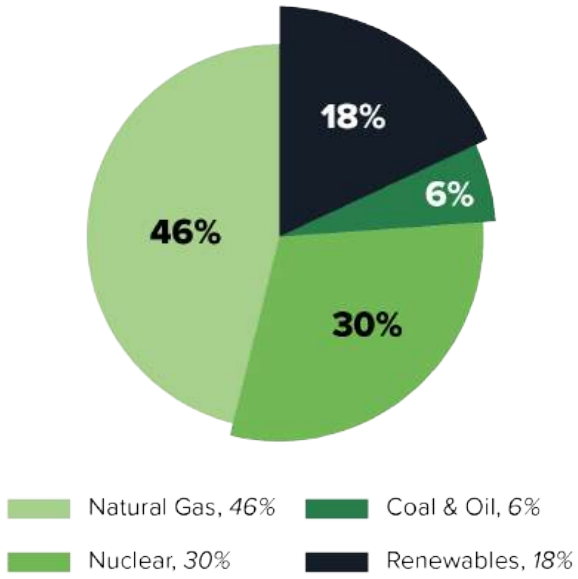
Duke Energy's electricity, which is supplied to Charlotte, has gotten cleaner in recent years due to changes in how the electricity was generated. Duke Energy has a goal to reach net-zero emissions from energy generation by 2050, with interim goals of 50% reduction by 2030 and 80% reduction by 2040. In order to reach these goals, Duke Energy is transforming its energy mix, investing in "a diverse mix of low- and zero carbon generation, such as solar, advanced nuclear, pumped hydro and energy storage."[45] Since 2019, Duke has primarily shifted its generation mix from coal and oil to natural gas, which is a less polluting energy source. At the same time, Duke has further invested in zero carbon energy such as renewables and nuclear, with plans to focus on growing renewable capacity in the coming years. Duke Energy will need to continue to transform and meet these goals in order for Charlotte's emissions from electricity to decrease.

By 2030, 18% of Charlotte's electricity will be generated by renewable sources, up from 3% today.

2023 Energy Mix



Projected 2030 Energy Mix

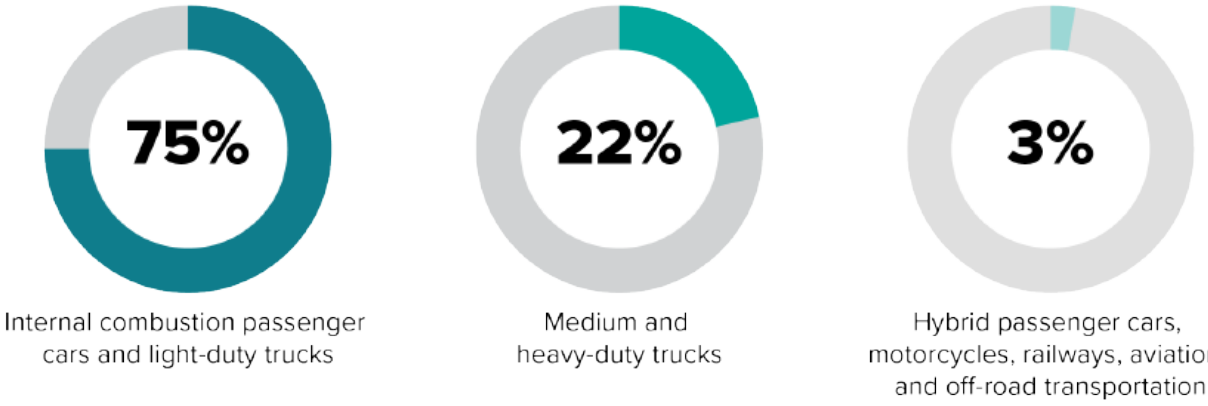


Emissions from natural gas consumption in Charlotte increased 16.4% from 2019 to 2023. This increase is logical for a growing city, but must still be addressed to drive down emissions. The 2018 SEAP and the SEAP+ both include strategies to address emissions from natural gas, including energy efficiency improvements and beneficial electrification. A side effect of electrification is that, while it reduces natural gas consumption, it increases electricity consumption, making a clean electric grid even more critical to achieving the city's targets. It is anticipated to continue to see electrification numbers increase while natural gas decreases as the city continues to strive toward its goals.

On Road and Other Transportation

Transportation accounted for 2,689,440 mt CO_2e, or 33.9% of the city's emissions total, and includes off-road, rail, and air occurring within the city. Transportation GHG emissions are produced directly by the use of fuel or indirectly by the use of grid-supplied electricity.

2023 Direct Transportation Emissions by Source



GHG Emissions Inventory Appendix

The largest source of transportation emissions in 2023 was internal combustion (ICE) gasoline-powered passenger cars and light-duty trucks, which together are responsible for an estimated 75.0% of Charlotte's calculated transportation emissions.

Emissions from on-road vehicles in Charlotte dropped by 34.9% from 2019 to 2023. Some of this change is due to updates in how emissions are measured. The 2023 inventory used vehicle miles traveled (VMT) to account for on road transportation, as opposed to fuel consumption data scaled down from state-level data as in previous years. This allows for a more specific accounting of vehicular trips on our roadways.

Another factor is the growing number of more efficient vehicles, including electric and hybrid cars. Electric vehicles (EVs) don't produce tailpipe emissions, but they do create emissions from the electricity used to charge them. As Duke Energy moves toward cleaner electricity, these emissions will decrease even more.

When charged at home, EVs can produce fewer emissions compared to gas-powered cars.[46] Since 2019, hybrid vehicle ownership in Mecklenburg County has gone up by 54%, and electric vehicle ownership has grown by 458%. Even though people are driving slightly more overall, emissions have still gone down thanks to the increase in these cleaner vehicles.

In the 2023 inventory, VMT by on-road vehicles were subdivided by vehicle class and fuel type, an update from the 2019 inventory. This change more accurately captures the different rates of emissions from different types of vehicles (e.g., electric cars, medium- and heavy-duty trucks).

Electric and hybrid vehicle data were added to the inventory to reflect reduced or zero emissions from these vehicles, which have become more prevalent in Charlotte.

Electric vehicles produce no direct tailpipe emissions, since they do not combust fuel during operation. However, energy generation needed to charge EV batteries may produce emissions. These emissions are included under buildings (residential, commercial, government, or industry, depending where they are charged), rather than under transportation as EV electricity consumption cannot currently be disaggregated from overall electricity use in the buildings.

Waste

Charlotte's waste sector emissions – totaling 1,143,676 mt CO2e and comprising 14.4% of the total – originate from numerous activities including solid waste disposal, biological treatment of waste, and wastewater treatment and discharge for all waste and wastewater generated within the city boundaries.

Residential

As the city continues to grow and expand, it is natural for the volume of waste to increase as more people and activities are contributing to it. Fortunately, to counteract this trend, Charlotte has seen a 3.5% decrease in per capita residential waste generation since 2019. Emissions from residential waste – including all general household waste generated by residents within city boundaries – decreased 11.7% from 2019 to 2023, while the city's population increased by over 25,000.

Commercial

In the 2023 inventory, the city expanded the scope of its GHG inventory by including emissions from commercial waste which is captured at the county level. While this increases the city's overall emissions reported from waste, better and more accurate commercial waste generation data gives Charlotte additional visibility into the complete waste sector and the ability to develop emissions reductions solutions.

Commercial waste is an important part of Charlotte's GHG emissions as the city continues to grow and expand, with construction waste accounting for 7.3% of the commercial waste stream. As this is the first time this category has been reported, 2023 will be the baseline year for future comparisons.

Wastewater

Wastewater treatment accounts for 9% of the waste sector's overall emissions. The City of Charlotte is more accurately capturing the emissions from this category, allowing for improved tracking and solution development. In the city's effort to better understand emissions from wastewater treatment, data was collected for two existing wastewater treatment plants (WWTP) that are new to the 2023 emissions inventory: Ashe Plantation WWTP and Rocky River Regional WWTP. As the city continues to mature in emissions tracking and management, this additional data and improvements in methodology play a critical role in building understanding of the emissions from the waste sector.

Summary of changes related to waste tracking

Since 2019, the city has made a concerted effort to more accurately track emissions across the board. Critical updates to the methodology for tracking waste emissions as of this year's inventory include:

- **Inclusion of commercial waste for the first time (waste from businesses, construction, healthcare facilities, and schools, among other commercial activities)**
- **Improvement of the calculation methodology for wastewater treatment emissions to account for both process emissions and emissions from digester gas utilization and flaring**
- **Two existing wastewater treatment plants are new to this year's inventory**

Climate Risk Assessment Full Report

Development of the climate risk assessment

To conduct this climate risk assessment, the city followed leading guidance from C40 Cities and the Global Covenant of Mayors (GCOM), both large global alliances of cities and city leadership committed to driving climate action, which consisted of these key steps:

1. Assessed peer cities along with the city's previous work and reporting to develop a list of climate risks most relevant to the city and its regional context.
2. Utilized climate scenarios to identify which risks are more likely, and the potential impact of likely risks.
3. Informed the findings with important historical and socioeconomic context for the City of Charlotte.
4. Integrated public stakeholder feedback to highlight priority risks for the City of Charlotte and validate impacts.
5. Developed this narrative report on process and key findings to summarize the work.

Climate-related risk glossary:

Acute physical risks are sudden and severe climate events that can be immediately dangerous to health and safety. The acute physical risks selected for Charlotte's climate risk assessment include urban flooding, severe storms, hurricanes/tropical cyclones, and wildfire.

Chronic physical risks develop slowly over time and last for a long period. Chronic physical risks selected for Charlotte's climate risk assessment include extreme heat, precipitation, drought, and water stress.

Physical risks are often categorized as either chronic or acute. This classification distinguishes the nature of the risks and how they might affect the environment and people over different periods of time.

Transition risks are the potential challenges that could arise because of the shift from a fossil fuel-based economy to one that is more sustainable and reliant on renewable energy.

Method

A list of climate risks was informed by analysis of peer cities and research and review of the city's previous work and reporting. The city selected a focused set of risks relevant to the city and its regional context with attention given to representative risks that align with historical impacts.

The City of Charlotte utilized climate scenarios to inform the climate risk assessment. A scenario is a framework for what our world could look like in the years to come, based on greenhouse gas concentrations, socioeconomic trends, and international regulation. Scenarios serve as a forecast of economic, socioeconomic, and environmental conditions that help scientists, policymakers, and the public understand the potential outcomes of our actions today on the planet's future. Scenario analysis supports Charlotte in identifying priority risks to inform decision-making, allocate resources, and develop policies to help safeguard the city and its residents from the impacts of a changing climate.

Charlotte's climate risk assessment was performed under two possible future scenarios, forming "bookends" at each end of a range, according to the best available scientific consensus from the Intergovernmental Panel on Climate Change. A low carbon future scenario, aligned to SSP1-RCP2.6 which corresponds to about 1.8°C (~3.2°F) of warming by 2100 and lowered overall GHG emissions. The other scenario is a high carbon future scenario, aligned to SSP5-RCP8.5 which corresponds to about 4.3°C (~7.7°F) of warming by 2100 and high emissions.[1]

In the low carbon future scenario, the world transitions to a low carbon future through an increase in climate-related regulation, climate incentives, and an economic focus on sustainable development and renewable energy. The low carbon future scenario is an aspirational scenario because it assumes significant progress toward current climate goals such as those related to reducing emissions and shifting away from carbon-emitting fuels. Progress

1 Katherine Calvin et al., "IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. IPCC, Geneva, Switzerland.," First (Intergovernmental Panel on Climate Change (IPCC), July 25, 2023), https://doi.org/10.59327/IPCC/AR6-9789291691647.

hinges on technological innovation and commitment from influential industries and organizations, city partners, and the City of Charlotte. Additionally, solutions proposed in the pursuit of this goal will need to consider equitable access and provide opportunities for all communities to experience the benefits of the energy transition.

Alternatively, in the high carbon future scenario, we expect to see delayed action on climate change and continued dependence on carbon-emitting fuels leading to higher global emissions. The failure to reduce emissions leads to more frequent and widespread extreme weather events. In this scenario, Charlotte and its residents could face more significant financial consequences from climate change. The results of analyzing under the high- and low-end potential futures enables us to think about the most impactful and resilient investments for the city, acknowledging that the future falls somewhere in between.

Results

Extreme climate events are projected to intensify and become more frequent in the future, regardless of action in the near term. As the results of Charlotte's climate risk assessment are distilled below, it is important to keep in mind that the identified impacts to Charlotte are likely and long-term climate planning is key to mitigating the worst impacts.

Charlotte, and North Carolina, have already experienced the impacts of more active and powerful hurricane seasons firsthand, as experienced in the fall of 2024 with Hurricanes Debby and Helene impacting the area, leading to flash flooding, tornadoes, fallen trees, and power outages across the city.[2] Recalling the recent impacts of extreme climate events in Charlotte naturally raises the question: will these events continue to increase in frequency and intensity in the future?

Given Charlotte's history of exposure to extreme weather, the following physical hazards were analyzed to understand the potential impacts and frequency of occurrence under both the low carbon future and high carbon future scenarios:

Table 1: Climate risks analyzed for Charlotte, NC.

Physical hazard	Definition	Type
Severe thunderstorms	Rain showers with thunder that also produces one or more of the following: winds gusting greater than 57.5 mph, hail that is one inch in diameter or greater, or a tornado.[3]	Acute
Hurricanes/ tropical cyclones	A type of storm characterized by a rotating, low-pressure weather system that has organized thunderstorms. Tropical cyclone intensity is defined by the surface wind speed, with lower intensity cyclones identified as tropical depressions and storms. Once the storm's surface winds reach 74 mph or greater, it is classified as a hurricane.[4]	Acute
Urban flooding	When water from heavy rainfall flows into urban areas faster than it can be absorbed into the soil or managed by drainage systems.	Acute
Wildfire	Uncontrolled and non-prescribed burning of plants in natural settings that can expand into residential and urban areas depending on weather conditions; presents a risk of air quality degradation to surrounding areas as well as additional indirect risks.	Acute
Extreme heat	When temperatures are substantially hotter than average and reach dangerous levels; measured in days per year where the max temperature reaches or exceeds 95°F.	Chronic
Drought	A prolonged period, usually a season or more,[5] of below-average precipitation leading to a natural shortage of water; measured in days per year where precipitation is less than 0.01 inches.	Chronic
Water stress	Periods of time where the demand for water exceeds the available amount; measured as a ratio of total water demand to available renewable surface and groundwater supplies.	Chronic
Precipitation	Refers to any form of water that falls from the clouds and reaches the ground, including rain, ice, snow, and/or hail; measured as the total annual precipitation in inches.	Chronic

2 "Charlotte Traffic Area Impacted by Tropical Storm Debby | Wcnc.Com," accessed September 19, 2024, https://www.wcnc.com/article/news/local/tropical-storm-debby-impacts-roadways-electricity-charlotte-area/275-6ded05c9-6f86-4f5f-9b94-90bce2aee09a.

3 "Thunderstorm Basics," text, NOAA National Severe Storms Laboratory, accessed November 21, 2024, https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/.

4 National Oceanic and Atmospheric Administration US Department of Commerce, "What Is a Hurricane?," accessed November 21, 2024, https://oceanservice.noaa.gov/facts/hurricane.html.

5 "Drought Basics | Drought.Gov," accessed November 20, 2024, https://www.drought.gov/what-is-drought/drought-basics.

Many of these assessed physical hazards interact and happen in conjunction with other physical hazards. For example, heavy precipitation events may also bring about intense flooding. For the purpose of this assessment, physical hazards are discussed one by one, but the city recognizes that many of the impacts are related and may occur simultaneously. Additionally, the cumulative effect of the acute risks often provides a basis for the severity of chronic risks. For example, if there were no severe thunderstorms or hurricanes, precipitation in the Charlotte area may not be assessed at the level of risk it is.

Acute physical risks

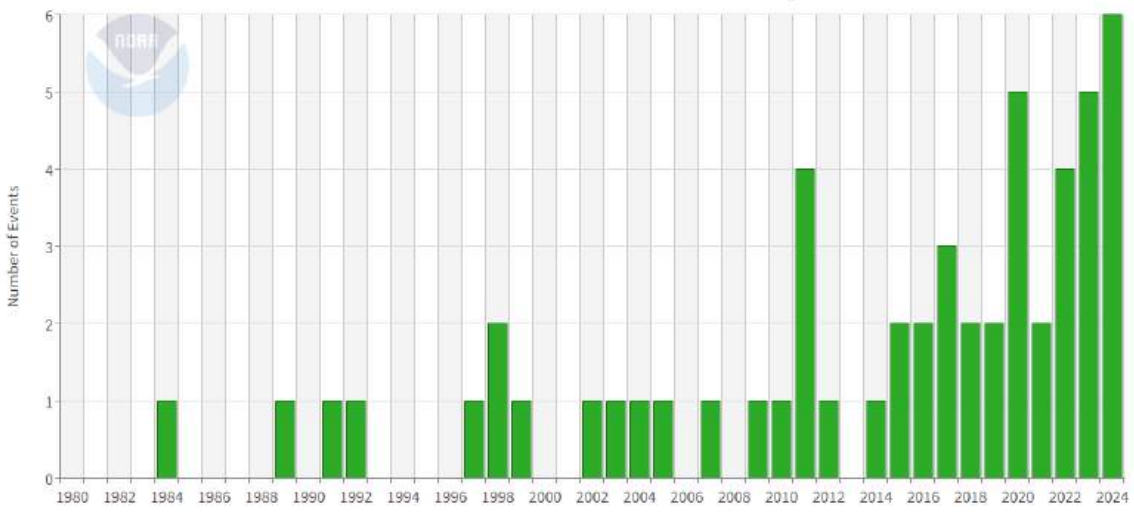
The acute physical risks assessed include urban flooding, severe storms, hurricanes/tropical cyclones, and wildfire. Charlotte is projected to see more intense hurricanes and increased risk of severe storms and urban flooding. While wildfire may not be an immediate risk for Charlotte, the frequency and intensity of wildfires is also projected to increase. This introduces a new challenge for Charlotte's climate resiliency as wildfires near and far present indirect risks to the city, namely deterioration of air quality and respiratory illness. Adaptation strategies for acute physical risks are often geared toward immediate event response and recovery efforts (e.g., emergency preparedness plans, early warning systems) and resilient infrastructure designed to withstand specific extreme events (e.g., impact-resistant roofing shingles). Acute physical risks are often difficult to model and project when compared to the long-term climate shifts that drive chronic physical risks. As a result, the impacts of the acute physical risks are described more qualitatively, and where quantitative data is readily available, it is included.

Severe thunderstorms

Table 2: Severe thunderstorm impacts

Impacts	**Key impacts include increased strain and overload of drainage and wastewater systems, power/utility outages, road closures, tree fall and debris, and potential increases in property damage.**

Figure 1: North Carolina Billion-Dollar Severe Storm Events 1980-November 2024 (CPI-Adjusted)[6]



In recent years, the frequency of billion-dollar severe storm events have increased in the state of North Carolina, continuing to raise total disaster recovery and repair costs across the state. Between 1980 and 1991 (the first 11 years in the graph), North Carolina averaged 0.27 billion-dollar severe storm events annually. In the most recent 11 years (2013–2024), the state has averaged roughly 3.1 billion-dollar severe storm events per year marking a significant uptick since the 1980s.

6 Adam B. Smith, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)" (NOAA National Centers for Environmental Information, 2020), https://doi.org/10.25921/STKW-7W73.

The escalating frequency and intensity of severe thunderstorms presents a significant risk for Charlotte.[7] From 2014 to 2018, North Carolina weathered an average of 2 billion-dollar-plus severe storms annually. However, in the subsequent five-year span from 2019 to 2023, the state has seen a near doubling of this trend, with an average of 3.6 billion-dollar-plua severe storms each year. As of November 25, 2024, the state has experienced six billion-dollar severe storm events. Five of these storms unleashed tornado outbreaks, resulting in significant damage to homes, businesses, vehicles, and critical transportation and utility infrastructure.[8]

In a high carbon future, the number of days conducive to severe thunderstorm development is expected to double in the southeast and eastern U.S.,[9] indicating that climate change is contributing to more favorable atmospheric conditions for these storms. It is important to note that this is not just a rise in the frequency of severe storms, but also an escalation in their intensity. The observed intensification of severe thunderstorms suggests that the City of Charlotte may experience higher levels of damage and destruction when these storms form or pass through. Severe thunderstorms could also displace residents, temporarily and potentially permanently, and strain the city's infrastructure. Stormwater and utility systems, crucial during normal conditions, are at risk of being overwhelmed and damaged during more intense storms, leading to costly repairs and recovery.

Hurricanes/tropical cyclones

Table 3: Impacts of hurricanes and tropical cyclones

Impacts	**Key impacts, in addition to those from severe thunderstorms, include increased demand on emergency response resources, challenges with effective evacuation, extreme rainfall flooding leading to injuries and fatalities, and personal property damage from high winds and debris.**

From 1980 to 2024, North Carolina has faced 121 billion-dollar-plus disasters, second-only to Georgia's 133, with hurricanes playing a significant role.[10] While Charlotte's current hurricane risk is moderate, data suggests tropical storms are intensifying more rapidly along the Atlantic Coast.[11] This rapid intensification means Charlotte could see a future impacted by more powerful and damaging hurricanes either by bigger hurricanes encompassing Charlotte in their path or hurricanes moving faster and reaching Charlotte before they downgrade to tropical storm status. Either option leads to increases in hurricane-driven rainfall, potentially unleashing more severe urban flooding in the area. The city could face unexpected recovery and repair costs, transportation disruption, power outages, and damage to communications infrastructure.

As of November 2024, the City of Charlotte and the state of North Carolina are still reeling from the aftermath of Hurricane Helene which made landfall in Florida on September 26, 2024, as one of the most damaging storms to ever strike the state. The damage and recovery costs from Hurricane Helene, which are still under assessment, are estimated to be at least $53 billion. Helene produced torrential rains, tornado outbreaks, and significant flooding and wind damage along its path from Florida to North Carolina. The storm was responsible for over 1,400 landslides and damage to 6,000 miles of roads, 1,000 bridges, and 160 water and sewer systems. In addition to the impacts to the state's infrastructure, Helene claimed 96 lives and damaged or destroyed over 126,000 homes.[12] Western North Carolina was hit particularly hard, with the mountain city of Asheville sustaining significant damage from the storm.

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7 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

8 Adam B. Smith, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)" (NOAA National Centers for Environmental Information, 2020), https://doi.org/10.25921/STKW-7W73.

9 "Severe Thunderstorms and Climate Change," Climate Change: Vital Signs of the Planet, accessed November 26, 2024, https://climate.nasa.gov/news/897/severe-thunderstorms-and-climate-change.

10 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

11 Karthik Balaguru et al., "Increasing Hurricane Intensification Rate Near the US Atlantic Coast," Geophysical Research Letters 49, no. 20 (2022): e2022GL099793, https://doi.org/10.1029/2022GL099793.

12 "Hurricane Helene's Damage, Related Expenses in North Carolina Shattering Records, Estimated at $53 Billion - CBS News," October 24, 2024, https://www.cbsnews.com/news/hurricane-helenes-north-carolina-damage-53-billion-record/.

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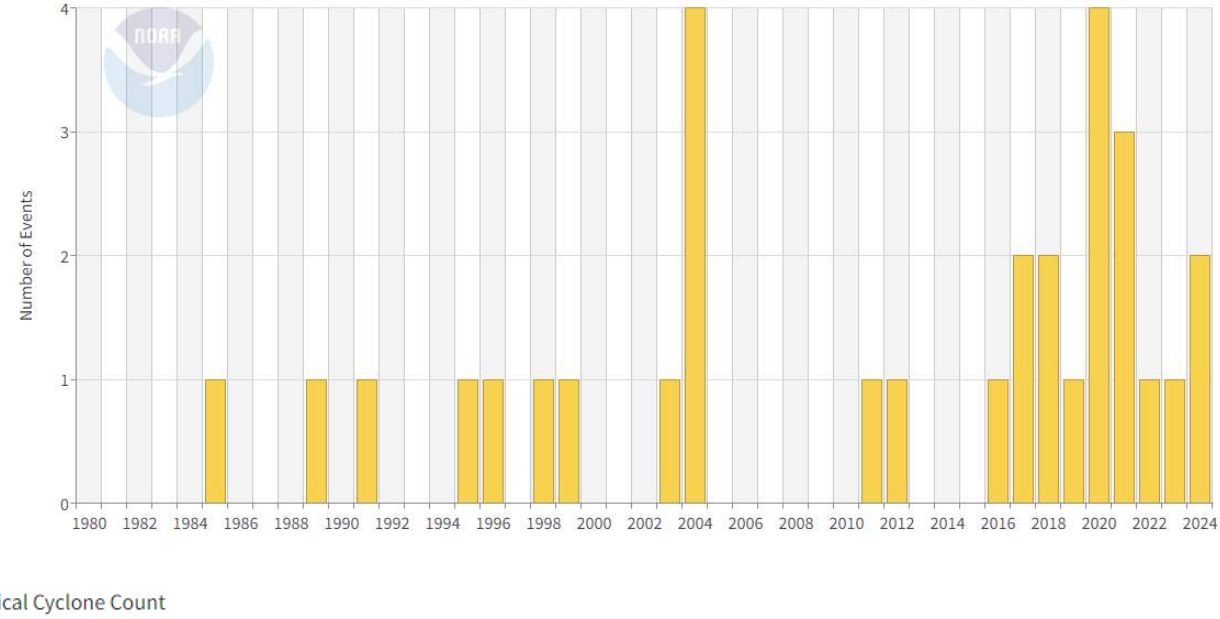
North Carolina is no stranger to intense hurricanes. A few notable storms have reshaped how the state thinks about extreme storms and emergency preparedness. In 2018, Hurricane Florence rapidly intensified to a Category 4 hurricane before making landfall as a Category 1 storm, unleashing historic flooding and widespread infrastructure damage across the Carolinas. The storm forced the shutdown of major interstates along with over 2,000 primary and secondary roads.[13] The storm presented a serious challenge for widespread evacuation efforts, especially for residents in assisted living facilities, who are likely to experience poor immediate health outcomes due to stress and disruption.[14] With recovery and repair costs surpassing $30 billion, Hurricane Florence stands as one of the most expensive hurricanes to ever strike the Carolinas. Within just a month of Hurricane Florence, Hurricane Michael, a Category 5 storm when it made landfall in Florida, brought even more devastation, disruption, and damage to North Carolina totaling an additional $31 billion in damages.[15]

At the time of writing, the City of Charlotte recognized a milestone anniversary of one of the strongest storms to strike the U.S. Atlantic Coast, Hurricane Hugo. On September 22, 1989, a little over 35 years ago, Hurricane Hugo made landfall near Sullivan's Island, South Carolina and generated the highest storm surge ever recorded, 20 feet, on the East Coast. The storm brought nearly 100-mile-per-hour wind gusts to the City of Charlotte and caused extensive tree fall, tornado outbreaks, and disrupted power and utilities leaving over 85% of Charlotte without power for days after the storm.[16] To this day, Hurricane Hugo is still discussed during hurricane season in Charlotte and set the precedent for the importance of hurricane preparedness for the inland city.

Figure 2: North Carolina billion-dollar tropical cyclone events 1980-November 2024 (CPI-Adjusted)[17]



13 "A Look Back at the Floods of Hurricane Florence | Wcnc.Com," accessed September 3, 2024, https://www.wcnc.com/article/weather/hurricane-florence-anniversary-flooding-weather-carolinas/275-dcacd91e-fb2a-4767-b708-3a9a324a9b1b.

14 Cassandra L. Hua et al., "Evacuation and Health Care Outcomes Among Assisted Living Residents After Hurricane Irma," JAMA Network Open 7, no. 4 (April 26, 2024): e248572, https://doi.org/10.1001/jamanetworkopen.2024.8572.

15 Adam B. Smith, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)" (NOAA National Centers for Environmental Information, 2020), https://doi.org/10.25921/STKW-7W73.

16 Kaitlin Wright, "35 Years Ago Hurricane Hugo Slammed Into Carolinas," WCCB Charlotte's CW (blog), September 20, 2024, https://www.wccbcharlotte.com/2024/09/19/35-years-ago-hurricane-hugo-slammed-into-carolinas/.

17 Adam B. Smith, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)" (NOAA National Centers for Environmental Information, 2020), https://doi.org/10.25921/STKW-7W73.

In recent years, the frequency of billion-dollar tropical cyclones/hurricanes has increased in the state of North Carolina, continuing to raise total disaster recovery and repair costs across the state. Between 1980 and 1991 (the first 11 years in the graph), North Carolina averaged 0.27 billion-dollar tropical cyclone events annually. In the most recent 11 years (2013–2024), the state has averaged roughly 1.54 billion-dollar tropical cyclone events per year, marking a significant uptick since the 1980s.

Urban flooding

Table 4: Impacts of urban flooding

Impacts	**Extreme flooding events can cut off access to utilities and emergency services, shut down transportation routes, damage homes and structures of key facilities, inundate communication and internet infrastructure, and degrade water quality due to rapid introduction of contaminants and sediment.**

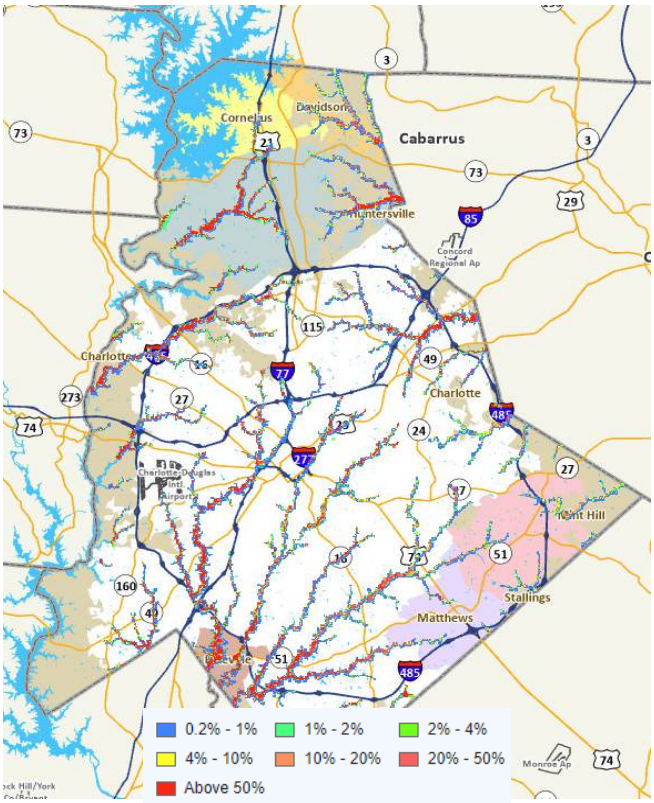


Figure 3: City of Charlotte floodplains and annual chance of flooding

As Charlotte grows, urban flooding emerges as a critical issue. Increased annual precipitation coupled with the prevalence of impervious surfaces play a significant role in the severity of flash flooding in Charlotte. Impervious surfaces are hard areas that don't let water soak into the ground. This includes infrastructure such as roads, sidewalks, driveways, and parking lots. When it rains, water runs off these surfaces instead of being absorbed, which can increase the risk of flooding in extreme precipitation events. Increased runoff during heavy rains and storms puts properties, especially those in or near floodplains, at risk. Stormwater runoff from impervious surfaces can also exacerbate pollution of nearby streams and rivers as the stormwater picks up debris and chemicals from the roads and parking lots. Charlotte's concentration of impervious surface is as high as 59% in some areas of the city, indicating that these more developed areas may be more prone to urban flooding.

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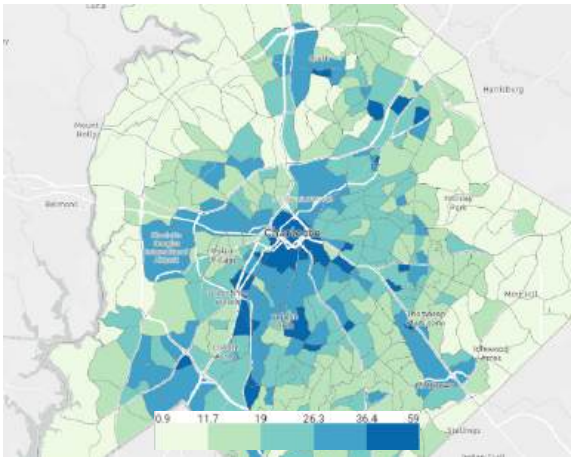


Figure 4: Percentage of land area that is impervious across Charlotte

Between now and 2050, Charlotte is projected to see an increase between 10 and 20% in annual financial loss from flooding, including costs associated with damage to buildings, infrastructure, and residential homes.[18] Extreme flooding can disrupt or damage transportation infrastructure, cut off access to utilities, hamper emergency services, overwhelm drainage systems, inundate or shut down wastewater treatment plants, and breach dams.[19] Additionally, frequent flooding can lead to decreased water quality as sediment and other contaminants are intensively introduced to the city's water bodies, and flash flooding can cause water treatment overflows leading to stream contamination.[20]

Frequent and devastating flooding can lead to temporary or permanent displacement of impacted residents and businesses. In effort to mitigate the impacts of flooding, Charlotte-Mecklenburg Storm Water Services (CMSWS) has developed a Flood Risk Assessment and Risk Reduction plan that includes flood risk management tools and sensors to support the City of Charlotte in preparing for and managing extreme floods. As of 2024, through the CMSWS buyout program, 450 high-risk homes and businesses have been removed from areas located in floodplains, and over 700 families have been relocated to less vulnerable locations. As a result, Charlotte is projected to save roughly $300 million from these flood mitigation efforts.[21] Additionally, expanding tree cover in the city and supporting stream restoration efforts can help to absorb more stormwater volume in flooding events. Healthy streams are critical for redirecting stormwater to adjacent floodplains that help to slow down stormwater flow.[22] Similarly, Charlotte's trees absorb and redirect 1.2 billion gallons of stormwater annually that might otherwise end up in waterways after storms.[23]

18 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

19 "Hurricane Florence Has Gone, but Challenges for the Carolinas Have Just Begun - The New York Times," accessed September 3, 2024, https://www.nytimes.com/2018/09/22/us/hurricane-florence-carolina.html.

20 Katherine Calvin et al., "IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. IPCC, Geneva, Switzerland.," First (Intergovernmental Panel on Climate Change (IPCC), July 25, 2023), https://doi.org/10.59327/IPCC/AR6-9789291691647.

21 "Flood Management Risk Tools and Flood Sensors | Storm Water Services," accessed August 20, 2024, https://stormwaterservices.mecknc.gov/flood-management-risk-tools-and-flood-sensors.

22 "Reedy Creek Stream Restoration," accessed November 25, 2024, https://www.charlottenc.gov/Services/Stormwater/Projects/Reedy-Creek-Stream-Restoration.

23 "Canopy Value - Charlotte Tree Plan," accessed September 19, 2024, https://charlottetreeplan.weebly.com/canopy-value.html.

Wildfire

Table 5: Wildfire impacts

Impacts	**Key impacts include degradation of air quality, reduced access to utilities and emergency services, displacement, and respiratory illnesses and fatalities.**

Figure 6: Wildfire risk in Charlotte area[24]

While wildfire risk in Charlotte is low, or less than the 50th percentile,[25] compared to other regions of the country, data suggests that wildfires are expected to become more frequent and destructive by 2050. Warmer average temperatures, drought, water stress, and extreme heat are likely to lead to weather conditions conducive to a higher occurrence of wildfires and more destructive fire events. A key area of focus for wildfire management is the interface where human development meets undeveloped or wildland, formally known as the wildland urban interface (WUI). WUI fires are not isolated to the western states that are more commonly associated with wildfire risk. In fact, North Carolina is one of the top 5 states in the U.S. for the greatest total number of houses in the WUI, an area that across the U.S. is growing by approximately 2 million acres per year.[26]

24 "EJScreen," accessed November 25, 2024, https://ejscreen.epa.gov/mapper/.
25 "EJScreen," accessed November 25, 2024, https://ejscreen.epa.gov/mapper/.
26 "What Is the WUI?," U.S. Fire Administration, accessed November 25, 2024, https://www.usfa.fema.gov/wui/what-is-the-wui.html.

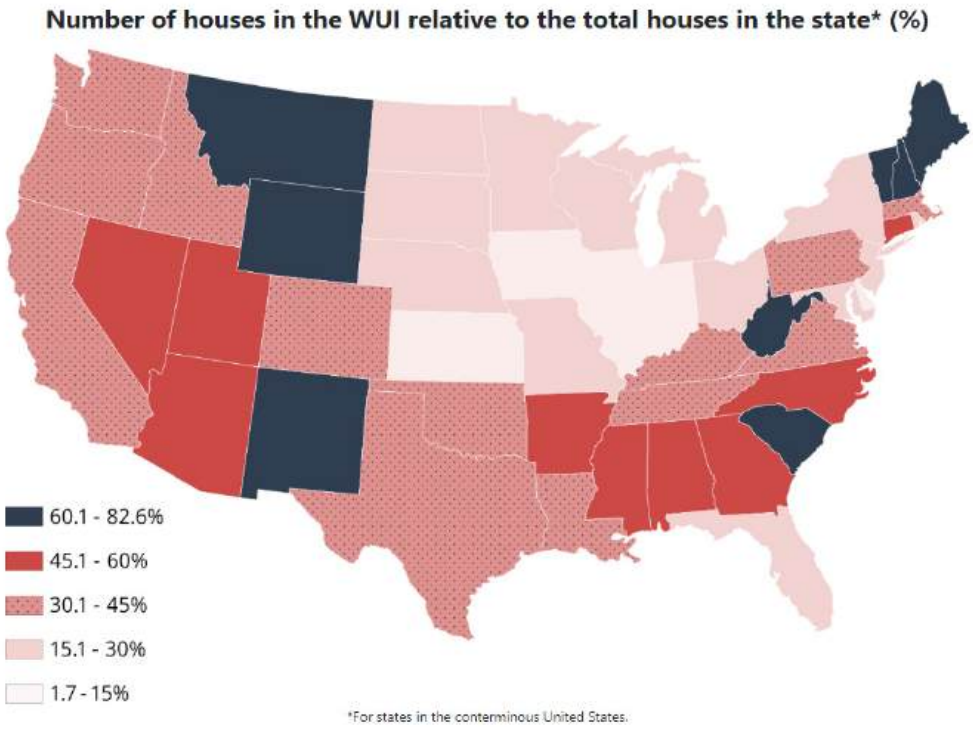


Figure 7: Number of houses in the WUI relative to the total number of houses in the state (%)

As recent as 2023, very dry atmospheric conditions in the eastern region of North Carolina contributed to the Great Lakes Fire,[27] which grew from 7,000 acres to 32,000 acres in just two days and cost the U.S. Forest Service $12 million to control.[28] The smoke from wildfires of this size and severity can travel across community and state lines, presenting indirect risks for cities like Charlotte that are situated in relative proximity to significant fire outbreaks. More frequent wildfires across the state can lead to severe declines in air quality increasing the incidence of respiratory illnesses, especially for vulnerable populations. Wildfires near the city can also lead to personal injury, damage and disruption to transportation infrastructure, displacement of residents, and strained healthcare and emergency services.[29]

Chronic physical risks

Chronic physical risks assessed for Charlotte include extreme heat, precipitation, drought, and water stress. Extreme heat events are projected to increase significantly while drought, water stress, and precipitation trends see moderate increases. Since chronic physical hazards occur over a longer timeframe, adaptation strategies often involve infrastructural changes across various sectors (e.g., expanding shaded spaces to combat heat) and long-term resource management strategies (e.g., water conservation plans). Additionally, chronic physical risks are driven by long-term shifts in climate that have often been quantified and tracked. Each chronic physical risk described below has an associated metric for measuring the change in frequency or severity of the hazard.

27 "National Interagency Coordination Center Wildland Fire Summary and Statistics Annual Report 2022," n.d.
28 "The Great Lakes Fire in the Croatan National Forest Is Now Fully Contained," accessed September 16, 2024, https://www.publicradioeast.org/2023-07-07/the-great-lakes-fire-in-the-croatan-national-forest-is-now-fully-contained.
29 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

Extreme heat

Table 6: Extreme heat projections and impacts

Projections	Measurement	Baseline (1961-1990 average)	2030		2050	
	Hot days: days per year where the max temperature reaches or exceeds 95°F[30]		Low carbon future	High carbon future	Low carbon future	High carbon future
		7 days	27.7	29.1	37 days	48 days
			+296% from baseline	+316% from baseline	+429% from baseline	+586% from baseline
Impacts	Key impacts to Charlotte from exposure to extreme heat include higher incidence of heat-related illnesses and fatalities, strain on healthcare services and facilities, decreases in worker productivity for outdoor workers, and increased costs for cooling and water.					

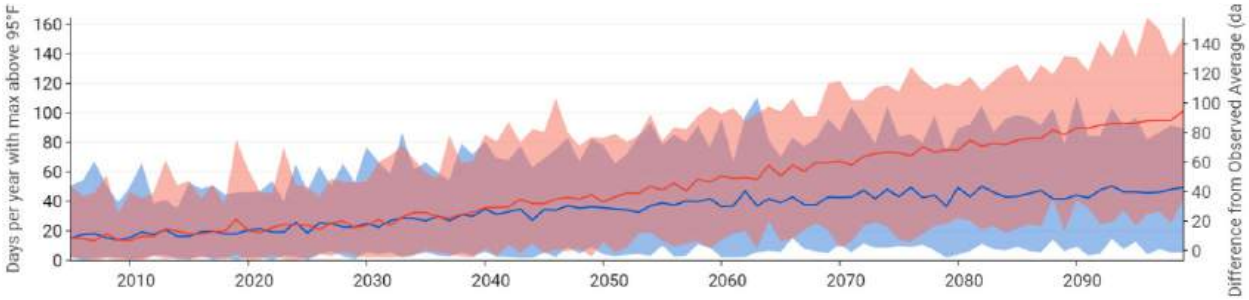


Figure 8: Charlotte's urban heat island
Legend: Red = high carbon future, Blue = low carbon future

Increases in extreme heat can have devastating effects on Charlotte's vulnerable and high-risk population and the environment. Compared to Charlotte's baseline average, the city has already seen a 300% increase in the number of extreme heat days annually.

When temperatures reach 95°F, or higher, and combine with high humidity, extreme heat becomes a critical risk as it hampers the body's ability to cool down, leading to serious, sometimes life-threatening health issues including dehydration, cramps, heat exhaustion, heat stroke, and potentially death.

Charlotte's vulnerable and high-risk population are especially at risk for heat-related illness. The Charlotte area's 80,000 mining, logging, and construction workers, who often work outdoors, are more vulnerable to the impacts of extreme heat. With the data suggesting a continued rise in extreme heat days regardless of scenario, Charlotte's healthcare system may face increased pressure, potentially straining services due to higher incidence of heat-related illnesses and fatalities.

30 "Mecklenburg County - Charlotte, NC," accessed August 1, 2024, https://crt-climate-explorer.nemac.org/.

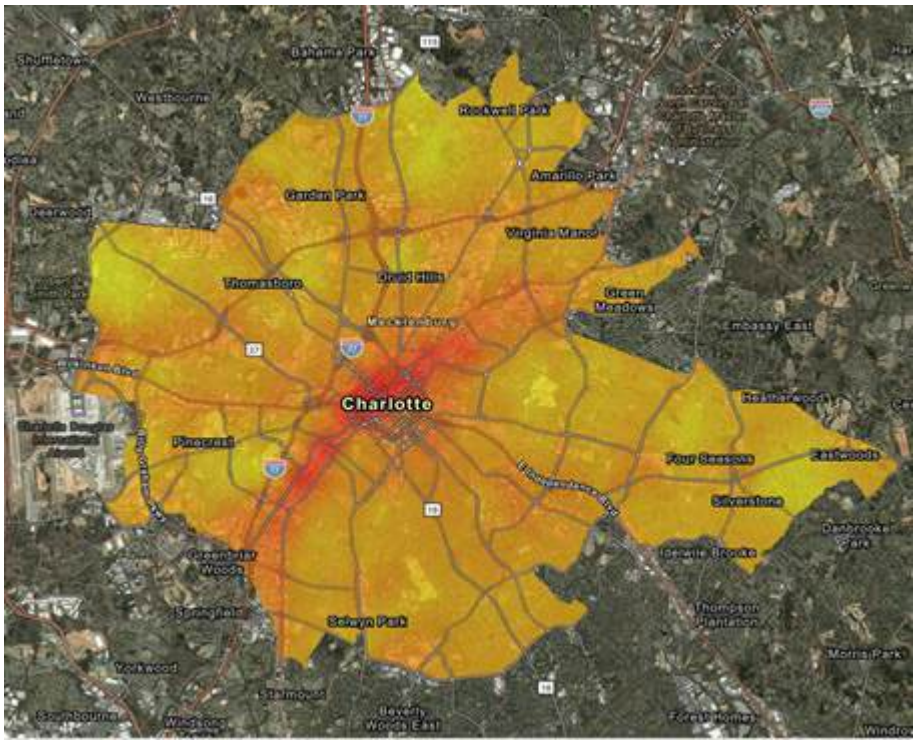


Figure 9: Projected days per year that reach 95°F or higher

Residents in urban areas are disproportionately affected by extreme heat, primarily due to a phenomenon known as the "urban heat island" effect, where sparse greenery and abundant heat-absorbing surfaces contribute to elevated temperatures. Daytime temperatures within City of Charlotte's heat island can be up to 12.9°F hotter than the city's rural surroundings,[31] and these areas can notably retain some additional heat overnight.[32] Urban heat islands often have a marked lack of vegetation, tree canopy, and greenspace which provide necessary relief from extreme heat. Historical development patterns, including the discriminatory housing practice of redlining, have contributed to a reduced presence of vegetative cover and greenspace, often resulting in the urban heat island effect.[33] Additionally, some neighborhoods may not have access to cooling centers, which are public air-conditioned spaces where people can seek temporary relief from heat,[34] or efficient air conditioning at home, further exacerbating the vulnerability of these neighborhoods.[35]

31 The Charlotte Heat Mappers, "Charlotte's Urban Heat Island," ArcGIS StoryMaps, November 22, 2024, https://storymaps.arcgis.com/stories/05410760c283469f99331a3cd85883ad.

32 "Mecklenburg County, NC Extreme Heat Map and Heat Wave Forecast," firststreet.org, accessed November 21, 2024, https://firststreet.org/.

33 OAR US EPA, "Heat Islands and Equity," Overviews and Factsheets, November 6, 2019, https://www.epa.gov/heatislands/heat-islands-and-equity.

34 "Cooling Centers | Climate Health and Risk Tool," accessed September 3, 2024, https://climatesmarthealth.org/articles/cooling-centers/.

35 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

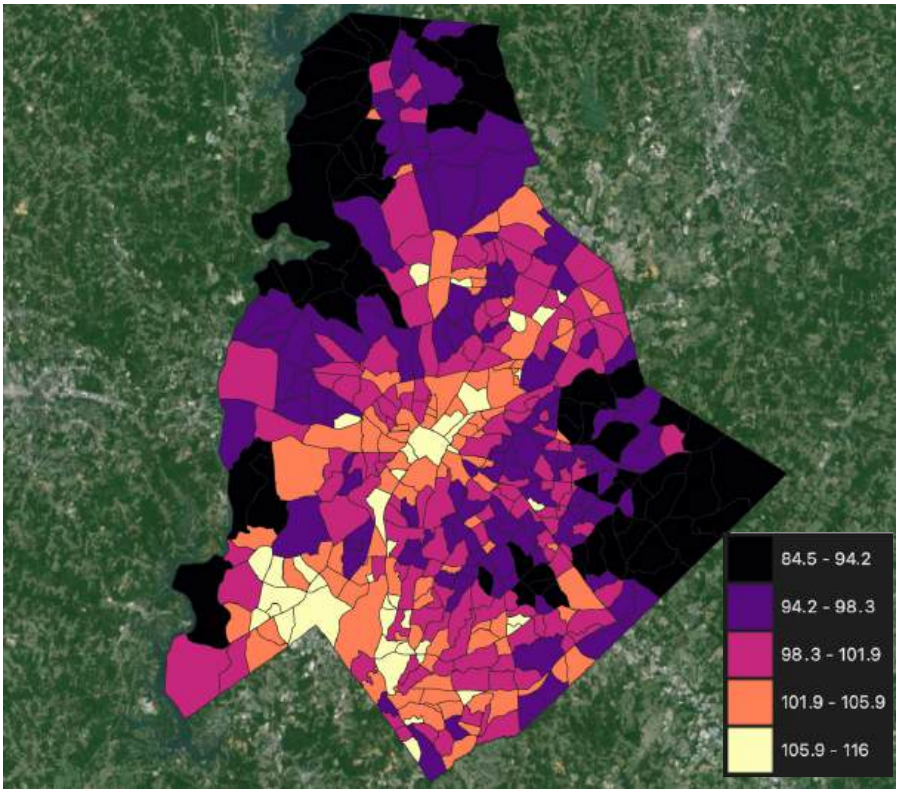


Figure 10: Charlotte average land surface temperature (LST) 2021-2023 by neighborhood profile area (NPA)

The escalation in extreme heat, as mapped in Figure 10, is likely to result in higher household energy consumption for cooling purposes as residents rely on air conditioning for more days each year than they did the year prior. Current estimates indicate that Charlotte residents require additional energy for cooling for approximately 212 days per year, and that number is projected to grow to approximately 223 cooling days annually in around 30 years. The city's electricity usage for cooling alone is projected to increase roughly 12.9% concurrently.[36] This could lead to higher energy bills for Charlotte's residents and strain the city's energy grid. Higher energy bills pose a financial risk for some Charlotte residents who already spend a larger portion of their income on energy costs compared to the rest of the population. When this proportion is significantly above average, it is referred to as an energy burden. Any increase in energy costs as extreme heat days increase could put residents already burdened by high energy expenses at risk of payment issues and service disconnection,[37] further limiting their access to cooling during extreme heat.

36 "Mecklenburg County, NC Extreme Heat Map and Heat Wave Forecast," firststreet.org, accessed November 21, 2024, https://firststreet.org/.

37 "LIHEAP and Extreme Heat: How the Low-Income Home Energy Assistance Program Is Assisting Families with Staying Safe, Healthy, and Prepared for Extreme Heat Events.," accessed November 26, 2024, https://www.acf.hhs.gov/blog/2022/04/liheap-and-extreme-heat.

Drought and water stress

Table 7: Drought and water stress projections and impacts

Projections	Measurement	Baseline (1961-1990 average)	2030		2050	
	Dry days: days per year where precipitation is less than 0.01 inches[38]		Low carbon future	High carbon future	Low carbon future	High carbon future
		194.7	+0.9%	+1.7%	+1.0%	+1.2%
	Water stress: ratio of total water demand to available renewable surface and groundwater supplies	0.73	0.78	0.72	1.13	1.64
Impacts	Key impacts to Charlotte include decreased water quality due to decreased dilution of contaminants, strain on water infrastructure, increased cost of water, and restrictions on water use.					

Drought and water stress are related and are discussed as two sides of the same coin for the purposes of this analysis. Drought refers to the environmental conditions brought about by extended periods of low precipitation, while water stress refers to high water demand in times of low water supply. Drought often brings about increased water stress, but water stress can exist in times without an active drought. It is important to note that drought and water stress are measured and projected differently. Drought is often projected by leaning on persistent weather conditions such as dry days, as in Table 7 above, and measuring the rates of evaporation and transpiration (indicators of how much moisture is circulating in the atmosphere). Water stress is often measured as a ratio of water demand to water supply, which includes some weather-related considerations coupled with data on surface and groundwater supplies.

Further, the triggers for drought and water stress are different but related. For example, drought is often triggered by low precipitation and thus reduced recharge of surface and groundwater supplies. In times of drought, it is common to see visibly lower water levels in rivers and lakes. Water stress is often triggered by drought but can also be triggered by increases in water demand. Population growth, industrial growth, and legal battles over water resources are potential root causes for increases in water demand. As the relationship between water demand and water supply changes because of drought or the various influences on demand, times of imbalance between the demand and supply lead to periods of time where more water is demanded than is sustainably able to be supplied. The signs of water stress are not often visible to those who don't work in water management, but the effects can be felt when water prices increase, or temporary restrictions are placed on water use.

Currently, Charlotte has a low risk of drought,[39] but that is expected to increase in the future as the number of dry days increases. The community's growing population impacts water supplies as water demand may increase in the future. Responsible watershed management is critical to monitor how Charlotte's available water supply is keeping up with increased water demands. Based on the current data, water stress in Charlotte is projected to reach extremely high levels regardless of scenario by 2050, meaning that water demand is on track to outpace the sustainable supply of water resources. For residents, this means that water prices are likely to increase in

38 "Mecklenburg County - Charlotte, NC," accessed September 10, 2024, https://crt-climate-explorer.nemac.org/.
39 "Map | National Risk Index," accessed September 1, 2024, https://hazards.fema.gov/nri/map.

the future.[40] As climate change alters the frequency of dry days in Charlotte, it is likely that the city may see more prolonged droughts that threaten the city's water systems, diminish water quality, and increase the risk of harmful contaminants.[41]

Precipitation

Table 8: Precipitation projections and impacts

Projections	Measurement	Baseline (1961-1990 average)	2030		2050	
	Total annual precipitation (in.)[42]		Low carbon future	High carbon future	Low carbon future	High carbon future
		45.3	+1.9%	+2.8%	+3.8%	+4.9%
Impacts	Key impacts include increased long-term risk of flooding, decreased water quality, reduced lifespan of road and tarmac surfaces, and altered lake and reservoir levels.					

Figure 11: Projected total annual precipitation for Mecklenburg County, North Carolina[43]

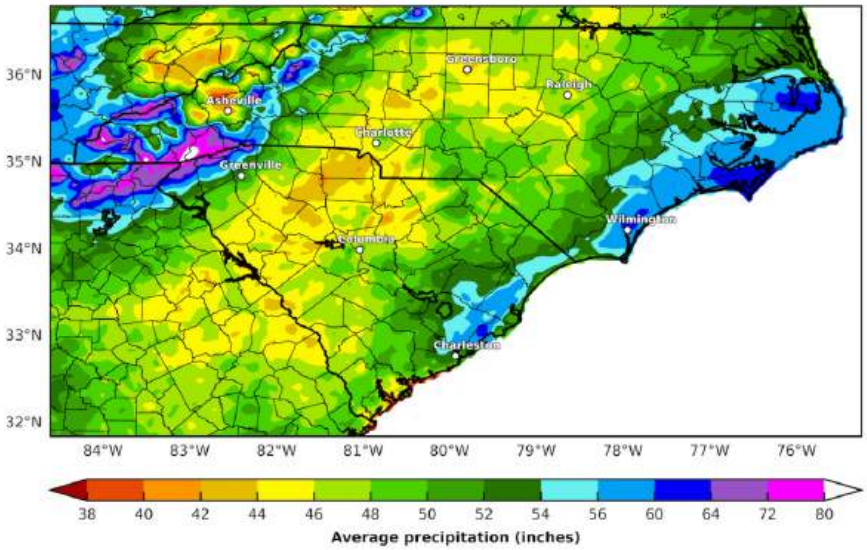
40 "Aqueduct Water Risk Atlas," accessed August 3, 2024, https://www.wri.org/applications/aqueduct/water-risk-atlas/#/?advanced=-false&basemap=hydro&indicator=w_awr_def_tot_cat&lat=-14.445396942837744&lng=-142.85354599620152&mapMode=view&month=1&opacity=0.5&ponderation=DEF&predefined=false&projection=absolute&scenario=optimistic&scope=baseline&timeScale=annual&year=baseline&zoom=2.

41 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

42 "Mecklenburg County - Charlotte, NC," accessed August 1, 2024, https://crt-climate-explorer.nemac.org/.

43 "Mecklenburg County - Charlotte, NC," accessed September 16, 2024, https://crt-climate-explorer.nemac.org/.

Figure 12: Average annual precipitation in the Carolinas (2002-2016)[44]



Precipitation shapes Charlotte's climate challenges, influencing drought, water stress, and the severity of events like flash floods. From 1961 to 1990, the city averaged 45 inches of rain annually, but by 2050, current climate models indicate this will increase by 4-5% in either of the potential future scenarios.[45] Although this increase many not seem significant, this level of uptick can shorten the lifespan of roads and disrupt transportation networks.[46] For perspective, each 1 inch of rain equals 17.4 million gallons of rainwater per square mile,[47] meaning that Charlotte's 308.3 square miles[48] could stand to receive up to an additional 5.4 billion gallons of rainwater per year by 2050 in a high carbon future. Intense rainfalls risk contaminating surface waters and decreasing water quality. This was a notable impact in the wake of Hurricane Florence in 2018, where, after the storm, elevated levels of fecal coliform bacteria were detected in North Carolina surface waters. The contamination of the state's critical freshwater resources lasted for up to eight weeks after the storm.[49] Such incidents underscore the need to reassess water management in areas vulnerable to flash flooding as extreme precipitation events become more frequent and intense as annual precipitation increases.[50]

Transition risk

Transition risk refers to the potential challenges communities might face as the world shifts toward a more sustainable and low carbon future, like externalities due to the high- or low carbon scenarios. These risks are often driven by emerging policy and regulation, technological innovation, consumer and market preference changes, and resource availability challenges that arise in the effort to reduce global emissions.

For this assessment, focus is put on the economic, transportation, and urban planning transitions amid the city's

44 "CPPP | Carolinas Average Precipitation," accessed December 10, 2024, https://artsandsciences.sc.edu/geog/research/cisa/atlas/carolinas-precip-map.html.

45 "Mecklenburg County - Charlotte, NC," accessed August 1, 2024, https://crt-climate-explorer.nemac.org/.

46 Mark J. Koetse and Piet Rietveld, "The Impact of Climate Change and Weather on Transport: An Overview of Empirical Findings," Transportation Research Part D: Transport and Environment 14, no. 3 (May 1, 2009): 205–21, https://doi.org/10.1016/j.trd.2008.12.004.

47 "Rainfall calculator: How Much Water Falls during a Storm? USGS Water Science School," accessed November 26, 2024, https://water.usgs.gov/edu/activity-howmuchrain.php.

48 "U.S. Census Bureau QuickFacts: Charlotte City, North Carolina," accessed November 26, 2024, https://www.census.gov/quickfacts/fact/table/charlottecitynorthcarolina/PST045223.

49 Survey-of-Surface-Water-Quality-Associated-with-Hurricane-Florence-September-2018-Final.pdf

50 Darren L. Ficklin et al., "Hydrological Intensification Will Increase the Complexity of Water Resource Management," Earth's Future 10, no. 3 (March 2022): e2021EF002487, https://doi.org/10.1029/2021EF002487.

rapid growth. As Charlotte anticipates a population increase of 50% or more by 2050, as shown in Figure 13, the city recognizes the importance of sustainable development to manage this growth effectively in a changing climate. Charlotte's expansion poses a challenge to climate change preparedness, not just for physical risks discussed above, but potentially intensifying transition risks as well. Proactively evaluating and preparing for these transition risks is a critical component of Charlotte's sustainability strategy, enabling the city to build on its existing commitments, uncover new opportunities, tackle inequity, and align with the evolving global economy.

Economy

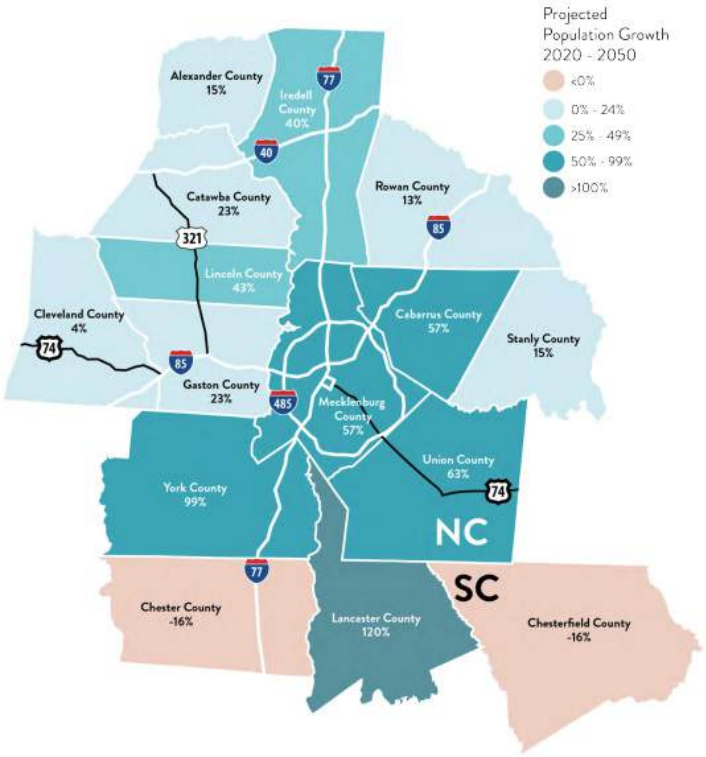


Figure 13: Projected Charlotte area population growth 2020-2050[51]

As Charlotte continues to strive toward its sustainability goals, there is an opportunity for a workforce skilled in new industries that emerge, such as the clean energy industry. North Carolina is expected to add over 509,000 new jobs by 2032,[52] exceeding the national growth rate. Moreover, since 2017, North Carolina has added 17,500 clean energy sector jobs,[53] and that number is projected to grow to 38,000 by 2030,[54] indicating clean energy will contribute significantly to the state's growth, with Charlotte positioned to benefit significantly from job creation. Ensuring equitable access to these emerging job opportunities in the clean energy sector and beyond is critical to allow all communities to share in Charlotte's economic development.

A 2021 study in Charlotte revealed a connection between job availability and transportation access. The findings

51 Charlotte Regional Business Alliance, "Population and Demographic Changes in the Charlotte Region," accessed September 10, 2024, https://charlotteregion.com/clientuploads/Data/Population_and_Demographics_Changes_2021.pdf.

52 "North Carolina Employment Projections to 2032," NC Department of Commerce, accessed November 19, 2024, Employment Projections | NC Commerce.

53 "Momentum Builds for the Clean Energy Economy in 2023 as Over 14,100 Jobs and Billions in Investment Come to North Carolina | NC Commerce," accessed September 20, 2024, https://www.commerce.nc.gov/news/press-releases/2023/12/18/momentum-builds-clean-energy-economy-2023-over-14100-jobs-and-billions-investment-come-north.

54 "North Carolina's Clean Energy Jobs Potential Through 2030," National Renewable Energy Laboratory, accessed November 19, 2024, State Clean Energy Employment Projection Support | State, Local, and Tribal Governments | NREL.

suggest that improving transit options for lower-income households could result in higher median incomes and better job accessibility.[55] This is particularly important for Mecklenburg County, where there are significant income disparities: White and Asian households earn considerably more than Black and Latinx households, highlighting a racial wealth gap.[56] The City of Charlotte, situated in Mecklenburg County, mirrors this county-wide trend. Without a concerted effort to incorporate equity and accessibility into economic growth strategies, there's a risk that Charlotte's economic expansion could unintentionally exacerbate this divide, benefiting those with existing access to new jobs while excluding communities with historic barriers to access.

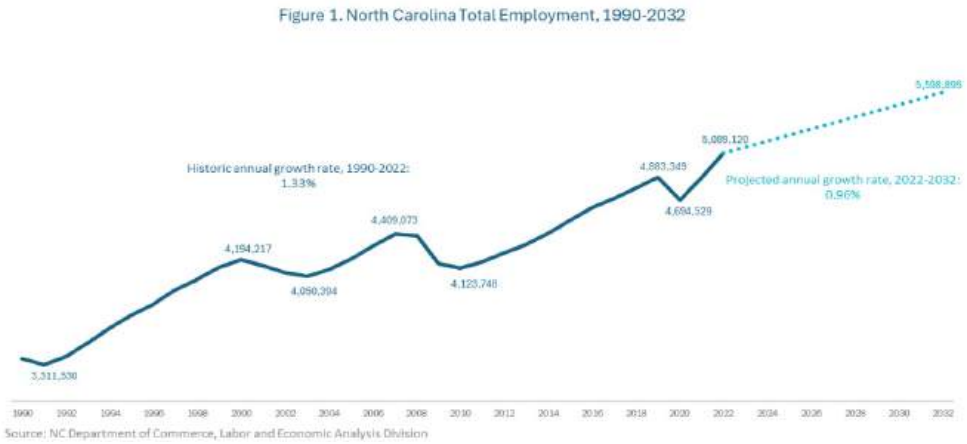


Figure 14: North Carolina total employment, 1990-2032[57]

Furthermore, Charlotte faces the challenge of addressing climate-related health risks in the workforce, which impact an estimated 65 million Americans nationally.[58] These risks, such as heat-related illnesses and the mental effects of climate change, highlight the importance of not only maintaining but also improving the city's workforce through education and health initiatives. Such initiatives include job hazard analyses, evaluation of needs for personal protective equipment (PPE),[59] and workplace heat inspections.[60] As Charlotte prepares for growth in sectors like renewable energy and e-mobility, ensuring the health and safety of its workforce is essential. The community's ability to safeguard and grow its skilled and healthy workforce will be crucial in supporting sustainable industrial and commercial growth. Charlotte's focus on health, equity, and accessibility in its workforce development strategy will be vital in building an economy that is resilient and inclusive, capable of navigating the challenges posed by climate change.

55 Elizabeth Delmelle, Isabelle Nilsson, and Providence Adu, "Poverty Suburbanization, Job Accessibility, and Employment Outcomes," Social Inclusion 9, no. 2 (May 13, 2021): 166–78, https://doi.org/10.17645/si.v9i2.3735.

56 "How Jobs Contribute to the Racial Wealth Gap – UNC Charlotte Urban Institute," accessed September 16, 2024, https://ui.charlotte.edu/story/how-jobs-contribute-racial-wealth-gap/.

57 "North Carolina Employment Projections to 2032," NC Department of Commerce, accessed November 19, 2024, Employment Projections | NC Commerce.

58 "How the Climate Crisis Is Impacting Jobs and Workers | World Economic Forum," accessed September 16, 2024, https://www.weforum.org/agenda/2023/10/climate-crisis-impacting-jobs-workforce/.

59 "Impacts of Climate Change in the Workplace | Occupational Safety and Health Administration," accessed November 26, 2024, https://www.osha.gov/emergency-preparedness/impacts-of-climate-change.

60 "US Department of Labor Announces Enhanced, Expanded Measures to Protect Workers from Hazards of Extreme Heat, Indoors and out | Occupational Safety and Health Administration," accessed November 26, 2024, https://www.osha.gov/news/newsreleases/national/09202021.

Transportation

Transportation infrastructure, a cornerstone of Charlotte's growth and development, will play an even more crucial role in the transition to a low carbon future, especially as this is the highest GHG emitting sector in Charlotte (34%). This shift necessitates adapting the city's current infrastructure, primarily designed for internal combustion engine (ICE) vehicles, to support a broader range of transportation options, including public transit, electric vehicles (EVs), e-bikes and bicycles, pedestrian pathways, and other sustainable modes of transportation that emerge over time. Without a dedicated approach to retrofitting existing transportation systems and investing in new infrastructure, especially public transportation infrastructure, there is a risk that Charlotte misses out on opportunities to reduce emissions, traffic congestion, and associated costs in the transition to a low-carbon future.

Presently, over 75% of Charlotte's residents commute in single-occupancy vehicles.[61] However, Charlotte's Strategic Mobility Plan aims to significantly transition 50% of single-occupancy vehicle commutes to the use of alternative modes such as walking, biking, and public transit.[62] A majority of residents, roughly 51%, feel that travel has become more difficult in the past few years, and an overwhelming majority of residents, nearly 90%, supporting street redesign that expands access to all users, not just cars.[63]

Easing vehicular traffic congestion, which leads to increased air pollution, hinges on encouraging an increase in the use of bus and rail systems. The Charlotte Area Transit System (CATS) buses, accounting for 57% of the city's daily transit trips, and light rail accounting for the other 43%, are pivotal in revolutionizing Charlotte's transportation landscape and advancing the energy transition. To that end, in 2023, CATS was awarded a $30 million federal grant that will be utilized to introduce 15 battery electric buses (BEBs) and 15 hybrid electric-diesel buses.[64] Additionally, Charlotte is working to increase resiliency across the city's various transportation options, introducing an on-demand pilot program in 2022 to improve coverage between transit routes and offer residents ride-hailing within certain areas. As the city expands transportation options to encourage mode shift, electrification and resilience, it is essential to prioritize equity and accessibility, guaranteeing that all residents have ample and fair access to these modes of mobility. Equitable access allows Charlotte to maximize the benefits of reduced air pollution and improved energy efficiency in the transportation sector.

In addition to the mode shift goal discussed above, EVs are set to be a key player in Charlotte's move towards a low carbon future, offering a cleaner alternative to traditional ICE vehicles and significantly cutting tailpipe emissions. North Carolina has already seen a rise in EV adoption, bolstered Executive Order No. 80 which aims to increase the number of registered zero-emission vehicles to at least 80,000 by 2025 and the clean energy businesses that are moving to the state.[65] Currently, as part of Charlotte's fleet decarbonization efforts, electric vehicles make up 3% of the city's fleet. While EVs play a role in reducing the city's emissions, they also introduce a new challenge: the need for expanded charging infrastructure to keep these vehicles running smoothly within and around Charlotte.

61 "Charlotte's New Mobility Plan: Ambitious Goals, Tons of Data – UNC Charlotte Urban Institute," accessed September 16, 2024, https://ui.charlotte.edu/story/charlottee28099s-new-mobility-plan-ambitious-goals-tons-data/.

62 City of Charlotte, "Charlotte Strategic Mobility Plan: Plan in Brief," accessed September 10, 2024, https://www.charlottenc.gov/files/sharedassets/city/v/1/growth-and-development/documents/smp/charlotte-strategic-mobility-plan_plan-in-brief_june-2022.pdf.

63 "Charlotte's New Mobility Plan: Ambitious Goals, Tons of Data – UNC Charlotte Urban Institute," accessed September 16, 2024, https://ui.charlotte.edu/story/charlottee28099s-new-mobility-plan-ambitious-goals-tons-data/.

64 "Charlotte Area Transit System Awarded $30 Million to Advance Its Fleet," accessed November 27, 2024, https://www.charlottenc.gov/CATS/News/cats-awarded-30million.

65 North Carolina, Executive Office of the Governor Roy Cooper. Executive Order No. 80: North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy, EO80--NC-s-Commitment-to-Address-Climate-Change---Transition-to-a-Clean-Energy-Economy.pdf.

Currently, Charlotte has 936 available EV charging ports, of which, nearly a third are municipally funded. Some of those ports are solar powered to provide additional grid resilience in the transition from ICE vehicles to EVs.[66] The city has leveraged policy as a vehicle to promote EV charging expansion with the Unified Development Ordinance (UDO) cementing the city's requirements to include EV chargers in the planning and development of multi-family stacked dwellings, the residential component of mixed-use developments, hotels, and parking lots.[67] Across the state, however, North Carolina trails behind Florida and Georgia in terms of available charging ports per capita.[68] To achieve the ambitious target of 1.25 million EVs on the road by 2030,[69] ramping up charging infrastructure is essential to maintain the level of investment and growth in the EV industry in the state. Charlotte has the potential to lead this charge, making EV charging more accessible and thereby accelerating the state's transition to a greener future.

Place Type Analysis

Climate change poses a profound challenge to the sustainability and resilience of urban environments, impacting Charlotte's landscape, as categorized by Place Types, in distinct ways. Place Types think about a place more holistically and at a larger scale, incorporating guidance for land use, transportation, layout, and design. Place Types help to articulate desired physical characteristics with context-sensitive application across the city, while helping to prioritize trade-offs associated with our shared goals.[70] As Charlotte continues to grow and thrive in the context of a changing climate and associated climate risk levels, it is important to link this analysis directly to our growth plan to set a foundation for resiliency in Charlotte.

This analysis delves into the intricacies of how climate risk affects where people live (residential place types and parks and preserves), work (commercial, campus, manufacturing, and mixed use) place types and play (neighborhood, community, and regional place types). These three over-arching categories are informed by 10 defined place types defined in Charlotte's 2040 Comprehensive Plan,[71] where the original 10 are grouped to form the three place types for this analysis based on shared characteristics, land use, and building types:

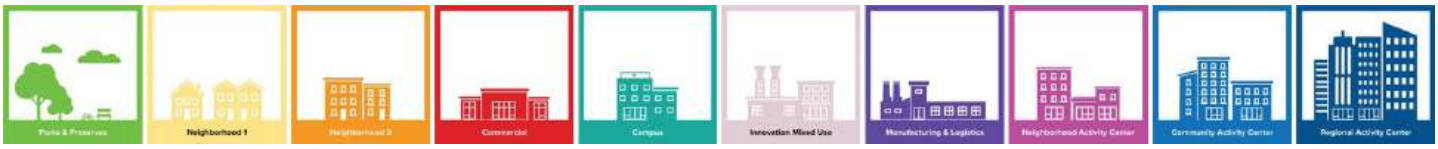


Figure 15: Illustration of the 10 place types

- Industrial and commercial: includes commercial, campus, manufacturing and logistics, innovation mixed-use, community activity center, and regional activity center place types
- Residential: includes neighborhood 1 and 2 as well as the neighborhood activity center place types
- Parks and preserves: includes parks and preserve place types

66 "SEAP Dashboard," accessed November 18, 2024, https://community.charlottenc.gov/pages/seap-dashboard.
67 "Article 19. Off-Street Vehicle & Bicycle Parking | Read The UDO," accessed December 12, 2024, https://read.charlotteudo.org/articles/article-19-off-street-vehicle-bicycle-parking/.
68 NC State University, "Getting North Carolina Ready for Electric Vehicle Charging," accessed September 12, 2024, https://www.ncdot.gov/initiatives-policies/environmental/climate-change/Documents/nc-ready-electric-vehicle-charging.pdf.
69 NC State University, "Getting North Carolina Ready for Electric Vehicle Charging," accessed September 12, 2024, https://www.ncdot.gov/initiatives-policies/environmental/climate-change/Documents/nc-ready-electric-vehicle-charging.pdf.
70 City of Charlotte, "Charlotte Future: 2040 Comprehensive Plan," accessed August 2, 2024, https://www.cltfuture2040plan.com/sites/default/files/01-CF2040_Policy-Plan.pdf.
71 City of Charlotte, "Charlotte Future: 2040 Comprehensive Plan," accessed August 2, 2024, https://www.cltfuture2040plan.com/sites/default/files/01-CF2040_Policy-Plan.pdf.

The map below (Figure 16) gives an overview of the concentration of the various place types across the City of Charlotte.

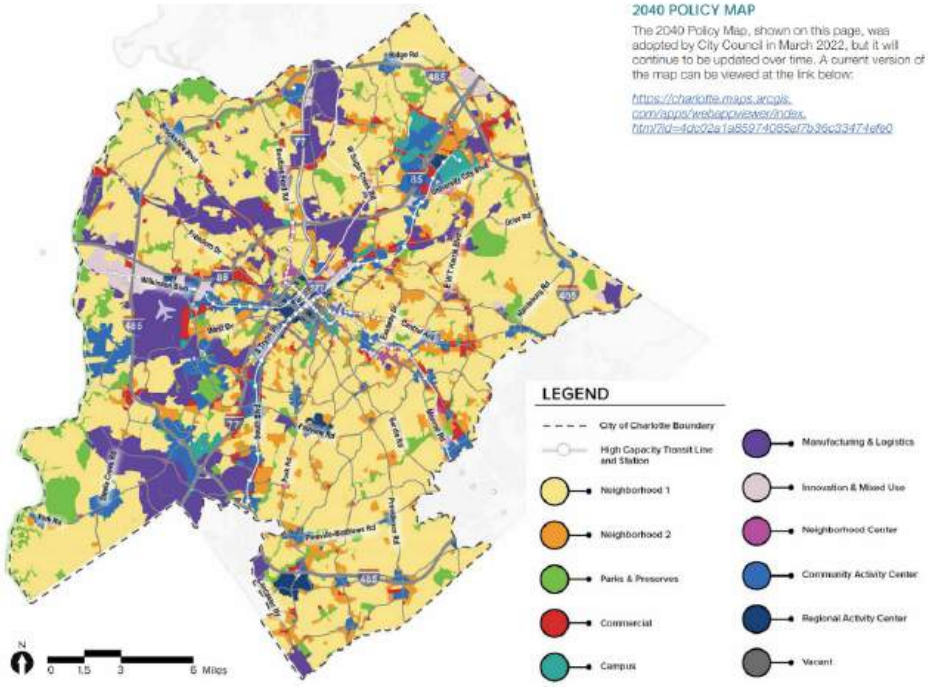


Figure 16: 2040 Policy map[72]

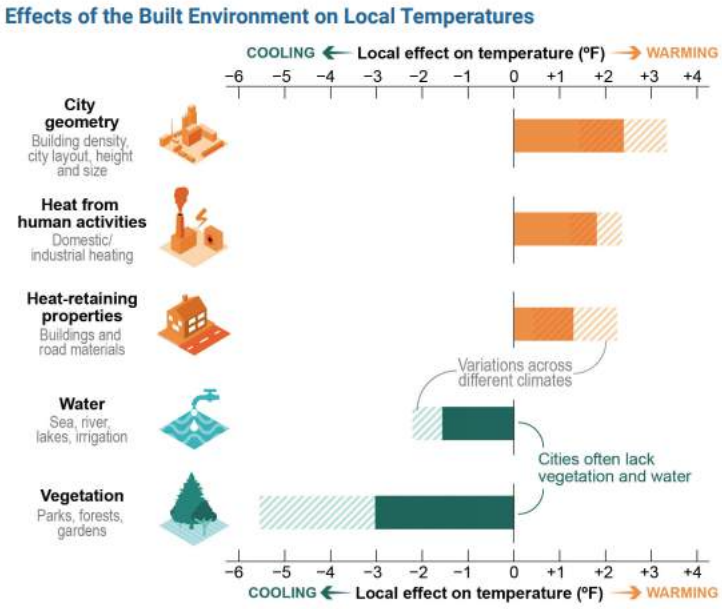


Figure 17: Effects of the built environment on local temperatures[73]

72 City of Charlotte, "Charlotte Future: 2040 Comprehensive Plan – Policy Map Manual," accessed November 18, 2024, 2040 Policy Map Manual – Charlotte Future 2040 Comprehensive Plan.

73 Steven G. McNulty et al., "Southeast," Fifth National Climate Assessment (U.S. Global Change Research Program, Washington, DC, November 14, 2023), https://nca2023.globalchange.gov/chapter/22/.

Industrial and commercial

Industrial and commercial zones in Charlotte, with their high levels of impervious infrastructure and energy use, are especially prone to operational disruptions and supply chain issues during extreme climate events.

Table 8: Mitigating and exacerbating factors for the industrial and commercial place types

Factors that protect against climate events (i.e., mitigating)	Factors that create additional considerations for climate events (i.e., exacerbating)
• Flood barriers • Stormwater management systems • Wind-resistant design • Storm shutters • Water-efficient technology • Cool roofing • Strengthened building materials	• Aging infrastructure • Large glass windows • High water demand • Impervious surfaces • High building and infrastructure density

The concentration of asphalt, concrete, and other hardscaped materials that absorb heat in industrial and commercial areas leads to increased urban heat island effects, as further explained in the "extreme heat" discussion. These same surfaces, being impervious, lead to higher stormwater runoff and increased opportunities for urban flooding without appropriate mitigation and stormwater management. Finally, as Charlotte braces for more frequent and intense hurricanes, adopting wind-resistant designs and strengthened, more resilient building materials will enhance the resilience of these "work" and "play" areas.

Residential

Residential areas face climate-related challenges that directly affect human health, such as urban heat island effects, deteriorating air quality, and home/property damage such as mold.

Table 9: Mitigating and exacerbating factors for the residential place types

Factors that protect against climate events (i.e., mitigating)	Factors that create additional considerations for climate events (i.e., exacerbating)
• Flood barriers, including stilts, piles, and platform homes • Stormwater management systems • Permeable surfaces • Strengthened building materials • Reinforced roofing • Hardened utilities • Tree canopy	• Impervious surfaces • Proximity to wildland urban interface (e.g., zone of transition between developed and undeveloped land)[74] • Increased population in vulnerable areas • High water demand • Aging infrastructure

In Charlotte, the variety of density across the city affects how climate hazards will impact neighborhoods. The Place Types that make up the areas Charlotteans live have similar impervious surface concerns as the industrial and commercial place types, namely that urban heat absorption increases with more hardscape. Additionally, the more people that live in floodplains, or other areas of the city that are more at-risk to climate events than other, the larger the potential impact from extreme events. Accounting for aging infrastructure as the city grows is critical as the city strives to grow efficiently because older structures may require additional investment and adaptation to increase resilience to climate events.

The increases in severity and frequency of extreme weather events and their impacts to Charlotte's residents underscores the critical need for deliberate design and development in the city's residential areas, ensuring they are equipped to face ongoing climate challenges.

74 "What Is the WUI?," U.S. Fire Administration, accessed November 25, 2024, https://www.usfa.fema.gov/wui/what-is-the-wui.html.

An exploration of inequities in residential climate resilience

An analysis of Charlotte reveals a stark disparity in tree canopy coverage between predominantly White and Black neighborhoods as an example of the impacts of historical zoning and development decisions. Data shows that predominantly White communities, mainly concentrated in the southern and southeastern parts of the city, enjoy more tree coverage compared to predominantly Black communities concentrated in the north, in part due to the influence of historical redlining. Redlining is a discriminatory practice that emerged in the United States in the 1930s and refers to the practice of delineating areas, often minority communities, where banks and other financial institutions would avoid investments, such as mortgage lending. Past redlined areas have been found to have less vegetative cover, higher temperatures than other parts of a city.[75] This pattern, highlighted in Figure 18, illustrates greater exposure to extreme heat in predominantly Black neighborhoods.[76] Neighborhoods without tree canopy could experience temperatures that are 15-25°F hotter than less developed areas,[77] underscoring the need for equitable climate resilience efforts.

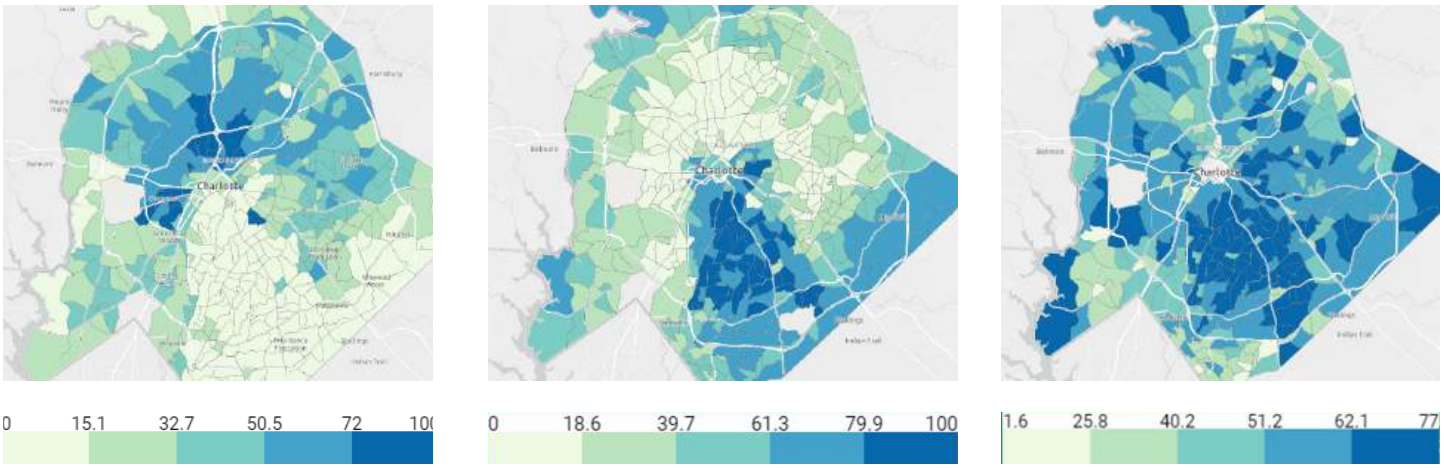


Figure 18: Predominantly Black and White neighborhoods and the presence of tree canopy[78]

Parks and preserves

Parks and preserves are vital to urban health, acting as natural coolants, soil stabilizers, and flood defenses, yet they face threats from ecological imbalances and biodiversity loss. In a growing city, these areas are essential for mitigating climate change effects and bolstering urban resilience.

75 "Full Article: Urban Heat Management and the Legacy of Redlining," accessed November 18, 2024, https://www.tandfonline.com/doi/full/10.1080/01944363.2020.1759127.

76 OAR US EPA, "Heat Islands and Equity," Overviews and Factsheets, November 6, 2019, https://www.epa.gov/heatislands/heat-islands-and-equity.

77 "Canopy Value - Charlotte Tree Plan," accessed September 19, 2024, https://charlottetreeplan.weebly.com/canopy-value.html.

78 "Charlotte/Mecklenburg Quality of Life Explorer," accessed September 16, 2024, https://mcmap.org/qol/#15/.

Climate Risk Assessment Full Report

Planning with climate risk in mind

Understanding the mitigating and exacerbating factors of climate exposure in these place types is crucial for developing tailored strategies that enhances the city's adaptive capacity and supports a multifaceted approach to resiliency planning. For Place Types associated with where people work, this might involve retrofitting buildings for energy efficiency and disaster resilience. In places where residents live, urban planners might prioritize sustainable housing, community cooling centers, and access to emergency services. Meanwhile, enhancing resiliency where people play may require an emphasis on ecological restoration and the creation of multi-use areas that can withstand climate stressors and serve residents during climate events.

A note on trees:

Trees provide invaluable ecosystem benefits and services to the city of Charlotte. Trees support Charlotte's resilience against climate by:

- Redirecting stormwater that would otherwise reach Charlotte's waterways
- Reducing the need for cooling
- Alleviating the impacts of heat
- Removing carbon dioxide from the air
- Improving air quality
- Buffering to reduce pollution from nearby roadways

Notably, Charlotte has been ranked #1 in North America for the Husqvarna Urban Green Space Insights (HUGSI) Green Space Index Rankings. The city has 47% tree canopy cover that:

- Sequesters 138,000 tons of carbon annually
- Prevents 34 million gallons of runoff
- Removes just under 7 million pounds of pollution from the air
- Stores 3.3 million tons of carbon in the canopy

Figure 19: Insights on the value of tree canopy

Charlotte recognizes that the effects of climate change are not experienced uniformly within cities. Marginalized communities often bear a disproportionate burden of climate risks, underscoring the importance of integrating equity considerations into resiliency efforts. By adopting place-based strategies that acknowledge the distinct challenges and roles of places where Charlotteans live, work, and play, the City of Charlotte can foster a more resilient urban landscape. This, in turn, ensures that all residents, regardless of their socio-economic status, can thrive in the face of a changing climate.

Charlotte's inaugural climate risk assessment analysis serves as a foundational step in this direction, guiding Charlotte toward a more equitable and sustainable future.

This work enables the city to identify climate-related vulnerabilities and align mitigation and adaptation actions to improve overall resiliency.

Table 9

Factors that protect against climate events (i.e., mitigating)	Factors that create additional considerations for climate events (i.e., exacerbating)
• Tree canopy • Drought and heat-tolerant landscaping • Native plant species • Buffering	• Unhealthy trees close to infrastructure • Steep slopes • Erosion

Parks and preserves are vital to urban health, acting as natural coolants, soil stabilizers, and flood defenses, yet they face threats from ecological imbalances and biodiversity loss. In a growing city, these areas are essential for mitigating climate change effects and bolstering urban resilience.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Endnotes

Endnotes

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