The Town of Nags Head Electric Vehicle Action Plan

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Prepared For:

TOWN OF NAGS HEAD

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Photo: Outerbanks.com

Executive Summary

The number of electric vehicles (EVs) on the road in the United States is growing at a steady rate. More electric cars will necessitate more electric car chargers, both in public spaces and in private homes and rental properties. Local governments must prepare for the steadily increasing demand for electric car chargers, by educating business and property owners of the benefits of providing car charging stations, and by making charging stations available in public spaces.

The need to adapt to the rise of electric vehicles is especially important for small towns that rely on tourism. As more and more visitors begin to arrive by electric vehicle in the coming years, towns that are tourist destinations must prepare to meet the charging needs of their residents and guests.

In 2021, the Town of Nags Head, North Carolina approached the Duke Nicholas School of the Environment for assistance in preparing for electric vehicles in their town. A Masters' Project team was formed to create this comprehensive Electric Vehicle Action Plan to assist Nags Head in planning for a successful and more environmentally-friendly future. Our team consists of Camila Zárate Ospina, who has a background in environmental engineering, Narissa Petchumrus, with a background in public policy, and Will Price, who has a background in law. We were graced with the supervision of Dr. Timothy Johnson, Ph.D., the Associate Dean for Professional Programs and Chair of the Energy & Environment Program at the Nicholas School.

The overall objective of this Action Plan is to determine what the charging and infrastructure needs of the town will be as the number of EVs increases, and then to make recommendations to the Town of Nags Head based on these findings.

To accomplish this goal, this team carried out extensive research into EV sales, charging requirements, local demographics, relevant laws, and comparable plans created by other cities/states. The team created a mathematical model to ultimately predict the charging infrastructure needs of the town for the next thirty years, based on projected sales figures and tourist behavior. Moreover, the team conducted numerous interviews with experts and local stakeholders to fully evaluate the needs and perspectives relevant to the plan. Consideration was made for issues of resiliency and equity particular to Nags Head. Finally, the team identified sources of grant funding and support for vehicle electrification, should the town choose to install its own chargers or electrify its municipal fleet.

Based on the results of this work, this plan concludes with recommendations for the town to pursue, separated into four broad categories: infrastructure, policy and outreach, resiliency, and sources of funding.

Regarding infrastructure, the results of the model projecting EV numbers in Nags Head recommends that the Town install 100 to 250 EV chargers by the year 2030. This figure includes both publicly accessible chargers and chargers installed in private homes and rental properties. The model further recommends that the town focus on the more affordable, slower-charging Level 2 type of charger, rather than the more expensive DC fast charger, because visitors stay for an average of five days, meaning that slower, more abundant Level 2 chargers will be more useful to the town than the less plentiful, much faster DC fast chargers.

With respect to policy and outreach, we recommend that the town develop a relationship with the North Carolina Utilities Commission (NCUC) with the objective of laying the groundwork for support of future EV plans. We further recommend that the town present to local business owners and property managers on the importance and benefits of installing charging infrastructure in business parking lots and private rental properties. Our recommendation that town install 100 to 250 chargers, including both private and public chargers, by the year 2030, is informed by the fact that roughly 80 percent of all tourists stay in private rental properties. It will be up to developers and property managers to install chargers at the properties where the majority of visitors will be parking their vehicles.

Regarding resiliency, we recommend exploring the possibility of creating a microgrid for the town, that will be resistant to power outages caused by weather conditions on the coast. Similarly, utilizing battery storage could be another way to increase resiliency in the electric grid as more and more drivers rely on electricity to power their vehicles in the event of an emergency evacuation scenario. Finally, generally hardening electric infrastructure in the town will increase the reliability of EV chargers and the grids they draw from.

Finally, we recommend that Nags Head explore several promising sources of funding as it considers installing EV chargers. The Volkswagen Settlement fund provides millions of dollars of grant money in North Carolina for the purpose of constructing EV infrastructure. The Volkswagen fund is distributed in phases spanning several years, making the timing of the funding proposal deadlines ideal for Nags Head to evaluate their course of action and apply. Similarly, the federal Infrastructure Investment and Jobs act promises several million dollars for North Carolina to build EV charging infrastructure, on a timeline that should be compatible with Nags Heads decision-making process, should the town choose to apply for grants.

It is our hope that this action plan can serve as a useful tool for towns other than Nags Head. Just as we began our work by reviewing EV plans from other towns and cities, this document will serve as a good resource for other groups who are interested in learning more about electric vehicles and what their growth will mean for small towns, especially towns that rely on tourism, or are located on the coast.

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Glossary of Acronyms and Terms

ADA Americans with Disabilities Act
BEV Battery electric vehicle
BNEF Bloomberg New Energy Finance
CCS SAE Combined Charging System Society of Automotive Engineers
DCFC Direct Current Fast Charging
DER Distributed Energy Resource
DOE Department of Energy
DOT Department of Transportation
EO Executive Order
EV Electric vehicle
EVO Electric Vehicle Outlook
EVSE Electric vehicle supply equipment
FCV Fuel cell vehicle
GHG Greenhouse gas
HDV Heavy duty vehicle
HEV Hybrid electric vehicle
ICE Internal combustion engine
IEA International Energy Agency
LDV Light duty vehicle
NCBC North Carolina Building Code
NC DEQ North Carolina Department of Environmental Quality
NC DOT North Carolina Department of Transportation
NCUC North Carolina Utility Commission
NEC National Electric Code
NEMA National Electrical Manufacturer's Association
NREL National Renewable Energy Laboratory
OEMs Original Equipment Manufacturers
OPEC Organization of Petroleum Exporting Countries
PG&E Pacific Gas & Electric
ROW Right-of-way
PHEV Plug-in hybrid electric vehicle
PUC Public Utility Commission
TOU Time of Use
V2B Vehicle-to-building
V2G Vehicle-to-grid
ZEV Zero emission vehicle

I. Introduction

This Electric Vehicle Action Plan was created for the coastal community of Nags Head, North Carolina, to help the town navigate the anticipated rise of electric vehicle usage in the United States. Moreover, this action plan can serve as a guide for other small towns that are interested in preparing to see more EVs on the roads.

Electric vehicles are becoming increasingly popular, both for consumer car owners and for commercial and municipal vehicle fleets. Electric car sales are growing steadily in the United States. In 2013, only 0.1 million EVs were sold in the U.S. In 2021, 608,000 EVs were sold nationally.[1] From 2018 to 2020, EVs have maintained roughly 2% of the sales shares for new cars in the U.S. The national car market declined 23% overall in 2020 due to Covid, but EV sales declined less than the overall market, maintaining a 2% market share.[2] EV sales in North Carolina have followed this national trend. In December of 2018, roughly 7,000 EVs of all types were registered in the state; by December 2021 that number has grown to 25,000 EVs registered in North Carolina.[3]

Electric vehicles are attractive alternatives to traditional fossil fuel vehicles, both because they are in some ways more convenient, economical, and low-maintenance than gas cars, and because they are better for the environment, due to the fact that they produce less of the pollution that contributes to global warming.[4]

Global warming increases the risk of disasters like hurricanes, droughts, and floods.[5] Carbon dioxide pollution is a major contributor to global warming, and reducing carbon dioxide emissions will reduce the rate of global warming.[6] Electric vehicle adoption helps to reduce global warming by replacing traditional gas-powered vehicles with cars and trucks that produce far fewer greenhouse gases to get us from point A to point B.[7]

Developing a cohesive action plan for electric vehicles is an especially important undertaking for Nags Head. Tourism contributes a great deal to the Town's economy. In 2019, Nags Head had a population of 2,900,[8] yet saw roughly 170,000 visitors in 2021.[9] Tourism employs 1/3 of the citizens of Dare County, of which Nags Head is a part.[10] Nags Head is not served by a ferry or bus system, meaning that all tourist traffic must arrive by car. As EVs occupy larger and larger portions of the region's vehicle sales, Nags Head needs a cohesive plan to serve the increasing number of electric vehicles visiting its shores each vacation season. The purpose of this Action Plan is to create a guiding document with concrete recommendations that Nags Head can utilize so that it is ready to meet the future. Moreover, becoming a leader in EV charging infrastructure could help Nags Head to market itself as the go-to destination for vacationing EV drivers looking for a convenient road trip with their electric car.

This Action Plan will answer two questions: What will be the charging and infrastructure needs of the town as the number of EVs increases, and what steps can the town take to make needed improvements? We will begin with an introduction to the basics of EVs, followed by a report on the general trends of EVs in the market today. The next section will answer this question: why should the Nags Head planning board and local stakeholders be concerned about EVs and meeting their anticipated charging demands? After addressing these preliminary issues, the report will turn to an analysis section. First, we will review existing conditions in Nags Head, potential scenarios for EV growth, and opportunities and constraints for a potential EV plan, including existing and upcoming policies, laws, and regulations. We then survey potential sources of support and funding for EV infrastructure, and best practices gleaned from other EV action plans and case studies. The next section will address the importance of resiliency and equity in enacting this EV action plan. Finally, we provide recommendations for the town based on this research and analysis.

II. Methods

For the development of this Action Plan, we divided the project into three main phases. The first or introductory phase involved research on general EV trends, the basics of EV and EV infrastructure, impacts of climate change in coastal communities, and a first approximation to the Town of Nags Head community members and general conditions, which include the types of business and geography of the Town. During the first phase, in collaboration with the Town of Nags Head planners, we developed a comprehensive list of stakeholders that can give the Town insightful input for the development of the EV Action Plan. A detailed description of the stakeholder list can be found at the end of this section.

In the second phase, we began our analysis of the project, delving into the conditions unique to Nags Head, including existing infrastructure, local code, and the needs of the planning board and local stakeholders. At this phase, we also constructed a model which could predict the EV charging needs of the Town in the future. This was done by projecting EV adoption trend predictions from three different sources, then multiplying these numbers with the predicted number of residents and tourists in a peak summer tourism month to generate a predicted range of EVs in the town each year. By applying these figures to industry standard recommendations for the number of chargers required per vehicle, we are able to conclude with a target range of EV chargers that the town should have available by 2030 and 2050.

In the third phase, we apply our research and analysis to the question at hand to produce a range of recommendations for the town of Nags Head as it implements its EV Action Plan. These recommendations are broken down by timing requirements (actions that need to be taken within the next 2 years and actions that can be taken later), and by four categories - infrastructure; policy and outreach; resiliency; and sources of funding.

i. Stakeholder Descriptions

We identified key stakeholders based on their occupation or subject expertise that would provide the Town with insightful input for the development of this EV action plan. For each stakeholder, we either exchanged questions via email, met through video conferencing software, or engaged in phone interviews depending on need. We developed a general list of questions we asked of all stakeholders, as well as specific questions for specialists as they came up during the course of our research. The content of the general questions would include perceptions of hesitation in hosting EV chargers, ideal locations for siting them, or what information/resources would be needed to consider hosting chargers. Descriptions of the stakeholders and the rationale for interviewing them is provided below:

1) Jacob Bolin, Program Manager with Plug-in NC

As the Program Manager of Plug-in NC, Jacob regularly consults with important EV NC stakeholders such as electric utilities, state agencies, NC Electric Cooperatives, relevant NC state agencies, clean energy advocacy organizations, site hosts, and EVSE service providers to coordinate EV infrastructure planning and program design.

2) Winnie Wade, External Affairs Manager with Dominion Energy

Winnie Wade as the External Affairs Manager is responsible for communicating Dominion Energy's policies and programs to local government representatives and other stakeholders within Dominion's Northeastern NC service territories.

3) Lee Nettles, Managing Director for the Tourism Bureau of the Outer Banks

Lee Nettles as the Managing Director for the Tourism Bureau is familiar with areas that are frequented by tourists, which can signal potential locations for future EV chargers. He is also aware of estimates of the number of tourists that arrive to the Outer Banks on and off-season.

4) Karen Brown, President/CEO of the Outer Banks Chamber of Commerce

Karen Brown as the President/CEO of the Chamber of Commerce is familiar with the businesses present within the Outer Banks and therefore is an ideal liaison to communicate the needs of businesses surrounding what would be needed to host charging infrastructure.

5) Eric Claussen, Director of Works for the Town of Nags Head

Eric Claussen as the Director of Public Services is responsible for overseeing the Town's infrastructure services such as emergency response regarding flooding/natural disasters and transportation management. He is a key stakeholder surrounding natural disaster mitigation and how that would impact EV chargers being integrated into the Town's built environment.

6) Jennifer Weiss, Senior Advisor for Climate Change Policy at the NC DOT

Jennifer Weiss as a Senior Advisor within the NC DOT is knowledgeable about how to apply for critical government funding for expanding EV Charging Infrastructure such as funding from the VW Settlement and under the Infrastructure and Investment Jobs Act, both discussed in the sources of funding section.

III. Basics of electric vehicles and electric vehicle infrastructure

A. What are electric vehicles?

Typically, the term *electric vehicle* is used for vehicles that are powered by an electric motor instead of a conventional internal combustion engine and have a battery instead of a gasoline tank.[11] However, there are different types of electric vehicles, and depending on the type, these may use gasoline, electricity, or both, as their fuel. Hybrid Electric Vehicles (HEVs) are low-emission vehicles powered by an internal combustion engine and an electric motor that uses energy stored in a battery.[12] HEVs use gasoline as the fuel for the internal combustion engine, and their battery is not charged by plugging in, but through a regenerative braking.[13] Plug-In Hybrid Electric Vehicles (PHEVs) have an internal combustion engine and an also an electric motor that uses energy stored in a battery.[14] PHEVs can operate in all-electric mode or all-gasoline mode, and their batteries can be plugged in to an electric power source to charge.[15] All-Electric Vehicles (EVs) are vehicles that do not use gasoline at all. EVs have a battery which stores electricity to power the vehicle and all its accessories. EVs are charged through a charging port which allows the vehicle to receive external power to charge the battery pack.[16] Unless indicated otherwise, this report focuses on EVs.

EVs have multiple distinctive characteristics compared to gas or diesel vehicles. The most important feature of electric vehicles is that they do not produce tailpipe emissions. In the United States, 29% of the total emissions of greenhouse gases come from the transportation sector, representing the largest share of GHG in the country.[17] In this regard, one electric vehicle could prevent the emission of 8,500 lb of CO_2 per year compared to a conventional gas vehicle, considering that, on average, a family car is driven 15,000 miles a year in the state of North Carolina.[18] In addition to CO_2, tailpipe emissions from a light duty vehicle also include oxides of Nitrogen (NOx), which contribute to the formation of smog; Particulate Matter (PM), which are tiny particles of solid matter that can reach people's lungs and are associated with cardiovascular

problems; carbon monoxide (CO), a colorless and odorless poisonous gas; and Formaldehyde (HCHO), a lung irritant and carcinogen.[19]

Besides the differences regarding air and climate pollutants, electric vehicles have greater energy efficiencies than conventional vehicles. The energy efficiency of a vehicle indicates the amount of energy coming from the fuel source that is converted into actual energy to move the vehicle. Electric vehicles convert over 77% of the electrical energy they receive into vehicle movement, while gas powered vehicles only convert between 12 and 30% of the energy stored in gasoline into the vehicle movement.[20]

B. What is Electric Vehicle Supply Equipment?

Electric Vehicle Supply Equipment (EVSE) includes the equipment used to charge the vehicles (charger hardware), the wiring, the installation of payment systems such as card readers, the data contracts, and the transformers potentially needed to provide electricity to the charging points. This section provides the description of each of these elements, and an overview of the minimum and maximum costs of each component.

i. Types of chargers

Level 1 residential charger
Level 1 chargers have standard 120 V outlets, that is, regular household outlets used to charge cellphones or laptops. They represent the most inexpensive costs regarding installation and supplemental equipment since virtually all homes and businesses already have multiple regular outlets.[21] Level 1 chargers generally provide 40 miles of range per 8 hours of charging, depending on the EV's range.[22] Level 1 chargers are considered slow-charging.

Level 2 residential and commercial charger
Level 2 chargers typically provide electricity through 208 V and 240 V outlets, which can be found in commercial applications. Level 2 chargers provide 10 to 20 miles of ranger per 1 hour of charging,[23] and are the most common type of charger in the United States, representing over 80% of public ports.[24] Level 2 chargers are considered slow-charging.

Not all residences and businesses have the electrical panel capacity to host a Level 2 charger. Consequently, they will need an electrical panel upgrade to a 200-amp service, which costs range between $750 and $2,000.[25] The electrical panel of a home or business is the central conduit for power flowing from the utility grid to the household circuits.[26] Electrical panels usually have individual breakers, which are responsible for providing electricity to a specific part of the home or business.[27] In most cases, each EVSE unit needs an available dedicated circuit.[28] The majority of homes and businesses come with electrical panels of 60-amp or 100-amp. To host a Level 2

charger in addition to typical home appliances such as oven, air conditioner, and an electric stove, an electrical panel of 200-amp is required. In addition to the panel upgrade, the installation of Level 2 chargers requires a certified electrician and an electrical permit, increasing costs in comparison to Level 1 chargers. These costs represent a potential barrier for the broad use of EVs.

Level 2 chargers installed in residences and workplaces are typically installed on private property and, as such, they are not accessible to renters and tourists who would benefit more from public charging infrastructure.[29] For that reason, although the high deployment of Level 2 chargers is beneficial and the most popular in the United States, it presents challenges of broader accessibility that need to be considered in policies regarding EV infrastructure.

Direct Current Fast Chargers (DCFC)

Direct Current Fast Chargers **(**DCFC) are the fastest chargers available to date and can provide 60 to 80 miles of range per 20 minutes of charging.[30] As of 2020, DCFC chargers represented approximately 15% of chargers in the United States.[31] DCFC is considered fast-charging.

DCFC chargers are typically public chargers, which facilitate accessibility to visitors and tourists. However, they are also the most expensive chargers, as will be discussed in the section below. A report from the Rocky Mountain Institute (2021) recommends that to transition from early adoption to mass market deployment of EVs, policymakers need to focus on a high-coverage public DCFC.[32] However, it is important to note that DCFC have power draws that can cause challenges with equipment overloading, voltage regulation, and congestion in the electricity grid.[33]

DCFC chargers are not standardized, and they serve different vehicles depending on the vehicle charging port. SAE Combined Charging System (CCS) and CHAdeMO fast chargers can be used by virtually all EVs, while Tesla DCFC can only be used by Tesla vehicles, since they have a different charging port. In 2019, Tesla launched an adapter to CCS so Tesla vehicles could use CCS and CHAdeMO DCFC chargers like all other EVs.[34]

ii. Cost of chargers

The costs of charging infrastructure are mainly driven by the power rating of the chargers, that is, at higher power ratings, higher are the costs.[35] Other factors that affect the charger's costs include the location of the charger, which impacts the degree of weatherproofing needed, the mounting style (wall-mounted or on a pad), and if they are 'smart' chargers or not.[36] Smart chargers are networked chargers that allow the electric utility to inhibit charging during peak electricity demand hours, when providing power is expensive, and allow charging during low electricity demand hours, when electricity prices are lower.

The following figures show minimum and maximum costs per kW of Level 2 and DCFC, and the range of costs of Level 2 and DCFC hardware.

CHARGER TYPE	KW RATING	MINIMUM COST/KW	MAXIMUM COST/KW
Level 2: Residential	2.9	$131	
	5.8	$87	$98
	7.7	$52	$90
Level 2: Commercial	7.2	$444	$542
	7.7	$326	$391
	9.6	$396	$448
	14.4	$501	
	16.8	$292	
DCFC	50	$400	$716
	150	$504	$667
	350	$366	$429

lowest cost highest cost

Figure 1. Cost of chargers by type and KW rating. Source: Nelder, C., Rogers, E. (2019). Reducing EV Charging Infrastructure Costs. Rocky Mountain Institute. Retrieved on January 14, 2022 from https://rmi.org/insight/reducing-ev-charging-infrastructure-costs/

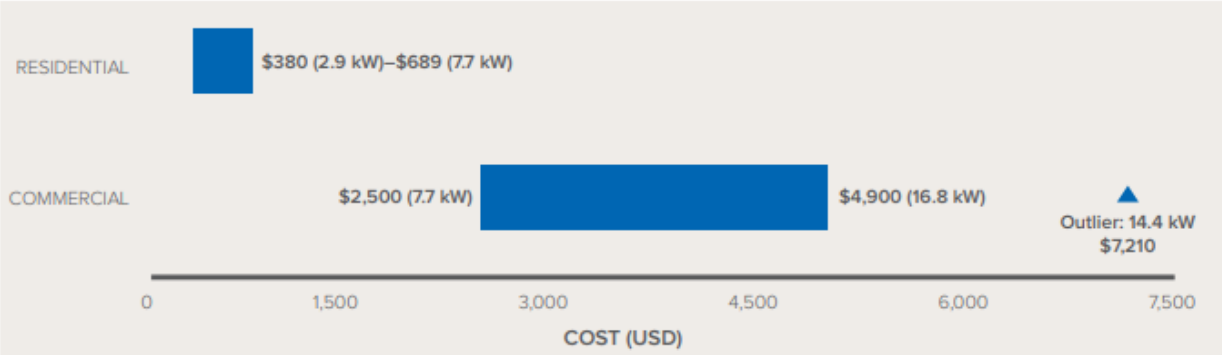

Figure 2. Cost of Level 2 chargers by kW rating. Source: Nelder, C., Rogers, E. (2019). Reducing EV Charging Infrastructure Costs. Rocky Mountain Institute. Retrieved on January 14, 2022 from https://rmi.org/insight/reducing-ev-charging-infrastructure-costs/

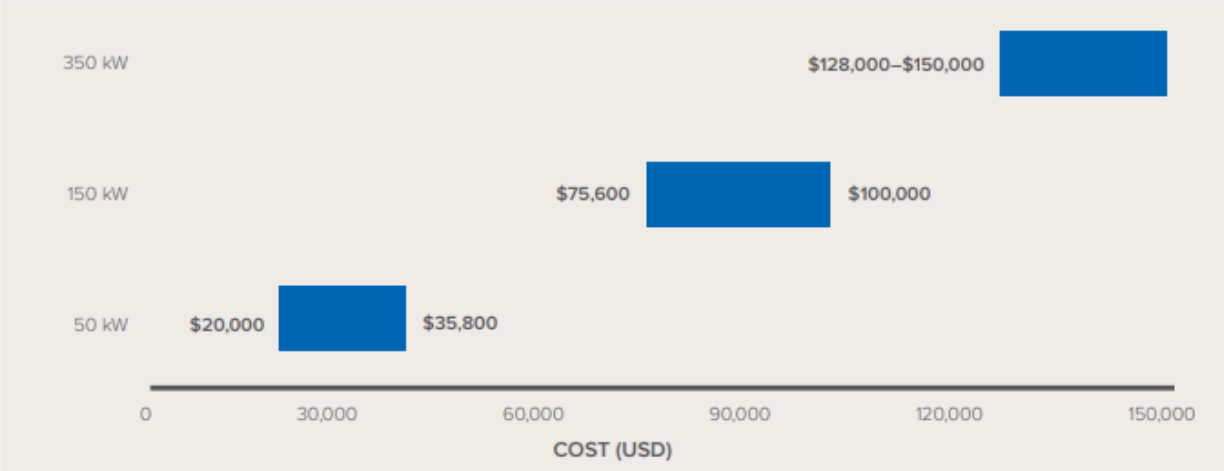

Figure 3. Cost of DCFC by kW rating. Source: Nelder, C., Rogers, E. (2019). Reducing EV Charging Infrastructure Costs. Rocky Mountain Institute. Retrieved on January 14, 2022 from https://rmi.org/insight/reducing-ev-charging-infrastructure-costs/

iii. Network and data contracts

Smart charging stations or networked chargers are connected to a central system via WiFi, the cellular network, or ethernet.[37] These stations can perform two-way communications with the electric utility, or any other entity that can manage the charging station remotely, offer radio-frequency identification (RFID), credit card payments, monitor and analyze use, and facilitate customer support.[38] Networked chargers usually involve ongoing payments for the WiFi, cellular, or ethernet services through a pre-agreed contract.[39] As with any other contract, the contract's length and services provided depend on the supplier. A report from the Rocky Mountain Institute from 2019 suggests that at the current stage of the EV infrastructure market development, it is more beneficial to negotiate shorter contracts. Short contracts allow for flexibility and further negotiation in the near future since data costs are expected to decrease over time.[40] Additionally, the report suggests that whenever possible, contract negotiations should be done across an entire service territory and not on a charger-by-charger basis.[41] Data contract costs vary between $84/year/charger and $240/year/charger, while network contract costs range from $200/year/charger to $250 /year/charger.[42]

iv. Transformers

The increasing use of EVs can generate higher levels of electricity demand, and a higher probability that a site will require the upgrade of a distribution transformer. Typically, coastal cities need to bring additional power supplies to support new charging sites.[43] The following figure illustrates the different ranges of grid upgrade costs depending on the additional power required.

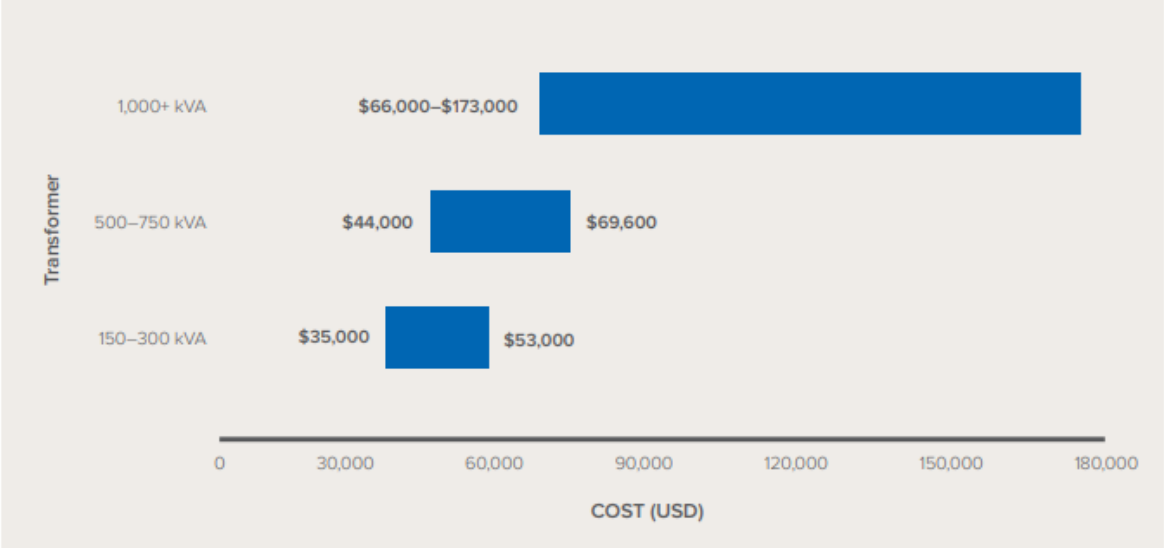

Figure 4. Cost of transformers. Source: Nelder, C., Rogers, E. (2019). Reducing EV Charging Infrastructure Costs. Rocky Mountain Institute. Retrieved on January 14, 2022, from https://rmi.org/insight/reducing-ev-charging-infrastructure-costs/

v. "Make-ready" infrastructure and physical installation

"Make-ready" infrastructure refers to the necessary electrical infrastructure that connects the electricity grid to the chargers, including conduit and wires, electrical panels, and mounting pads. Typically, the installation of public make-ready infrastructure such as DCFC and Level 2 chargers involves interventions such as trenching or boring, while the installation of Level 2 residential chargers requires of a certified electrician and potential electricity panel upgrades. It is estimated that the make-ready costs account for 30-40% of the capital costs of the charger's installation.[44] This section briefly describes what the physical installation of make-ready infrastructure involves.

The EVSE unit is connected to the electrical service by wires that are enclosed in an electrical conduit. Chargers installed in public spaces, such as a parking lot, require of trenching or boring to create a path for the conduit.[45] The costs drivers of this process include labor costs, distance to be trenched, types of material being dug, and the potential replacement of the material (asphalt or concrete replacement).[46] The cost variability of this processes is very high since they depend on multiple factors and the specific conditions of the site.[47] Regarding electric panels, additional installations are needed when there is insufficient capacity on the existing electrical panels for the dedicated circuits. As discussed in the description of Level 2 chargers, not all residences, businesses, or public spaces have the electrical panel capacity to host a Level 2 charger. Consequently, they will need an electrical panel upgrade to a 200-amp service. In that scenario, an electrician will need to create additional capacity by replacing or upgrading the panel, which can cost between $750 and $2,000.[48] In the case there is sufficient capacity on the panel,

additional breakers can be added to the panel.[49]

vi. Operation and maintenance

Operation and maintenance costs for EVSE include software subscriptions, charges for electricity, billing, site rental or lease, and preventive and corrective maintenance.[50] Maintenance necessities and costs are less certain than installations costs since the EV market is still rapidly evolving.[51] Networked units with advanced features and communications systems may require maintenance more frequently than other chargers since they have more components.[52]

Naturally, maintenance costs depend on the type of charger. Typically, Level 1 chargers do not require any maintenance besides keeping the equipment clean. In rare occasions, there may be the need to replace the outlet, which can have cost between $7-$40 depending on whether it is for an indoor or outdoor application, and if it protects against electrical shock.[53] Maintenance of Level 2 chargers includes the replacements of cords because of accidental damage or wear, periodic technical troubleshooting if it is a networked charger, and manual system resets.[54] The replacement or maintenance costs for accidental damage, wear or vandalism are generally covered by the warranty. DCFC require periodic maintenance of the cords and their cooling systems, technical troubleshooting, and manual resets for software malfunction if these are not covered in the data and network fees.[55]

It is important to establish responsibility for periodic maintenance and maintenance costs and determine if the site host, charging network, or installer is responsible to minimize the number of chargers out of service, especially during months of peak tourist visits. While actual maintenance costs vary, station owners should account for maintenance costs of up to $400/year/charger.[56]

Operation charges include electricity consumption charges, electricity demand charges, and the network fees previously discussed.[57] Electricity consumption charges are the costs users have to pay for consuming electricity.[58] Electricity consumptions costs for EVSE owners is measured in dollars per kilowatt-hour ($/kWh) and determined based on the amount of electricity consumed. Generally, commercial rates are between $0.08 and $0.15 per kWh, and industrial rates are lower.[59] For the case of Dominion Energy in North Carolina, commercial rates for the months of June through September are between $0.07-0.09/kWh, and for the months of October through May $0.06-0.08/kWh.[60]

Electricity demand charges are fees that allow the utilities to recover some of the costs associated with providing and distributing electricity to the consumers.[61] Electricity demand charges are only bore by non-residential customers.[62] Locations that host EVSE such as Level 2 or DCFC generally increase their electricity consumption and may be charged for demand chargers.[63] A report from the Renewable Energy Laboratory states that sites that host EVSE can experience increases in demand chargers from $0 to $2,000/month. In North Carolina, Dominion Energy

does not have a program that addresses the increase in demand chargers for EVSE hosts or owners. However, these costs can be reduced through rebates, the design of new incentives led by the utility, and charging management practices. For example, scheduling EVSE energy consumption for off peak time, as is the case for smart chargers.

vii. Electric vehicle ownership models

There are multiple ownership models for EVSE. Charging stations may be owned by the electric utility, the utility customers (hosts or a city), a third-party network, or a combination of the previous options. In the "Full Ownership" model, all the EVSE is installed and maintained by the utility, and the utility collects the revenue from the charging stations.[64] There are models that combine the electric utility with a private concessionaire, in which the utility owns and installs all the EVSE elements, and a third-party operates the EVSE. The revenues are collected by both the third-party and the utility.[65] In the "Make Ready" model, the utility is in charge of all the infrastructure up to the charging station, and a third-party from the private sector installs, owns, and operates the EVSE.[66] In this model, like in the Utility with Private Concessionaire, the revenues are collected by both the utility and the third-party. Generally, for models where the city owns and operates the charging station, the city revenues are the highest, but they are unlikely to recover the investments costs.[67]

IV. Current trends in electric vehicles

A. General background on EV trends

According to Pew, EV sales in the US doubled in 2021 compared with 2020, and car buyers in 2022 will have twice as many electric models to choose from.[68] According to the International Energy Agency's (IEA) 2021 Global EV Outlook (EVO) consumers still spent $120 billion USD on electric car purchases in 2020 despite Covid-19, a 50 percent increase from 2019.[69] This increase is comprised of a 41 percent increase in sales and a 6 percent rise in average prices.[70]

Regarding pricing trends for EVs according to Kelley Blue Book: "the average transaction price for an EV in April 2021 was $51,532, which is more than $11,000 higher than a full-size gas-powered car, and nearly $30,000 more than the average compact car sale."[71] It is also important to note though that EV prices are not monolithic as they vary in price. Many current EV models are luxury cars, while some EV models are only a few thousand dollars more than their gas counterpart. What is driving the higher sticker price for EVs are their batteries since they are the most expensive cost component behind them. The materials that produce batteries such as lithium have increased in cost. According to a 2021 Bloomberg article: "this could lead to battery price declines stalling for an extended period of time or could even rise for the next few years before decreasing."[72] Battery pack prices will need to drop well below $100/kWh for EVs to

reach parity with internal combustion engine (ICE) vehicles, $80/kWh to meet consumer preferences for higher ranges and heavier vehicles, or $60/kWh to be considered cheaper than ICE vehicles in all segments and countries.[73] Battery prices are projected to reach $80/kWh in 2026 and $60/kWh in 2029, down from $137/kWh in 2020.[74] "Price parity" is when an automaker can make the same profit margin building and selling EVs without relying on government subsidies.[75]

New data extracted from a recent Consumer Report reliability survey reveals that BEV and PHEV drivers save 50 percent on repair and maintenance costs compared to a gas car's average vehicle lifespan.[76] BEVs specifically were estimated to save consumers about 60 percent on fuel costs compared with the average gas car in their class.[77] The same survey also compared nine of the most popular EVs on the market under $50,000.[78] For all EVs analyzed, the lifetime ownership costs were many thousands of dollars lower than all comparable ICE vehicles' costs, with most EVs offering savings of between $6,000 and $10,000.[79] Data also obtained by CR from ALG, a data and analytics subsidiary of automotive pricing and information website TrueCar, shows that when adjusted for federal purchase incentives, both BEVs and PHEVs are expected to depreciate at the same rate as ICE vehicles in the same class over the first five years of ownership.[80]

The IEA's 2021 Global EVO also reveals that installation of publicly accessible chargers increased by 45 percent in 2020, which is slower than the 85 percent increase in 2019 likely due to Covid-19.[81] Installation of slow chargers in the United States increased by 28 percent in 2020 from the prior year to a total of 82,000 chargers, while faster chargers in the US total 17,000.[82]

Despite these trends, a trend that still prevails includes significant barriers to EV adoption. Several barriers that persist include: 1) a lack of accessible charging infrastructure compared to gasoline infrastructure, 2) general perception of the unaffordability of EVs compared to ICE vehicles, 3) concerns with range and charging time, and 3) not enough offerings of EV types. In addition, federal incentives decreased in 2020 because federal tax credits for Tesla and GM cars were fully depleted.[83] To help overcome a few of these barriers, 71 percent of EV100 members support more favorable EV tax benefits and 70 percent favor more supportive policies at state, regional and city government levels.[84] EV100 members include global businesses committed to switching their owned and contracted fleets up to 7.5 tons to EVs and installing charging infrastructure for employees and customers by 2030.[85]

B. How vehicle manufacturers are pivoting to EVs and the place of transportation electrification in broader GHG mitigation goals

As of January 9, 2021 according to EVAdoption.com: "there are 19 BEV (battery electric vehicle) models available in the US and 26 total including model variants."[86] According to the IEA's 2021 Global EVO, Sport utility vehicle (SUV) models account for 50 percent of available EVs in all markets and the motivation automakers are pursuing to electrify this segment are for the following reasons:

- "SUVs are the fastest growing market segment in Europe and China, and by far the largest market share in the United States.
- SUVs command higher prices and generally offer higher profit margins than smaller vehicles. This means Original Equipment Manufacturers (OEMs) find it easier to bear the extra costs of electrification for SUVs since the powertrain accounts for a smaller share of the total cost compared with a small car.
- Electrifying the heaviest and most fuel consuming vehicles goes further toward meeting emissions targets than electrifying a small car."[87]

Clearly automakers will be expanding their offerings of EVs in the 2020s. The same IEA 2021 Global EVO reveals that 18 of the 20 largest automakers (in terms of vehicles sold in 2020) have announced intentions to increase the number of available models of electric light-duty vehicles (LDVs).[88] Some automakers have announced commitments in eventually switching only to EV production. For example, Volvo announced they will only sell electric cars from 2030; Ford will only do electric car sales in Europe from 2030; General Motors plans to offer only electric LDVs by 2035; and Volkswagen aims for 70 percent electric car sales in Europe, and 50 percent in China and the United States by 2030.[89] [90] [91] [92] This transition in shifting production translates to estimated cumulative sales of electric LDVs of $55-$72 million by 2025 and these cumulative sales are aligned with the trajectories of the IEA's Sustainable Development Scenario.[93] Sales of ICE vehicles need to stop around 2035 to get global road transport to net zero by 2050.[94]

In addition, the pivot for automakers aligns with goals outlined in the current Biden-Harris Electric Vehicle Charging Action Plan that sets an ambitious target of 50 percent of EV sale shares in the U.S. by 2030.[95] North Carolina has also set its own ambitious targets. Governor Roy Cooper built on Executive Order (EO) 80 by issuing EO 246 in January 2022. EO 246 increased the statewide GHG emission reduction goal to 50 percent by 2030.[96] EO 246 also calls for "a 1,250,000 increase in registered ZEVs by 2030 and for 50 percent of new vehicle sales in North Carolina to be ZEVs by 2030.[97] EO 246 also calls upon the NC DOT to develop a Clean Transportation Plan."[98]

C. Range of EV sales and on-road projections

Several industry outlooks reveal that forecasts of zero-emission vehicles have increased their projections. Bloomberg New Energy Finance's (BNEF) own forecast for the global ZEV fleet in 2040 was increased from 495 million vehicles in its 2019 forecast, to 677 million in its 2021 Electric Vehicle Outlook (EVO).[99] The IEA has raised its 2030 BEV fleet forecast by 7 percent since 2019, while the Organization of Petroleum Exporting Countries (OPEC) has raised its 2040 estimate for the global EV and FCV fleet by 11 percent.[100] These stronger forecasts comprise of a range of factors including: "improving battery technology and costs, faster roll-outs of charging infrastructure, a wider range of vehicle models on offer to customers, and longer range and faster charging speeds available on the newest vehicles."[101]

ZEVs will also capture a higher sales share of passenger vehicles sooner than expected.[102] According to BNEF, share of sales is a useful metric and distinct from total ZEV sales because various reports have different views of how overall global vehicle sales will change over time.[103] These differing views depend on "overall car ownership trends, as well as the roles of autonomous and shared mobility technologies, and other modes of transport."[104] As displayed in the figure below, BNEF's Long-Term EVO 2021, ZEVs' share of passenger vehicle sales reaches 70 percent globally by 2040, up 20 percent from BNEF's 2019 report.[105] IEA's 2021 Global EVO calls for an estimated 11 percent BEV share of passenger vehicle sales by 2030.[106] U.S. state-level targets to phase out sales of ICEs now cover a quarter of auto sales in the country.[107]

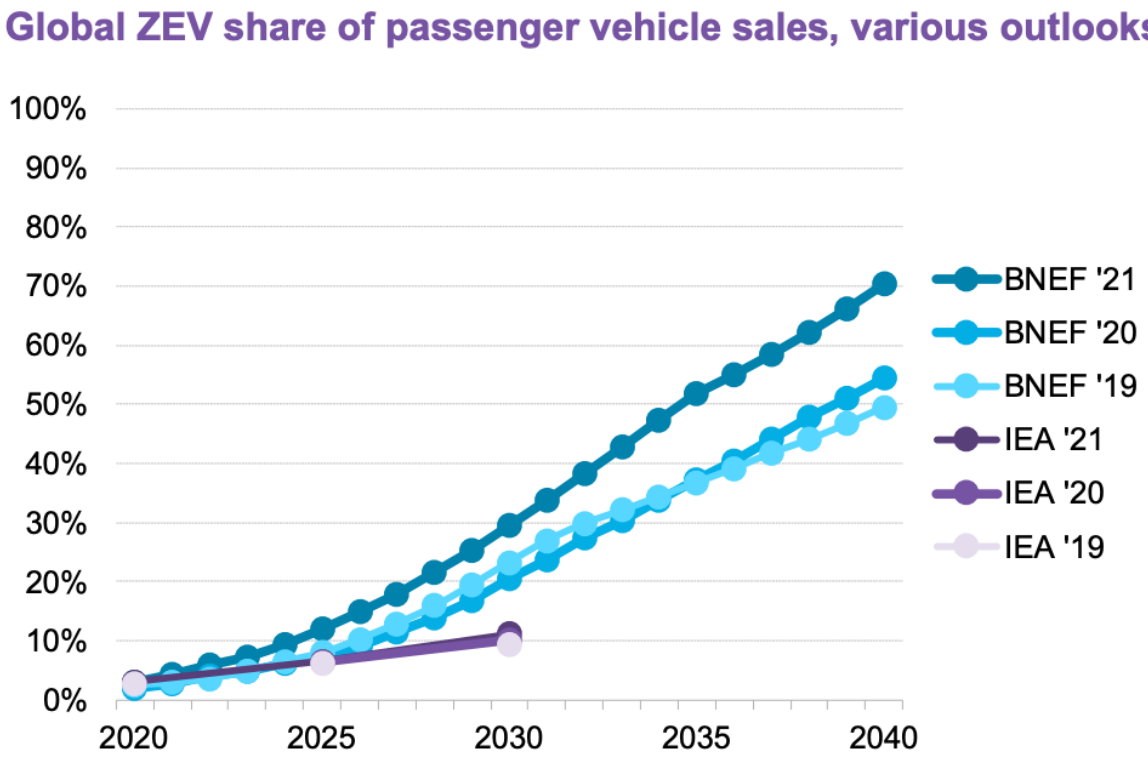

Figure 5. Global ZEV Share of Passenger Vehicle Sales, Various Outlooks
Source: BloombergNEF, IEA

Long-term outlooks for BEV adoption are becoming more aggressive as displayed in the figure below. BNEF in its 2021 Long-Term EVO projects global passenger and commercial ZEV fleets will hit 677 million vehicles by 2040.[108] Across passenger and commercial vehicles in total, the 2040 ZEV fleet share went from 25 percent in 2019 to 36 percent in the 2021 report.[109] The IEA's 2021 Global EVO increases its BEV fleet by 7 percent, to 91 million in the 2021 report.[110] OPEC revised its projected 2040 EV and fuel cell vehicle (FCV) fleet up by 11 percent in its most recent World of Oil publication, to 369 million EVs and FCVs on the road.[111]

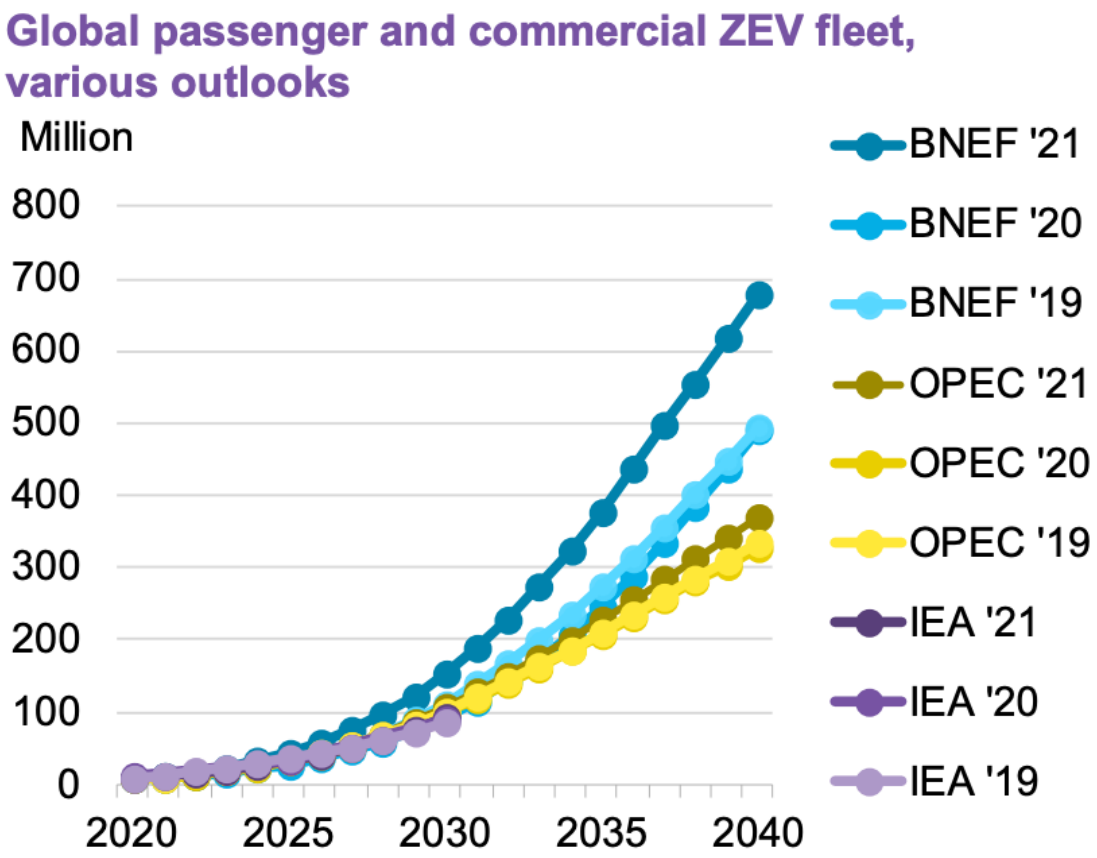

Figure 6: Note: OPEC includes all EVs and FCVs. BNEF '19 and IEA reports are BEVs only. (*) IEA report only goes through 2030. Source: BNEF, IEA, OPEC

V. Why the rise of EV usage is important for the Nags Head Planning Board and local stakeholders

Given the increased adoption of EVs by automakers and consumers, the Town of Nags Head is situated in a unique position to help lead by example and accelerate the Outer Banks transition towards accommodating EV drivers and overall transportation electrification. This transition presents both opportunities and challenges that the Town of Nags Head should anticipate.

EVs are highly positioned to become the future of transportation and it is imperative to prepare for this. It is also critical to prepare for potential demand on the grid associated with EV charger installation, expansion, and usage. Transportation to the Town of Nags Head and the Outer Banks from a tourism perspective is solely through personal light duty vehicles (LDVs). The Town of Nags Head will need to accommodate EV driving tourists so the town is accessible. This can have the impact of increasing tourism revenue as EV tourists will be able to access the Outer Banks. In addition, this can also provide the benefit of designating Nags Head as a green destination and set a shining example for all of the Outer Banks. Nags Head can also be cost

effective by considering shifting their municipal fleet to electric LDVs and heavy duty vehicles (HDVs). Not only will this decarbonize transportation to address climate change concerns, this will also provide lower municipal fleet costs regarding maintenance and energy costs compared to ICE counterparts. This transition though will require training public works staff and first responders about EV cars and charging infrastructure.

To take advantage of the benefits above involves addressing several challenges associated with these opportunities. There are valid concerns regarding how EVs and associated charging infrastructure would fare regarding a harsh marine environment that is susceptible to natural disasters and given that EVs possess a limited range. Nags Head is a marine environment, with corrosive salt spray posing a challenge to infrastructure.

In addition, the entire Outer Banks is extra susceptible to natural disasters exacerbated by climate change, which can have profound implications on electrical infrastructure. The Outer Banks are affected by rising sea levels. An article from the Carolina Political Review reveals that "from 2011 to 2015, sea levels rose up to 5 inches in some locales, the fastest in the past 2000 years."[112] This rise is directly attributable to climate change, which will cause increased flooding and coastal erosion. In addition, the Outer Banks are barrier islands that buffers the mainland. Rising sea levels can erode this natural defense, thus increasing vulnerability to storms and flooding across NC. This can result in damaging coastal and non-coastal infrastructure.

EVs also require reliable electricity and if this is disrupted, this could pose severe challenges to EV owners who need to evacuate. In the case that EV chargers are in the path of a hurricane or a property is underwater, they would need to be de-energized. Even if electricity is not disrupted during an evacuation event, there is concern of the grid being overwhelmed by demand. EV models also vary by how much time they take to charge, which would be a massive inconvenience for someone who needs to evacuate immediately. Lastly another issue that makes EV charging different from gas stations is users will need to set up an account ahead of time at the charging station versus typically paying directly at a gas pump. This is an issue EV drivers would not want to deal with during a natural disaster or an evacuation.

This EV Action Plan will detail approaches that will address these challenges so Nags Head can realize the numerous benefits of expanding EV charging infrastructure.

VI. Research and results

In this section, we review the available data and resources, focusing on 1) existing conditions in Nags Head, including consideration of infrastructure, policies, and laws and regulations; 2) Stakeholder needs and objectives; and 3) opportunities and constraints for EVs in Nags Head.

In conducting our research, we consider first where Nags Head is today, including its population, tourist activity, and current charging infrastructure. We then research national and local trends to predict the state of EVs by 2030 and by 2050 to determine what steps Nags Head must take from this point to be prepared for EVs by these future dates. In exploring these steps, we review relevant laws and regulations, interview stakeholders, and identify means of funding any infrastructure construction that may be necessary. We also take an important look at what it will mean to implement these changes in a way that is equitable; i.e., in a way that extends the benefits of environmentally-friendly changes to historically disenfranchised populations.

Overall, the town of Nags Head should be prepared for the possibility that by 2030 there will be somewhere between 1,600 and 5,300 EVs in Nags Head during peak summer months. Roughly 80% of visitors will be staying in private rental homes, and the majority will be families visiting for 5 or more days. Nags Head should be prepared to have adequate charging infrastructure for this volume of EVs by 2030, meaning that between private and public chargers, there should be between roughly160 to 540 chargers in the town.

Grant funding is available for charging infrastructure, most prominently the Volkswagen Settlement fund and the federal Infrastructure Jobs and Investment Act. Applications for the final distribution of Volkswagen settlement funds will be available roughly at the beginning of 2024, meaning that the town should decide if it wants to build public chargers and/or electrify any of its vehicle fleet by mid-2023 to have ample time to prepare applications for grant funding.

A. Existing conditions: public infrastructure

In the past decade, the state of North Carolina has seen a gradual increase in electric vehicle registrations and EV public charging stations, as can be seen in the figure below.[113] The Outer Banks has increased registrations from less than 100 EVs to between 100 and 500 EVs.[114] It is important to note that, although there are 19 chargers installed in the Outer Banks, there are not many chargers installed along highway 64, which counts with only 3 chargers outsides of urban centers, and connects Nags Head with the Piedmont region. This might be an obstacle for tourists and EV drivers who are traveling from the piedmont to the coast.

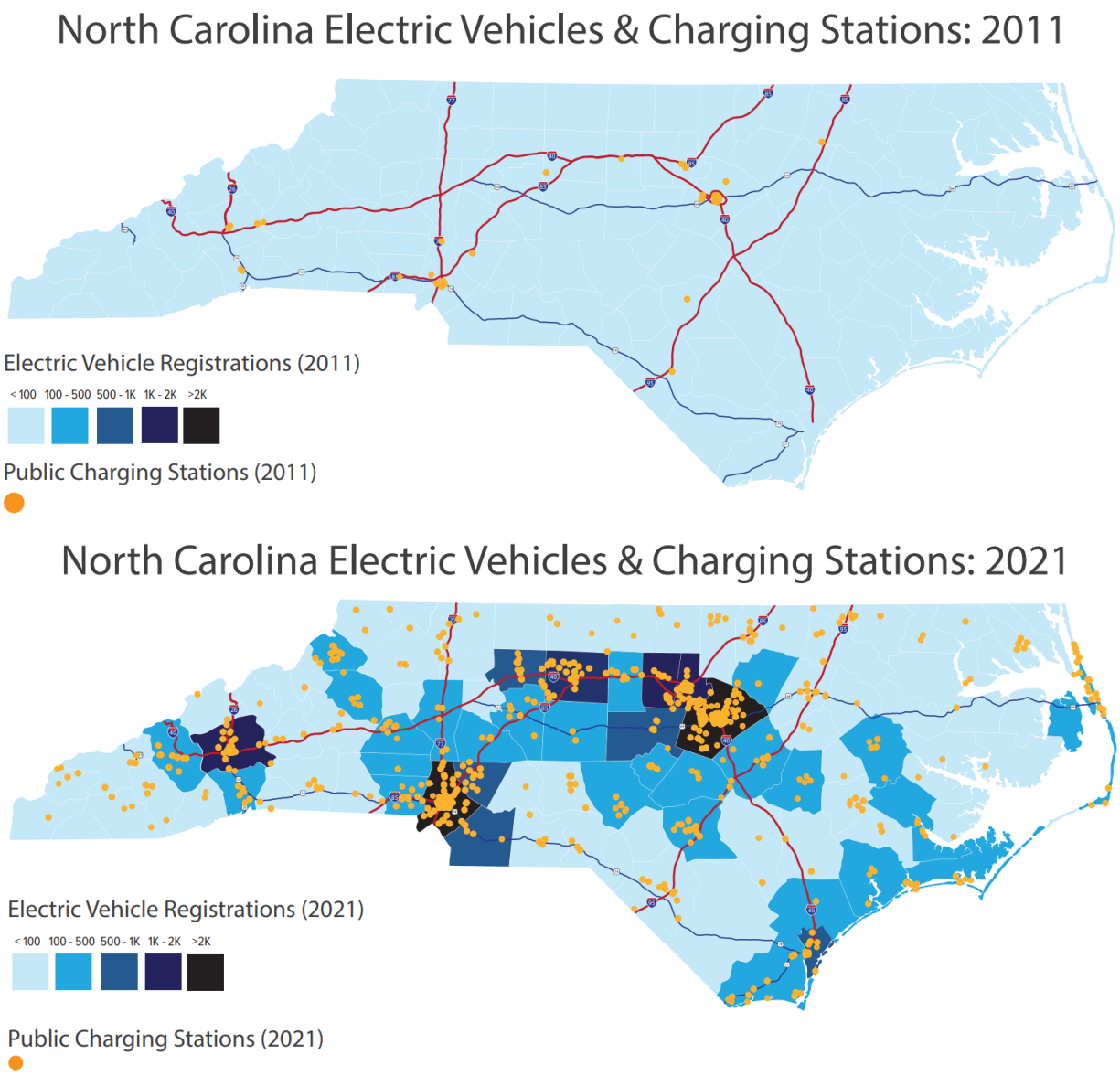

Figure 7. North Carolina's EV registrations and EV charging stations for the years 2011 and 2021. Source: Plug-in NC. (2022). North Carolina Electric Vehicles & Charging Stations: 2011 – 2021. Source: Plug-in NC

As of April 2022, the Town of Nags Head had three public charging points: two Level 2 charger, one Level 2 Tesla charger, and one Tesla DCFC charger.[115] There is one more Level 2 charger nearby in Roanoke Island, as it is illustrated in the figure below. All the chargers are located next to commercial buildings.

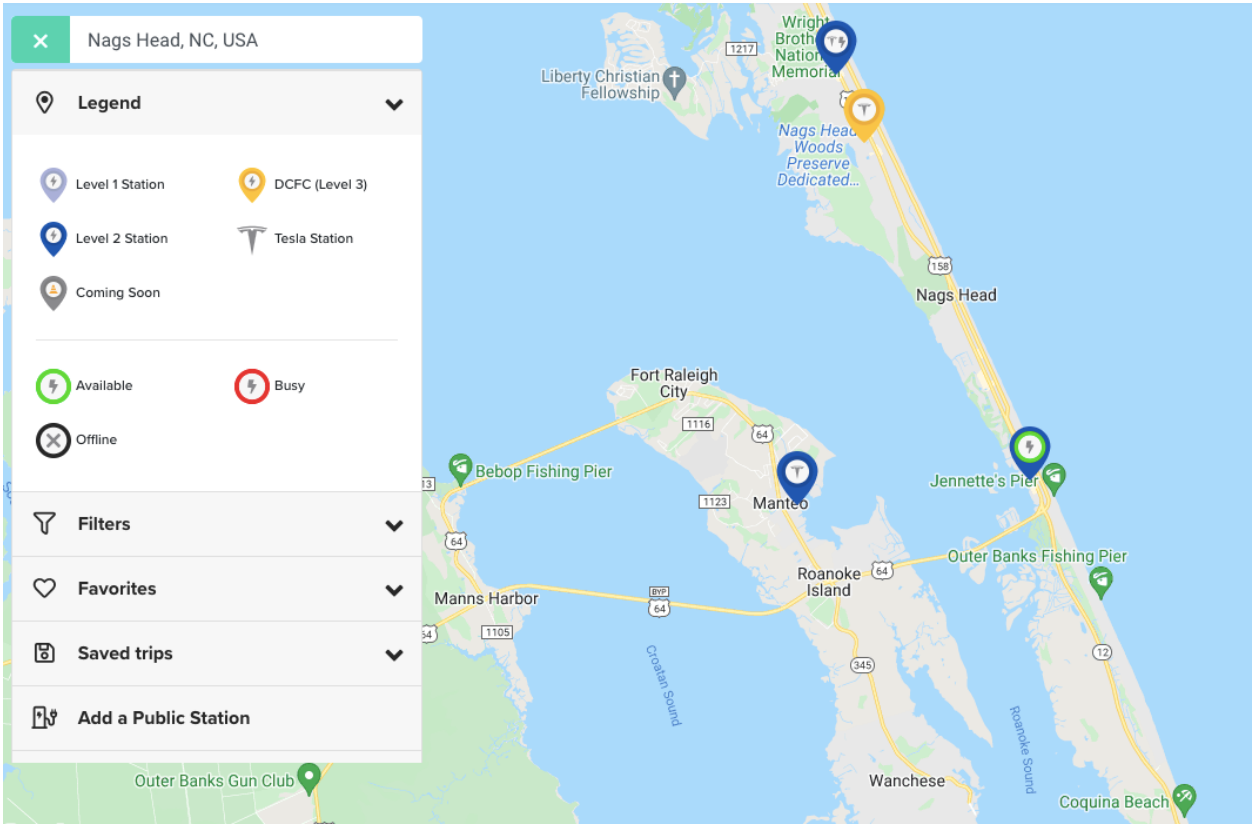

Figure 8. EV chargers in the Town of Nags Head, March 2022.
Source: ChargeHub. (2021).

B. Scenarios for EV growth

To determine the charging needs of the Town of Nags Head, we developed three scenarios for EV growth. These scenarios allowed us to see the EVs' sales share from total vehicle sales, the number of EVs that would be present in the Town of Nags Head by 2030 and 2050, and ultimately the number of chargers that should be available in the Town by 2030 and 2050. Since the number of people present in the Town differ from month to month depending on the time of the year, we decided to project the scenarios including the EVs from the population that lives in Nags Head, and for the population that visits Nags Head for tourism and recreation purposes. As expected, Nags Head receives a greater number of visits during summer months.[116] To ensure that there would be sufficient charging infrastructure to meet the demand of all the tourists present in the Town throughout the year, we used the number of tourists in peak summer months in addition to the population of Nags Head for the projections.

The following figures show the parameters used to calculate the total number of new vehicles on the roads each year, and the results obtained. This calculation was made under the main assumption that vehicles out of the market equal the number of vehicles' new sales each year.

According to the calculations, the population in the Town of Nags Head would buy approximately 167 new vehicles per year, and Nags Head's visitors would buy approximately 15,061 new vehicles per year. The detail process followed to obtain the following results can be found in the Appendix.

Town of Nags Head		
Parameters: found in the literature	Value	Units
Nags Head population (2022)	2,923	people
Household size in NC	2.5	people
Average number of vehicles per household	2.2	vehicles
Daily average miles driven per person in NC	36.4	miles/day
Average car lifespan in miles	200,000	miles
Paramaters: calculated	Value	Units
Households	1,169	households
Vehicles in Nags Head (2022)	2,514	vehicles
Average miles driven in NC	13,286	miles/year
Average car lifespan	15	years
Vehicles out of the market/new sales	167	vehicles/year

Figure 9. Parameters for the new vehicles' sales calculation considering only the Town of Nags Head.

Visitors in Peak Summer Month		
Parameters: found in the literature	Value	Units
Visitors (2021)	263,630	people
Household size	2.5	people
Average number of vehicles per household	2.15	vehicles
Daily average miles driven per person	36.4	miles/day
Average car lifespan in miles	200,000	miles
Paramaters: calculated	Value	Units
Households	105,452	households
Visitor's vehicles in Nags Head	226,722	vehicles
Average miles driven	13,286	miles/year
Average car lifespan	15	years
Vehicles out of the market/new sales	15,061	vehicles/year

Figure 10. Parameters for the new vehicles' sales calculation considering the visitors of the Town during the peak summer month of July.

We used three different forecasts for EVs' sales shares growth, which are shown in the figure below.

EV Sales Share from Total Vehicle Sales		
Author	Forecast	Year
International Energy Agency	11%	2030
North Carolina Executive Order 246	50%	2050
Bloomberg NEF	70%	2040

Figure 11. Three scenarios for EV growth.

Using that information, we used a linear interpolation to find percentages of EV sales share from total vehicles' sales for each year, and the total number of EVs that would be present in the Town of Nags Head during a peak visitor's summer months. The results are shown in the figures below. Detailed results for each year are shown in the Appendix.

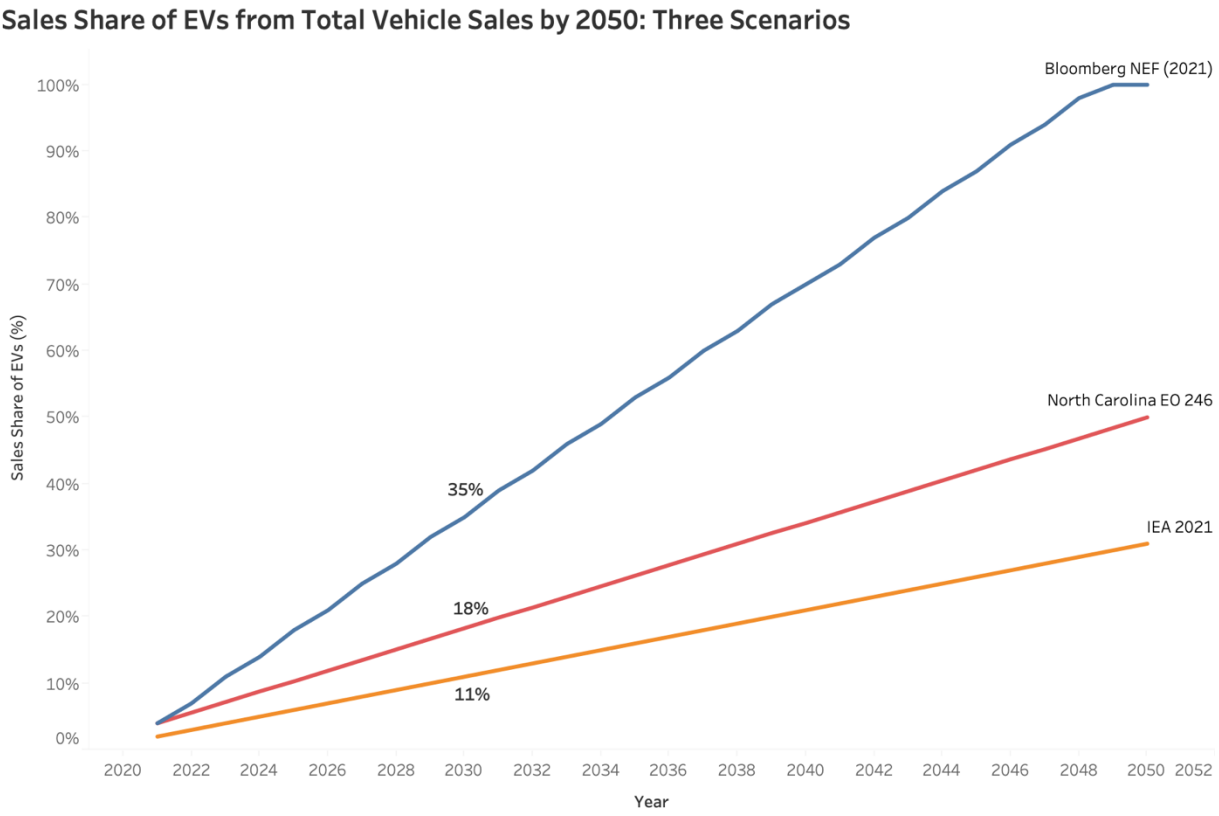

Figure 12. Three scenarios for EV growth.

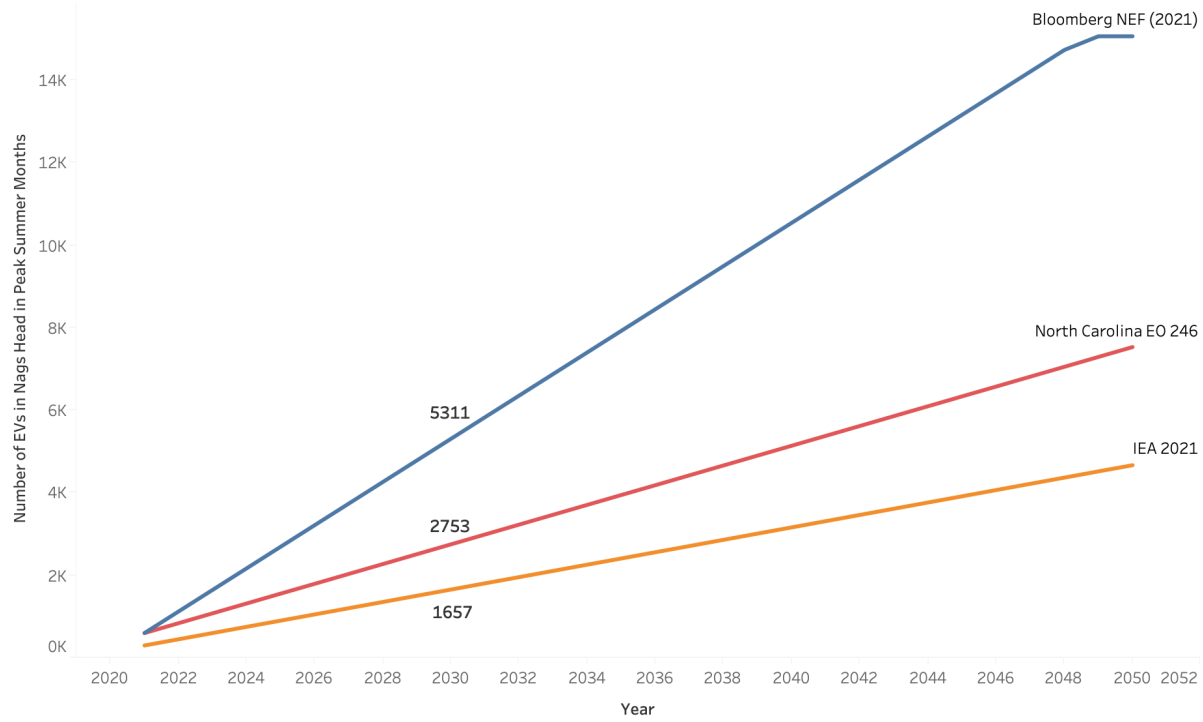

Figure 13. Three scenarios for EV growth.

The average EVs to charger's ratio in the United States is 18:1. However, the ratio that is recommended globally is 10:1. With this information and the projections for EV growth, we calculated the total number of chargers to be installed in the Town of Nags Head by 2030 and 2050 according to the three growth scenarios. These results can be seen in the table and figures below and a detailed display of the number of vehicles to be installed by each year can be seen in the Appendix.

United States average - Number of chargers per scenario			
Year	International Energy Agency (2021)	North Carolina EO 246	Bloomberg NEF (2021)
2030	93	155	298
2050	262	423	846

Figure 14. Three scenarios for EV growth.

Recommended globally - Number of chargers per scanerio			
Year	International Energy Agency (2021)	North Carolina EO 246	Bloomberg NEF (2021)
2030	168	278	537
2050	472	762	1,523

Figure 15. Three scenarios for EV growth.

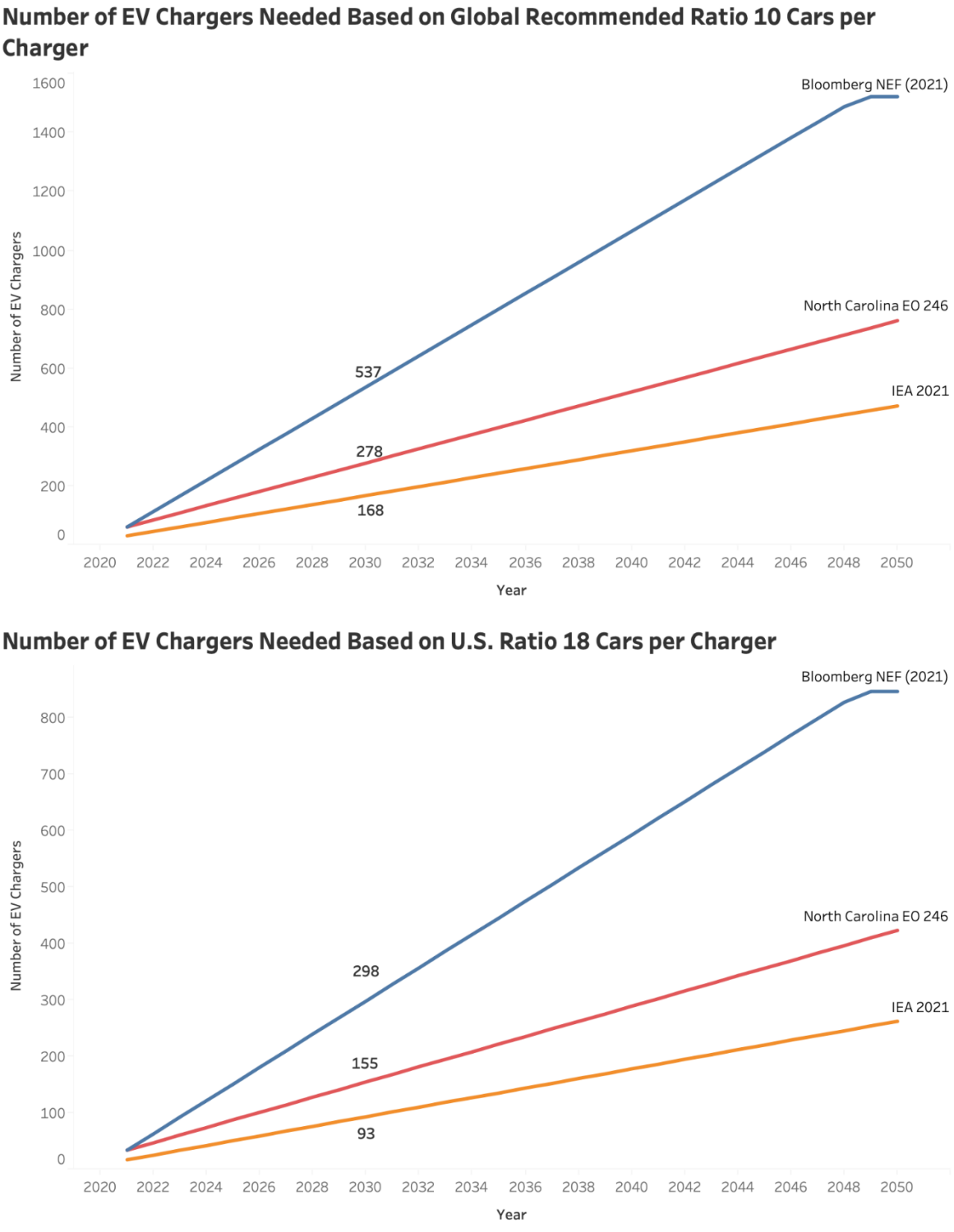

Figure 16. Three scenarios for EV growth.

C. Opportunities and constraints for EV's in Nags Head

i. Dominion Energy and Surrounding Utilities/Electric Cooperatives

The utility that supplies the Town their energy is Dominion Energy. They operate in 13 states and provide energy for up to 7 million customer accounts. Dominion's service territory within North Carolina is along Northeastern NC to the coast. According to the Town, there have been differences in engagement between the Town and Dominion Energy compared to Dominion Energy and their territory in Virginia, or Duke Energy's engagement regarding EV infrastructure within their territories. Dominion Virginia's website lists a program called Charging Rewards, which incentivizes residential customers for allowing them to leverage their Level 2 EV smart chargers to adjust charging behavior during periods of high energy demand. However, for its NC territory regarding EVs, its website lists useful resources including an EV charging guide, developing a workplace charging policy, hosting a fast-charging station, workplace charging case studies, light duty fleet EVs, and an overview of electric buses. There is no mention though of specific incentives for NC customers.

According to a virtual interview with Dominion's External Affairs representative Winnie Wade on March 1st, 2022, the difference in engagement between the VA and NC service territories is policy. Wade stated that previous Governor of VA Terry McAuliffe was an aggressive proponent of EV infrastructure, with NC Governor Cooper being somewhat aggressive yet moving in the right direction. Despite the VA and NC territories being serviced by the same utility, if Dominion would want to increase their EV incentives or services for their NC territory, this would require engaging with the NC Utilities Commission (NCUC) as any matter regarding expanding infrastructure would involve ratepayers. Wade did mention though that Dominion is trying to implement some pilot programs within NC, although the model of these programs is highly inspired by already existing program Powering Smart Transportation in VA.

Other surrounding utilities and electricity cooperatives offer a suite of concrete development plans and incentives listed below:

a. Duke Energy- Park & Plug NC:
    i. "Duke Energy will install, own and operate a variety of EV chargers to provide a foundational level of EV infrastructure and to help facilitate EV market growth across North Carolina.

        1. This will include installing, owning and operating up to 40 Fast Chargers at 20 locations, 160 level 2 chargers at public locations and up to 80 level 2 chargers at multifamily dwellings. These chargers will make it easier for EV drivers to charge and allow us to gather data on EV charging habits.

b. Additionally, Duke Energy will offset the purchase of 15 electric school buses by districts across the state in order to gather operational data and explore the capabilities of the vehicle-to-grid technology." [117]
c. Cape Hatteras Electric Co-op:
    i. *"EVSE Rebate and Time of Use (TOU) Rate*: Cape Hatteras Electric Co-Op offers a rebate of $100 to residential customers who install a Level 2 charger."[118] It also offers a TOU rate to residential customers with an EV.
    ii. *EV Rental*: "To provide first-hand education and awareness of the growing EV industry, Cape Hatteras Co-op offers a 2019 Nissan Leaf rental for their members."*[119]*
d. Randolph Electric Membership Corporation (EMC).
    i. *TOU Rate:* "Randolph Electric Membership Corporation (EMC)'s Electric Vehicle Utility Program (REVUP) program offers residents who own an EV a Plug N2 Savings TOU rate."*[120]*

These additional plans and incentives can serve as an opportunity to envision various models of incentives and programs that the Town of Nags Head would want to be able to receive as well.

ii. Business and Tourism

In an email interview with the President of the Outer Banks Chamber of Commerce Karen Brown on January 8, 2022, Brown emphasized both education and outreach are important to gather information about stakeholder interests, needs, and concerns about charging infrastructure. Brown mentions that businesses would need more understanding and knowledge regarding costs, data on users, the infrastructure, and capability of hosting a charger on their particular property. In addition, she has not heard businesses and their respective customers express a need for EV charging as they need to be educated to express demand for infrastructure. This does not imply that the business climate is not open to EV charging, however they need to be educated and understand the need. Ideal locations to host charging according to Brown would be businesses that host customers that spend more than 30 minutes there such as restaurants, laundromats, gyms, and movie theaters.

In a phone interview with the Managing Director of the Outer Banks Visitors Bureau Lee Nettles on February 24, 2022, Nettles mentioned a subtle, yet growing trend of summer tourists inquiring about EV charging and arriving with EVs. Nettles mentioned that 70 percent of the Outer Banks annual occupancy collection is from the months of June – August, which reveals that it is a seasonal destination. Analyzing the seasonal destination component, summer months experience peaks in electricity consumption in addition to seasonal tourists, so it will be imperative to prepare the grid for expected summertime demand plus increasing EVs visiting the island. Nettles also mentioned that he has personally seen a gradual increase in EV charging infrastructure in the Outer Banks, in particular a popular EV charging location is a Tesla

charging station at a Harris Teeter in Kill Devil Hills. However, he does see the island's welcome centers in Kitty Hawk and Manteo as ideal locations to host chargers as both of these sites have a cooperative relationship with the NC Department of Transportation (NC DOT). He also mentioned Town Hall, other municipal parking lots, the former Tanger Outlets in Nags Head, Jennette's Pier, and Jockey's Ridge State Park would be ideal charging sites. Kitty Hawk Kites has also been identified as an environmentally engaged local business, which would be a useful partner to engage. The Visitors Bureau website does contain a mapping tool from the app Plugshare showing available chargers, however physical signage from Nettles' perspective is not evident with the exception of the Tesla charging station signage in Kill Devil Hills.

iii. Other Climate Initiatives within Nags Head

Nags Head currently has two climate initiatives that would serve as excellent partnership opportunities upon adoption of this EV Action Plan. The two initiatives are described below:

1) The NC Coastal Resiliency Program

The description of this program is directly informed from both the client and the Town's website:

> "In 2021, Nags Head was chosen as one of many communities to participate in the NC Division of Coastal Management's (DCM) Resilient Coastal Communities Program (RCCP). This new program addresses the need to advance coastal resilience for municipalities in the 20 coastal counties in North Carolina. This program provides funding and technical assistance to Nags Head for developing resilience strategies and associated project engineering, design, and implementation, and incentivizes innovative solutions (natural and nature-based). The overall goal of the RCCP is to involve the community in setting coastal resilience goals, assessing the existing conditions and needed capacity, and identifying and prioritizing projects that will enhance Nags Head's resilience and response to coastal hazards. This process will eventually result in a Resilience Strategy for the Town of Nags Head."[121]

2) Energy Transitions Initiative Partnership Project (ETIPP)

The description of this program was directly informed by an email with the client on February 17th, 2022:

Nags Head is partnering with Sandia National Lab, the National Renewable Energy Lab (NREL), and the Department of Energy (DOE) to advance disaster resiliency by assessing how energy efficiency, renewable energy, and microgrid technologies can ensure critical facilities remain online and reliable following extreme events. This project

will establish energy resilience goals for the Town, integrate those goals into ongoing planning initiatives, and evaluate a subset of municipal buildings for efficiency opportunities coupled with future demand profiles to estimate microgrid viability and size. Project results will support the pursuance of implementation funds through future grant applications for FEMA's BRIC (Building Infrastructure and Resilient Communities) program and other related grants.

These two programs align with this EV Action Plan in numerous ways. Both the NC Coastal Resilience Program and ETIPP address resiliency and can provide technical assistance on how to maintain critical facilities. The NC Coastal Resilience Program intersects with the challenges of siting EV charging infrastructure in coastal environments. Coordinating with both program teams behind implementing several of the recommendations this EV Action Plan will propose will be key.

D. Best Practices and lessons learned in other cities, towns, and states

Many other towns, cities, and states have created their own EV guides tailored to meet their local needs. These case studies provide valuable insight for our own work. Three useful examples are summarized here to provide a fuller understanding of EV plans.

i. City of Alexandria, Virginia

The City of Alexandria, Virginia formulated its EV Action Plan in 2021. As part of the plan, there city developed a set of recommendations and findings that can be useful for the Town of Nags Heads. The first finding is to explore the installation of right-of-way (ROW) charging instead of charging in extensive parking lots.[122] ROW charging is located in between neighboring properties, curbs, and next to sidewalks. ROW charging has been successful when chargers, Level 1 and Level 2, are installed in lampposts. When energy inefficient light bulbs are replaced with efficient light bulbs, there is excess electrical capacity that can be used by the EVs.[123] ROW charging is especially recommended for residential areas where parking spaces can be used for longer times than congested areas. The Alexandria's Plan makes emphasis in aligning the ROW charging locations with the larger planning goals of the city or town, especially when there are plans for bike lanes or transit stops.[124] Additionally, the Alexandria's Plan stresses the importance of eye-catching signage and painted parking spots are critical to getting attention and deterring non-EV drivers from occupying ROW charging spaces.[125]

Another finding from the City of Alexandria Plan indicates that to decrease the costs of charging station deployment, the electric utility could design tariffs that alleviate demand charges at public charging stations.[126] As mentioned in the Basics of EVs' section of the report, demand chargers are fees that utilities charge non-residential or commercial customers for the service of maintaining constant supply of electricity.[127] However, these fees were designed for small-to-

medium commercial customers and industrial customers, not for Level 2 or DC fast chargers. A study from the Rocky Mountain Institute from 2017 shows that for the case of 50kW charging stations, 90% of the electricity costs are due to demand charges.[128] The report suggests that the electric utility could set low fixed chargers that would cover routine costs of maintenance and billing, and to change the rates by location. For example, having low rates in locations where chargers are underutilized.[129] To follow this recommendation, the Town of Nags Head would have to advocate for this tariff design with Dominion Energy.

The City of Alexandria's EV Plan also makes emphasis on the importance and usefulness of utility-led "make-ready" programs to bear the costs of charging infrastructure and accelerate the deployment of EVSE.[130] Dominion Energy implemented a program that provides rebates for qualifying EV charging stations, charging infrastructure and installation, and network fees.[131] Given the importance of electric utilities participation in the EVSE deployment process and their impacts on costs and the lessons learned from the Alexandria Plan, the Town of Nags Head would benefit from strengthening its relationship with Dominion Energy and advocating for these policies.

ii. Investor-owned utility Pacific Gas & Electric, California

Investor-owned utility Pacific Gas & Electric (PG&E) provides a useful guide that details code requirements surrounding EVSE installation to promote safety. Expanding any kind of infrastructure requires being aware of these practices. The code requirements guide provides insights surrounding indoor charging and flood zones that would be relevant for Nags Head.

According to PG&E's code requirement guide the need for ventilation in indoor charging facilities is rare, however some EV batteries will require ventilation if there is indoor charging. [132] Very few EV batteries are flooded lead-acid or nickel-iron batteries, the two technologies that release hydrogen and would require ventilation for indoor charging.[133] Current batteries are typically sealed lead-acid, nickel-metal hydride (NiMH), or lithium-ion/lithium-polymer advanced batteries that do not emit gases.[134] In the few circumstances where non-sealed batteries are used, electrolysis (the separation of water into hydrogen and oxygen) can be caused when a flooded lead-acid or a nickel-iron battery is fully charged and additional current is added to the battery.[135] This gas mixture can lead to potential explosions if at a specific concentration, so ventilation would need to be provided if indoor charging will be a publicly available option as EV and battery models would vary. This information is important if our client considers siting charging infrastructure in an indoor or enclosed setting given the corrosive marine environment of Nags Head.

The Town of Nags Head is also highly susceptible to coastal flooding. If an EV charger is being considered in a flood prone zone, PG&E's guide states that all chargers need to be installed

above the base flood elevation or waterproofed to include personnel protection so that it complies with codes for electrical equipment which may become submerged.[136] This is something to take into consideration.

E. Nags Head Building Code

Generally, publicly available charging stations must comply with the Americans with Disabilities Act (ADA). Specifically, this means the 2010 ADA standards and the 2012 NC Building Code (NCBC), Chapter 11.[137] Based on the NCBC guidelines for parking facilities, it is recommended that the first charging space installed in any set of contiguous charging spaces be sized for van-accessibility.[138] A facility owner may install charging hardware such that it can be shared by a standard charging space and an accessible charging space. While the NCBC generally requires that accessible parking be on the shortest accessible route to the associated building entrance, accessible charging spaces may be on a longer route, because the primary purpose of the charging spaces is for charging, not parking.[139] The authors of the EVSE installation handbook do not recommend marking accessible charging spaces as disabled-marked vehicles only because non-disabled-marked vehicles using that spot do not reduce the number of required accessible parking spaces in the facility.

Charging hardware must be installed with a clear floor space, typically 30" wide and 48" long.[140] The connector cable must be at a minimum height of 18" for indoor installations, and 24" for outdoor installations, per the 2011 National Electric Code (NEC) § 625.

Taken together, these codes require that a charging station in a public parking lot in North Carolina have the following features: A van accessible charging space (8' wide with an adjacent access aisle greater than 8' wide); an accessible route from the parking space to the charging hardware that is greater than 48" in width; mounting the charging hardware at street level and set back from the curb line; mounting the charging hardware in a way that it is not in the direct line of vehicle travel; bollards no closer than 4' to each other to protect the charging unit; connection to an accessible route to the associated facility.

Nags Head Code of Ordinances § 7.17 delineates electric vehicle charger installation requirements in the town. Single and Two-Family dwellings may have charging stations as a permitted accessory use. When installed outside, they are subject to the same dimensional regulations as HVAC and other similar mechanical and electrical equipment.[141] For institutional, commercial, and multi-family developments, Nags Head requires that EV charging spots do not make up more than 40% of the total available parking spaces. Operators of chargers are not required to reserve spots for the use of electric vehicles, and if spots are reserved for EV use, such spots do not count towards the minimum required parking for the site. Adequate lighting

and signage are required for such charging stations. In Nags Head, a commercial property's principal use may not be as an electric vehicle charging station or EV battery exchange station.[142] Charging stations may still be installed on commercial property that has a different principal use.

F. Federal/State Laws, Policies, and Regulations

Current federal and state laws and regulations do not particularly constrain or promote the development of electric vehicles in North Carolina. Session Law 2019-132 codifies plug-in electric vehicle and delineates the relationship between the electric utility and operators of EV charging stations, essentially stating that charging stations are not defined as a public utility, and that providing power to a charging station by a utility is subject to that utility's terms and conditions.[143] Exempting charging stations from being classed as a public utility allows charging stations to actually sell electricity to consumers, a right generally reserved only for utilities in North Carolina. This means that charging stations can charge by the kilowatt-hour (a unit of energy), rather than simply by the hour, as was previously the case.[144]

Electric vehicles in North Carolina are afforded a handful of benefits, as well as some drawbacks. EVs in North Carolina are exempt from emissions inspections, making annual inspection fees somewhat cheaper. However, EVs must also pay an annual road maintenance fee to compensate for the funds the NC DOT would have taken in from gasoline taxes on a combustion vehicle.[145] A study by NC State University shows that EVs in North Carolina avoid paying roughly $100 in annual gasoline taxes, but currently pay $130 in annual fees.[146] EVs may use HOV lanes in North Carolina, although the only HOV lane currently in North Carolina is the I-77 corridor between Charlotte and Morrisville.

At the federal level, consumers are entitled to federal income tax credits of up to $7,500 when purchasing a new EV.[147] These credits are tied to each manufacturer, meaning that once a certain number of credits are issued for the sale of a manufacturer's vehicles, the credits are no longer available. For example, in 2020 General Motors sold a sufficient number of EVs that current purchasers of General Motors EVs will not be eligible for a rebate.[148]

The recent federal infrastructure bill, as well as corresponding initiatives in North Carolina, have provided several sources of funding for EVs. These opportunities will be discussed in the following section on sources of support and funding.

G. Sources of Support/Funding

i. Utilities

The Town of Nags Head is situated in a unique position where they can deepen the relationship between Dominion Energy and the Northeastern NC territories they serve. Regulatory proceedings are an effective way to pursue impactful policies, incentives, and programs. Engaging in proceedings can influence how programs are designed at the state-level and even shape utility tariffs.

According to a mini guide from the National Council on Electricity policy that advises how to become effectively involved with public utility commissions (PUCs), local governments can address numerous issues:

- "Traditional areas such as siting poles and wires, approving franchise agreements, or setting rates.
- Access to energy efficiency and renewable energy programs for facilities, including street lights.
- The use of municipal facilities for public benefit, such as siting electric vehicle chargers or community solar gardens on municipal buildings or land.
- Reliability and resilience of power supply as it contributes to public health and emergency response.
- Access to energy programs that support affordability and bill stability for disadvantaged customers and enhance local economic development.
- Approaches to meet renewable energy and greenhouse gas reduction goals adopted by voters or elected officials.
- Access to energy data that supports or enables policy implementation (e.g., commercial or government building energy benchmarking).
- Emerging areas such as how utility business models help achieve community goals."[149]

The list above demonstrates numerous benefits that can promote the Town's desire to expand EV infrastructure and encourage Dominion Energy to offer additional financial incentives for Northeastern NC.

ii. Government Funding

a. Volkswagen Settlement Funds

There is significant funding available for electric vehicle infrastructure in Nags Head and the

surrounding area through various government grants. The most prominent of these sources is known as the Volkswagen settlement funds, a large pool of funding created as the result of a legal settlement between Volkswagen and the federal government.

The Volkswagen funds are disbursed from the federal government to individual states. In North Carolina, the Department of Environmental Quality (DEQ) is responsible for disbursing the funds. The disbursals will take place in three phases. Phase 1 is complete; Phase 2 recently began on February 28, 2022. The application period will close on May 31, 2022. In Phase 1, North Carolina spend $4.6 million on charging infrastructure. The DEQ expects to spend the same amount in Phase 2 on charging infrastructure.[150]

A map from the DEQ showing EV fast chargers funded in Phase 1 of the funding process is shown below.[151] As can be seen on the map as a blue line, a proposed priority corridor for fast chargers is planned to run right to the outer banks, and the Manteo area, but no chargers were funded along this corridor in the first phase. This would be another strong argument for Nags Head and eastern North Carolina to receive top priority for funding in the second phase.

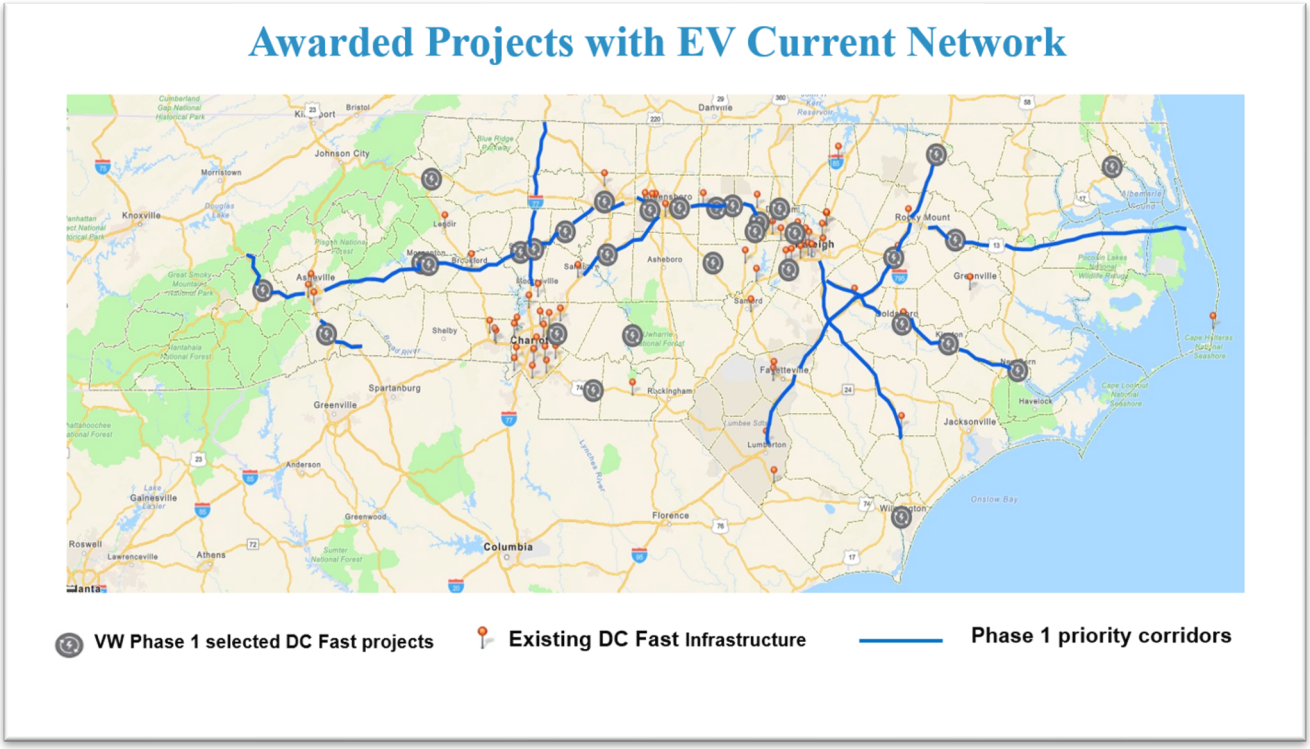

Figure 17. Awarded Projects with EV Current Network. Source: North Carolina Department of Environmental Quality. Retrieved April 22 from https://files.nc.gov/ncdeq/Air%20Quality/motor/vw-phase-1-images/Awarded-DC-Fast-Map-2020.png

b. Infrastructure Investment and Jobs Act

At the federal level, the Infrastructure Investment and Jobs Act passed in late 2021 carries the promise of future funding for charging infrastructure. North Carolina is expected to receive $109 million over five years to support the expansion of an EV charging network in the state.[152] North Carolina will also can apply for $2.5 billion in grant funding dedicated to EV charging in the bill.[153]

The project team interviewed Jennifer Weiss, Senior Advisor for Climate Change Policy at the NC DOT on January 28, 2022 regarding the Infrastructure Investment and Jobs Act. Ms. Weiss made several recommendations for Nags Head if they are going to apply. First, she recommended that Nags Head highlight the need for EV fast chargers as part of evacuation route infrastructure, stressing the importance of providing charging for the growing number of EVs that may need to be used to evacuate the coastline and outer banks. Second, Ms. Weiss advised that multiple municipalities can apply together for up to $15 million in funding. This would allow municipalities to work together to create a larger charging corridor. Applying with other municipalities would allow for a more deliberate, planned charging corridor to be created, with charging stations logically spaced for visitors to the outer banks. This would also serve to address the issue that EV drivers need a way to get to Nags Head in their EVs, not just be able to charge once they arrive. The Town of Nags Head should consult with Ms. Weiss to access this funding.

c. Other Resources for Federal Government Funding

Both the DOE and DOT websites provide sources of funding for EV infrastructure. The Clean Cities Coalition Network maintains a database of potential funding opportunities within and outside of the DOE that should be checked regularly.[154] In addition, the DOT's website offers a rural EV infrastructure funding matrix, which is a list of federal programs that can fund rural EV infrastructure, sorted alphabetically by agency.[155] The matrix will be expanded to reflect new programs in the 2021 Bipartisan Infrastructure Law.[156]

Smart City Initiatives

Local governments such as the Town of Nags Head can make an impact on how effectively EV charging infrastructure is integrated because of their deep understanding of their own municipalities. The City of Columbus, Ohio in June 2016 managed to secure a $50 million Smart City Challenge grant from the US Department of Transportation, beating cities such as Austin and San Francisco in the process. They proposed a comprehensive, integrated plan addressing challenges in residential, commercial, freight, and downtown districts using a number of new technologies, including connected infrastructure, electric vehicle charging infrastructure, an

integrated data platform, autonomous vehicles, and more.[157] When Columbus's EV initiative began in 2016, less than half of 1 percent of new vehicles purchased were electric and the goal with funding was to increase EV adoption by making 1.8 percent of all new LDV registrations electric.[158] After the EV grant program concluded, the city announced that it had reached its target goal with more than 3,323 electric models sold between April 2017 and February 2020.[159] Smart Columbus's winning EV strategy focused on building a broader ecosystem for EVs, from charging infrastructure, to integrating renewables and considering consumer demand's impact on the grid.

Columbus was able to leverage smart city initiatives to expand not only the amount of EVs on their roads, but utilize that money for charging infrastructure and renewable energy to power infrastructure. The Town of Nags Head also can leverage similar funding. The Strengthening Mobility and Revolutionizing Transportation (SMART Challenge) Grant Program, established by the Infrastructure and Investment Jobs Act will provide $500 million to encourage the adoption of smart city or community technologies by large, mid-size and rural communities.[160] According to the grant program, effective use of technology and project benefits include:

> "1) increase resiliency of the transportation system
> 2) incorporate relevant security solutions, including those needed for cybersecurity, and address emergency situations based on the scope and necessity."[161]

The use of grant funds can be directed towards:

> "A) Connected vehicles, which send and receive information about their movements in the network, use vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian communications to provide connectivity that will enable countless safety, mobility, and environmental applications.
>
> > i) leverage the smart grid (a programmable and efficient energy transmission and distribution system) to support the adoption or expansion of roadway electrification, energy capture, and electric vehicle deployment, including electrically assisted bicycles, or freight or commercial fleet fuel efficiency
> >
> > ii) explore and utilize interactions between electric vehicles and intelligent transportation systems with the smart grid."[162]

H. Addressing Resiliency

In an email interview with Eric Claussen who is the Director of Public Services for the Town of Nags Head on March 4th, 2022, he provided some insights regarding benefits and challenges of

providing resilient EV infrastructure. From Claussen's point of view, the electric grid is susceptible to prolonged outages, so if the Town becomes reliant on EVs or EV equipment, there needs to be an understanding of what that resembles during and after a major weather event. During a major weather event though, V2G is a future potential solution given natural gas's limited service on the island. V2G stands for "vehicle to grid" and it allows for energy from an EV's battery to be exported back to the electrical grid.[163] The potential benefit of a V2G exchange is EV fleets being able to absorb excess electricity during periods of low demand and discharge it during periods of high demand.[164] The rechargeable battery and bi-directional power capability in EVs and PHEVs can also make them well suited to provide ancillary services (services that help grid operators retain reliable electricity) to the grid while parked such as grid regulation and storing/discharging electricity.[165] Currently, only Nissan BEVs (LEAF & e-NV200 van) can use V2G due to their CHAdeMO charging technology.[166] EV manufacturers are still working on developing this technology for broader adoption. Currently, there is a pilot project between General Motors and the California electric utility PG&E testing V2B (vehicle to building) power backup applications. This program will test the capability of GM's EVs in providing power to homes during blackouts or times of high demand.

Regarding susceptibility to harsh marine elements, EV chargers face two distinct threats: 1) flooding during a storm surge event and 2) corrosion from everyday exposure to salt spray. In addition, rental property owners considering installing EV charging have additional considerations. Many beach homes have carports underneath and circuit breakers cannot be located on the bottom of the home due to flooding. In addition, the Town of Nags Head potentially pursuing fleet electrification would need to be selective on the locations of equipment and charging stations. With the development of the Public Services master plan according to Claussen, the plan details implementation of EV charging equipment inside of enclosed equipment storage facilities and potentially at the public-facing Administration Office. This can protect the charging stations from saltwater intrusion. Between the coastal environment challenges and beach access congestion, Claussen also does not believe in the feasibility of installing EV charging infrastructure on beach accesses due to obvious corrosion concerns. Existing EV infrastructure in the community, such as the Harris Teeter in Kill Devil Hills needs to be reassessed to evaluate the life expectancy given the salt air. In a virtual interview on March 1, 2022 with Dominion Energy External Affairs Representative Winnie Wade, some of Dominion's existing infrastructure in Nags Head is built as contaminate construction. This type of construction attempts to limit corrosion and salt on the lines. Most transformers in Nags Head are stainless steel, along with meter bases as stainless steel is considered the most corrosion-resistant metal.

Another choice for backup power that is more ideal than relying upon fossil fuels already exists in the Outer Banks and would benefit from an interconnected Smart Grid ecosystem are microgrids. A microgrid can improve reliability during storm events by generating their own

power and their ability to be islanded from the main electrical grid. North Carolina's electric cooperatives have four active microgrids, with a fifth one in development as displayed in the figure below:

Figure 18. North Carolina's Electric Cooperative Microgrids.
Source: NC Electric Cooperatives

The Ocracoke Island microgrid, located in the Outer Banks which our client is also geographically situated in, started operating in February 2017. North Carolina's Electric Cooperatives developed and installed the microgrid in partnership with local cooperative Tideland EMC.[167] Ocracoke Island's remote location leaves it vulnerable during weather events and isolated from central power generation sources.[168] The microgrid will support better power reliability for the island and serve as a resource that can be called on during times of peak demand.[169]

I. Equity

Data from Data USA reveals that Nags Head in 2019 has approximately 2,900 people, a median age of 49.6, and a median household income of $65,968.[170] The Data USA data visualization in the figure below also reveals a demographic breakdown of the Town of Nags Head. The largest ethnic groups are white and Non-Hispanic two or more ethnicities:

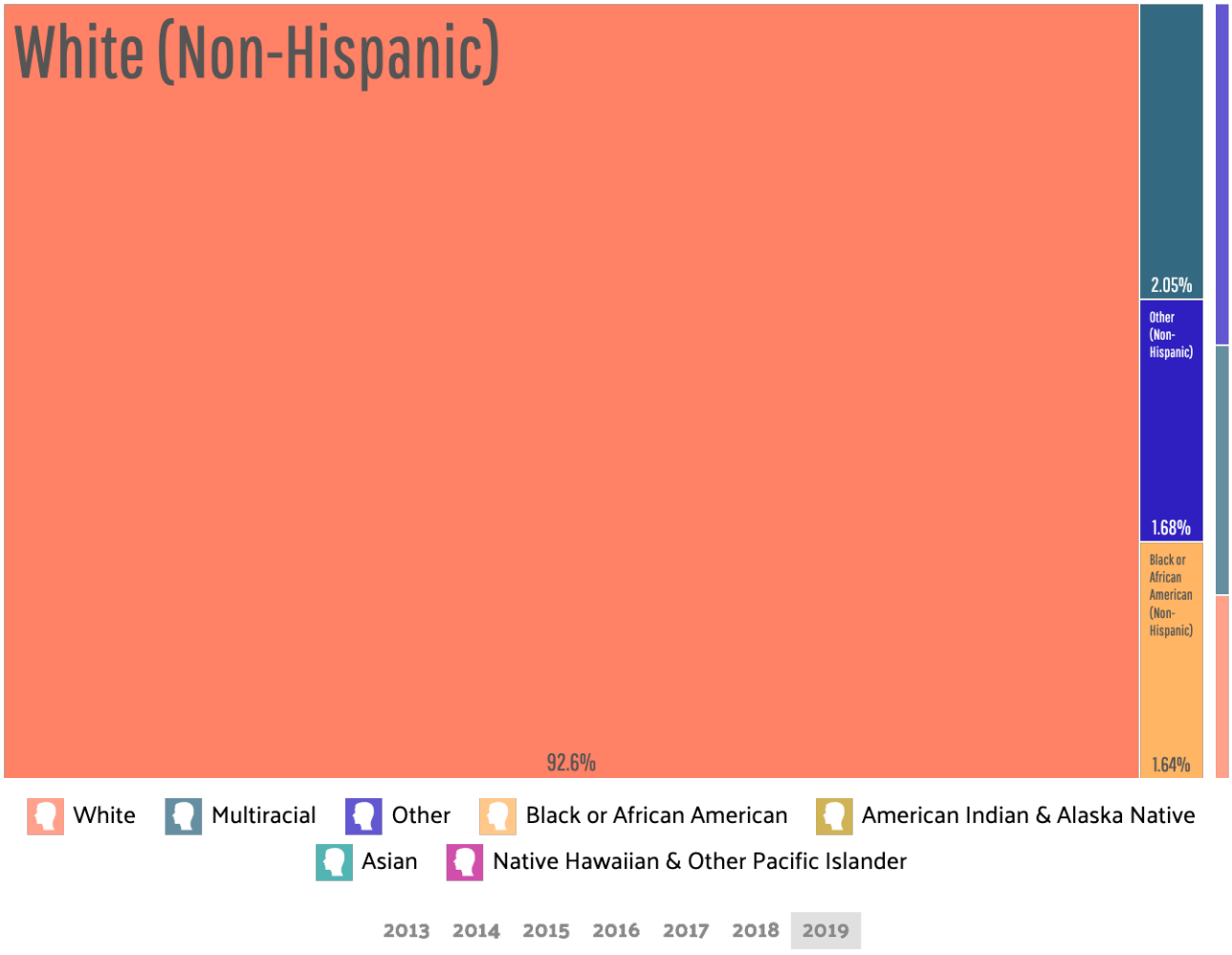

Figure 19. Race and Ethnicity of the Town of Nags Head. Data from the Census Bureau ACS 5-Year Estimate. Source: Data USA

In 2019, the median age of all people in Nags Head, NC was 49.6, but people in Nags Head, NC are increasingly aging. In 2018, the average age of all Nags Head, NC residents was 43.[171] The age group comprising the largest share in Nags Head are between the ages 65-74.

Given the demographic information on Nags Head, this will require a retooling of what types of vulnerabilities to consider. Given that the major demographic are older white people who are middle and upper middle class, there is an angle regarding potential social support isolation due to age. There is the possibility of elderly populations living in Nags Head without nearby family, which having social support helps to spread awareness and ultimately accessibility about EVs. Considering elderly populations in planning will be key.

In addition, there should be more research and outreach measures regarding the non-white population of Nags Head given the obstacles that lead to people of color being systematically undercounted on the US Census. There are not enough Census takers who speak additional

languages and more outreach needs to be conducted with both non-white and white populations experiencing homelessness.

Overall due to historic policies such as redlining, low-income and communities of color are disproportionately exposed to pollution and other environmental burdens, especially pollution from vehicles. EVs have the potential to provide long term cost savings and also reduce tailpipe emissions exposure for these heavily burdened communities. Given the general EV trends discussion in this report, there is still some time until EVs reach cost parity or become cheaper than ICE vehicles. Low-income and communities of color experience gaps in general car ownership compared to their white counterparts, with the gap for EV ownership being even more pronounced. Consumers overall still need financial assistance to buy EVs. According to The Greenlining Institute: "vouchers, rebates, tax credits, and sales tax exemptions are the most common EV financial incentives for consumers."[172] Out of these incentives, The Greenlining Institute promotes vouchers as the most effective purchase incentive tool because they reduce the price of the EV at the time of purchase and directly place dollars into the hands of those who need them the most.[173]

Currently, there does not appear to be any vouchers offered to low-income residents of North Carolina. Greenlining's EVs for All Equity Toolkit is heavily based on California's landscape. However, this can still serve as a template that NC policymakers should consider offering to low-income and communities of color. This is still relevant to the majority demographic bucket for Nags Head as many elderly populations live on fixed incomes. Given the overall increase in the cost of living due to the varied impact of the Covid-19 pandemic and the association between air pollution and respiratory issues, EVs play a role in reducing air pollution and it is critical that they are accessible regardless of income level.

VII. Recommendations for Nags Head

Our recommendations for Nags Head are divided into four broad categories: a) infrastructure, b) policy and outreach, c) resiliency, and d) sources of funding. Within these categories, we separate recommendations by decision-making time-period, i.e. does the choice need to be made immediately, within two years, within 30 years, and so on.

A. Infrastructure

i. Within the next year

Begin to consider public charging. Identify public parking areas that would be ideal for the town to install charging infrastructure. There should be plentiful space so that local business and activity would not be impeded by reserving some spots for EV charging. The chargers will need to be installed adjacent to the curb where they could be installed without impeding traffic. They

will also need access to a stable connection to the electrical grid. They should be locations where visitors would enjoy staying for a period of several hours. Consider the Nags Head Woods Preserve, the Nags Head Town Park, Dowdy Park, Jockey's Ridge State Park, Jennette's Pier, and public beach access points.

If any of the installed chargers require internet access, we recommend that the Town utilizes short-term data contracts. Our research shows that this is a quickly evolving industry, and data rates are likely to decrease.

ii. Within the next two years

Consider providing a financial incentive for real estate developers to install EV chargers in newly constructed rental properties. Another option could be to mandate that all new homes built after a certain point have charging available. This could be as simple as incentivizing or requiring that a 220-volt outlet be installed in the parking area or garage of any new home. These outlets are the same type that are installed for washers, dryers, and other large home appliances, and would not be a major burden for construction. Simply having an outlet easily accessible in the parking area will allow EV drivers to use the charging cable that comes with their vehicle, or for the property owner to install a level 2 charger at their convenience.

iii. By 2030

Install 100 to 250 chargers, including public and private chargers. This recommendation is based on our model, which predicts that this range of charger availability will be needed by 2030, based on current EV sales trends. At this stage, it would be prudent for the town to re-evaluate the town's charging needs with current data.

Note that this figure includes both public and private chargers. Roughly 80% of visitors to Nags Head currently stay in private rental properties, and stay for a period of 5 days on average. With this in mind, the town should focus on expanding access for level 2 chargers, rather than DC fast chargers. The most common use scenario will be a visitor coming to town for a week, so being able to plug in for several days at their rental property, or throughout the day at a public charger as they enjoy the beach, are the best options to make available. Because Nags Head is a destination, rather than a stop on the way for the majority of EV users, DC fast chargers will not be as important as in other towns.

B. Policy & Outreach

i. Within the next year

Outreach educating property managers and business owners on the importance of preparing for EVs and understanding their individual needs. This can be done through informal outreach or creating a brief presentation/document that can be disseminated. There are several key points our client should highlight. The predicted increase of EVs should be shared with them in a few easily understandable data points. For example, there will be roughly 3,000 EVs in Nags Head during peak summer months, which will require roughly 200 chargers to be available. Because 80% of visitors stay in rental properties, Nags Head should seek to have most of these chargers installed on rental properties. Engaging business owners on the value they would place on sacrificing a parking space for an EV charging spot would help craft an ideal financial incentive as cost is a source of hesitancy for hosting EV chargers. A carefully crafted incentive would help offset some of the charger's initial costs. Finally, NC State has an excellent brief guide to installing EV chargers.[174]

Contact the utility Dominion Energy prior the installation of new EVSE in commercial sites to obtain information about demand chargers. Demand chargers should be minimized or eliminated for a beneficial and cost-effective use of EVSE and to avoid sudden electricity charges increases.

ii. Within the next two years

Begin to develop a relationship with the North Carolina Utilities Commission to pursue more EV incentives and infrastructure from their utility. The desire for expanding EV infrastructure within the Town of Nags Head is an unintended policy window that can promote the Town's interests. Our client should develop relationships with NCUC staff by following utility proceedings, filing public comments, and partnering with other local Outer Banks municipalities to participate in proceedings. As the energy landscape changes in the coming years, it will be important for the town to be informed as new issues develop.

Begin planning for a separate smart city initiative. It would be in the Town's benefit to consider a similar smart city project like Columbus, OH or designate another working group to develop a smart city initiative like the scope of this EV Action Plan. This will be important to integrate increasingly advanced EVs, EV infrastructure, and associated technology into a broader ecosystem.

Consider revising the local code to encourage EV use. As it stands, the code's only consideration for EV chargers is to expressly prohibit EV chargers as the primary purpose of a commercial property, and to require that no more than 40% of a parking lot may be dedicated to EV

charging.[175] With current trends projecting that there will be thousands of EVs in Nags Head every summer by 2030, these restrictions are antithetical to progress. If the local code is going to be revised to encourage installation of chargers in rental properties, as recommended in the infrastructure section, then the code should be further revised to remove these restrictions. If anything, the code should encourage installation of EV chargers in public lots.

Finally, Nags Head should coordinate with the Outer Banks Visitors Bureau to increase awareness of EV chargers and benefits. Signage throughout the Outer Banks to guide drivers to available EV charging will be increasingly important as EV numbers increase over the coming years.

C. Resiliency

i. Within the next two years

Establish plans for developing a microgrid. The Town should partner with other Outer Bank cities, Dominion Energy, NCUC, the DOE, and other entities in the case of needing a DER that can be islanded from the grid.

ii. By 2030

Expand battery storage. Battery storage located near congestion points could compensate for the additional demand arising from plugging in the EVs.[176] Dominion Energy needs to be engaged regarding installing DERs along main congestion points, or close to major charging sites. As gasoline is usually stored during a natural disaster, battery storage will need to store energy for EV drivers. Utilities can also be encouraged to leverage DERs that include distributed generation and storage, such as residential solar systems and batteries.[177] A less ideal choice would also be planning for EV drivers with backup energy via diesel generators for emergencies.

Harden electric infrastructure. Hardening is meant to prevent outages and minimize system damage by addressing physical vulnerabilities so infrastructure can better survive natural disasters.[178] There are limitations in this EV Action Plan's ability to find research on specific EV charger models that are hardened for marine environments such as Nags Head. EV chargers should be in enclosed sites, sited on higher ground, or if neither option is feasible then requesting for EV chargers that are hardened for a marine environment from EV charging manufacturers. When engaging with EV charging manufacturers, it is worthwhile to request information on any available EV charging models that have are NEMA Type 4X rated. NEMA Type 4X equipment is designed to provide some protection against sea salt spray.[179] In addition, the Town of Nags Head or even rental property owners should consult an electrician regarding where electrical components such as circuit breakers should be located given susceptibility to flooding.

D. Sources of Funding

i. Within the next year

Within the next year, Nags Head should determine if it wants to pursue installing chargers in public spaces. This should be done soon, because the final phase of the Volkswagen Settlement fund dispersal will be done in 2024. The town will need time to decide if it wants to build, and to compose an application.

Volkswagen settlement funds will also be available for fleet electrification for municipal vehicles, and school bus electrification. Both options may be of interest for the town, and the decision should be made in time to apply for the final phase of Volkswagen funding by 2024.

The town should also consider forming a coalition or working group with neighboring municipalities to apply for grants as a collective. In interviews with Department of Transportation staff, we have learned that the DOT is interested in seeing plans for a unified charging network across multiple districts or counties. Nags Head could benefit from this—one need that was identified in our research was for DC fast chargers on routes into Nags Head. Demand for fast chargers in the town itself may be relatively low, but EVs traveling from central North Carolina and Virginia will need fast chargers to reach the outer banks, and there are currently very few fast charger options along these routes.

ii. Within the next two years

Apply for Volkswagen settlement grants and infrastructure bill funding to fund infrastructure projects for charger installation, and/or fleet electrification.

Work with NC DOT to also apply for SMART Challenge Grant Program funding under the Infrastructure Bill. SMART Challenge Grant money could be accessed under similar considerations such as resiliency for transportation and emergency situations such as evacuation during a natural disaster event. The grant criteria are also clear on utilization for vehicle-to-infrastructure (ex. V2G and V2B), increased EV deployment, and EVs being increasingly paired with autonomous driving features interacting with a grid that is prepared to handle such coupling.

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APPENDIX

Annex 1. Equations used to fill out the tables presented in Figures 9 and 10.

$$Number\ of\ Households = \frac{population}{household\ size}$$

$$Number\ of\ vehicles\ in\ Nags\ Head = households * vehicles\ per\ household$$

$$Average\ miles\ driven\ in\ NC\ \left(\frac{miles}{year}\right) = \ daily\ average\ miles\ driven\ per\ person\ in\ NC * days\ in\ a\ year$$

$$Average\ car\ lifespan\ (years) = \frac{average\ car\ lifespan\ (miles)}{average\ miles\ driven\ in\ NC\ \left(\frac{miles}{year}\right)}$$

$$New\ sales\ or\ vehicles\ out\ of\ the\ market\ \left(\frac{vehicles}{year}\right) = \frac{number\ of\ vehicles\ in\ Nags\ Head}{average\ car\ lifespan\ (years)}$$

Annex 2. Results from the projections: Percentage of EV sales share from total vehicle sales from 2022 to 2050 corresponding to the Town of Nags Head, according to three growth scenario and number of EVs in the Town of Nags Head.

	% share of EVs in car sales			New EVs in Nags Head		
Year	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)
2021	4.0%	2%	4%	7	4	7
2022	5.6%	3%	7%	10	6	13
2023	7.2%	4%	11%	12	7	19
2024	8.8%	5%	14%	15	9	25
2025	10.3%	6%	18%	18	11	30
2026	11.9%	7%	21%	20	12	36
2027	13.5%	8%	25%	23	14	42
2028	15.1%	9%	28%	26	16	48
2029	16.7%	10%	32%	28	17	54
2030	18.3%	11%	35%	31	19	59
2031	19.9%	12%	39%	34	21	65
2032	21.4%	13%	42%	36	22	71
2033	23.0%	14%	46%	39	24	77
2034	24.6%	15%	49%	42	26	83
2035	26.2%	16%	53%	44	27	88
2036	27.8%	17%	56%	47	29	94
2037	29.4%	18%	60%	50	31	100
2038	31.0%	19%	63%	52	32	106
2039	32.6%	20%	67%	55	34	112
2040	34.1%	21%	70%	58	36	117
2041	35.7%	22%	73%	60	37	123
2042	37.3%	23%	77%	63	39	129
2043	38.9%	24%	80%	65	41	135
2044	40.5%	25%	84%	68	42	141
2045	42.1%	26%	87%	71	44	146
2046	43.7%	27%	91%	73	46	152
2047	45.2%	28%	94%	76	47	158
2048	46.8%	29%	98%	79	49	164
2049	48.4%	30%	100%	81	51	167
2050	50.0%	31%	100%	84	52	167

Annex 3. Results from the projections: Percentage of EV sales share from total vehicle sales from 2022 to 2050 corresponding to the visitors of the Town of Nags Head, according to three growth scenarios and number of EVs visiting the Town of Nags Head.

	% share of EVs in car sales			New EVs - Visitors in peak summer months		
Year	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)
2021	4.0%	2%	4%	603	302	603
2022	5.6%	3%	7%	842	452	1,126
2023	7.2%	4%	11%	1,081	603	1,649
2024	8.8%	5%	14%	1,320	754	2,172
2025	10.3%	6%	18%	1,559	904	2,696
2026	11.9%	7%	21%	1,797	1,055	3,219
2027	13.5%	8%	25%	2,036	1,205	3,742
2028	15.1%	9%	28%	2,275	1,356	4,265
2029	16.7%	10%	32%	2,514	1,507	4,788
2030	18.3%	11%	35%	2,753	1,657	5,311
2031	19.9%	12%	39%	2,992	1,808	5,835
2032	21.4%	13%	42%	3,231	1,958	6,358
2033	23.0%	14%	46%	3,470	2,109	6,881
2034	24.6%	15%	49%	3,709	2,260	7,404
2035	26.2%	16%	53%	3,948	2,410	7,927
2036	27.8%	17%	56%	4,186	2,561	8,451
2037	29.4%	18%	60%	4,425	2,711	8,974
2038	31.0%	19%	63%	4,664	2,862	9,497
2039	32.6%	20%	67%	4,903	3,013	10,020
2040	34.1%	21%	70%	5,142	3,163	10,543
2041	35.7%	22%	73%	5,381	3,314	11,066
2042	37.3%	23%	77%	5,620	3,465	11,590
2043	38.9%	24%	80%	5,859	3,615	12,113
2044	40.5%	25%	84%	6,098	3,766	12,636
2045	42.1%	26%	87%	6,337	3,916	13,159
2046	43.7%	27%	91%	6,575	4,067	13,682
2047	45.2%	28%	94%	6,814	4,218	14,205
2048	46.8%	29%	98%	7,053	4,368	14,729
2049	48.4%	30%	100%	7,292	4,519	15,061
2050	50.0%	31%	100%	7,531	4,669	15,061

Annex 4. Results from the projections: Grand total number of EVs in the Town of Nags Head during months of peak visits. The results include vehicles owned by the local population and vehicles owned by visitors.

	Total Number of EVs in the Town of Nags Head - Local population and Visitors		
Year	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)
2021	610	306	610
2022	852	458	1,139
2023	1,093	610	1,668
2024	1,335	763	2,198
2025	1,577	915	2,726
2026	1,818	1,067	3,255
2027	2,059	1,219	3,784
2028	2,301	1,372	4,313
2029	2,542	1,524	4,843
2030	2,784	1,676	5,371
2031	3,026	1,829	5,900
2032	3,267	1,981	6,429
2033	3,509	2,133	6,958
2034	3,751	2,286	7,488
2035	3,992	2,437	8,016
2036	4,234	2,590	8,545
2037	4,476	2,743	9,074
2038	4,717	2,894	9,603
2039	4,958	3,047	10,133
2040	5,200	3,200	10,661
2041	5,441	3,351	11,190
2042	5,683	3,504	11,719
2043	5,924	3,656	12,249
2044	6,166	3,808	12,778
2045	6,408	3,961	13,306
2046	6,649	4,113	13,835
2047	6,891	4,265	14,364
2048	7,133	4,417	14,894
2049	7,374	4,570	15,229
2050	7,615	4,722	15,229

Annex 5. Results from the projections: Grand total number of chargers for a ratio of 18 EVs to 1 charger.

	Number of Chargers Ratio 18:1		
Year	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)
2021	34	17	34
2022	47	25	63
2023	61	34	93
2024	74	42	122
2025	88	51	151
2026	101	59	181
2027	114	68	210
2028	128	76	240
2029	141	85	269
2030	155	93	298
2031	168	102	328
2032	182	110	357
2033	195	119	387
2034	208	127	416
2035	222	135	445
2036	235	144	475
2037	249	152	504
2038	262	161	534
2039	275	169	563
2040	289	178	592
2041	302	186	622
2042	316	195	651
2043	329	203	681
2044	343	212	710
2045	356	220	739
2046	369	229	769
2047	383	237	798
2048	396	245	827
2049	410	254	846
2050	423	262	846

Annex 6. Results from the projections: Grand total number of chargers for a ratio of 10 EVs to 1 charger.

	Number of Chargers Ratio 10:1		
Year	North Carolina EO 246	International Energy Agency (IEA 2021)	Bloomberg NEF (2021)
2021	61	31	61
2022	85	46	114
2023	109	61	167
2024	134	76	220
2025	158	92	273
2026	182	107	326
2027	206	122	378
2028	230	137	431
2029	254	152	484
2030	278	168	537
2031	303	183	590
2032	327	198	643
2033	351	213	696
2034	375	229	749
2035	399	244	802
2036	423	259	855
2037	448	274	907
2038	472	289	960
2039	496	305	1,013
2040	520	320	1,066
2041	544	335	1,119
2042	568	350	1,172
2043	592	366	1,225
2044	617	381	1,278
2045	641	396	1,331
2046	665	411	1,384
2047	689	427	1,436
2048	713	442	1,489
2049	737	457	1,523
2050	762	472	1,523