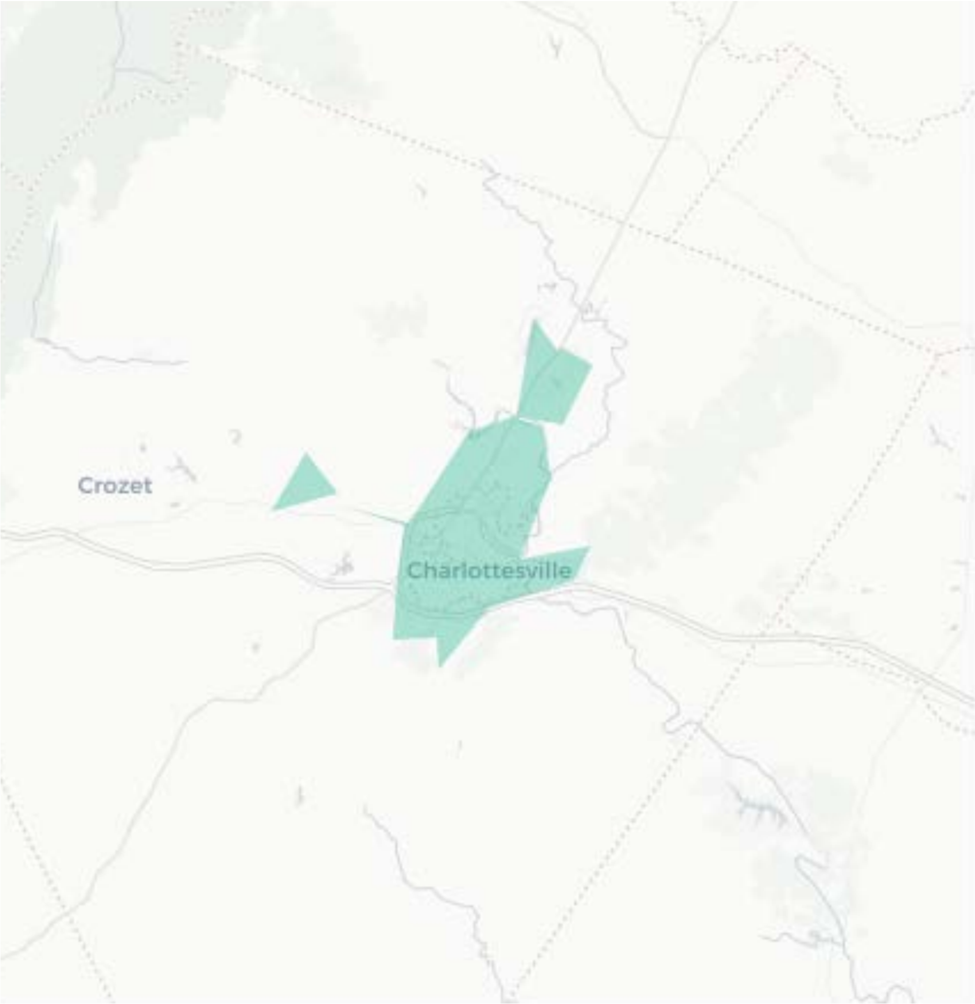

Electric Vehicle Charging
Infrastructure Projection and 10% Deployment Scenarios

Charlottesville, VA

June 30,2021

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Through this report we have the opportunity to work collaboratively towards improving air quality, boosting economic development, and enhancing the quality of life across the Commonwealth. To support 10% electrification in the Charlottesville area we must achieve 1,127 Workplace Level 2 Charging Plugs, 697 Public Level 2 Charging Plugs, & 89 DC Fast Charging Plugs

EVI-Pro Tool Lite

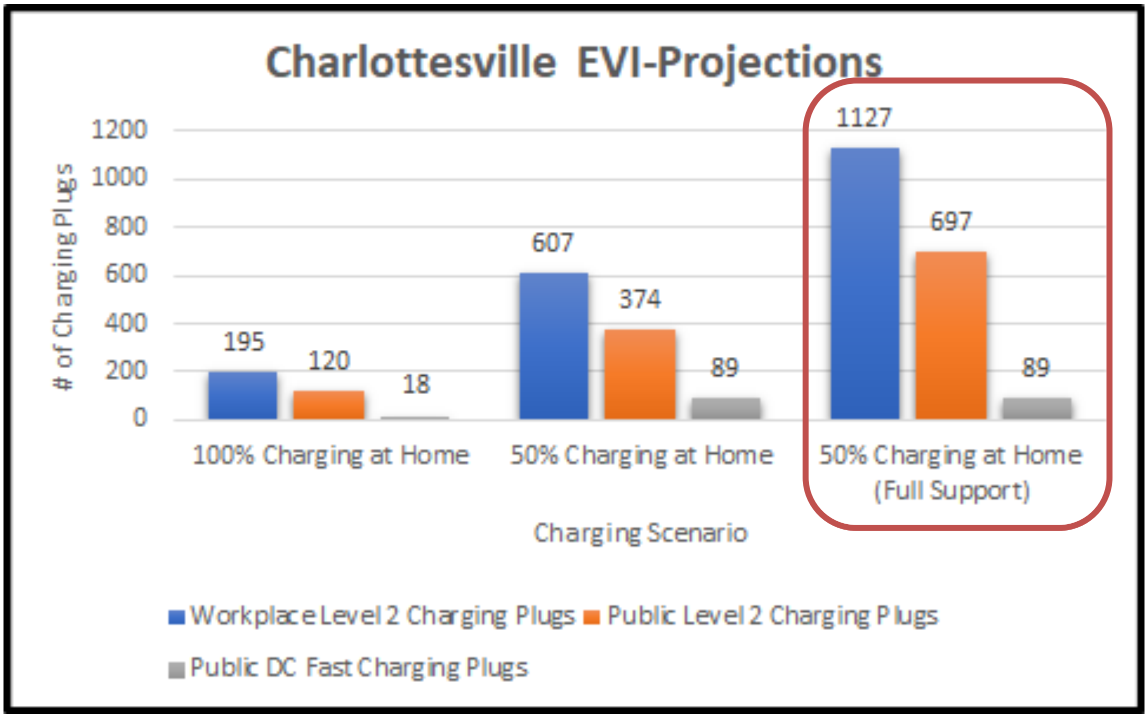
The EVI-Pro Tool Lite is a simplified version of the Electric Vehicle Projection Tool created by the National Renewable Energy Laboratory (NREL) and the California Electric Commission. The EVI-Pro Tool uses simulations of current driving behaviors among all light-duty vehicles to provide major urban areas with projections of necessary quantities and types of Electric Vehicle Charging Infrastructure (EVSE) in residential, workplace, and public areas under a variety of user-designated scenarios. User-designations include the number of EVs you would like to support, percentage of electric vehicle (EV) types, and level of support given to Plug-in Hybrid (PHEVs) to operate on their batteries opposed to gasoline.

In the following, Charlottesville is run through the EVI-Pro tool for projections to reach the first 10% EV ownership in that region using 2016 reports of total light-duty vehicles on the road. Furthermore, we present supporting 50% of charging at home with full support of PHEVs to operate on electricity. Vehicle mix remains constant with the EVI-Pro default 15% of PHEVs with 20 miles range, 35% of PHEVs with 50-mile range, 15% of All-electric with 100 miles range, and All-electric with 250 miles range. This default is on track for Virginia with our current and expected mix of vehicles at the time of this report.

The EVI-Pro Tool Lite incorporates some defaults in its model that are limiting that we would like to suggest initial changes to are suggested to better anticipate the regional market. The first limitation is that the model expects plug-in hybrid vehicles to run completely on gas. We believe that this model should anticipate full service to plug-in hybrid vehicles to minimize the imported high carbon gasoline, these vehicles could use electricity on a consistent daily basis. The limitation is that the tool only allows for modeling between 50% or 100% charging at home. Today, only 40 % of Americans and Virginians have access to electricity within 20 feet of where they park at home meaning that home charging is already overestimated in the current model. These changes would result in an increase in the projected number of chargers needed to prepare for the 10% market scenarios, while more accurately representing how EVs are used in the Commonwealth. Note that these are projections for EV ownership and not EV sales. EV sales can serve as a misleading metric when attempting to calculate total EV adoption over many years. This is due to the multi-year lifespans of vehicles; it takes years after purchase to phase out internal combustion engine vehicles even when EV sales are high.

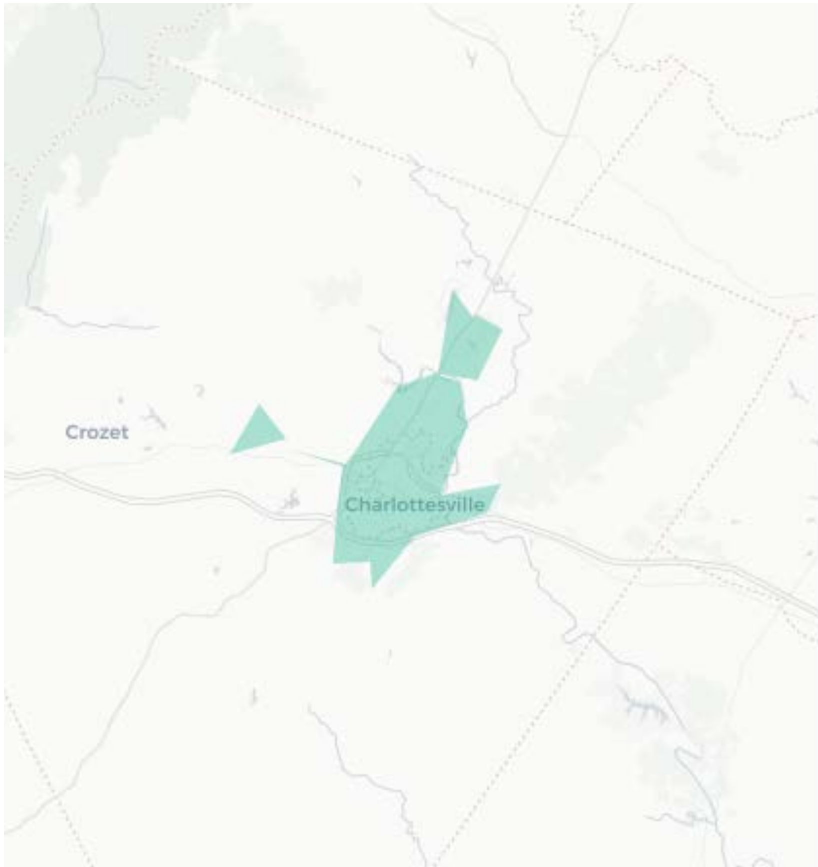
EVI Pro Tool Lite Charging Infrastructure model for 10% EV Ownership - including all types of vehicles

*Full support means most PHEV drivers would not need to use gasoline on a typical day.



In the chart above there are three sets of EVI-Projections with different charging scenarios of what future charging deployment may look like. The first scenario outlined assumes that 100% of the population that owns an EV will have accessibility to home charging, which is not realistic when reflecting on the previously stated statistic that 40% of Americans lack an outlet within 20 feet of where they park. The second outlines a 60% charging scenario where 50% of the EV owner population has access to charging at home. This is an important distinction because already we can see a dramatic increase in the amount of workplace and public charging required to support 10% ownership; however, this metric suffers from 'partial support'. In the EVI-Pro tool there is a default 'partial support' limiting plug-in hybrid vehicles to run mainly on gasoline. When we switch this default to 'full support', as seen in the third scenario, we force the EVI-Projection to consider that all plug-in hybrids will run solely on electricity.

Looking at Charlottesville EVI-Projections, there is an expected 3,680 single home level 2 charging plugs. Furthermore, we can take into account the amount of necessary available Multi-Unit Dwelling/Curbside charging, which we estimate to be about 920 level 2 charging plugs.



This region was mapped using 2017 Census Urbanized Area data from (https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html) and shaped by the National Renewable Energy Laboratory. Highlighted region contains 50,000 or more people.

The EVI pro tool lite currently calculates for pre-determined regions based on 2017 Census Urbanized Area data that highlights regions that contain 50,000 or more people. As a result, this Charlottesville projection not only includes Charlottesville but also some of its surrounding areas including parts of Norfolk, Hampton, Newport News, and Chesapeake. While not a built-in function, there is the capability to use the EVI pro tool lite to calculate charging needs for individual localities, towns, or neighborhoods. This can be done by using the tool to select state and an analogous region, then choose the volume of vehicles you would like to model for that city - an approximate 10% electrification of a city with likely 50,000 registered vehicles would be "5000".

In the Charlottesville area, to support 9,200 plug-in electric vehicles you would need:

1,127 Workplace Level 2 Charging Plugs

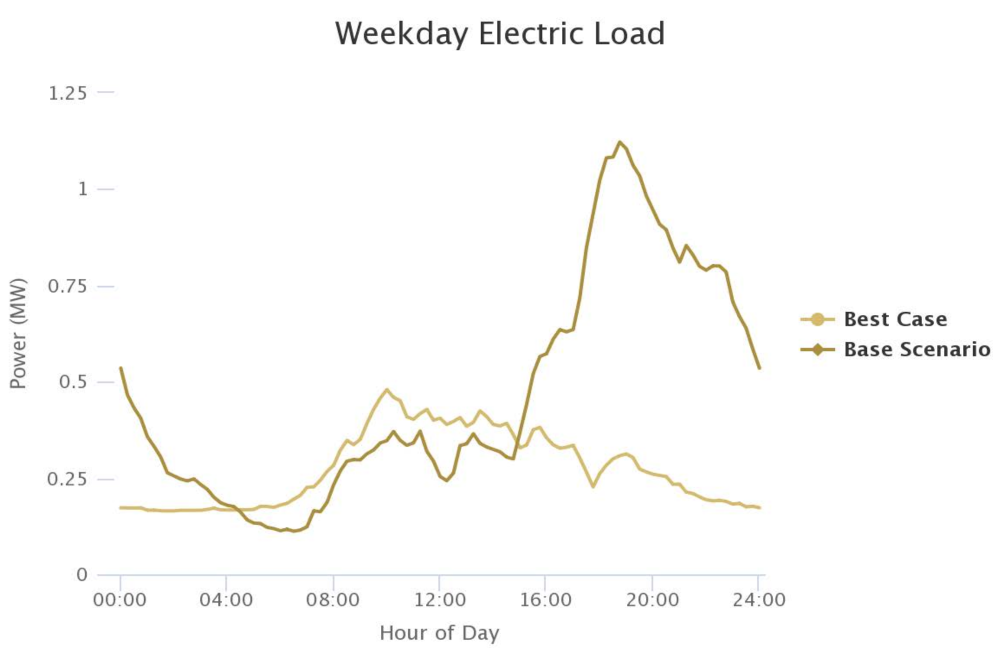
697 Public Level 2 Charging Plugs

There are currently 23 plugs with an average of 1.9 plugs per charging station per the Department of Energy's Alternative Fuels Data Center Station Locator.

89 Public DC Fast Charging Plugs

There are currently 15 plugs with an average of 3.8 plugs per charging station per the Department of Energy's Alternative Fuels Data Center Station Locator.

Grid resiliency and demand charges are also a concern when localities look to increase EV support. Presented is an analysis of the electrical power demand during the day to support 1,000 EVs in Charlottesville from the EVI-Pro Tool Load Profile tab. This chart demonstrates that with minimal public and workplace chargers, most of the EV owning population would plug in around 8:00 pm when returning home. This scenario demonstrates how planning can reduce stress on the grid. As outlined in this chart "best case scenario" the addition of public and workplace charger can help flatten the curve by allowing people to charge away from home during the day thus more evenly distributing charging time and alleviating electrical grid stress.

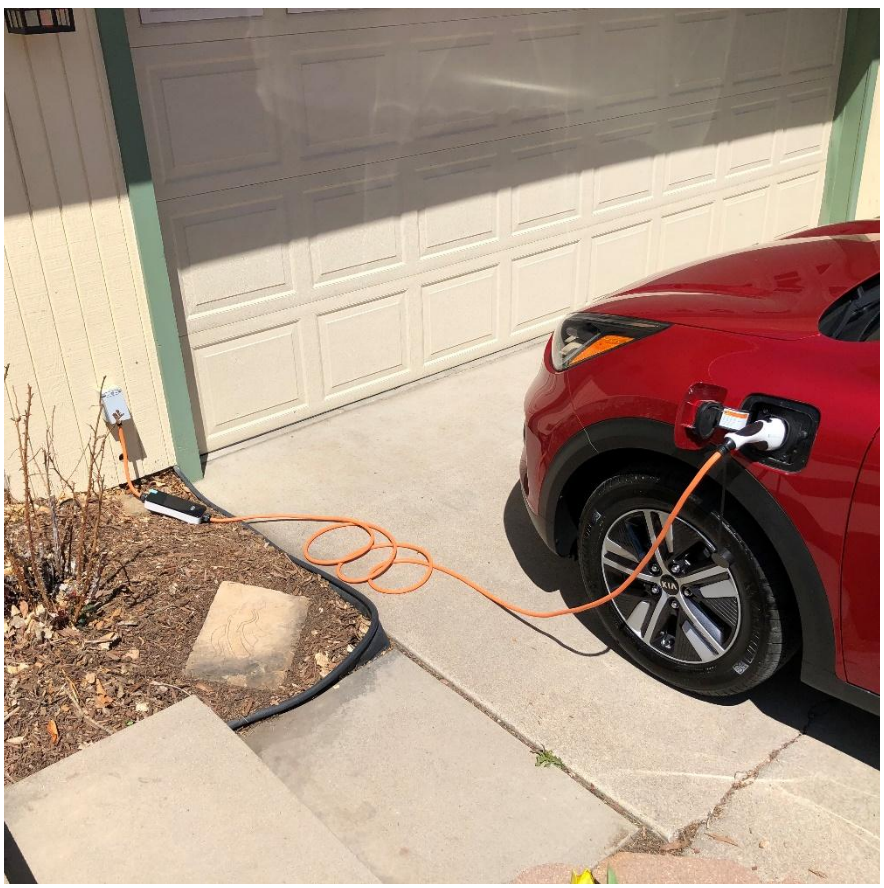


Charging Station Types Overview

There are three major charger types and their price, charging speeds, and usage varies. The three types, Level 1, Level 2, and DC Fast Charging (DCFC) charging capabilities are outlined below.

Charger Type	Alternating or Direct Current	Amperage	Voltage	Power	Range per Hour of Charging
Level 1	Alternating	12-16 Amps	120 Volts	1.3-1.9 kiloWatts	3-6miles
Level 2	Alternating	Up to 80 Amps	208-240 Volts	Up to 19.2 kiloWatts	80 miles
DC Fast Charging	Direct	Up to 200 Amps	208-600 Volts	50-350 kiloWatts	300+ miles

Level 1 Chargers: L1 chargers use an alternating current and are used primary for residential or workplace charging due to their long charge times. Nearly every EV comes with a traditional three-pronged plug for an outlet with a J1772 standard connector plug for insertion into the vehicle. Home ground fault interrupter outlets serve level 1 chargers.



Level 2 Chargers: L2 chargers also use an alternating current, but at a higher amperage and voltage, resulting in a decent improvement in charge time. L2 chargers can be used for residential and workplace charging but require a larger investment in infrastructure. Some L2 chargers can be plugged into 240-volt outlets like those used for dryers and other larger household appliances, but often L2 chargers have hard wired charging equipment. L2 chargers have become commonplace for public charging and also used a J1772 connector plug.

DC-fast charging (DCFC): DC fast chargers use a direct current allowing them to deliver a significant increase of amperage and voltage. DCFC operates on the North American CCS combo standard, and many offer the CHAdeMO or Tesla connections. DC chargers are able to charge 60 – 300 miles of range per 20 minutes, making it timely charging along heavy traffic corridors and heavy-duty fleet use.

While DCFC is the fastest charging option, it is also the most expensive and its high speeds are not necessary in every situation. DCFC can be great in instances such as along highway routes where quick top-ups are needed, but one of the great things about EV charging is that it can be done over longer periods of time at less expensive rates. Take for instance a charger in a movie theater parking lot, where we would expect the average customer to spend about three hours inside of the establishment. In this case, many vehicles could top up their battery using a high-powered Level 2 charger. A DCFC in this instance would be able to charge the car battery quicker, but with the customer inside enjoying their movie, they would not be able to move the vehicle for other drivers to charge, meaning that DCFC would be a less efficient option.

Charlottesville Community Profile

Commute Time (2013-2017)		
Worked from home	1,574	6.5%
Under 15 minutes	10,434	46.1%
15-24 minutes	8,035	35.5%
25-34 minutes	2,082	9.2%
35-44 minutes	702	3.1%
45-59 minutes	588	2.6%
Over 60 minutes	792	3.5%
Mean Travel Time to Work (minutes)		18

Data Provided by the Virginia Economic Development Partnership

Understanding your localities driving habits can aid in decisions such as charger placement and level of charger. For example, understanding average commute time will help demonstrate the driving range needed which will indicate what type of charging will be most effective. It is important to consider that in many cases public charging infrastructure is intended to support and extend EV range, not to fully charge every EV battery every day. Your average ICE vehicle owner doesn't top off their tank with gas at the end of every day and we do not expect EV owners to top off their battery every day either. Much of Charlottesville's commute is under 34 minutes. Charging even on level 1 could often be completed in 8 hours or 3 hours for level 2.

Charlottesville Community Profile

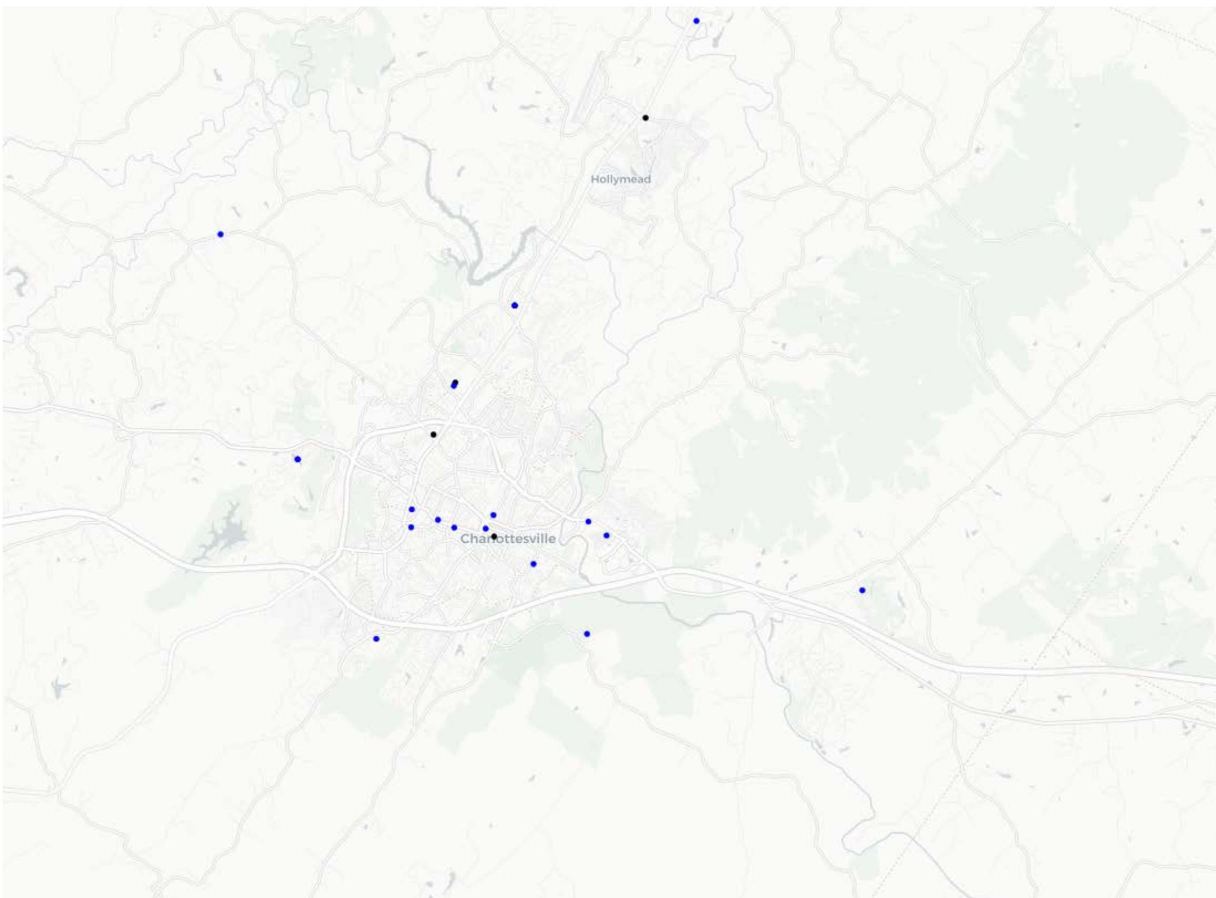
Employment by Sector* (4th Qtr. 2018)		
Agriculture Forestry Fishing and Hunting	N.D.	N.D.
Mining Quarrying and Oil and Gas Extraction	0	0
Utilities	N.D.	N.D.
Construction	1,815	4.4%
Manufacturing	951	2.3%
Wholesale Trade	691	1.7%
Retail Trade	3,426	8.4%
Transportation and Warehousing	231	0.6%
Information	1,216	3.0%
Finance and Insurance	1,560	3.8%
Real Estate and Rental and Leasing	535	1.3%
Professional Scientific and Technical Services	2,778	6.8%
Management of Companies and Enterprises	480	1.2%
Administrative and Support and Waste Management	2,591	6.3%
Educational Services	767	1.9%
Health Care and Social Assistance	3,326	8.1%
Arts Entertainment and Recreation	521	1.3%
Accommodation and Food Services	5,981	14.6%
Other Services	2,186	5.3%
Total Government	11,759	28.7%
Federal Government	405	1.0%
State Government	8,331	20.3%
Local Government	3,023	7.4%
Unclassified	91	0.2%
Total	41,020	100.0%

N.D. - Not Disclosed

Employment trends can also indicate where workplace chargers will have the greatest impact. For example, in Virginia in 2018 the "Total Government" employed 28.7% of the population making it a considerable sector for workplace EVSE deployment efforts. Large employment sectors with high visibility like government, retail, or accommodation and food services can also be excellent choices for EVSE deployment as they can serve as success stories and help demonstrate and gauge charging utilization. Retail site chargers can be used for employees and the public.

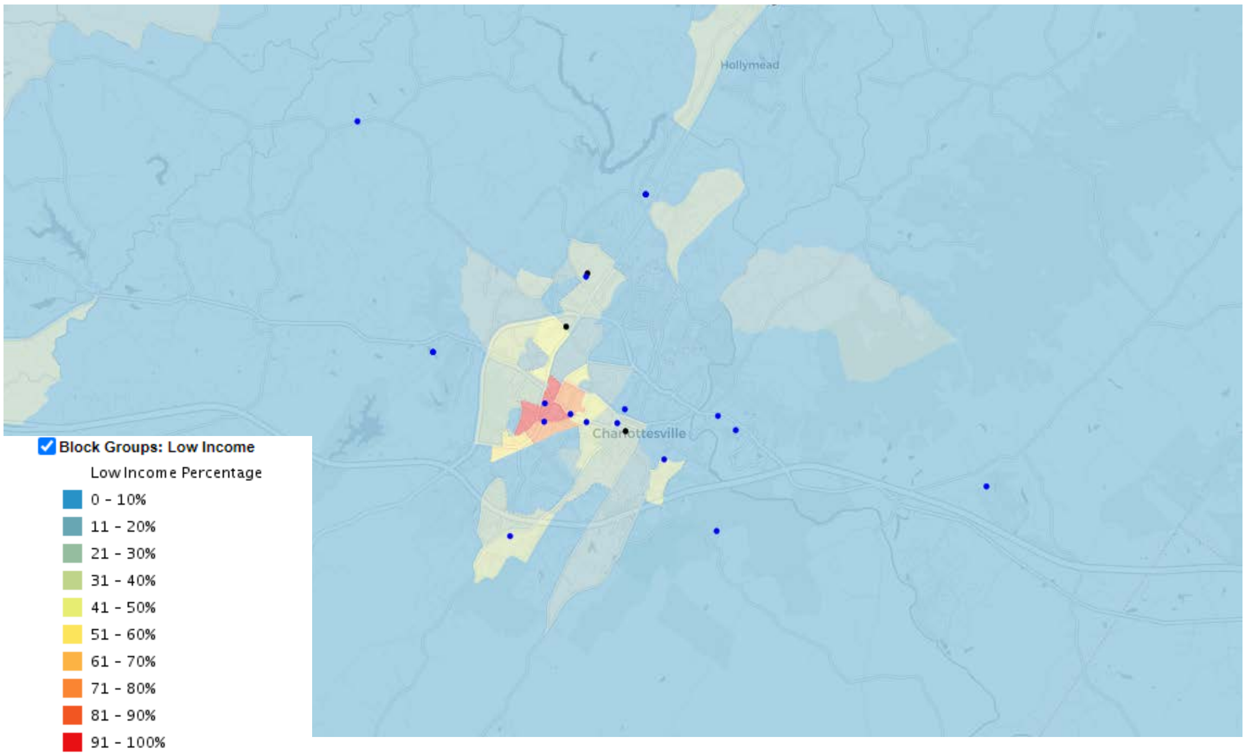
Resources for Equitable Charging Deployment

Below is the **Energy Zones Mapping Tool** produced by Argonne National Laboratory. In this image there is an EVSE overlay showing locations and types of electric vehicle charging stations in Charlottesville. EVSE data was collected from the Alternative Fuel Data Center Station Locator (https://afdc.energy.gov/stations/#/find/nearest). Black circles represent DC fast chargers and blue circles represent Level 2 chargers. Using this tool, you can see where current EVSE infrastructure efforts are and have been. An understanding of geographical EVSE trends in your area will better equip you when increasing EVSE accessibility.



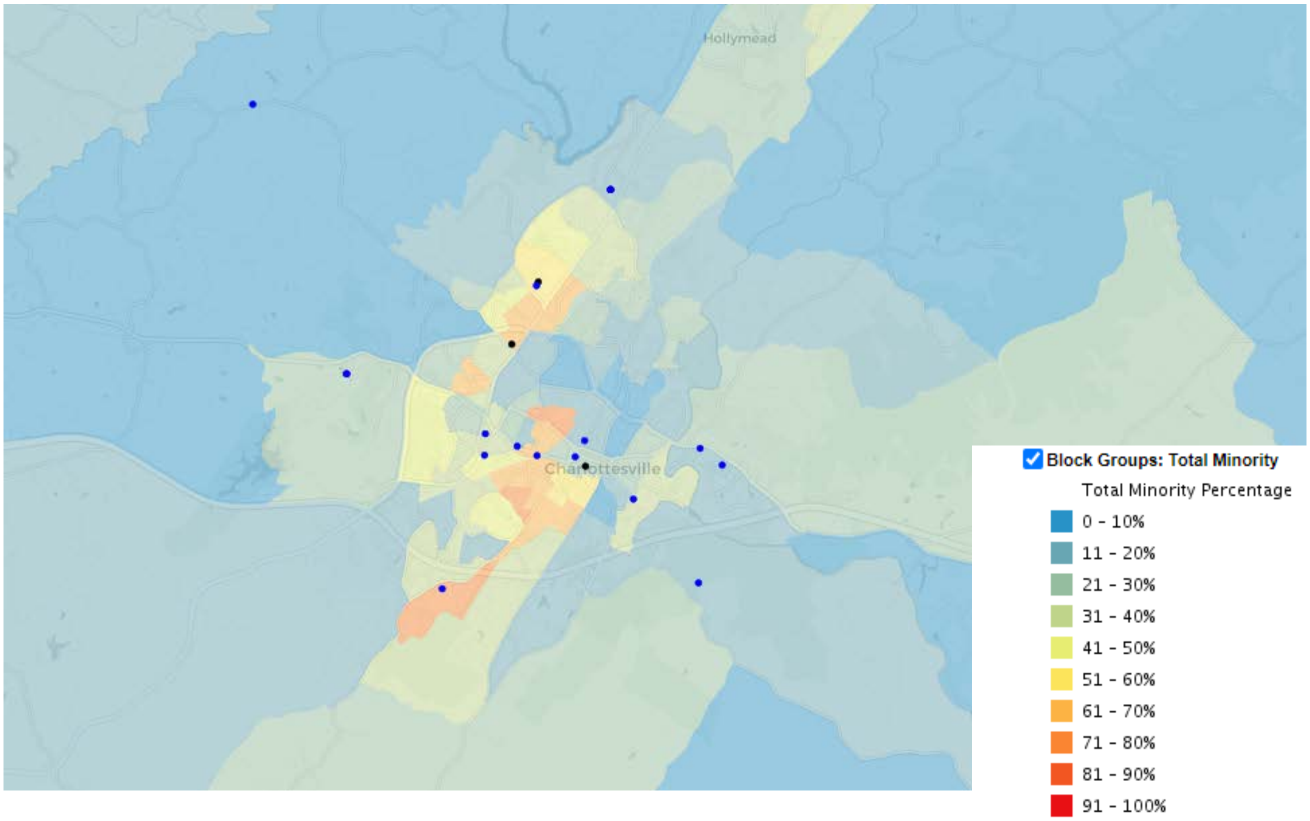
The following images provide a lens of how we can maximize equitable EV charging station deployment. By including low-income populations and communities of color in EVSE planning we ensure that our collective efforts of electrification do not leave anyone behind. Continued use of the EZMT will ensure equitable filtration of EVSE planning perspectives and lead to successful EV adoption.

EZMT with Low-Income and EVSE Overlay over Charlottesville



This map demonstrates the alignment of charging infrastructure and low-income communities. Similar to block groups with high percentages of minority populations, underserved areas often have limited access to charging. Low-income populations are disproportionately impacted by transportation costs which take up a large portion of their income. Electric vehicles with their comparatively low fuel costs averaging at $1 per gallon of gas equivalent can help offset their high transportation costs, but only if charging is accessible to all people.

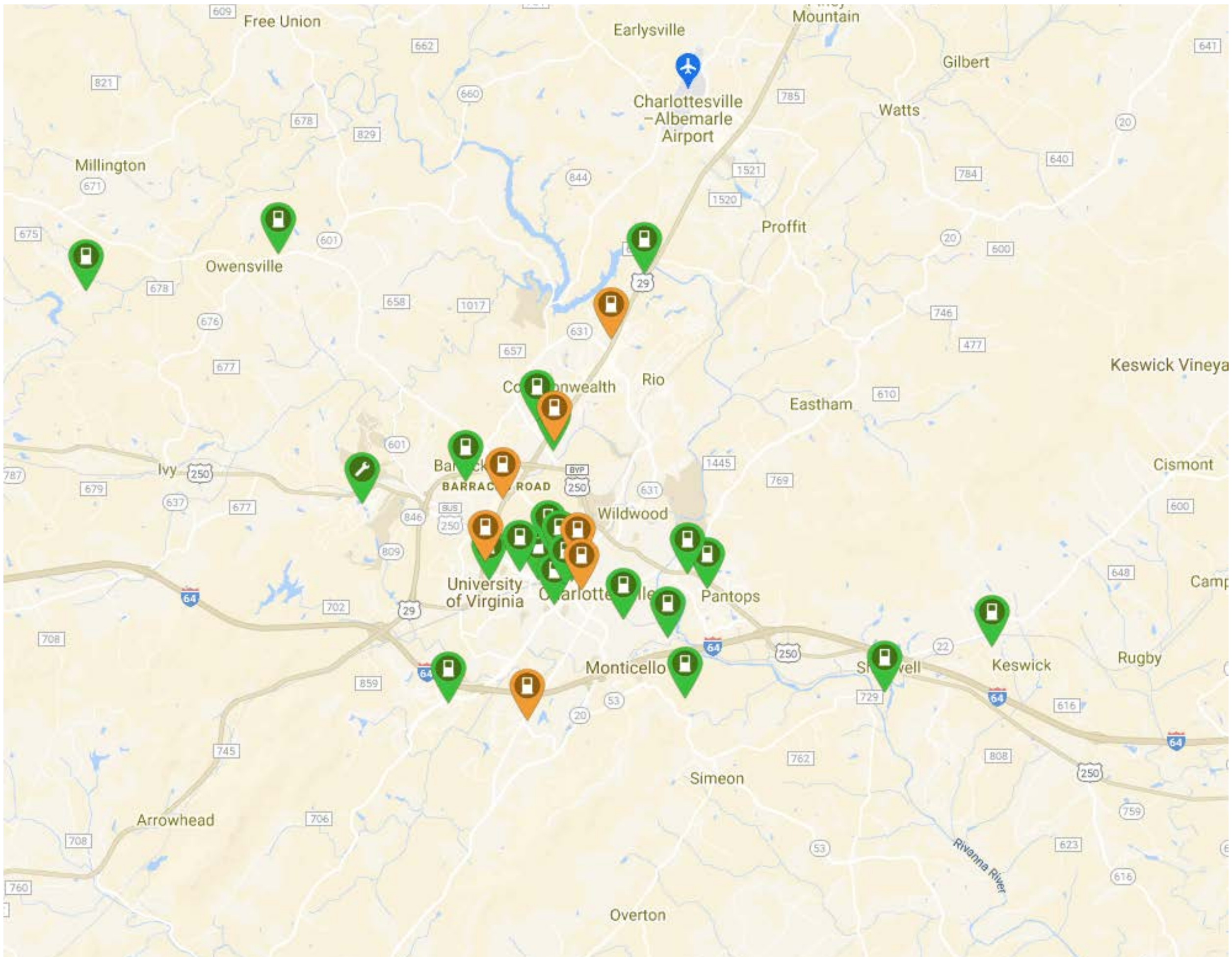
EZMT with Total Minority and EVSE Overlay over Charlottesville



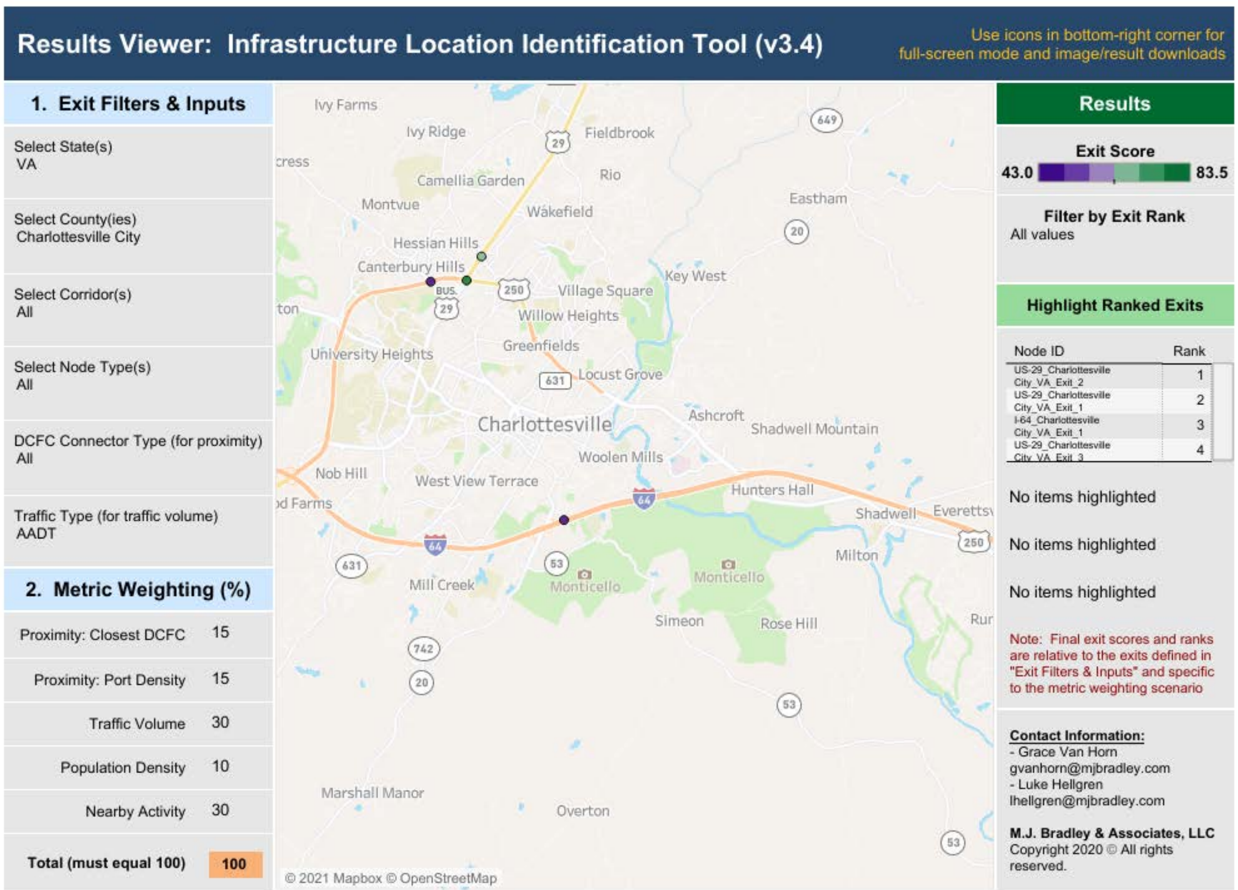
This map demonstrates where chargers are currently sited in relation to communities of color. Frequently, charging infrastructure has been sited in majority-white neighborhoods. When planning infrastructure for the future it is important to consider equitable distribution to ensure that charging will be accessible to all people.

Other Tools for EVSE Planning

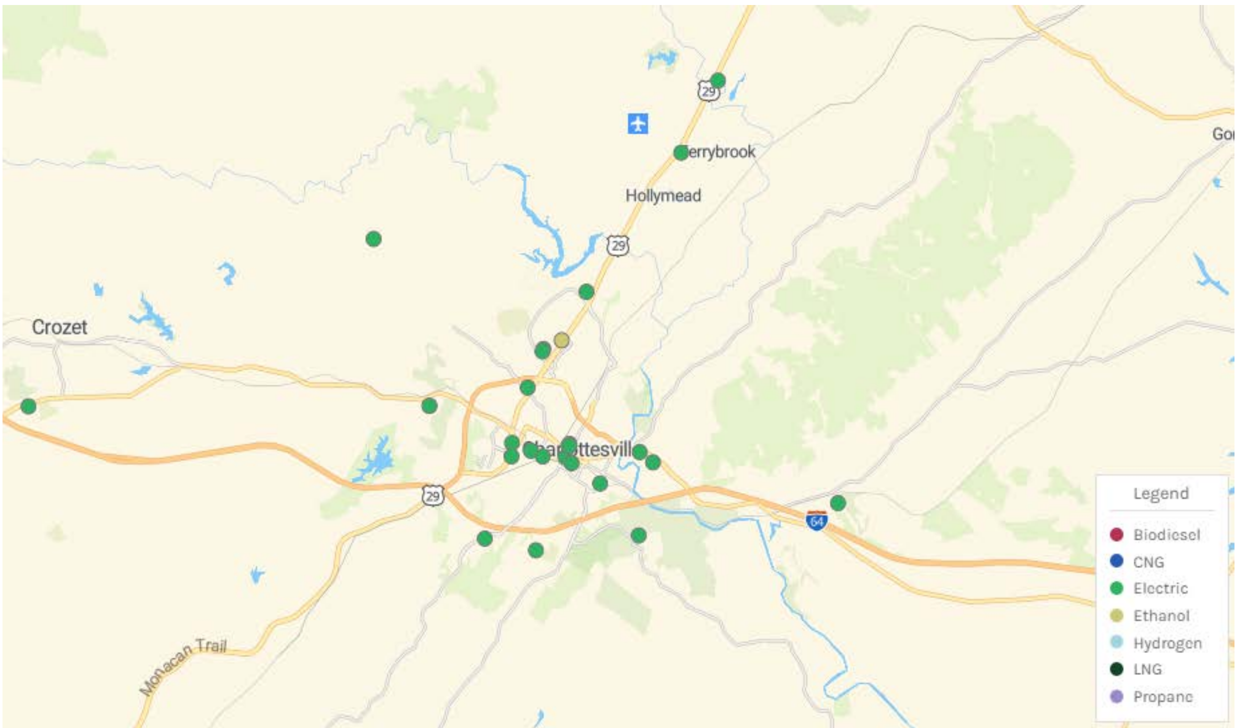
PlugShare is a very accessible charging station locator that allows users to see what stations are currently being used, under repair, and allows users to document chargers visually and share experiences. The app and site function like a social media platform where EV owners can plan trip routes, check-in at stations, give reviews, and share information about stations that are down or under repair. Below is the Charlottesville region using PlugShare. For more understanding and personal use of the program visit: https://www.plugshare.com/



MJ-Bradley Tool, example below**,** is designed to grade regional corridor exits on several categories ranging from DCFC proximity, DCFC port density, traffic volume, and population density. All points are corridor exits to measure a traveler's accessibility to charging stations. If the Exit Score is high and green, it is suggested that planning and EVSE infrastructure investment be prioritized in that area, relative to other exits within the region. For more understanding and personal use of the program visit: https://www.mjbradley.com/content/electric-vehicle-infrastructure-tools



The Alternative Fuel Station Locator is a resource created by National Renewable Energy Laboratory available on the Department of Energy's Alternative Fuel Data Center. This station locator allows users to find any alternative fueling location including, electric vehicles chargers. Furthermore, the locator has a 'Fuel Corridors' tab where users can plan trips along routes with pre-existing alternative fueling infrastructure. Complete station data can be downloaded using the tool. https://afdc.energy.gov/stations/#/find/nearest



If you want to learn more about how to use these tools check out our Virginia statewide report at vacleancities.org Formal Reports.

Resources:
EVI-Pro Tool Lite: https://afdc.energy.gov/evi-pro-lite
Alternative Fueling Station Locator: https://afdc.energy.gov/stations/#/find/nearest
PlugShare: https://www.plugshare.com/
MJ-Bradley Tool: https://www.mjbradley.com/content/electric-vehicle-infrastructure-tools
EZMT Energy Zone Mapping Tool: https://ezmt.anl.gov/
Virginia Economic Development Partnership: https://www.vedp.org/community-profiles

Images provided by National Renewable Energy Laboratory Public Access Images