City of Alexandria, Virginia

MEMORANDUM

DATE: FEBRUARY 28, 2022

TO: CHAIRMAN NATHAN MACEK
AND MEMBERS OF THE PLANNING COMMISSION

FROM: KARL W. MORITZ, DIRECTOR
DEPARTMENT OF PLANNING & ZONING

SUBJECT: DOCKET ITEM #4 -- SUP2021-00126 -- 3601 RICHMOND HIGHWAY

In response to Planning Commissioners' recent comments, staff would like to forward additional information regarding the request for a Special Use Permit to waive the sign requirements of Article IX of the Zoning Ordinance for the installation of digital text and graphic signage. During briefings with the Planning Commission this week, commissioners asked a number of questions related to the proposal which staff seeks to address as part of this Memorandum.

City's Electric Vehicle Charging Infrastructure Readiness Strategy –
Commissioner Brown requested that the City's Electric Vehicle Charging Infrastructure Readiness Strategy, which was endorsed by City Council in April 2021 and referenced by staff in the report for this docket item, be appended to the report as an additional material. Thus, staff has provided the aforementioned report as an attachment to this Memorandum.

Electric Vehicle Charging Equipment as an Accessory Use –
Commissioner Brown inquired as to the use definition and the process for approving the installation of Electric Vehicle Charging Stations at an existing site. With City Council's approval of Zoning Text Amendment #2021-00003 in September 2021, "Structures or mechanical equipment associated with electrical vehicle charging" were added to the Zoning Ordinance as permitted accessory buildings, uses and structures in Section 7-101(O).

Potential Impacts of Signage on Driver Attentiveness –
Vice Chair McMahon inquired if the signage had the potential to negatively impact driver distraction. City staff notes that driver distraction issues have not resulted at Volta EV charging stations with similar signage, also located near drive aisle and pedestrian crossing areas, in parking garages at the Potomac Yard Giant and the Bradlee Shopping Center Safeway. In addition, drivers are limited to slow speeds in the parking lot at Potomac Yard Shopping Center,

allowing for greater reaction times to pedestrian and vehicular traffic. Finally, driver distractions would be minimal as the changing advertisements shown on the signage do not rapidly change, are not animated and the signage does not resemble regulatory driving directives, such as stop or yield signs.

Future Considerations Regarding Digital Signage –
Vice Chair McMahon inquired if City staff anticipates reconsidering how digital signage is defined and evaluated at any point in the future, considering two were recently approved at Potomac Yard. Staff confirmed at the hearing for the Potomac Yard limited digital wayfinding signs that a comprehensive re-write of the City's sign requirements, Section IX of the Zoning Ordinance, is scheduled to be taken to public hearings in late 2022 or early 2023. As part of this process, the definition and requirements associated with digital signage will be reconsidered.

Staff continues to recommend approval of Special Use Permit #2021-00126.

Attachments:

1. Electric Vehicle Charging Infrastructure Readiness Strategy

ECO-CITY ALEXANDRIA

Electric Vehicle Charging Infrastructure Readiness Strategy

City of Alexandria, Virginia

May 2021

ACKNOWLEDGEMENTS

This report was made possible through the contributions of many dedicated individuals.

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REPORT DEVELOPMENT

This report was developed during 2020. In April 2020, due to COVD-19, City staff provided a pre-recorded presentation and opportunity for the Alexandria community to provide input and feedback. In July 2020, the City sought further community input via an online survey to evaluate charging needs and to help evaluate locations for publicly accessible chargers. This report builds on several prior initiatives in Alexandria, such as the Driving Alexandria Safely Home (DASH) zero emission bus project and the Environmental Action Plan 2040 goals.

Special thanks to participants of surveys and to those who provided detailed comments to the City. Please visit the City's website (www.alexandriava.gov) for questions or contact information.

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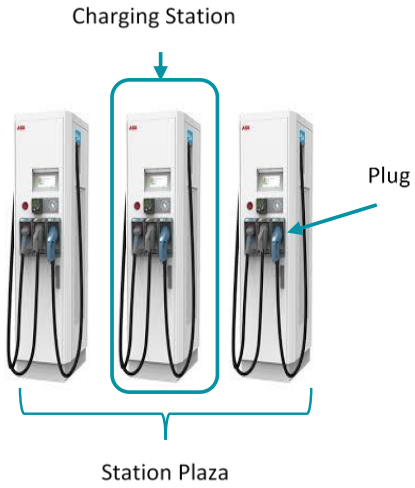
GLOSSARY

AC	Alternating current.
BEV	Battery electric vehicle. A vehicle powered exclusively by electricity, such as the Nissan LEAF.
CCS	Combined charging system. This is a direct current fast charging standard supported by Volkswagen, General Motors, BMW, Daimler, Ford, FCA, Tesla, and Hyundai.
CHAdeMO	This is a direct current fast charging standard developed in Japan, originally supported by Nissan, Mitsubishi, and Fuji Heavy Industries (which manufactures Subaru vehicles). Toyota later supported the standard as well, and Tesla sells an adapter allowing its vehicles to use CHAdeMO chargers.
Charging Infrastructure	Above- and below-ground equipment and wiring that supports charging vehicles. In this document, charging infrastructure refers to both the charging station and to any utility or customer make-ready equipment needed for the station.
Connector	The component of a charging station that connects with the vehicle and provides electricity. Connector is sometimes used interchangeably with the terms charge point or port. This document uses the term plug. See Figure 1 below.
DCFC	Direct current fast charging (DCFC) equipment. DCFCs are sometimes called DC Level 3 (typically 208/480V AC three-phase input) and enable rapid charging of an electric vehicle.
Decarbonize	The process of planning and implementing strategies to reduce carbon dioxide emissions within a jurisdiction.
EAP	Environmental Action Plan.
Electrification	The switching of processes typically powered by a fossil fuel source (gasoline, diesel, or any other derivative of oil) to electricity.
EV	Electric vehicle. A vehicle powered, at least in part, by electricity. Unless otherwise noted, the term EV in this report refers to all plug-in vehicles and includes BEVs and plug-in hybrid electric vehicles (PHEVs, defined below). The term EV is synonymous with plug-in electric vehicle (PEV, defined below).
EVI-Pro Lite	Analytical platform developed by the National Renewable Energy Laboratory used to estimate the number of chargers needed for a given electric vehicle population in jurisdictions across the country. Available at: https://afdc.energy.gov/evi-pro-lite.
EVRS	Electric Vehicle Charging Infrastructure Readiness Strategy for the City of Alexandria.

EVSP	Electric vehicle service provider. An EVSP provides the connectivity across a network of charging stations. Connecting to a central server, they manage the software, database, and communication interfaces that enable operation of the station.
GHG	Greenhouse gas. GHGs are gases that trap heat in the atmosphere, such as carbon dioxide, methane, and nitrous oxide.
GTSA	Grid Transformation and Security Act.
ICEV	Internal combustion engine vehicle. A vehicle that combusts fuel, such as gasoline or diesel, for power.
LCFS	Low Carbon Fuel Standard.
Level 1 Station	AC Level 1 station (often referred to simply as Level 1). Provides charging through a 120V AC port.
Level 2 Station	AC Level 2 station. Offers charging through 208 V (typical in commercial applications) to 240 V (typical in residential applications) electrical service.
Level 3 Station	See DCFC.
LMI	Low- to moderate-income.
Make-ready	Work or costs associated with connecting a charging station to the electricity grid.
MFD	Multifamily dwelling. Also called multi-unit dwellings, these are apartments, condominiums, and group quarters. The other major housing category used in this report is single-family homes.
Micromobility	A small, manually, or electrically powered vehicles used to travel short distances. Examples include bicycles, e-bicycles, scooters, e-scooters, one-wheels, and skateboards.
MWCOG	Metropolitan Washington Council of Governments.
Opportunity Charging	Charging an electric vehicle when a good opportunity arises (e.g., for 30 minutes at the grocery store when purchasing food), rather at a dedicated time and place each day (e.g., at home at night).
PHEV	Plug-in hybrid electric vehicle. A vehicle powered by electricity or an internal combustion engine.

Figure 1. Station, Plug, and Station Plaza



Plug	The component of a station that connects with the vehicle and provides electricity. Plug is sometimes used interchangeably with the terms connector, charge point, or port. This document uses the term plug. See Figure 1.
Port	The component of a station that connects with the vehicle and provides electricity. Port is sometimes used interchangeably with the terms connector or plug. This document uses the term plug. See Figure 1.
Public	Publicly accessible.
ROW	Right-of-way.
SCC	State Corporation Commission. Virginia regulatory agency whose authority encompasses utilities, insurance, state-chartered financial institutions, securities, retail franchising, and railroads.
Shared Mobility	The shared use of any form of transportation—bicycle, scooter, motorcycle, ICEV, or electric vehicle—in a way that reduces the need for personal ownership of these vehicles and devices.
Station	A stand-alone piece of equipment capable of charging a vehicle. Station is sometimes used interchangeably with the terms charger, pedestal, machine, EVSE, or dispenser. See Figure 1.
Station Plaza	A set of one or more stations at a single location operated by the same electric vehicle service provider. See Figure 1.
TMP	Transportation management plan.
US DOE	United States Department of Energy.
VCEA	Virginia Clean Economy Act. Legislation designed to reduce the Commonwealth's greenhouse emissions to zero by 2050.
Well-to-wheels	A complete vehicle fuel-cycle analysis that includes the emissions associated with fuel mining, transport, and production (well-to-tank), as well as vehicle operation (tank-to-wheels).
ZEV	Zero emission vehicle.

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EXECUTIVE SUMMARY

The Alexandria Electric Vehicle Charging Infrastructure Readiness Strategy (EVRS) provides a framework for advancing electric vehicle charging infrastructure in the City of Alexandria, Virginia. The intended audience for the EVRS is government staff and electric vehicle stakeholders in the broader community. Content is based on the latest literature, expert input, two public engagement surveys, and a spatial analysis. The EVRS culminates in 31 recommendations for the City, described below.

Motivation

In 2019, electric vehicles accounted for approximately 5% of new passenger vehicles sales in Alexandria compared to about 2% nationally. Among all registered passenger vehicles, Alexandria has about 500 electric vehicles. Although these numbers are modest today, Alexandria's electric vehicle population is growing quickly. In the long term, electric vehicles are an important element of the City's efforts to mitigate the impacts of climate change and reduce greenhouse gas emissions by 80% to 100% by 2050 (City of Alexandria, 2019). Driving an electric vehicle powered by Alexandria's grid produces the equivalent greenhouse gas emissions on a lifecycle basis as driving a car that gets 85 miles per gallon (UCS, 2020). As the electricity supply shifts toward greater renewable and clean energy electricity sources, electric vehicles will further lower greenhouse gas emissions relative to gasoline vehicles. Electric vehicles lack tailpipe emissions and therefore improve local air quality. As such, they provide a significant public health benefit, particularly among populations vulnerable to poor health outcomes resulting from poor air quality.

Most automakers are investing heavily in transportation electrification and are releasing a diverse set of electric models in the next few years. The EVRS framework will help City staff prepare for this transition by anticipating charging needs and galvanizing stakeholders toward a unified vision of the future. The EVRS provides a framework of current initiatives, technologies, and public perceptions related to electric vehicle charging in Alexandria, as well as a set of recommendations to build a thriving electric vehicle ecosystem in the city over the long term.

FUNDAMENTALS OF CHARGING INFRASTRUCTURE

Charging infrastructure includes the equipment used to charge electric vehicles as well as the wiring, conduits, substations, and transformers needed to provide electricity supply to the charger ("make-ready infrastructure"). Electric vehicle charging stations are typically categorized by charger location and power level. The broadest categories of charger locations include residential, workplace, and publicly accessible. Three power levels include Level 1 (rated up to 7.7 kW), Level 2 (rated up to 22 kW), and direct current fast charging (DCFC) stations (rated at 50 kW or higher). The higher the power level, the faster the charge but also the higher the cost of installation and operation. To reduce system cost, best practice is to match the charging power to the specific dwell time of a parking location (e.g., slower chargers can be used for parking spots with longer dwell times). See Chapter 2 for more foundational information about electric vehicles and charging infrastructure.

Recommendations

The EVRS is built around a set of 31 recommendations—including potential near- and long-term actions—that could result in a more effective increase of electric vehicle charging infrastructure. See Chapter 1 for details on each recommendation. The recommendations address six key areas:

A. **Meeting Charging Demand.** Actions that remove charging availability as a barrier for segments of the population like vehicle owners without private parking.
B. **Enhancing Communications and Awareness.** Actions that inform and build capacity among the general population.
C. **Strengthening Zoning, Building Codes, and Permitting.** Actions that remove barriers to installing new charging infrastructure.
D. **Advocating in State Government or with Dominion Energy.** Actions for which City staff can advocate at the state level or with Dominion Energy that will strengthen the region's electric vehicle ecosystem.
E. **Building Successful Business Models for Chargers.** Actions that improve the business case for publicly accessible charging stations.
F. **Implementing the Recommendations.** Actions aimed at advancing the implementation of the Recommendations above.

Table 1 shows specific recommendations by area.

Table 1. Summary of Recommendations for Alexandria

Meeting Charging Demand	
A-1	Promote parking synergies for residents of multifamily dwellings
A-2	Consider right-of-way charging opportunities for residents lacking off-street parking
A-3	Serve as a clearinghouse of potential charging locations.
A-4	Create shared mobility hubs
A-5	Promote charging locations at grocery stores, parks, and retail stores
A-6	Promote DCFC stations near highway off-ramps
Enhancing Communications and Awareness	
B-1	Establish near- and medium-term targets for publicly accessible electric vehicle charging infrastructure
B-2	Establish a process to benchmark progress
B-3	Demonstrate community leadership
B-4	Champion charging infrastructure by electrifying the city fleet, as outlined in the EAP for 2040
B-5	Build and maintain internal competencies
B-6	Promote Alexandria as an Electric Vehicle Capital City
B-7	Utilize innovative pilot programs
Strengthening Zoning, Codes, and Permitting	
C-1	Amend zoning ordinance to include charging stations as a permitted accessory use
C-2	Establish electric vehicle installation checklist
C-3	Encourage electric vehicle charging in parking space requirements
C-4	Adopt curbside management policies to prioritize electric vehicle charging
C-5	Revise standard conditions to increase minimum requirements

C-6	Adopt design criteria related to electric vehicle charging stations
C-7	Consider appropriate standards for historic districts
C-8	Train local officials
C-9	Allow developers to use a transportation management plan (TMP) fund for electric vehicle infra.
Advocacy in State Government and with Dominion Energy	
D-1	Advocate for opportunities that accelerate charging station deployment
D-2	Advocate for opportunities that accelerate electric vehicle adoption
D-3	Advocate for continued, equitable decarbonization of electricity supply
Building Successful Business Models for Chargers	
E-1	Coordinate between parties interested in new charging stations
E-2	Develop dealership programs for offering chargers
E-3	Consider City investment to support publicly accessible charging
E-4	Develop City-owned charging stations as a last resort
Implementing the Recommendations	
F-1	Establish Inter-Departmental Implementation Working Group
F-2	Appoint an Electric Vehicle Navigator

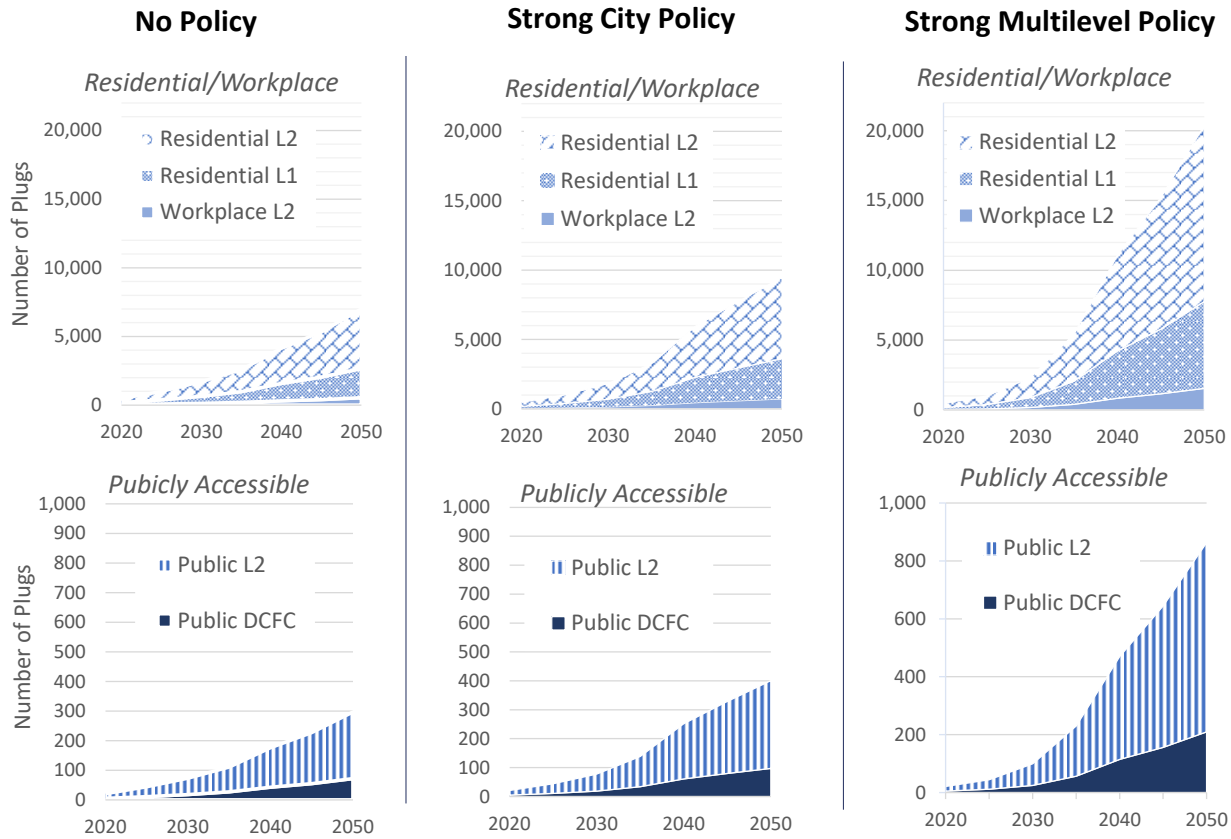
Charger Projections

A key question for City planners is *How many chargers are needed in the future to support expected electric vehicle populations?* Chapter 4 uses three scenarios of future vehicle population to address this question. These scenarios are not meant to provide a forecast but rather to understand plausible future vehicle adoption rates and associated infrastructure needs. The three scenarios are:

- **No Policy Scenario** – Electric vehicle adoption continues to grow at similar rates as the years 2015 to 2020 and reaches approximately 30% of new vehicle sales by 2050.
- **Strong City Policy Scenario** – Describes a future in which the City enacts many local policies that bolster electric vehicle sales and increase charging availability, but state and federal action is limited. In this scenario, electric vehicle sales reach approximately 70% of new electric vehicle sales by 2050.
- **Strong Multilevel Policy** Scenario – All levels of government are working together on aggressive transportation electrification policies. In this scenario, electric vehicle sales reach 100% of new vehicle sales by 2050. The three scenarios are consistent with the range sales scenarios in other energy-climate modeling that estimates future electric vehicle adoption (e.g., Williams et al., 2012; USDDPP, 2016).

Figure 2 shows the estimated number of charging plugs needed in Alexandria across the three scenarios. These charger projections are based on the National Renewable Energy Laboratory's Electric Vehicle Infrastructure Projection Tool (US DOE, 2020).

Figure 2. Future Charging Needed in Alexandria in Three Scenarios



Note: The top row of graphs shows number of residential and workplace plugs. The bottom row of graphs shows number of public plugs. Appendix E includes numerical values in graph.

The top three graphs show the estimated number of residential (including single-family and multifamily dwellings) and workplace plugs needed across the three scenarios. The bottom three graphs show the number of publicly accessible L2 and DCFC plugs needed. The anticipated number of residential chargers is expected to reach hundreds or even thousands in the next 10 years, even in the least-aggressive scenario. This is driven by the fact that most electric vehicle owners today prefer to charge at home at night-time.

Yet, in the long term the need for publicly accessible chargers will become more important as electric vehicle ownership will shift towards greater shares of "garage orphans" and visitors who do not have access or have availability to charge at their home or visitors. In the most aggressive case – Strong Multilevel Policy – as many as 100 publicly accessible chargers will be required by 2030 and over 800 by 2050. Note, these figures assume the number of vehicles owned and the vehicle miles traveled in Alexandria are the same in the future as today. Also, the Alexandria Mobility Plan and EAP 2040 promote reduction in vehicle mode share over time, which could reduce electric vehicle charging demand (City of Alexandria, 2019).

Importance of Equity

The EVRS framework works to reflect the City's ALL Alexandria commitments – see Resolution 2794 – throughout its analysis and recommendations, including ensuring that race and social equity is incorporated in all planning; recommending implementation considerations and the sustainment of structures and systems to advance race and social equity; finding alignments and recommending implementation of policies designed to advance race and social equity goals; and ensuring accountability mechanisms related to the progression and transparency of work to advance race and social equity.

Organization of Content

Table 2 summarizes the organization of this document by chapter and appendices. This document was made possible by funding from the City of Alexandria.

Table 2. Report Roadmap

Ch.	Title	Description
1	Recommendations for Alexandria	Provides prioritized list of actions to strengthen the City's charging infrastructure in the future.
2	Context and History	Describes electric vehicle initiatives undertaken in the region and compares electric vehicle deployment in Alexandria to that of other jurisdictions.
3	Basics of Electric Vehicle Charging	Provides introductory information about electric vehicles, chargers, and siting of chargers.
4	Current and Future Charging Needs	Describes three scenarios to bound potential charging needs in Alexandria between today and 2050.
5	Community Perspectives on Charging	Summarizes two public engagement surveys conducted during 2020 with electric vehicle stakeholders in Alexandria.
6	Priority Charging Locations	Identifies high-priority areas and sites for future charging locations in Alexandria.
Appendices	Appendix A	Gives detailed questions and responses to the public engagement Survey #1 launched in May 2020.
	Appendix B	Gives detailed questions and responses to the public engagement Survey #2 launched in July 2020.
	Appendix C	Provides the number of registered electric vehicles in Alexandria by model type, as of 2020.
	Appendix D	Describes the methodology and analysis of the costs of chargers needed in three future scenarios.
	Appendix E	Gives the numeric values of charging plugs needed across three future scenarios.
	Appendix F	Gives specific addresses of high-priority locations for chargers in Alexandria.

Limitations and Opportunities for Future Consideration

The pace of electric vehicle adoption is accelerating by way of increasing vehicle availability, decreasing costs, and normalizing of the technology. This rapid pace creates new opportunities for the City to

support the adoption of electric vehicles through promoting, coordinating, leading, and advocating for policies and programs to advance electric vehicle charging infrastructure is also rapidly advancing. Many cities, communities, and states are in the process of developing similar strategies and implementing programs to pursue and identify best practices. As such, there is still much to be learned, and the body of evidence supporting best practices, policies, and programs continues to emerge and evolve. This EVRS is based on information available at the time of its development and current factors such as the following:

- The adoption rate of electric vehicles and the existing and potential demand for electric vehicle charging infrastructure needs in Alexandria
- The City's existing policies, practices, and plans
- The status of electric vehicle policies at the regional, state (Commonwealth of Virginia), and federal levels
- The resources and evidence underlying best practices, policies, and programs available to cities to advance electric vehicle adoption and support related charging infrastructure
- An evolving electric vehicle and charging infrastructure industry and marketplace with numerous actors (such as battery and car manufacturers, automobile dealers, charging infrastructure companies, utilities, etc.), as well as evolving technology advancements, business models, building and electric codes—all within an overall trend of a disruptive technology environment advancing multimodal transportation, alternative mobility options, and enhanced bikeability and walkability.

While supporting the adoption of electric vehicles in Alexandria includes more than just charging infrastructure, the EAP 2040 adoption process and the development of this EVRS made it clear that supporting charging infrastructure needs is the most effective means for the City to support electric vehicle adoption in Alexandria (City of Alexandria, 2019). While the City should continue to advocate for the benefits of electric vehicle adoption, it does not see great value in playing a role in individuals' and businesses' purchase decisions for electric vehicles. Yet, the City can indirectly support purchase decisions by supporting policies and programs that make electric vehicle charging infrastructure available and accessible.

The following are notes regarding limitations of the EVRS:

- Many of the recommendations provided in Chapter 1 do not have a robust literature or set of examples to understand the full range of implications. Rather, the recommendations are based on the best available literature and examples, as well as thoughtful consideration by the City staff.
- The modeling conducted in Chapter 4 of future electric vehicle adoption; number of charging stations; electrical energy use and demand; and costs by individuals, businesses, utilities, private charging companies, and potentially the City are for informational purposes only. The modeling results provide information on *possible* future scenarios of charging infrastructure needs and how the City can support more widespread adoption of electric vehicles and electric vehicle charging infrastructure given implementation of various policies and programs at the local,

state, and federal levels. The modeling completed for this EVRS is based on a relatively small current electric vehicle population and uses the best techniques currently available to provide the City with as much useful information as possible for future planning and policy decision-making.

- As more robust and expansive policies and programs emerge and advance supporting adoption of electric vehicles and electric vehicle charging infrastructure, there will be need to reevaluate, refine, or pivot many of the recommendations in this EVRS.
- This EVRS is not intended as a standalone planning document for electric vehicle charging infrastructure needs, planning efforts, policy and program development, etc. Instead, this document should be used to help inform other relevant planning, policy, and programmatic efforts, including the Alexandria Mobility Plan, small area planning and relevant comprehensive plans, development planning and review, zoning, parks and open space planning, affordable housing plans, economic development plans, EAP 2040 implementation, Energy and Climate Change Action Plan development and implementation, the City's Capital Improvement Program, and the City's annual budget process (City of Alexandria, 2019).

As the City considers recommendations in this EVRS, and as the electric vehicle and electric vehicle charging infrastructure industry evolves, trends that may be useful for the City to consider or necessary for future study or evaluation include the following:

- **Vehicle-to-Building and Vehicle-to-Grid Technologies Opportunities.** As electric vehicles emerge as opportunities to support building electric system and electric grid interactivity for cost savings, electric reliability and resilience, and energy system transition, pursuing better understanding of the opportunities and benefits of these technologies and capabilities for the City and the Alexandria community.
- **Freight, Delivery Vehicles, Emergency Vehicles.** As electric vehicle technologies expand to various transportation segments, including freight hauling, delivery vehicles, and emergency vehicles, additional consideration may be needed to support such transportation needs. As these transportation segments have unique and individual use cases and needs, special infrastructure needs will likely need to be taken into consideration.
- **Utility Business Models and Rates.** The utility business model is evolving with the disruption of renewable energy, interactive communications technologies, storage technologies, emerging market constructs, and ways to incentivize more productive and efficient use of electrical grid assets and systems. As such, utility business models and rates to support electric vehicles and electric vehicle charging infrastructure will be critical to follow, understand, and advocate for best practices to provide balanced and prudent investments, reasonable and appropriate allocation of costs, and necessary incentives and benefits to customers and the utility alike.

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CHAPTER 1. RECOMMENDATIONS FOR ALEXANDRIA

This chapter presents a set of recommendations that address future charging needs in Alexandria. Subsequent chapters provide context, history, modeling, survey results, and resources relevant to these recommendations. Implementing recommendations in Chapter 1 requires City leadership but leverages expertise and investment from a wide set of stakeholders, including dealerships, homeowner associations, Dominion Energy, electric vehicle service providers, ridesharing firms, taxi companies, small businesses, private citizens, and others. Many recommendations include a short description of equity considerations, as discussed in the box below.

The recommendations in Chapter 1 address six key areas:

A. **MEETING CHARGING DEMAND**

B. **ENHANCING COMMUNICATIONS AND AWARENESS**

C. **STRENGTHENING ZONING, BUILDING CODES, AND PERMITTING**

D. **ADVOCATING IN STATE GOVERNMENT OR WITH DOMINION ENERGY**

E. **BUILDING SUCCESSFUL BUSINESS MODELS FOR CHARGERS**

F. **IMPLEMENTING THE RECOMMENDATIONS**

EQUITY SOLUTIONS

The icon to the left is used to indicate opportunities for supporting equity opportunities in programming, policies, and planning. The Urban Sustainability Director's Network provides a guide for incorporating equity into municipal clean energy, sustainability, and climate action programs (see here). Many of the equity solutions align with the Greenlining Institute's Electric Vehicles for All: An Equity ToolKit. Also, the Greenlining Institute launched the Toward Equitable Electric Mobility (TEEM) Community of Practice in Virginia to expand equity opportunities into transition to electric transportation, which will provide additional opportunities for including equity into recommendations.

All recommendations are based on best practices observed in other communities within the United States and abroad.[1] However, the electric vehicle industry is rapidly evolving in terms of technologies, costs, public awareness, and business models. Best practices are still emerging and municipal

[1] Additionally, adopting the majority of recommendations in Chapter 1 would align with the two most aggressive scenarios developed in Chapter 4: Strong City Policy Scenario and Strong Multilevel Policy Scenario.

governments deploy new, creative solutions. Given this relatively high level of uncertainty about program effectiveness, the recommendations are not ranked or prioritized. The City should revisit and potentially revise these recommendations every three to five years.

Meeting Charging Demand

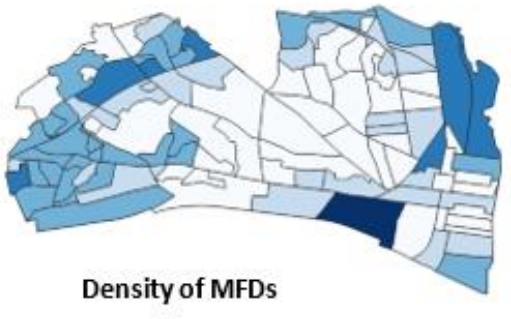
Recommendations in this section address three charging use cases: (1) residents in multifamily dwellings, (2) residents without driveways or garages, and (3) visitors, residents, and fleets requiring opportunity charging.

Residents of Multifamily Dwellings

Approximately 50% of residents in Alexandria live in multifamily dwellings (Census, 2020). The core challenge with installing charging at these buildings, is that tenants often do not own the space or must seek approval from their board or building management to install electricity outlet/charging stations. Additionally, many parking spaces do not have adequate wiring in place to add a charging station. At the time of this writing, only seven multifamily dwellings in Alexandria have parking lots or garages with plug access (with a total of 22 plugs). The recommendations below are aimed at overcoming these barriers.

RECOMMENDATION A-1. PROMOTE PARKING SYNERGIES FOR RESIDENTS OF MULTIFAMILY DWELLINGS.

Figure 3. Density of Multifamily Dwellings in Alexandria



Research from ICCT (2019) estimates that 52% to 81% of electric vehicle early adopters in multifamily dwellings rely solely on public and workplace chargers. To address this need, the City could promote and support coordination of synergies with owners of nonresidential parking lots (e.g., public and Washington Metropolitan Area Transit Authority Metro parking lots, places of worship, workplaces, retail locations, municipal garages) to install publicly accessible charging. These lots can serve both customers and employees during the day and, when otherwise empty at night, these lots could offer publicly accessible charging opportunities for residents or others in need of charging capabilities. Figure 3 shows the density of multifamily dwellings in Alexandria, by block group. Places of worship, workplaces, or retail locations may consider partnering or contracting with an EVSP to support charging infrastructure installation. Alternatively, for those business or organizations that qualify to use Alexandria's Commercial Property Assessed Clean Energy (C-PACE) program to leverage third-party financing to support installation of electric vehicle charging infrastructure, or any applicable incentive programs through Dominion Energy that may be available.

The Electric Vehicle Navigator can perform this coordination role (see recommendation F-2). The Urban Sustainability Director's Network's (USDN's) *Electric Vehicle Charging Access for Renters: A Guide to*

Questions, Strategies, and Possible Next Steps (2020) provides further guidance on potential opportunities to promote such synergies for offering publicly accessible and workplace charging opportunities (USDN, 2020).

EQUITY SOLUTION

The extent to which this recommendation is equitable will largely depend on the availability of charger locations and their proximity to underserved communities. The City should focus these synergistic charging locations in neighborhoods with larger numbers of underserved residents. Chapter 6 provides maps of areas which may qualify for specific focus.

Residents without Driveways or Garages

Recommendations in this section address charging use cases for residents without driveways or garages. This use case is relatively common in Alexandria, due in large part to the historic nature of many homes or the development trends at time of construction. To charge a vehicle overnight, these residents may require access to nearby, publicly accessible charging in locations such as the public right-of-way, surface lots, or in garages.

RECOMMENDATION A-2. CONSIDER RIGHT-OF-WAY CHARGING OPPORTUNITIES FOR RESIDENTS LACKING OFF-STREET PARKING.

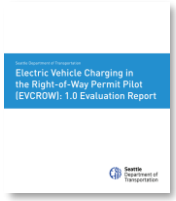
The City could facilitate installation of charging in the public right-of-way along public streets. Charging maps in Chapter 6 and high-priority locations identified in Appendix F could be used to prioritize locations for right-of-way charging stations. The City should anticipate public resistance stemming from the following concerns: (1) potential reduction of the inventory of available parking spaces, (2) business fears that spaces designated for electric vehicles will result in a decline in sales, (3) concerns about safety hazards from tripping, fire, or electrocution, and (4) aesthetic requirements, especially in the Old and Historic Alexandria District areas. The curbside prioritization recommendations that will be provided in the 2021 Alexandria Mobility Plan, further described in Recommendation C-4, may help address these community concerns.

A few cities in the United States operate right-of-way charging programs, including Berkeley, Los Angeles, New York City, Seattle, Sacramento, and Montgomery County, MD. For example, Los Angeles implements a well-known lamppost/parking meter-connected program with Level 1 or Level 2 chargers. City reports state that lamppost chargers work well for locations in which inefficient light bulbs were replaced with efficient light bulbs (so there is now excess electrical capacity). Consideration should also be given to right-of-way DCFCs similar to the City of Sacramento (who successfully partnered with EVgo to install a plaza of DCFCs in a city park that provide charging solutions to nearby residents). While the City has received several inquiries about establishing programs to standardize and permit residents to use extension cords from a household to an electric vehicle parked along a roadway, similar to programs offered by the City of Seattle, the City prioritizes implementing programs to install charging stations in the right-of-way instead. The City believes that providing standard right-of-way chargers would provide

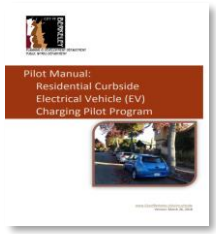
more value and be more reliable than establishing a means to permit and inspect electric cords crossing sidewalks or other public ways to ensure safety, equitable access and use, or Americans with Disability Act (ADA) compliance. Montgomery County, MD's Residential Electric Vehicle (EV) Charging Permitting Guidelines include detailed inquiry, determination, design, and permitting guidance and processes to support installation of charging infrastructure in circumstances where a properties may not have off-street parking access to for EV charging. Figure 4 summarizes other right-of-way (ROW) charging programs in Sacramento, Seattle, Berkeley, and Los Angeles.

Figure 4. Summary of ROW Programs in Other Cities

Sacramento partnered with EVgo to provide access to ROW.



Seattle has a ROW permit pilot open to any residence or business. City parking rules continue to apply.



Berkeley provides access to ROW for residential customers.

Los Angeles is known for a lamppost charging program that reduces the make-ready costs and removes permitting needs.

EQUITY SOLUTION

Prioritize underserved communities in developing parking arrangements for residents needing charging access while lacking off-street parking. At the same time, recognize that parking for gasoline vehicles may also be critical to mobility needs of people in underserved communities in the near term until the transition to electric vehicles is more pervasive. The Greenlining Institute's toolkit (2020) recommends offering free or reduced rate parking for electric vehicles as a way to make electric vehicles more affordable for underserved communities (Greenlining Institute, 2020).

RECOMMENDATION A-3. SERVE AS A CLEARINGHOUSE OF POTENTIAL CHARGING LOCATIONS.

The City could continue collecting recommendations for charging This is a market-driven (not top-down) approach that has worked exceptionally well in Amsterdam, one of the top cities in the world for electric vehicle adoption. In Amsterdam, once a member of the public submits a request for a new charging station, a member of the city reviews the request and assesses whether a new charge point is needed in the area concerned. If the City proceeds with the installation of a new station, the City publishes details about the location online on a map and communicates this information to electric drivers in the area. While resident-focused, these chargers are public.

Yet, city-ownership of the charging station is not the only option. Alternatively, the City can collect and compile resident requests for charging stations and serve as an intermediary with charging service providers, utilities, businesses or others that may be involved charging station deployment. Potentially, the City could maintain an active list of priority charging locations. See Chapters 5 and 6 for priority sites at the time of the writing of this document. The City could us its 311 system to intake requests for chargers.

EQUITY SOLUTION

Consider equitable access of charging stations as a part of any actions taken under Recommendation A-3. The Greenlining Institute's toolkit (2020) suggests using a "minimum deployment commitment" of electric vehicle charging infrastructure in underserved and LMI communities to ensure equitable access with a possible range of 10% to 20% of chargers (Greenlining Institute, 2020). Chapter 6 provides maps that incorporate equitable access locations.

BEST PRACTICE: ROW CHARGING

- Prioritize neighborhood/connector streets over arterial streets
- Cluster charging in high-priority locations
- Ensure that ROW charging maintains adequate clear sidewalk width
- Develop signage rules to communicate charging costs and parking rules
- Ensure that ROW charging aligns with existing planning goals
- Develop policy for ADA accessible curbside charging

Residential, Fleets, and Visitors Requiring Charging

Recommendations in this section address other publicly-accessible charging needs not addressed above. For example, vehicles that charge overnight sometimes need opportunity charges to extend their range. Similarly, visitors, fleet vehicle operators, and transportation network company drivers need convenient locations for plugging in.

RECOMMENDATION A-4. CREATE SHARED MOBILITY HUBS.

A Shared Mobility Hub is an emerging concept in transportation land-use planning where transportation connections, travel information, and community amenities are aggregated into a comfortable, seamless, understandable, and on-demand travel experience. Shared Mobility Hubs are typically located with major transit facilities and in places where frequent services intersect to allow easy transfers between mobility services. In addition to transit, Shared Mobility Hubs may include connections to car share, transportation network companies, taxis, bike share, bike parking, pick-up and drop-off, kiss-and-ride, freight delivery, as well as connections to local bike and pedestrian routes.

As is consistent with the 2021 Alexandria Mobility Plan's goal of supporting travel options, the City should develop Shared Mobility Hubs at one or more of its transit stations or park-and-ride locations in Alexandria. A Shared Mobility Hub in Alexandria could include four types of chargers:

- Publicly accessible chargers using a mix of different power levels. The goal should be to serve multiple dwell times, from commuters (Level 1 chargers), visitors (likely Level 2 or DCFC), or others
- Fast chargers aimed solely at taxis and transportation network companies. Examples of this type of dedicated charger are increasingly prevalent, such as in the District of Columbia, Colorado, and Seattle
- DASH electric bus charging stations
- Docks for electric micro-mobility bikes and scooters

Contra Costa County, California, recently developed an EV Blueprint (Figure 5) that details its Shared Mobility Hub concept.

Figure 5. Contra Costa County's EV Blueprint

Because Shared Mobility Hubs often feature multiple chargers of different power levels, early communication with Dominion Energy is necessary so that upgrades to the local distribution systems can be made, if needed. For example, if a Shared Mobility Hub has two electric buses charging at 50 kW each and 10 electric vehicles charging at 15 kW each, a local electric feeder line would need 250 kW of capacity just for these vehicles. Because distribution system upgrades generally take much longer than any other step in developing a Shared Mobility Hub, they should be prioritized first, if needed.

EQUITY SOLUTION

Shared Mobility Hubs are essential places to increase access to vehicle electrification for LMI and underserved communities. The increased availability of transportation options at Shared Mobility Hubs will improve equitable access to transportation services overall through more travel choices and reduced car ownership costs. Concerted efforts should be made to locate mobility hubs in locations that will serve LMI and underserved communities and to work with shared mobility providers to ensure services are accessible to these populations. Additionally, the Greenlining Institute's toolkit (2020)recommends a host of ways to increase equity in its shared mobility section of the practicality page, including measures such as targeted outreach and education (available in key languages), in-person trainings and orientations to teach customers how to use the shared mobility service, and exploring options for public transit and shared mobility system integration (Institute, 2020). Greenlining Institute, 2020).

RECOMMENDATION A-5. PROMOTE CHARGING LOCATIONS AT GROCERY STORES, PARKS, AND RETAIL STORES.

The second public engagement survey conducted as part of this project (see Chapter 5) demonstrates that the preferred sites for publicly accessible charging stations (other than on-street and at multifamily dwellings) are grocery stores and retail locations with accessible parking. These preferences align with a nationwide survey conducted by the Union of Concerned Scientists (USC) showing that grocery stores are the number one preferred publicly accessible charging location (USC, 2019b). Examples of such locations in Alexandria may include retail areas of North Potomac Yard, Bradlee Shopping Center, Alexandria Commons, the Shoppes at Foxchase, Van Dorn Plaza, Seminary Plaza, and many other locations like places of worship. The City could consider working with retail locations to promote and coordinate electric vehicle charging in these locations.

Aside from retail locations, public engagement survey results indicate City parks are locations with much community interest for publicly accessible charging. Overall, public engagement survey results suggest locations where electric vehicle drivers are able to charge while also attending to household needs or recreation are preferred opportunities for charging where a car can be charging while attending to other activities at the same time.

EQUITY SOLUTION

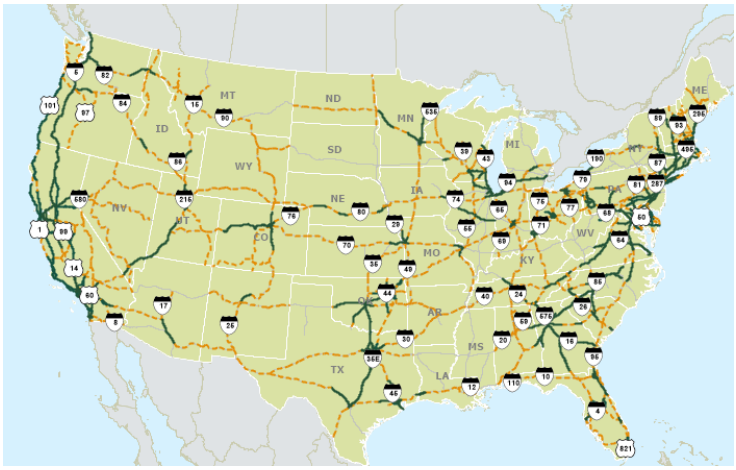
Publicly accessible locations for charging infrastructure are critical for ensuring equitable access to charging infrastructure. Parks especially are critical avenues for addressing equity and affordability for LMI and underserved communities. The City's Department of Recreation, Parks, and Cultural Activities (RPCA) has committed to equitable and safe access to parks, facilities, and programs and could be an important partner in developing charging infrastructure. Guidance from City Parks Alliance on smart investment and equitable urban parks provides additional resources on charging at parks.

RECOMMENDATION A-6. PROMOTE DCFC STATIONS NEAR HIGHWAY OFF-RAMPS.

Charging stations near major arterials and highways are important for long-distance travel and help alleviate drivers' range anxiety; a critical barrier to overcome to accelerate the adoption of electric vehicles. In general, major points of entry/exit into the City should have fast charging stations nearby, as is common for conventional gas stations. For Alexandria, these may include access points along I-495, I-395, and at intersections with major state highways (Rt 1, Rt 7, Rt 235, etc.). Consideration should be given to DCFC stations with a minimum power capacity of 50 kW, but more ideally of 150 kW to 350 kW because of the speed of these charging stations and the user demand to minimize charging time. Such charging stations should be highly visible and easy to access, with assistance from wayfinding applications and signage, especially for visitors who may be less familiar with Alexandria. The City's efforts to prioritize DCFC station locations near highway off-ramps would promote and enhance regional charging network opportunities, which includes the critical coordination with other Metropolitan

Washington communities, including Arlington and Fairfax counties in Virginia and the District of Columbia, to work together to increase and promote the availability of charging infrastructure to increase electric vehicle adoption. For charging network integration, the City should coordinate directly with regional and state highway corridor planners. Further, the City should leverage investment from EVSPs, such as Electrify America and ChargePoint, who are pioneering corridor charging. DCFC stations located near interstates could become part of the Federal Highway Administration's National Electric Vehicle Corridor system (Figure 6).

Figure 6. Federal Highway Administration National Electric Vehicle Corridors.



Enhancing Communications and Awareness

Recommendations in this section establish charging deployment targets, create awareness among the public, and develop capacity within City staff and relevant stakeholders.

RECOMMENDATION B-1. ESTABLISH NEAR- AND MEDIUM-TERM TARGETS FOR PUBLICLY ACCESSIBLE ELECTRIC VEHICLE CHARGING INFRASTRUCTURE.

The City could establish near-term (five-year) and medium-term (10-year) targets for the *total number of additional publicly accessible charging plugs*. Targets are important for several reasons, including communicating the City's priorities to a wide group of stakeholders, ensuring consistency of planning efforts over time and across City departments, and ultimately for ensuring the City direct appropriate resources to charging infrastructure. City targets could include both charger installation targets as well as electric vehicle adoption targets. For example, the City of Boston's Zero-Emission Vehicle Roadmap sets targets for City-owned and privately owned Level 2 and DCFC charging plugs through 2025 and encourages revisiting estimates with each Roadmap update as charger utilization data becomes more available and pervasive. The City may consider working with private charging companies to solicit utilization data to facilitate estimating community charging needs over time. Moreover, the City ofDenver's Electric Vehicle Action Plan sets a 15% goal of all new vehicle registrations that are electric by 2025 as an example of establishing community electric vehicle adoption targets. These targets could be integrated in relevant City planning documents dealing with climate change, transportation, development, and land-use. Such examples may include the EAP 2040 implementation plans, the Energy and Climate Change Action Plan, the Alexandria Mobility Plan, Small Area and Master Plan documents, the City's Capital Improvement Program budget, and many other related comprehensive plans (City of Alexandria, 2019; City of Alexandria, 2020a). Two regional and statewide examples that have already set

electric vehicle goals. In 2017, the Governor of the Commonwealth of Virginia set a statewide target of "driving infrastructure investments that will support an overall electric vehicle adoption rate of 15 percent by 2027, equal to approximately 1 million vehicles statewide." This statewide target can be used by local policy makers in Virginia. An additional regional target that was set in 2017 was by the Metropolitan Washington Council of Governments (MWCOG) in its Regional Climate and Energy Action Plan (MWCOG,2020). This goal was to "increase total electric vehicle ownership to 150,000 (including 10,000 plug-in and all electric) and have 1,000 public EV charging stations" in the Washington, Maryland, and Virginia region by 2020.

Potential targets are given in Table 3, which are based on the Strong City Policy scenario presented in Chapter 4. Given the rapidly evolving nature of vehicle and charging technology, the City should periodically—as frequent as every two years—reassess its charging deployment targets. This reassessment could take into account actions and targets by other cities (see Recommendation B-2 on benchmarking). Best-in-class tools like EVI-Pro and EVI-Pro Lite could support this target setting (US DOE, 2020).

Table 3. Potential targets for publicly accessible plugs in the City of Alexandria.

Scenario	Year	Total Light-Duty EV Population[a]	Publicly Accessible Level 2 Plugs Needed[b]	Publicly Accessible DCFC Plugs Needed[b]
Current	2020	522	16 needed (24 currently exist)	5 needed (1 currently exists)
Future	2025	1,390	34	10
	2030	2,560	59	18

[a] Electric vehicle population projection based on Strong City Policy scenario discussed in Chapter 4.

[b] The number of needed plugs is based on the plugs to EV ratio from the National Renewable Energy Laboratory's (NREL's) EVI-Pro Lite Tool for Washington DC metropolitan area.

EQUITY SOLUTION

Include specific targets for underserved communities and affordable housing units (e.g., 50% of new chargers are in underserved communities and affordable housing units).

RECOMMENDATION B-2. ESTABLISH A PROCESS TO BENCHMARK PROGRESS.

Using the goals established in Recommendation B-1, the City should establish an internal, recurring evaluation and reporting process by which its electric vehicle charging infrastructure deployment is benchmarked against comparable cities. The City should consider benchmarking itself with other MWCOG-member cities or cities in Virginia. Cadmus (2021) and the National Association of State Energy Officials (NASEO) recently released a Plug-In Electric Policy Impact Rubric, which allows metropolitan governments to self-evaluate the strength of their PEV policies on a scale of 0 to 100. Similarly, the American Council for Energy Efficient Economy (ACEEE) (2021) released the State Transportation Electrification Scorecard to rank states' efforts to remove barriers and enable residents and business to use and charge electric vehicles. In the future, ACEEE or other organizations may offer similar scorecards

to rank city efforts to remove barriers and support electric vehicle and electric vehicle charging stations within their communities. Additionally, the City could coordinate this benchmarking with its sister city in Dundee, Scotland, which recently adopted several transportation electrification initiatives; City staff have been engaged with Dundee staff on their efforts to share best practices. This would provide a transnational opportunity to build ties and share best practices. The most common benchmarks are either the ratio of chargers per electric vehicle or chargers per 1,000 people. Two sources that frequently publish chargers per electric vehicle ratios include Atlas's EVHub and ICCT electric vehicle reports. (Atlas Public Policy, 2019a; ICCT, 2020).

EQUITY SOLUTION

Specific targets for underserved communities and affordable housing units from Recommendation B-1 can help set benchmarks for evaluating progress on the equitable distribution of new chargers in these communities and against other cities.

RECOMMENDATION B-3. DEMONSTRATE COMMUNITY LEADERSHIP.

The City's leadership role in educating the public and championing electrifying transportation is one of its most important and valuable opportunities to promote electric vehicle adoption. This could be accomplished through public statements, media campaigns, events including electric vehicle festivals and rallies, and by providing robust information on the City's website to answer electric vehicle and electric vehicle charging infrastructure questions. In addition, promoting electric scooters and electric bike programs, the City's use of electric vehicles in its fleet (see Recommendation B-4), the City's support of the DASH transit system's electric bus program, and Alexandria City Public Schools (ACPS) electric school buses, provides a comprehensive demonstration of the City's leadership to support electric vehicles. Many people are simply not aware of what electric mobility is, what it involves, the capabilities of the vehicles themselves, and the benefits to consumers and the environment. Forth Mobility and Plug-In America provide resources about specific actions City can take for communications, currently available electric and hybrid vehicle models, incentives, among others.

The City could work with other regional municipal partners – such as MWCOG, Virginia Clean Cities, Greater Washington Clean Cities, Dominion Energy, and universities – to develop a landing page with resources, tools, information on incentives, and other educational material. The City of Boston's website offers a user-friendly and easy-to-navigate interface that could serve as an example (Figure 7) (City of Boston, 2020).

Figure 7. City of Boston Landing Page on Electric Vehicles

The core elements of such a page should include:

- Roadmaps, strategy documents, and plans related to electric vehicles and charging;
- Fact sheets describing past or current pilot programs;
- Installation guide for installing home, work, and/or publicly accessible charging stations;
- Information on electric micro-mobility services;
- Links to incentive and grant programs; and
- A frequently asked question sheet.

RECOMMENDATION B-4. CHAMPION CHARGING INFRASTRUCTURE BY ELECTRIFYING THE CITY FLEET, AS OUTLINED IN THE EAP 2040.

The City should leverage its participation in the Climate Mayors' EV Purchasing Collaborative to further electrify its light-duty vehicles and identify specific medium- and heavy-duty vehicles for electrification. The City is introducing battery electric and plug-in hybrid electric sedans and vans into the City's fleet of vehicles. Moreover, the City supports the DASH transit system's electric bus program. By implementing charging infrastructure for City fleet vehicles, the City can champion installation of charging infrastructure. The City should also consider opportunities to install charging infrastructure where it may not only support fleet needs but could also provide publicly accessible charging opportunities for the

Alexandria community. The City should consider facilitating an internal, multidepartment planning process to develop standard and consistent approaches to implementing charging infrastructure at City facilities, parks, and along the right-of-way where the City may be responsible for the charging infrastructure. Given the City's recent adoption of an Alternative Fuel Policy to guide fleet purchasing and operations, it will be imperative to develop internal standards and guidelines for supporting the implementation of charging infrastructure needs for City use purposes. Such planning process should include site coordination, vendor and technology standards, charging infrastructure management and governance policies and practices, access policies, funding coordination, and business model approaches. Such planning and governance process will also be critical to opportunities where the City may consider offering publicly accessible charging infrastructure as outlined in Recommendation A-5.

RECOMMENDATION B-5. BUILD AND MAINTAIN INTERNAL COMPETENCIES.

The City should clearly set the responsibility for supporting the implementation of electric vehicle charging infrastructure in the community within the City's organizational structure. This may include defining a person or department assigned to assist the coordination of the implementing electric vehicle charging infrastructure. This could be part of the responsibilities of Electric Vehicle Navigator as discussed in Recommendation F-2. The Electric Vehicle Navigator could track charging plugs in Alexandria—both publicly accessible plugs and restricted access plugs, possibly using the City's APEX system. The City could use this tracking to support Recommendations B-1 and B-2. Other jurisdictions have noted that databases that track publicly accessible charging stations, such as the Department of Energy's Alternative Fuel Data Center, undercount the actual number of plugs since not all new plugs are reported. The City should also standardize processes for training its staff and developing core competencies regarding electric vehicles. Again, the Electric Vehicle Navigator could be the City's focal point for developing training resources and periodic updates to City staff.

EQUITY SOLUTION

Equity is a critical competency that trainings for City staff must include. Trainings must provide a direct educational component about the connection between transportation electrification, environmental justice, and underserved communities. These trainings can also be applied to Recommendation C-8 which aims to grow critical competencies of local officials.

RECOMMENDATION B-6. PROMOTE ALEXANDRIA AS AN ELECTRIC VEHICLE CAPITAL CITY.

As discussed in Chapter 2, Alexandria has a 5% new electric vehicle sales share, which places it among the top markets in the United States for electric vehicle sales. Alexandria can gain recognition both domestically and abroad by leveraging its current status as a top electric vehicle market by branding itself as an Electric Vehicle Capital City—an informal designation that conveys Alexandria's leading status on the presence of electric vehicles. To position Alexandria as an Electric Vehicle Capital City, City staff should participate in external-facing reports, events, webinars, presentations, and promotional

campaigns. Additionally, the City would need to participate in research that compares electric vehicle adoption in its own jurisdiction with that of other jurisdictions (ICCT November, 2019, Urban Foresight, 2014). If an externally organized recognition program does emerge in coming years—similar to the US DOE/ICMA SolSmart designation—the City should consider applying and going through the process of designation.

Promoting Alexandria as an Electric Vehicle Capital City may also be valuable in the City's economic development efforts. For example, the City of Raleigh's Transportation Electrification Study identifies several actions the City can take to support equitable economic development. Alexandria could consider leveraging an Electric Vehicle Capital City brand in economic development marketing campaigns to showcase its leadership and electric mobility innovation to promote a community climate of technology innovation and support business recruitment efforts. To the extent possible, public-facing documents and City press releases should reference the need for a low-carbon economy and electric mobility future and highlight Alexandria's cumulative number of electric vehicles on the road, the policies that have led to sustained adoption success, and emphasize increases in recent electric vehicle adoption. Other methods for strengthening the electric vehicle ecosystem in Alexandria and sending strong market signals to investors include using public statements, events, or policies to support and encourage entrepreneurs to become active in the electric vehicle market, sending encouraging signals to government employees to find creative solutions to overcome electric vehicle barriers, and rewarding and incentivizing electric vehicle driving. Investing in electric vehicle signage to enhance wayfinding of electric vehicle infrastructure is another important way to increase public awareness of charging infrastructure availability. Such efforts may also increase opportunities for strategic public-private partnerships to support investments in Alexandria's transportation electrification initiatives.

RECOMMENDATION B-7. UTILIZE INNOVATIVE PILOT PROGRAMS.

Innovative pilot programs are programs with unique design components or programs that target unique barriers for electric vehicle adoption. Innovative pilot programs provide at least three benefits compared to other programs: (1) they draw attention to the City from the wider electric vehicle industry, (2) they attract investors such as charging station developers and commercial electric fleets, (3) they lay the groundwork for an expanded program, and (4) they allow the City to test and get feedback on programs without requiring full political or monetary commitment. Some of the most innovative electric vehicle pilot programs in recent years began with partnerships between a municipal government and an electric vehicle stakeholder or business. For example, the City of Alexandria runs the SolarizeAlexandria program, which includes opportunity for those investing in solar photovoltaic for their households or businesses can also buy a Level 2 charger. Elsewhere, the City of Berkeley, California, has a residential right-of-way electric vehicle charging infrastructure pilot program that permits homeowners to purchase and install charging stations (at their expense) either on their property or on city-owned right-of-way property. Parking is on a first-come, first-serve basis (City of Berkeley, 2020). Seattle, Washington, also has an innovative electric vehicle right-of-way program as described in Recommendations A-4: Creating shared mobility hubs; A-5: Promote electric vehicle charging locations at grocery stores, retail stores, and parks; B-4: Champion charging infrastructure by electrifying the city

fleet, as outlined in the EAP for 2040; C-3: Encourage electric vehicle charging in parking spaces; C-8: Training local officials; and E-3: Consider City investment to support publicly accessible charging.

EQUITY SOLUTION

When feasible, the City should leverage partnerships with MWCOG, Virginia Clean Cities, Greater Washington Clean Cities, universities, and Dominion Energy to build equity-focused pilot programs. These programs could include an equity-related performance target (e.g., 35% of programs in pilot program are from underserved communities) or could include steering committees composed of diverse mix of voices. While no specific pilot program has been identified in this recommendation, any pilot should consider equity best practices during the design phase. More examples of pilots that integrate equity can be found in the). practicality and accessibility section (Greenlining Institute, 2020).

Strengthening and Standardizing Zoning, Building Codes, and Permitting

Regulating how land is used in a community is one of the most powerful tools available to the City. City staff can use zoning, application of building codes, and permitting to incentivize the installation of charging infrastructure, support distribution grid extension for electric vehicle charging, and create charging hubs. Finding synergies with other development requirements, such as street lighting or telecom, can also strengthen zoning, building codes, and permitting. Recommendations in this section reduce or remove common barriers to installing new charging infrastructure.

RECOMMENDATION C-1. AMEND ZONING ORDINANCE TO INCLUDE CHARGING STATIONS AS A PERMITTED ACCESSORY USE.

Alexandria's zoning ordinance as of January 2021 does not clearly define charging stations as a permitted accessory use in all districts throughout the city. Defining charging stations (Level 1, Level 2, and DCFC) as a permitted accessory use in all districts will help to clarify the permitting process and make it clear that Alexandria supports the installation of chargers. In other jurisdictions, zoning reviews are usually the lengthiest part of the approval process, particularly for installing DCFC stations and are not always necessary. Often, zoning reviews are unnecessary because charging stations are an accessory use to the principal use of the site (i.e., charging stations are usually added to existing parking areas for already developed sites).

The City should consider amending the zoning ordinance to clarify that charging stations are a permitted accessory use. This can save time and resources on reviews by City staff and applicants, as well as considerations by the Board of Zoning Appeals members (O'Grady and Way, 2020). Examples of zoning language and definitions aimed at clarifying electric vehicle charging stations as permitted accessory uses can be found in such resources as the Great Plains Institute's summary of Best Practices in Electric Vehicle Ordinances (GPI 2019).

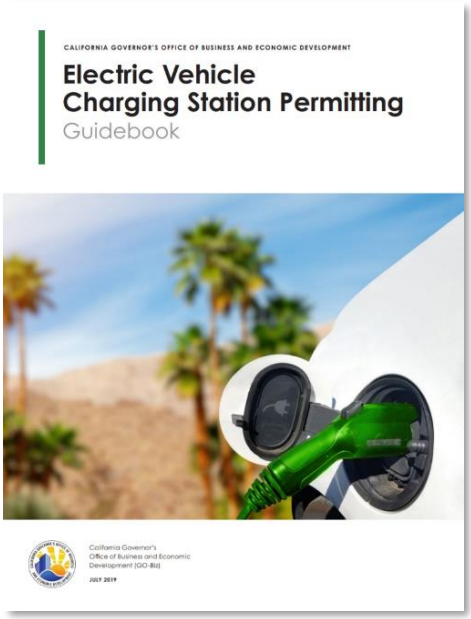
RECOMMENDATION C-2. ESTABLISH ELECTRIC VEHICLE INSTALLATION CHECKLIST.

RMI's recent investigation into charging infrastructure costs identifies "soft costs" – costs outside of direct materials and labor – as substantial and unpredictable enough to have influence on the overall cost of charging infrastructure. These soft costs include the direct costs and time to obtain necessary local building permits. The permitting checklist is just one option for reducing the complexity and streamline local permitting processes to reduce these soft costs. RMI also identifies uncertainty in easement processes and utility coordination, as necessary, as often consequential to the costs of permitting and installing charging infrastructure. To do its part in helping reduce these costs, the City could include information in a permitting checklist on how to engage with Dominion Energy and how to obtain any necessary easements, as applicable, to support those seeking to install charging infrastructure.

RMI also identifies online permit application as another best practice for reducing soft costs. The City's APEX Permitting & Land Use System is consistent with this recommendation by allowing application and issuing of permits electronically. In addition, the City could consider expedited permit reviews or waiving of certain permit fees for certain charging infrastructure types to expand charging infrastructure availability in the community.

To ensure the permitting process is clear for individuals installing a charger, provide a checklist to help individuals navigate through the application and plan review process. Consider mirroring Alexandria's existing solar photovoltaic system installation permitting checklist as a template (Alexandria, N.D.). Alternatively, the City could borrow content and layout from another municipal government. Checklists are particularly important in the permitting and installation of fast chargers. The City could incorporate a streamlined permitting process for DCFCs that fast-tracks the permit approval. Best practice information about checklists and permitting is available online. For example, the State of California administers an interactive map that shows which California municipal governments have electric vehicle permitting checklists. The same website also has an electric vehicle Permitting Scorecard with best practices, and a Permitting Guidebook, shown in Figure 8.

Figure 8. State of California's Charging Permitting Guidebook



Note: Guidebook available here.

RECOMMENDATION C-3. ENCOURAGE ELECTRIC VEHICLE CHARGING IN PARKING SPACE REQUIREMENTS.

Consider incentivizing the deployment of charging stations by adopting ordinances that count charging station spaces as more than one parking space for zoning purposes. Such ordinances exist in Stockton, California, which has a code that states: "Electric vehicle charging stations are permitted in all required and nonrequired off-street parking spaces. As an incentive for the provision of electric vehicle charging stations, a reduction in required parking is permitted up to two required parking spaces for each electric vehicle charging space provided, up to a maximum reduction of 10 percent of the total required parking."

Equity Solution

Any parking space requirements to encourage electric vehicle charging should be the same no matter the type of community, where particular inclusion is given towards electric vehicle parking in affordable housing parking spaces. The Greenlining Institute's equity toolkit advises that community mobility needs assessments should be conducted when siting electric vehicle charging infrastructure. This equity toolkit has additional recommendations for improving equity in electric vehicle parking.

RECOMMENDATION C-4. ADOPT CURBSIDE MANAGEMENT POLICIES TO PRIORITIZE ELECTRIC VEHICLE CHARGING.

With increasing concern for balancing needs for all roadway users, and the growth of transportation network companies, like Uber and Lyft, as well as online shopping and associated deliveries and demand for curbside pickups, drop-offs, and dwell times, is growing dramatically. Curbside space is generally available for anyone to use, at least for short durations. Chargers could be clustered within a single or adjacent city blocks to assist drivers with wayfinding and minimize traffic disruption from vehicles circling. The City should prioritize locations with predictable turnover and with predictable vehicle types with high potential station utilization. More guidelines for curbside management strategies are available in WXY's (2018) Curb Enthusiasm Deployment Guide for On-Street Electric Vehicle Charging.

Providing curbside charging is consistent with the upcoming 2021 Alexandria Mobility Plan's (AMP) recommendation to use parking policy to achieve broader City goals related to sustainability, congestion, and housing affordability. The AMP will provide prioritization guidelines for use of curbspace, and City Plan Priorities such as EV Charging are considered the highest priority for all street types. It is also consistent with recommendation A-3, aimed at providing EV charger access to residents without off-street parking.

Equity Solution

Adopting curbside management policies can increase the availability of electric vehicle charging and therefore could increase the accessibility of electric vehicles for some lower-income drivers of transportation network companies and taxi services.

RECOMMENDATION C-5. REVISE STANDARD CONDITIONS TO INCREASE MINIMUM REQUIREMENTS.

The City should expand the current standard conditions for the installation of Level 2 electric vehicle charging stations or for parking spaces to be EV-ready to apply to all multifamily, commercial, and industrial development. Currently 2% of parking spaces in new developments are required to have charging stations and additional 3% are required to be EV-ready.

To keep up with expected EV charging demand, the City should consider revising the standard conditions to align with those of other leading cities. In the Metropolitan Washington region, Arlington County requires a Level 2 electric vehicle charging station for at least 4% of parking spaces and [EV-ready] electric vehicle infrastructure for at least 15% of parking spaces. In the District of Columbia, any new construction or substantial improvement of a commercial building or a multi-unit building that includes 3 or more off-street parking spaces must include EV-ready infrastructure for at least 20% of parking spaces. For a national comparison, in 2019, the City of Boston announced new electric vehicle infrastructure requirements for parking garages in downtown that require 25% of parking spaces in new off-street parking areas to be equipped with electric vehicle charging stations, and the remaining 75% to be EV-ready, at a minimum, equipped to accommodate electric vehicle infrastructure expansion. Additionally, while the requirements in the City of Boston are regarding Level 2 charging infrastructure, DCFC stations are strongly encouraged. A number of other examples of municipal parking requirements can be found in in the Great Plains Institute Summary of Best Practices in Electric Vehicle Ordinances (GPI, 2019). The City could consider recommending additional EV charging be provided with developments in priority areas of the City through Small Area Plan updates or by leveraging the City's Green Building Policy. All new development and major renovations that require a Development Site Plan (DSP) or Development Special Use Permit (DSUP) are subject to comply with the City's Green Building Policy which includes certification with a third-party green building rating system. These third-party green building rating systems, such as the United States Green Building Council's (USGBC) LEED Version 4.1 BD+C for New Construction includes the ability to earn certification points by installing electric vehicle chargers for at least 5% of parking spaces or making 10% of parking spaces EV-ready. At this time, electric vehicle charging is not one of the City's directed-use "Performance Points" categories necessary for achieving Green Building Policy compliance. However, given the intent of using these Performance Points categories for Green Building Policy compliance is to achieve specific City energy and greenhouse gas emissions reduction policy goals, the opportune leverage the Green Building Policy may be a useful tool in the future.

Future building codes will support requirements for electric vehicle chargers, EV-ready, and EV-capability within new construction. The 2021 International Energy Conservation Code (IECC) will require new commercial developments with two or more parking spaces to include at least two EV-ready spaces and those with 26 or more parking spaces would be required to also make 20 percent of all spaces "EV capable" which is defined as having electrical panel capacity and space to support a branch circuit to each parking space. The Commonwealth of Virginia will need to adopt these new IECC code provisions into the Uniform Statewide Building Code in future years; however, anticipating these requirements in the future may serve to support their addition to standard development conditions. (Note: Virginia's

Uniform Statewide Building Code requires a single 120 V outlet to be installed in a garage which may offer sufficient charging capability for some electric vehicle drivers who may only need passive, longer-duration charging ("Level 1"). However, other needs may make Level 2 charging capabilities more advantageous.) Consistent with Recommendation B-3, the City may consider demonstrating community leadership by voluntarily increasing the minimum number of parking spaces with Level 2 or even DCFC electric vehicle charging stations and EV-ready infrastructure in new public developments, major building renovations, or park and other public development projects. This may apply to City, Alexandria City School District (ACPS), Alexandria Redevelopment and Housing Authority (ARHA), and other public agency new developments.

Coordinating interests and communications with the City's Planning and Transportation Commissions, Traffic and Parking Board, the Environmental Policy Commission, City agencies, the Northern Virginia NAIOP chapter's Alexandria Government Relationship Subcommittee, and other representatives from the development community will help in aligning goals and needs reflected in development standard conditions.

RECOMMENDATION C-6. ADOPT DESIGN CRITERIA RELATED TO ELECTRIC VEHICLE CHARGING STATIONS.

To ensure that electric vehicle charging stations are appropriately designed and sited in alignment with other community goals and concerns, the City could adopt design standards such as the following:

- Publicly accessible charging stations, particularly DCFC stations, should be encouraged to use the Open Charge Point Protocol (OCPP).
- Charging stations shall enable multiple forms of payment, including credit card, smart phone applications, keyless fobs, and toll-free number payment support. As much as possible, stations should be open access and prohibit network subscription-based services.
- Charging station outlets and connector devices shall be mounted to comply with state code and must comply with all relevant Americans with Disabilities Act (ADA) requirements.
- Charging station equipment shall be protected by wheel stops or concrete filled bollards.
- Charging station equipment should not reduce the size of the parking space below current minimum requirements.
- Cords shall be retractable or have a place to hang the connector and cord sufficiently above the pedestrian surface. Any cords connecting the charger to a vehicle shall be configured so that they do not cross a driveway, sidewalk, or passenger unloading area.
- Equipment mounted on pedestals, lighting posts, bollards, or other devices for on-street charging station shall be designed and located as to not impede pedestrian travel or create trip hazards within the right-of-way.
- Site lighting shall be provided where a charging station is installed unless charging is for daytime purposes only.
- Each charging station shall be posted with signage indicating the space is only for electric vehicle charging purposes. The following information shall be posted at all electric vehicle charging

stations: 1. Voltage and amperage levels; 2. Hour of operations if time limits or towaway provisions are to be enforced by the property owner; 3. Usage fees; 4. Safety information; 5. Contact information for reporting when the equipment is not operating or other problems.

- Charging stations should use managed charging solutions – including networked and smart charging capabilities – to support flexible and responsive electrical load management to better align charging needs with electrical system requirements. Such managed charging may also offer local electrical distribution grid integration opportunities in the future.

EQUITY SOLUTION

Electric vehicle charging station design requirements should be developed to include intentional accessibility components for individuals with disabilities. Partnering with community-based organizations to assess the target community's accessibility needs and to improve design standards could enhance equity considerations in decision-making. Offering multiple types of payment options ensures more equitable access for all electric vehicle drivers who may not have certain types of payment forms or the affordability of subscription services may not be accessible for some low-income EV drivers.

RECOMMENDATION C-7. CONSIDER APPROPRIATE STANDARDS FOR HISTORIC DISTRICTS.

To develop the design standards of Recommendation C-6, it is possible that additional considerations or standards may be necessary in Alexandria's Old and Historic District or Parker-Grey Historic District to specifically address siting electric vehicle charging stations. It may also be necessary to amend the City's historic preservation code to specifically allow electric vehicle charging infrastructure. The City of Santa Cruz, California, for example, exempts electric vehicle charging stations from requiring a historic alteration permit and includes the following language: "Installation of an electric vehicle charging station; however, all feasible efforts shall be made to minimize the visibility of electric vehicle charging stations on historic properties." (City of Santa Cruz, 2020)

RECOMMENDATION C-8. TRAIN LOCAL OFFICIALS.

To help develop and enforce new codes and standards, it would be beneficial for the City to offer training to local officials to increase their understanding of the electric vehicle charging infrastructure technology and safe installation and operation. Priority audiences for training could include the City's planning and zoning staff, historic preservation staff, Board of Architectural Review officials, code administration plan reviewers and inspectors, fire marshals, and first responders (including those in the Alexandria fire and police departments who may come into contact with electric vehicle charging infrastructure while responding to community emergency needs). Contra Costa Transportation Authority's Electric Vehicle Readiness Blueprint has identified the need for electricians and mechanics to become familiar with electric vehicles. The Blueprint lays out training needs for auto technicians, gives an overview of potential collaborators and resources, and suggests curriculum and cost estimates for

the program. Contra Costa's strategic plan for workforce training for electricians outlines the need for trainings that will help electricians to safely and effectively install electric vehicle chargers. This plan also estimates program costs for workforce trainings on installing electric vehicle charging stations.

RECOMMENDATION C-9: ALLOW DEVELOPERS TO USE TMP FUND FOR ELECTRIC VEHICLE INFRASTRUCTURE OR

The City administers a TMP fund that encourages developers to reduce traffic congestion created by new development sites. Developers pay into the fund and the City creates incentives for shared mobility or active transportation. The intention of the TMP program is to reduce single occupancy vehicles; therefore, it cannot fund electric vehicle projects unless they have a clear connection to shared rides. However, the City could consider amending its code to facilitate using TMP funds for electric shuttles, charging stations, or to incentivize shared rides through electric ride-hailing services. Alternatively, the City could consider setting up a separate fund that only supports opportunities specific to electric vehicles. At the time of this writing, the authors are not aware of a similar dedicated fund in other jurisdictions.

EQUITY SOLUTION

The City could include requirements that direct the use of some of these TMP funds for underserved or LMI communities or for people with disabilities.

RECOMMENDATION C-10: EXAMINE FUTURE CHARGING NEEDS AND SOLUTIONS OF ELECTRIC DELIVERY VANS, AUTONOMOUS SHUTTLES, EMERGENCY VEHICLES, AND GRID RESILIENCY/INTEGRATION OPPORTUNITIES.

Certain vehicle segments like delivery vans used for last-mile delivery are quickly electrifying and may need publicly accessible charging solutions in the future. Most analysts think these new electrified segments will mostly charge at home depots overnight during the initial years of roll-out (Kellison, 2019). However, as the vehicles become more prevalent, the City should seek opportunities for creative partnerships to attract the use of electric delivery vans within Alexandria and leverage private-sector funding for chargers and ensure curbside accessibility for charging. An example of a municipal program that aligned with Recommendation C-10 is New York City's Economic Development Cooperation's FreightNYC Plan (NYCEDC 2019), which is incorporating truck delivery charging stations. The aim of this program is to provide individuals, businesses, and fleets greater access to high power charging (defined as greater than 100 kW) at curbside locations throughout New York City.

Advocating in State Government or with Dominion Energy

Some of the most impactful policies regarding electric vehicle charging infrastructure derive from state- and federal-level policy action, as well as through electric utility regulation and programs. Recommendations in this section describe specific policies and programs the City could consider supporting through its state representatives, state agencies, federal policy advocacy, or in partnership with local electric and other utilities.

RECOMMENDATION D-1. ADVOCATE FOR OPPORTUNITIES THAT ACCELERATE CHARGING STATION DEPLOYMENT.

Table 4 provides a list of policy actions that are demonstrated to support greater charging infrastructure. These policy categories have been vetted through an exhaustive literature review and expert panel supported by the National Association of State Energy Officials in 2018 (NASEO, 2018). Policies with the highest priority level have the greatest amount of evidence to demonstrate they result in more electric vehicles. Besides those listed in Table 4, other common state-level policies that support charging infrastructure include anti-ICEing laws[2], standardized charging signage and wayfinding, use of government land for shared charging infrastructure, and marketing and communication campaigns around charging.

Table 4. Priority list of Advocacy Opportunities with the State and Utility (NASEO 2018).

Policy or Program	Description
Name: Charger rebates Priority: High **Who adopts**: State government or Dominion Energy	Provide incentives for publicly accessible chargers aimed at businesses, multifamily dwelling units, homeowner's associations, electric vehicle service providers (e.g., ChargePoint), or private citizens. These incentives should be at least $5,000 for public, workplace, or multifamily Level 2 plug and at least $50,000 per DCFC plug.[a] Dominion Energy is currently implementing the Smart Charging Infrastructure Pilot Program (SCIP), which covers charging equipment and networking costs for installation at multifamily, workplace, DCFC, and transit chargers. The City may wish to advocate for elements of these programs as Dominion Energy considers opportunities to make the SCIP permanent.
Name: Charging make-ready program **Priority**: Medium **Who adopts**: Dominion Energy	Utility-led make-ready programs pay for charging infrastructure up to the charging station. Make-ready programs are a key policy for enabling higher power charging stations or remote stations. Dominion Energy is currently implementing the SCIP, which covers make-ready costs for publicly accessible DCFCs and chargers supporting electrification of public transit systems. As Dominion Energy considers opportunities for establishing a permanent make-ready program, example models of long-term make-ready programs are currently in California and New York.
Name: Transportation Climate Initiative or Low Carbon Fuel Standard (LCFS) **Priority**: Medium **Who adopts**: State government	The Transportation Climate Initiative and low carbon fuel standards (LCFS) are alternatives to a carbon tax and regulate the carbon intensity of transportation fuels, while generating funds for investment in clean energy. At the time of this writing, three states have signed onto the initiative; the Commonwealth of Virginia is potentially considering joining in the future. Two states have adopted a LCFS: California and Oregon, while others like New York are considering implementing an LCFS in the future. For charging station owner-operators, LCFS generates hundreds or even thousands of dollars per year, per station. For example, CALeVIP (2020) estimates that in 2021, a public Level 2 charger generates about $500 per year of LCFS credit revenue

[2] Laws that penalize people who block electric vehicle charging stations.

Policy or Program	Description
	when credit prices are $150. On the high side, PG&E (2020) show that a charging station for a Class 8 electric truck driven 60,000 miles per year generates $33,900 in LCFS credit revenue using average 2019 credit values.
Name: EV-specific rates **Priority**: Medium **Who adopts**: Dominion Energy	Dominion Energy can spur electric vehicle ownership and charging station deployment by designing tariffs that alleviate demand charges at public or fleet fast chargers. A study by the Rocky Mountain Institute of 50 kW charging stations in California demonstrates that over 90% of a charging station's electricity costs are due to demand charges (Rocky Mountain Institute, 2017). The study concludes that best practice rate design is to reduce or eliminate demand charges for fast chargers. Some utilities take active steps to reduce the burden of demand charges, such as Eversource's EV Rider rate and PG&E's Business EV rate.
Name: Right-to-Charge Laws **Priority**: Medium **Who adopts**: State government	"Right to charge" laws provide residents at multi-unit dwellings (and other properties) with the right to install a charging station for the individual's use provided that certain conditions are met (e.g., the individual assumes responsibility for all associated costs). These laws do NOT require homeowner associations or rental property building owners to pay for the installation or operation of charging stations. These laws exist at the state-level in California, Oregon, Colorado, Hawaii, and Florida. California and Oregon laws protect owner- and renter-occupied units (other states only apply to owner-occupied units).

[a] These values may vary depending on the utilization of the charging stations. The values align with charger incentive values in other states such as Colorado and New York. For a financial analysis tool, see Great Plains Institute's DCFC charging financial calculator.

EQUITY SOLUTION

Equity opportunities can be built into any policy advocacy that calls for opportunities to accelerate charging station deployment; including advocating for policies that support and expand electric vehicle and electric vehicle charging station access to LMI and underserved communities.

RECOMMENDATION D-2: ADVOCATE FOR OPPORTUNITIES THAT ACCELERATE ELECTRIC VEHICLE ADOPTION.

WHILE this EVRS is focused primarily on charging infrastructure, state and federal policies aimed at increasing electric vehicle adoption would support many of the recommendations in this EVRS. Proposed policies in Appendix 13 of the Virginia Department of Mines, Minerals, and Energy's Electric Vehicle Incentive Working Group Feasibility Report (Chapter 973, 2020) could be important to this end. One effective policy at increasing electric vehicle sales in California and Northern Virginia is to grant electric vehicles access to high occupancy vehicle lanes. Virginia could also consider reducing the cost of tolls for toll funded roads for vehicles that have reduced emissions or reduce other fees and taxes, such as highway usage fees, the sales tax, or the annual registration fee for electric vehicles (which in 2020, was higher than it was for internal combustion engine vehicles). Virginia could also adopt clean car rules

and sales goals under Section 177 of the Clean Air Act. Federal and state policies could also enhance electric vehicle adoption through increased access to rebates for electric vehicles. The two most effective policies at spurring electric vehicle adoption, according to (NASEO, 2018), are the upfront rebates and clean cars rules (see Table 5 for more information on these policies).

The Sierra Club, PlugIn America, FORTH, and the Electrification Coalition also present numerous transportation electrification policy options in their 2020 report, AchiEVe: Model Policies to Accelerate Electric Vehicle Adoption. Some of these policy options for federal and state actors include setting zero emissions vehicle standards, establishing direct-sales legislation that allows electric vehicles to be available for purchase directly from the auto manufacturer, and providing used electric vehicles or setting special grants for private and public fleet purchases. The Virginia Drives Electric 2020 report by Generation 180 also advocates for Virginia to adopt similar policies such as clean vehicle standards and funding a point-of-sale electric vehicle rebate. The City of Alexandria's Environmental Action Plan 2040 Section 2.3.1 and Virginia's HB 717 all provide transportation electrification policy options for federal and state agencies as well.

Table 5. Priority List of Advocacy Opportunities with the State and Utility (NASEO 2018).

Policy or Program	Description
Name: EV purchase rebate **Priority:** High **Who adopts**: State government or Dominion Energy	Rebates for electric vehicle purchases, ideally offered at the time of vehicle purchase, are considered the strongest approach to increasing electric vehicle sales (NASEO, 2018). Other states offer between $1,000 to $5,000 per vehicle. This is in addition to the federal electric vehicle tax credit, which provides up to $7500 per electric vehicle. Good examples of rebate programs are in California and New York. Best-in-class programs are include focus on addressing needs of low-and moderate-income vehicle buyers, either through an income cap or a graduated rebate based on income. The 2020 AchiEVe: Model Policies to Accelerate Electric Vehicle Adoption report by Sierra Club described that one way states have addressed equity through rebates is to set eligibility tiers or limits based on income or vehicle price.
Name: Clean Cars (ZEV Mandate) **Priority:** High **Who adopts**: State government	The Clean Cars and Clean Cars 2 rules, also known as the zero emission vehicle (ZEV) Mandate, are rules led by California that include a consortium of 13 states that require auto manufacturers to sell increasing numbers of electric vehicles (UCS, 2019a). Along with the vehicle purchase incentive, the ZEV Mandate is among the most impactful approaches to driving electric vehicle sales (NASEO, 2018).

EQUITY SOLUTION

Equity opportunities can be built into any policy advocacy that calls for opportunities to accelerate electric vehicle adoption; including advocating for policies that support and expand electric vehicle and electric vehicle charging station access to LMI and underserved communities.

RECOMMENDATION D-3: ADVOCATE FOR CONTINUED, EQUITABLE DECARBONIZATION OF ELECTRICITY SUPPLY.

Supporting the electrification of transportation is one of the many important actions the City can support to reduce transportation-related greenhouse gas emissions. However, this reduction in greenhouse gas emissions from increasing the use of electric vehicles necessarily requires electricity generation come from sources which do not contribute greenhouse gas emissions into the atmosphere. As such, not only does the City need to be strong advocates for policies that benefit increasing acces and use of electric vehicles, but also policies that increase the renewable and clean energy electricity generation that supporting decarbonizing the electricity grid. As such, the City should continue to advocate that Dominion Energy and the Commonwealth continue decarbonizing the electricity grid in an equitable fashion. In 2020, the governor signed the Virginia Clean Economy Act, which requires Dominion Energy to transition to 100% carbon free electricity by 2045. This decarbonization is critical to ensuring the beneficial impacts of electric vehicles, and meeting the City's greenhouse gas emissions goals of a 80% to 100% reduction by 2050 (EAP, 2040). During this transition, residential and commercial electricity rates should be structured to enable vehicle electrification for households of all income levels. Rocky Mountain Institute recommends that rate design is structured to include time-varying volumetric rates, low fixed charges, the opportunity to earn credit for providing grid services, and low or no demand charges (Rocky Mountain Institute, 2017). Additionally, the authors suggest rates vary by location so that DCFC installed in overbuilt and underutilized areas of the grid can be achieved at lower cost.

Building Successful Business Models for Chargers

Recommendations below improve the business case for publicly-accessible charging stations. From a station owner-operator perspective, principles to ensure a success business model of charging stations include: (1) selecting a site with high daily utilization (GPI 2019), (2) ensuring high vehicle turnover throughout the day, (3) ensuring the charger is listed in public databases so electric vehicle drivers can find a charger when needed, and (4) partnering with site hosts who will help ensure availability and access to the charger at all times during the day. A recent financial analysis of 131,000 charging sessions at 185 Level 2 stations suggests that stations need a minimum of one charging session per day and, on average, charge a session fee of $10-$15 per session to be financially viable (Atlas, 2019b).

It is worth noting there are charging use cases in which siting a charger in a low utilization area is appropriate. In this case, public sector investment is likely needed to ensure financial viability of the station. For example, a jurisdiction may invest in charging stations in neighborhoods with low numbers of electric vehicles to fill spatial gaps, minimize driver range anxiety, and mitigate equity concerns.

RECOMMENDATION E-1: COORDINATE BETWEEN PARTIES INTERESTED IN NEW CHARGING STATIONS.

Similar to Recommendation A-3, the City can actively connect Electric Vehicle Service Providers (EVSP) with retail and related locations to support economic development opportunities in the community. EVSPs tend to look for strong business partners that provide land or that guarantee station revenue. In return, site hosts gain revenue by having an additional amenity in their parking lot. For example,

ChargePoint, a major EVSP in the United States, uses the informal rule of thumb that every minute of charging at a DCFC sited with a retail store, on average, results in $1 of additional revenue to that store (ChargePoint, 2018). Insights derived from such retail experiences may support business models and charging experiences that supports filling the gap for charging infrastructure needs while also enhancing existing business and the City's economic development goals (Atlas 2020).

EQUITY SOLUTION

Any City-investments that support publicly-accessible charging must incorporate equity considerations. The Greenlining Institute's equity toolkit offers recommendations for effective community outreach and coordination between stakeholders that can increase equity in planning.

RECOMMENDATION E-2: DEVELOP DEALERSHIP PROGRAMS FOR OFFERING CHARGERS.

Auto dealerships are a key stakeholder for enabling greater transportation electrification. The City could partner with its auto dealerships to offer an incentive program for installation of a home charger. This program would address the high costs faced by consumers at the time of vehicle purchase. Alternatively, the EV Navigator (Recommendation F-2) could ensure all dealerships in Alexandria were aware of incentives offered by Dominion Energy for residential charging. Dealerships could participate in electric vehicle trainings or partnerships such as the Electrified Dealer Program by Smart Columbus. In this program, dealerships share information on their electric vehicle sales with Smart Columbus and receive help from the City of Columbus on marketing electric vehicles. Dealerships in Alexandria could also apply to be PlugStar certified by Plug-in America (2021) – a nationwide program that acknowledges a dealership's efforts in electric vehicle sales. At the time of this writing, the only PlugStar-certified dealership in the Washington DC area was in Bethesda, Maryland[3].

RECOMMENDATION E-3: CONSIDER CITY INVESTMENT TO SUPPORT PUBLICLY ACCESSIBLE CHARGING.

To date, public funding has been critical to the financial profitability of charging stations, particularly for stations with lower daily utilization – and in particular for DCFCs. Without assurance of profitability, EVSPs are hesitant to invest in new stations. For example, in an analysis of 30,000 scenarios of Level 2 chargers in New York State, Atlas Public Policy (Atlas, 2019b) found that a grant worth between $5,000 and more than $20,000 resulted in 56% of charging sites being financially profitable for station owner-operators. Of the profitable scenarios, over 75% achieved payback in five years or fewer.

Municipal governments typically dedicate modest budgets for charging infrastructure but leverage that money when possible. For example, the City of Saint Paul, Minnesota dedicated $750,000 in city budget to charging infrastructure but received an additional $4 million from Xcel Energy and another $4 million from the federal government (Forth 2020). Similarly, the City of Portland partnered with a local electric

[3] Ourisman Honda

utility, Portland General Electric, to develop seven electric avenue hubs around the city's metro stops. Each station features four DC fast chargers and two Level 2 chargers (Forth 2020).

The majority of cities do not operate city-owned charging stations, instead opting for grants, incentives, and partnerships. As noted in Chapter 2, Dominion Energy is currently running a pilot program that provides funding for various types of chargers. The City should identify opportunities to leverage state funding as much as possible and consider, if appropriate, any City funding.

RECOMMENDATION E-4: DEVELOP CITY-OWNED CHARGING STATIONS AS A LAST RESORT.

In the absence of strong federal, state, regional, or utility action on installing stations, the City may need to own and operate its own charging stations. While typically not a net-positive revenue stream, city-owned and operated stations are useful for supporting unmet charging demand and developing a holistic, standardized parking management plan. For example, the City of Sacramento, California operates 168 electric charging plugs at city-owned garages. This relatively robust charging network allows the city to integrate its charging with city parking programs; the City can adjust parking fees and charging fees based on changing market demand and ensure equitable charging access. Additionally, approximately a third of the plugs in Sacramento's charging network are used by city-owned electric vehicles. These types of shared chargers help lower the financial risk associated with any given charger. Based on the spatial analysis in Chapter 6, the 10 sites with the most qualifying characteristics in Alexandria are shown in Table 6. Of these locations, six are public parks, schools, or publicly or City-owned. The City may consider these possible locations for near term charger installations.

EQUITY SOLUTION

Equitable access must be considered for any City-owned charging stations that are installed. The Urban Sustainability Directors Network's Equity in Sustainability report, as well as the Greenlining Institute's equity toolkit, can guide equity considerations in planning and identifying locations for City-owned, publicly-accessible chargers.

Table 6. Example of Top 10 Potential Sites of Interest in the Top Four Scoring Block Groups

Category	Type of Location	Street Address
Grocery Store	Whole Foods	1700 Duke Street, Alexandria, VA 22314
Shopping Center	Hoffman Town Center	Eisenhower Avenue, Alexandria, VA 22331
Shopping Center	Potomac Yard Center	3671 Richmond Hwy, Alexandria, VA 22305
Pharmacy	CVS Pharmacy	2441 Eisenhower Avenue, Alexandria, VA 22331
Public School	Charles Barrett Elementary School	1115 Martha Custis Drive, Alexandria, VA 22302
Park	Potomac Yard Park	2501 Potomac Avenue, Alexandria, VA 22305
Nature Center	Jerome "Buddie" Ford Nature Center	5750 Sanger Avenue, Alexandria, VA 22311
Recreation Center	The Mark Center Pavilion	5708 Merton Court, Alexandria, VA 22311
Public School	John Adams Elementary School	5651 Rayburn Avenue, Alexandria, VA 22311
Public School	William Ramsay Elementary School	5700 Sanger Avenue, Alexandria, VA 22311

Implementing the Recommendations

Prioritizing and implementing the Electric Vehicle Charging Infrastructure Readiness Strategy's recommendations will require commitment from City leadership, inter-departmental coordination, and collaboration with external stakeholders. In addition, it will necessitate consideration across City operations, community planning, and regulatory and equity policies. Electric vehicles and electric vehicle charging infrastructure considerations will need to be considered in many of the City's strategic, operational, and comprehensive plans. The City can prioritize high-impact, near-term actions for early implementation wins and scale its approach to supporting more pervasive electric vehicle charging infrastructure needs over time, including the potential to develop more formal organizational structures and dedicated capacity and resources.

RECOMMENDATION F-1: ESTABLISHING AN IMPLEMENTATION WORKING GROUP

Establish an inter-departmental implementation working group with members from appropriate City departments and external stakeholders to undertake equitable implementation of this EVRS's recommendations. This implementation working group can further evaluate and prioritize EVRS recommendations for benefits, impacts, and costs and resource requirements. The inter-departmental implementation working group participants would collectively prioritize recommendations, identify lead and supporting departments for each recommendation, develop resourcing and implementation plans, and monitor and report on implementation progress. Moreover, the group could develop a longer-term implementation plan to meet City electric vehicle charging infrastructure needs.

The EV Navigator identified in Recommendation F-2 will be valuable in supporting the work of this inter-departmental implementation working group and communicating the working group's priorities and progress to the Alexandria community. Should dedicated staffing be considered for the EV Navigator role, it may be beneficial to designate this person as the coordinator and leader of this implementation working group. This inter-departmental implementation working group may include representatives from the following City and partner agencies:

- Transportation and Environmental Services
- Transportation Planning
- Mobility Services
- Development and Right-of-Way
- Permitting and Inspections
- Traffic Engineering
- Environmental Quality
- Recreation, Parks, and Cultural Activities
- Planning and Zoning
- Fire Department
- General Services
- Office of Management and Budget
- City Manager's Office
- Office of Housing
- Information Technology Services
- Alexandria Economic Development Partners
- Alexandria Transit Company/DASH
- Alexandria Redevelopment and Housing Authority (ARHA)
- Alexandria City Public Schools (ACPS)
- Code Administration
- Project Implementation

RECOMMENDATION F-2: APPOINT AN ELECTRIC VEHICLE NAVIGATOR.

The City should consider appointing an Electric Vehicle Navigator to serve as a centralized point for contact and outreach coordinator to engage with the Alexandria community on electric vehicles and electric vehicle charging infrastructure matters. The Electric Vehicle Navigator could perform the following roles:

- Assist with development of educational materials to promote electric vehicle infrastructure for diverse audiences (drivers, dealerships, local governments, etc.).
- Educate community members on technical requirements, incentives, best practices, and benefits of electric vehicle charging infrastructure, including promoting consumer-facing smart phone and website applications and tools to help community members locate available charging infrastructure or promote charging infrastructure sharing.
- Consider coordinating a community EV advocates program similar to the City of Cincinnati to mobilize Alexandrian's to help the City educate and demonstrate the benefits of electric vehicles and provide information on electric vehicle charging infrastructure. Educate electric vehicle owners who have install charging infrastructure at their residence how to take advantage of Dominion Energy's Smart Metering and Time-of-Use rates, and successor or additional programs, to shift energy use, including charging, to more affordable times of the day.
- Use existing, open-source alternative fuel vehicle and infrastructure models and tools to assist with planning charging stations.
- Assist with developing and maintaining electric vehicle stakeholder lists and organizing meetings community meetings.
- In the context of multifamily buildings, serve as a central contact or ombudsman, working with the building's residents and key decision-makers (such as the building's management or condominium board) to answer questions and support efforts to install charging infrastructure on behalf of tenants. This may include promoting right-to-charge policies or programs where condo or homeowner associations may otherwise limit or restrict tenants from reasonable access to charging within the building of residency or dwelling location, such as right-to-charge statutes in California.
- Perform outreach at workplaces and tourism sites to determine interest in, and capability to, host charging stations for their respective needs. Develop ongoing promotion and guidance materials for City departments engaged in promoting and supporting electric vehicle charging infrastructure, including materials for the Department of Code Administration to provide through the City's Permit Center.

Similar electric vehicle outreach positions exist in many cities across the nation, such as the Energy Corps Electric Vehicle Outreach Coordinator in Helena, Montana, and the Dealership Outreach Coordinator with the State of California.

EQUITY SOLUTION

The Electric Vehicle Navigator can bring greater awareness of electric vehicles and related incentives to underserved communities by devoting a minimum fraction of their time to outreach activities with underserved communities (e.g., 50%). The Greenlining Institute's toolkit (2020) provides potential outreach activities in its "Making EVs practical and accessible" section, such as conducting a Community Mobility Needs Assessment, enabling electric Shared-use Mobility, and providing technical assistance to underserved communities (Greenlining Institute, 2020).

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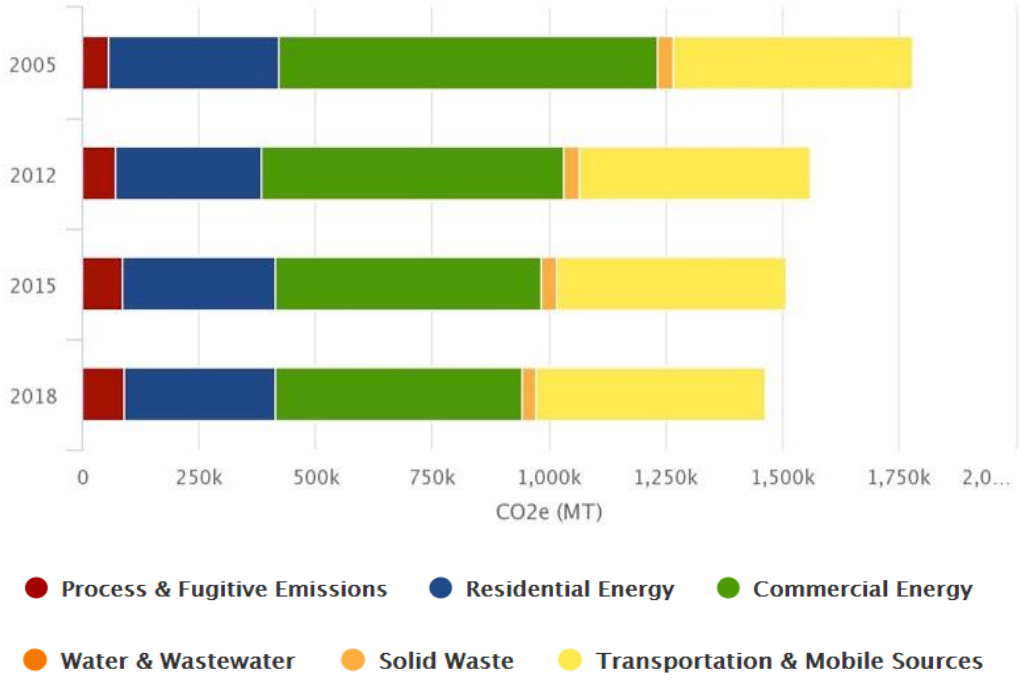
CHAPTER 2. CONTEXT AND HISTORY

Federal, state, utility, and municipal policies have promoted electric vehicles using a diverse mix of programs. Yet, electric vehicles still face barriers to widespread adoption related to affordability, convenience, and awareness. Many of these barriers are expected to subside over time as the market for electric vehicles grows. However, access to charging infrastructure will continue to be a major barrier for years into the future since many households cannot charge a vehicle at home. This chapter provides context and motivation for the EVRS.

Climate Action and Reducing Greenhouse Gas Emissions

Greenhouse gas emissions—primarily carbon dioxide—from transportation account for about 34% of Alexandria's overall greenhouse gas emissions (Figure 9), which contributes to human-induced climate change. In the Washington DC metropolitan area, and Virginia more broadly, transportation accounts for 40% and 48% of greenhouse gas emission, respectively. Electric vehicles serve as one, among many, solutions to reduce greenhouse gas emission even when the electricity used to charge them comes from today's conventional power mix. Importantly, as Dominion Energy shifts its electricity supply towards greater renewable energy generation in coming years, electric vehicles will become even more attractive relative to internal combustion engine vehicles.

Figure 9. Alexandria Greenhouse Gas Inventory



Public Health and Improving Local Air Quality

Transportation from vehicles is not only a significant source of carbon dioxide and greenhouse gas emissions, but the direct tailpipe emissions from internal combustion engine vehicles is also significant

cause of local air pollution. Direct tailpipe pollution from gasoline and diesel vehicles includes not only carbon dioxide, but also nitrogen oxides, particulate matter, hydrocarbons, carbon monoxide, and other compounds that are harmful to human health. This is especially true for vulnerable populations and those with sensitive immune systems who may be more likely to experience severe symptoms of COVID-19. Particulate matter is significantly problematic as it can cause respiratory problems as ultrafine particles can embed themselves deep in the lungs. Various hydrocarbons react with nitrogen dioxide and sunlight to form ground-level ozone. Ground-level ozone can inflame the lungs, cause chest pain, and induce coughing; all which make it difficult to breathe for those with compromised respiratory systems or for children still in development. Moreover, carbon monoxide is particularly dangerous to infants and those suffering from heart disease as it impacts the transport of oxygen in blood.

With no tailpipe emissions, electric vehicles reduce a significant portion of contaminants at the local level and lead to significantly improved local air quality. Expanding the adoption of electric vehicles offers a significant opportunity to improve local air quality and local health outcomes.

Equity

On January 23, 2021, the Alexandria City Council adopted Resolution 2794 to acknowledge racial inequity in the past and present and commit to adopting practices and policies that promote racial and social equity. The resolution advances ALL Alexandria, the City's commitment to pursue equitable outcomes for everyone in the community. The ALL Alexandria commitment centers on race and how it intersects with other areas of inequity. This includes all races, religions, countries of origin, sexual orientations, ages, genders, and abilities. The goal of the resolution is to reduce and eliminate disparities and inequities experienced by all people, especially those in communities of color and other groups who have been historically and systemically marginalized.

The EVRS framework works to reflect the City's ALL Alexandria commitments throughout its analysis and recommendations, including ensuring that race and social equity is incorporated in all planning; recommending implementation considerations and the sustainment of structures and systems to advance race and social equity; finding alignments and recommending implementation of policies designed to advance race and social equity goals; and ensuring accountability mechanisms related to the progression and transparency of work to advance race and social equity.

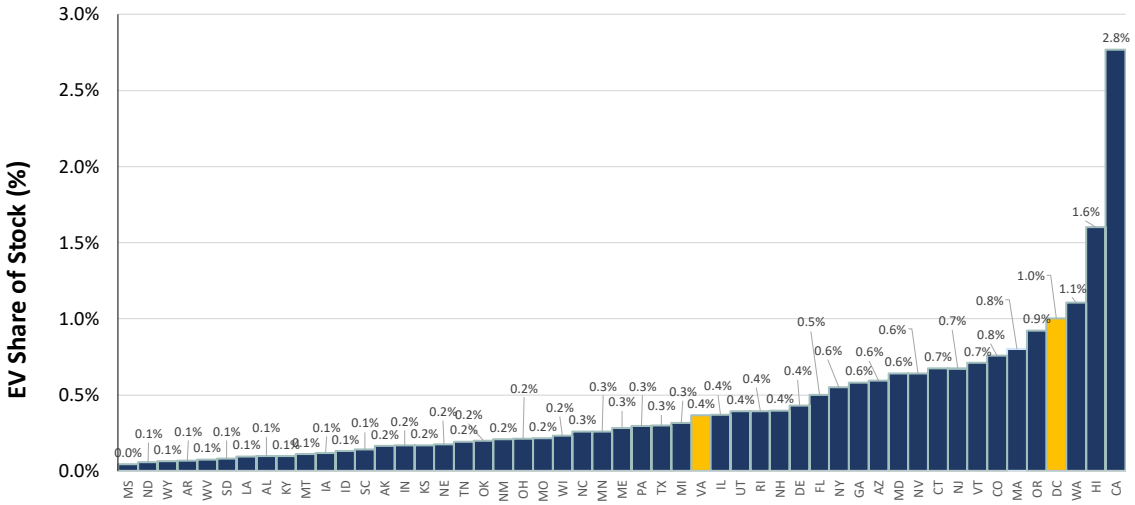
To more fully apply the ALL Alexandria commitments, the City is actively developing a Racial and Social Equity Plan. The plan will develop a racial equity policy that is applied to the prioritization of transportation investments, including transit, road and sidewalk infrastructure, complete streets, etc. Transportation electrification investments, and specifically the locations and availability of publicly accessible electric vehicle charging infrastructure, may prominently feature in such prioritization, especially when publicly funded through any City, state, or electric utility programs.

Comparison with Other Regions

At a statewide-level, the Commonwealth of Virginia has an estimated 25,000 electric vehicle registrations, of which 60% were BEVs and 40% are PHEVs (Atlas, 2019a). As shown in Figure 10, Virginia

ranks twenty-second in the United States in terms of the fraction of its light-duty vehicle stock that is electric vehicles, at 0.4%. The District of Columbia ranks fourth nationally, with 1% of its stock as electric vehicles. In leading electric vehicle markets, such as California and Hawaii, electric vehicles account for more than 1% of the vehicle stock and as much as 10% to 15% of new vehicle sales. Over time, as older internal combustion engine vehicles (ICEVs) are retired, the fraction of electric vehicles in the vehicle stock will certainly rise.

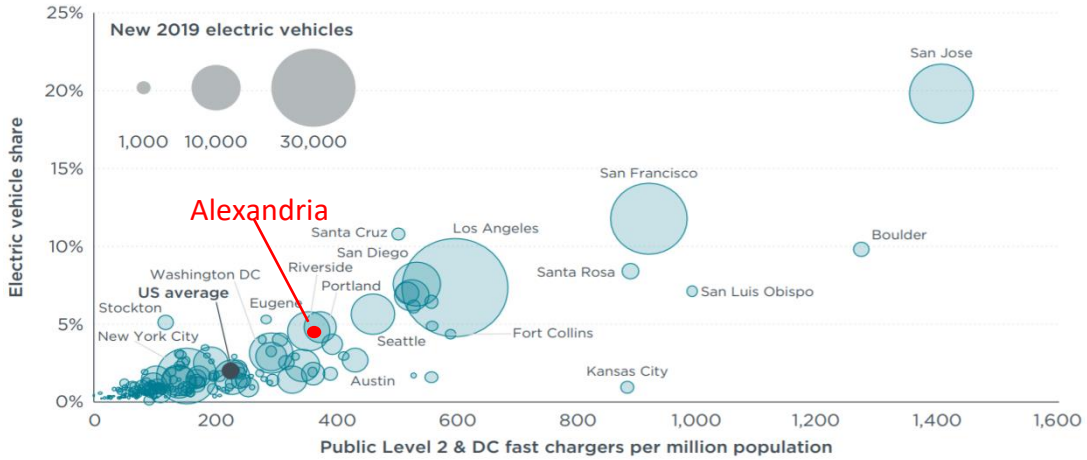
Figure 10. Share of Electric Vehicles Within All Passenger Vehicles



Note: Share of ALL light-duty vehicles that are electric vehicle, by state, in 2020 (i.e., fraction of vehicle stock). Virginia ranks twenty-second in electric vehicles and the District of Columbia ranks fourth.

At the city level, Alexandria has a higher penetration of electric vehicles than the Commonwealth of Virginia. Figure 11 shows how Alexandria compares to major U.S. cities in terms of its share of electric vehicles in new vehicles sales (y-axis) and the number of public Level 2 and DCFC plugs per million people (x-axis).

Figure 11. Electric Vehicle Share and Publicly Accessible Charging Availability for U.S. Cities.

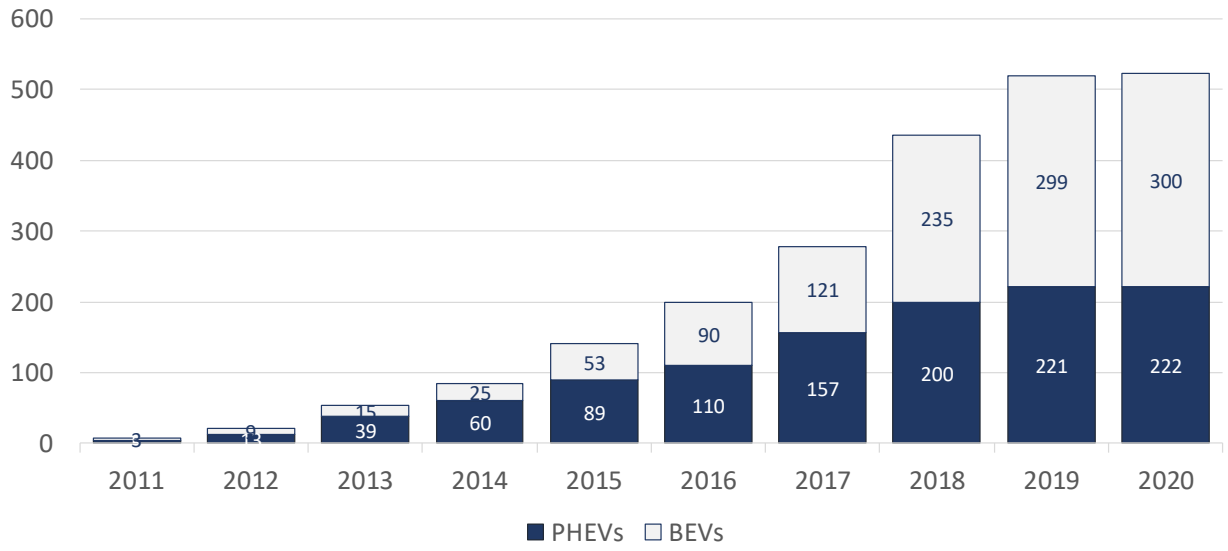


Note: Figure adapted from .

Alexandria exceeds the U.S average on both metrics, with approximately 5% electric vehicle share and 380 Level 2 and DCFC plugs per million people. This figure is adapted from research by the International Council of Clean Transportation, which suggests that San Jose, California has the highest adoption rate of electric vehicles, at over 20% of new vehicle sales. In European countries, such as Norway, electric vehicles account for over 50% of new vehicle sales (adapted from ICCT, 2017).

Figure 12 shows the growth in the cumulative registrations of PHEV and BEVs over time in Alexandria. Cumulative BEV sales outnumber PHEV sales by a small fraction, which is consistent with other regions of the United States (Atlas, 2019a). BEVs have larger batteries than PHEVs, and therefore also have greater charging needs. Historically, shifts in electric vehicle sales follow new electric vehicle model releases. For example, nationwide electric vehicle sales peaked in 2018 with the release of the Tesla Model 3. Several new electric vehicle models are expected in 2021 and 2022 (Electrek, 2020).

Figure 12. Cumulative Electric Vehicle Registrations in Alexandria



Note: Cumulative PHEV and BEV registrations in Alexandria as of April 2020.

Literature on Electric Vehicles and Charging

An abundance of research demonstrates the important role electric vehicles play in meeting long-term climate targets (NASEM, 2021; Williams et al., 2012; USDDPP, 2016)[4]. These studies overwhelmingly show that on-road transportation needs to be nearly entirely electrified by 2050 to reach emission targets aligned with the Paris Climate Agreement (Davis et al. 2018). Because the lifetime of internal

[4] These studies are only a few examples of the vast set of literature that demonstrates the importance of electric vehicles in meeting long-term climate goals.

combustion engine vehicles is typically around 12 to 14 years, the sooner a major transition can begin, the more likely a city like Alexandria can achieve its climate target.

This level of electrification requires a major ramp-up of charging stations. A recent study by the National Academies of Sciences (NASEM) suggests that by 2030, the United States needs approximately 3 million public Level 2 chargers and 120,000 public DCFCs to be on track for meeting deep decarbonization goals (NASEM, 2021). This compares to the roughly 110,000 conventional gasoline stations in the United States.

Rogers' Diffusion of Innovations Theory (Rogers' Theory) is often used to characterize how different segments of the population will adopt electric vehicles (Rogers, 2003; Lee, Hardman, and Tal, 2019). For example, today's early adopters of electric vehicles tend to have a higher income, a higher education, are more likely to be middle-aged, and are more likely to be male (Axsen, Goldberg, and Bailey, 2016). These segments are motivated to adopt an electric vehicle because of a deeply held environmental concerns, interest in technology, or a desire to signal social status (known as conspicuous consumption) (Noel et al. 2017 ;Axsen, Goldberg, and Bailey, 2016).

Rogers' Theory suggests that as Alexandria moves from early adopters of electric vehicles to later adopters, access to at-home charging and reliance on publicly available electric vehicle infrastructure will become increasingly important. In general, these groups are less environmentally orientated, less technology oriented, have a lower income, are less educated, and have lower access to at-home charging (Axsen, Goldberg, and Bailey, 2016). Additionally, these later adoption segments may have a higher preference for PHEVs over BEVs than earlier segments (Axsen, Goldberg, and Bailey, 2016).

Among the various potential roles of municipal governments, coordination of charging infrastructure is arguably the most impactful means to advance electric vehicle ownership. Several studies show that electric vehicle adoption and charging infrastructure availability are strongly correlated (Mersky et al., 2016; Sierzchula et al., 2014; Javid and Neja,t 2017). Narassimhan and Johnson found that charging infrastructure significantly influences per-capita electric vehicle purchases but, as expected, that the impact of charging infrastructure diminishes as the range of BEVs increases (Narassimhan and Johnson, 2018). Similarly, charging infrastructure deployment appears to be most impactful at early stages of electric vehicle deployment when potential drivers need confidence they can refuel at any time.

State and Utility Actions on Electric Vehicles

The Commonwealth of Virginia has taken numerous steps in recent years to support the advancement of electric vehicles and to support the expansion and building of electric vehicle charging infrastructure. Along with the state government's efforts, Virginia's regulated investor-owned, cooperative, and municipal electric utilities have also worked to advance electric vehicle opportunities in the Commonwealth.

In 2010, the Virginia Clean Cities, in partnership with the Rocky Mountain Institute, launched Project Get Ready, a program designed to engage interested stakeholders from across Commonwealth to achieve multiple objectives:

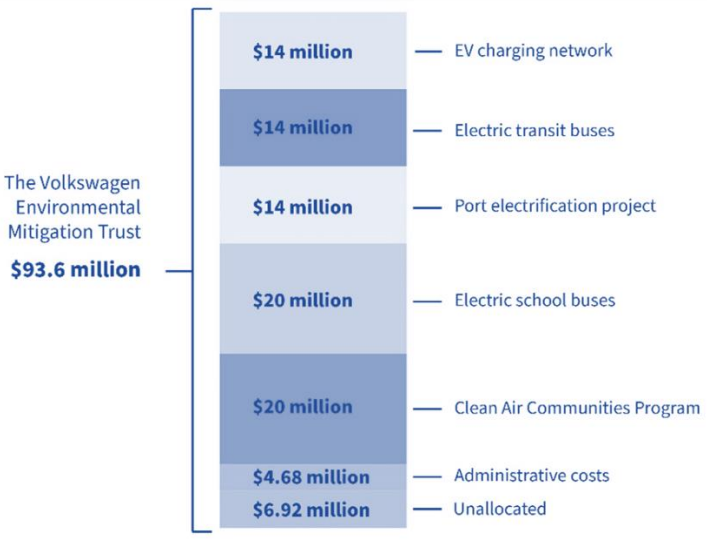
- Detail how to overcome potential barriers associated with the adoption electric vehicles and electric vehicle charging infrastructure
- Outline communication strategies to educate partners and the general public
- Identify existing and potential incentives for advancing electric vehicle ownership
- Outline ways to expand electric vehicle charging infrastructure opportunities

In 2011, Dominion Energy Virginia—the regulated, investor-owned electric utility providing electric distribution, transmission, and generation services to customers in areas of the Commonwealth including the city of Alexandria—introduced two experimental opt-in pilot rate structures for residential customers charging an electric vehicle at their household. While now unavailable for Virginia customers' use, these rate schedules provided one of the first rate opportunities in Virginia to support electric vehicle adoption.

In 2016, as a result of the settlement between the U.S. Department of Justice, Environmental Protection Agency, and Volkswagen, the Commonwealth of Virginia received over $93 million to implement projects and programs to mitigate air pollution from transportation (Figure 13). The Volkswagen Mitigation Trust, administered by the Virginia Department of Environmental Quality, invests these funds in programs and projects to reduce transportation air pollution caused by Volkswagen's alleged violation.

Of the total Virginia Mitigation Trust funding, $14 million is dedicated to support installation of a network of Level 2 and DCFC electric vehicle charging stations in the Commonwealth with focus along highly-trafficked interstate corridors and in metropolitan areas, including areas in Northern Virginia. Additionally, the Volkswagen Mitigation Trust supports spending nearly $20 million for Class 8 local freight trucks, Class 4-7 local freight trucks, Class 4-8 buses, airport ground support equipment, and associated electric vehicle charging infrastructure (DEQ, 2020).

Figure 13. Allocation of Virginia's VW Settlement funding



Source: DEQ 2020

In 2018, as required by the Code of Virginia, the Virginia Department of Mines, Minerals, and Energy developed the comprehensive Commonwealth's 2018 Energy Plan that identifies actions over a 10-year period consistent with the goal of implementing the Commonwealth's Energy Policy, including promoting the use of motor vehicles that utilize alternate fuels and are highly energy efficient (Commonwealth of Virginia 2018a; 2018b). The 2018 Energy Plan acknowledges transportation is the largest end-use energy-consuming sector in Virginia and responsible for a significant majority of Virginia's greenhouse gas emissions. The plan provides three strategic recommendations to advance the adoption of electric vehicles and electric vehicle charging infrastructure in Virginia:

- Adopt the Advanced Clean Cars program to advance low-emission vehicle and ZEV standards.
- Develop a comprehensive Virginia Transportation Electrification Action Plan by 2021 to establish a goal for new electric vehicle charging infrastructure and explore opportunities to accelerate vehicle electrification.
- Establish a Green Fleet program and clean vehicle purchasing standards for state agencies and public fleets across Virginia.

Also in 2018, the Virginia General Assembly passed the expansive Grid Transformation and Security Act (GTSA) to support the investment in renewable energy electricity generation, energy efficiency, and grid modernization by Virginia's regulated, investor-owned electric utilities (Commonwealth of Virginia, 2018c). The GTSA included opportunities for investment in "electrical facilities and infrastructure necessary to support electric vehicle charging systems" as part of overall grid modernization efforts. Subsequently, the State Corporation Commission (SCC) approved Dominion Energy Virginia's implementation of an electric vehicle charging infrastructure program as part of a GTSA investment plan.

In 2020, Virginia experienced the passage of the monumental Virginia Clean Economy Act (VCEA). The VCEA sets the Commonwealth on a path to achieve net-zero carbon emissions economy-wide by 2045 for all sectors including electricity, transportation, building, agricultural, and industrial. While the VCEA's primary focus is to expand the renewable energy electricity generation and decarbonize Virginia's electricity grid, given the transition of transportation to use electricity from the electrical grid as its primary fuel source, there is significant benefit to decarbonizing transportation. For example, according to the Union of Concerned Scientists, electric vehicles charged in Dominion Energy Virginia's service territory have an equivalent greenhouse gas emissions per mile of a gasoline car that obtains an 85 miles-per-gallon fuel economy (UCS, 2020). As the grid continues to decarbonize, this value will likewise improve.

Virginia's 2020 General Assembly session also saw several legislative actions specific to promoting the adoption of electric vehicles and support electric vehicle charging infrastructure operation. First, select state government agencies are now permitted to locate and operate retail, fee-based electric vehicle charging stations at their facilities and lands, thus providing publicly-accessible charging stations opportunities. Second, Virginia Code now prohibits common interest community associations from prohibiting the installation of an electric vehicle charging station within the boundaries of a member's designated parking space, or, in the case of a property owners association, the boundaries of a lot

owner's property. Provisions for installation and removal are also prescribed to support proper charging station installation. In addition, the Virginia Department of Motor Vehicles is permitted to lower registration fees for electric vehicles as an incentive for electric vehicle ownership.

Finally, the Virginia General Assembly established a working group—consisting of staff from the Virginia departments of Mines, Minerals, and Energy; Environmental Quality; Motor Vehicles; and Taxation—to determine the feasibility of implementing a rebate program to support the purchase of electric vehicles. The working group's findings are to be delivered in fall 2020 with a program to become operational, if funded, by the end of 2021.

In spring 2020, as a result of emerging need to consider electric vehicles and electric vehicle charging infrastructure issues in in future proceedings, the SCC established a case proceeding to explore issues related to electric vehicle adoption in a comprehensive manner. The SCC acknowledged that increased adoption of electric vehicles in Virginia has the potential to affect the affordability and reliability of electricity service delivered to consumers by Virginia's regulated utilities (SCC, 2020). In this case, the SCC asked numerous pointed questions on the existing development and projected growth of electric vehicles in Virginia: how rate design can impact electric vehicle adoption and use, how electric vehicles may impact storage-specific issues related to the operation and costs of Virginia's electric grid, and the role of utilities in support publicly-accessible charging station infrastructure. A hearing was held in July 2020 where numerous stakeholders, including the City of Alexandria, provided comments. The SCC's findings and final order are currently pending.

In fall 2020, Dominion Energy Virginia launched the SCIP program to support electric vehicle adoption in Virginia as a result of SCC-approved investments through the GTSA. The SCIP provides rebates for qualifying electric vehicle charging station infrastructure and installation to support charging opportunities in multifamily dwellings, workplace charging applications, publicly accessible DCFC charging opportunities, as well as charging for public transit agencies transitioning to battery-electric buses. The pilot program is limited in scope and funding and will inform opportunities Dominion Energy Virginia may support advancing electric vehicle adoption in the future. Many of Virginia's other regulated, investor-owned, cooperative, and municipal electric utilities are offering programs or projects supporting the adoption of electric vehicles.

There is much ongoing interest in the Commonwealth's advancement of electric vehicles and electric vehicle charging infrastructure given Virginia is a growing opportunity for significant adoption of electric vehicles. For example, the Electrification Coalition—a national, nonprofit electric vehicle advocacy and policy organization supporting the advancement of electric vehicles by working with federal, state, and local governments and stakeholders—launched a State Electric Vehicle Policy Accelerator in five states, including Virginia, to develop a replicable model advancing electric vehicle adoption through policy action bolstered by fleet-scale deployment efforts. This effort began in fall 2020 and aims to develop a statewide electric vehicle policy blueprint for action with Virginia-specific recommendations, a resource toolkit with best practices and cases studies, facilitation of policy bootcamps for educating stakeholders, and support proof of concept efforts to advance innovative policy solutions for advancing electric vehicle adoption.

In 2021, transportation electrification opportunities are a focus of the next steps to advance the Commonwealth of Virginia's clean energy and climate action efforts. Virginia joins 13 other states actively promoting electric vehicles by adopt a clean car standard. This clean car standard requires auto manufacturers to provide more electric vehicles to dealerships by 2025 for sale to interested electric vehicle owners. This clean car standard also includes offering incentives via dealerships to those who purchase an electric vehicle. In addition, the statutorily-required Virginia Energy Plan now requires an analysis of electric vehicle charging and related infrastructure needs to support the Commonwealth's 2045 net-zero carbon target in the transportation sector.

Municipal Plans and Actions on Electric Vehicles

The City of Alexandria has been a long leader in sustainability, as demonstrated as far back as the 1998 Quality of Life Summit. In 2012, the City worked closely with the MWCOG to support the development of the region's first Electric Vehicle Readiness Plan for the metropolitan Washington region (MWCOG, 2012). This plan outlined a framework for establishing regional readiness for the adoption of electric vehicles in the Washington metropolitan area and to promote a consistent set of practices to remove barriers to electric vehicle adoption and infrastructure planning. Such efforts seeks to help ensure that the Washington metropolitan area can collectively experience the health, environmental, and sustainability benefits that electric vehicles offers.

In 2008, Alexandria City Council adopted the Eco-City Charter, the first environmental charter adopted in the Commonwealth of Virginia (City of Alexandria, 2008). The Charter defined Alexandria's commitment to ecological, economic, and social sustainability. The core values and 10 guiding principles of the Eco-City Charter formed the basis for the City's first EAP in 2009. The plan was updated in 2019 in the Environmental Action Plan 2040, which sets a target of a 50% reduction in greenhouse gases by fiscal year 2030 and an 80% to 100% reduction by 2050 (City of Alexandria, 2019). The adoption of electric vehicles and advancement of electric vehicle charging infrastructure features prominently in the EAP 2040's Climate Change, Energy, Transportation, and Air Quality sections, which support goals, targets, and actions to achieve the City's aforementioned greenhouse gas reduction targets.

The City also works closely with regional local governments and organizations to advance electric vehicle and electric vehicle charging infrastructure adoption. For example, while not a direct participant, the City observed and learned from Fairfax County government's initiative to study the effects of widespread electric vehicle adoption on infrastructure requirements and to determine design approaches to be considered in county's zoning processes. The study, produced by the MITRE corporation as a sustainability objective proffer in a development site application, offered the Washington metropolitan area an opportunity to learn more about electric vehicle charging infrastructure in Northern Virginia applications (MITRE, 2011). The Fairfax County Land Development Services' website also provides useful information on permitting related to electric vehicles.

The City also works closely with the U.S. Department of Energy's Clean Cities Coalition program through the Virginia Clean Cities and Greater Washington Clean Cities Coalition organizations to promote electric vehicle policies and adoption in Virginia and Washington DC metropolitan region (Clean Cities, 2020; Virginia Clean Cities, 2020; GWR Clean Cities, 2020). Additionally, the local Council of Governments has held several electric vehicle workshops to inform and advocate for electric vehicles and electric vehicle chargers.

The City of Alexandria has approximately five times the national average sales rate of new electric vehicles.

In December 2020, the MWCOG Board of Director's adopted a 2030 regional Climate and Energy Action Plan with aggressive goals to achieve a 50% reduction in regional greenhouse gas emissions by 2030 (MWCOG, 2020). This 2030 regional Climate and Energy Action Plan includes numerous actions to reduce greenhouse gas emissions across buildings, the electricity grid, waste, tree canopy, and transportation. Considering the reduction of greenhouse gas emissions from transportation, the plan includes actions to expand light-duty vehicle adoption, accelerate electrification of medium- and heavy-duty vehicles and to build out the regional electric vehicle charging network. The plan calls for significantly expanding workplace, publicly accessible Level 2 chargers, and DCFC locations. The plan acknowledges ways the MWCOG can support jurisdictions, including support in adopting EV-ready new construction ordinances or incentives, conducting regional electric vehicle gap analysis to identify most critical gaps in electric vehicle charging network, and advocating for state and federal national incentives for electric vehicle charging deployment and technology advancement. The plan also acknowledges the ways member local governments can support building a regional electric vehicle charging network, such as the following recommended efforts:

- Conducting local electric vehicle planning, including public fleet, transit, and community-scale initiatives
- Requiring new developments to install electric vehicle infrastructure or be EV-ready
- Providing or promoting incentives for electric vehicle infrastructure deployment in communities
- Developing electric vehicle infrastructure plans for community deployment
- Developing electric vehicle infrastructure strategies for the public fleet and for deploying electric vehicle charging infrastructure at public facilities, garages, and refueling facilities
- Forming partnerships with utilities, transit agencies, and electric vehicle infrastructure providers to deploy charging infrastructure in the community
- Implementing innovative pilot initiatives to advance new technologies, including vehicle-to-grid, regenerative power, and solar-powered electric vehicle infrastructure

In addition, the plan emphasizes equity considerations in electric vehicle charging infrastructure planning and implementation, including prioritizing disadvantaged communities to ensure equitable access to charging and the benefits of public health, including reducing gasoline and diesel use where these fuels are the major causes of criteria air pollutants and associated adverse health impacts. Electric vehicles, which release no tailpipe emissions, can help to significantly reduce local air pollution.

Several City plans describe a need for expanding electric vehicle infrastructure. For example, the City's 2018 Smart Mobility Framework Plan calls for implementing an electric vehicle charging station management program (City of Alexandria, 2018). Alexandria's Complete Streets Design Guidelines discuss aspects of electric vehicle charging station design and considerations, such as signage, location, preferred plug type, payment system, and maintenance. The upcoming 2021 Alexandria Mobility Plan recommends the City prioritize electric vehicle charging along the curb and explore charging options at mobility hubs. These guidelines do not discuss the number of chargers needed or specific locations within Alexandria. At a sub-city level, four of Alexandria's neighborhoods outline a vision for electric vehicle charging infrastructure in their Small Area Plans (City of Alexandria, 2020a). Arlandia focuses on increasing PHEVs. The Old Town North and North Potomac Yard Small Area Plans use similar language and describe the need to prioritize electric vehicle charging at residential, commercial, and office parking areas. The North Potomac Yard Environmental Sustainability Master Plan includes specific short-, mid-, and long-term actions for increasing electric vehicle charging opportunities in the North Potomac Yard area.

Electric vehicle readiness is also incorporated into other City documents. For example, the standard conditions for new construction require the following:

- **For single-family dwellings and townhouses having indoor garages.** Developers to provide at least one parking space per dwelling with the necessary infrastructure (240 V and at least 40 amp dedicated conduit and power plug) installed for future Level 2 electric vehicle chargers. (Note: Virginia's Uniform Statewide Building Code requires a single 120 V outlet to be installed in a garage which may offer sufficient charging capability for some electric vehicle drivers who may only need passive, longer-duration charging ("Level 1"). However, other needs may make Level 2 charging capabilities more advantageous.)
- **For multifamily or office where charging stations are required.** Provide Level 2 electric vehicle charger installation for a minimum of 2% of the required parking spaces. An additional 3% of the required parking spaces shall have necessary infrastructure (240 V and at least 40 amp dedicated conduit and power plug) installed for future Level 2 electric vehicle chargers.

In recent years, the City has begun a number of vehicle electrification programs such as electrifying school buses, transit buses, and light-duty fleet vehicles. The fiscal year 2020 budget supports the purchase of only electric or hybrid gas-electric passenger vehicles. The budget also supports the development of a strategy document—this EVRS—to facilitate electric vehicle charging infrastructure for public and private vehicles across Alexandria.

It is clear many of Alexandria's residents are interested in supporting the City's role to advance electric vehicle charging infrastructure, and this EVRS is intended to outline such opportunities. The EVRS

considers the opportunities the City can facilitate to anticipate the electric vehicle charging infrastructure needs of City residents, workforce members, and visitors as electric vehicles become more mainstream, including the following:

- Evaluating projections for current and future electric vehicle charging infrastructure needs
- Recommending locations for publicly accessible charging infrastructure with integration into a broader regional electric vehicle charging infrastructure network
- Recommending charging infrastructure options, including hardware, business ownership, and operation models, interoperability, and operations and maintenance solutions
- Reviewing the City's zoning, building codes, permitting, and inspection codes and development processes and requirements to recommend updated, or new, language to promote and anticipate electric vehicle charging needs
- Recommending policies, approaches, and synergies for locating electric vehicle charging infrastructure at businesses, multifamily dwellings, single-family homes, right-of-way, and other locations

CHAPTER 3. BASICS OF ELECTRIC VEHICLE CHARGING

This chapter is organized into a series of questions that provide basic information about the quickly evolving field of electric vehicles and electric vehicle charging infrastructure.

What are Electric Vehicles?

Both PHEVs and BEVs use electrical energy, stored in batteries in the vehicle, for propulsion via an electric motor. PHEVs can also use gasoline to supplement the electricity, whereas a BEV can only use the electrical energy stored in onboard batteries. Together, this report refers to PHEVs and BEVs as electric vehicles or EVs.[5]

Today's PHEVs have an all-electric range of 20 to 55 miles, which is slowly increasing as battery technology improves. The most common PHEVs in Alexandria include the Ford Engergi, Chevy Volt, and Toyota Prius Prime. BEVs have a range of 80 miles to more than 400 miles, depending on the model. As with PHEVs, the average BEV range has increased over time. The three most common BEVs in Alexandria today are the Tesla Model 3, Tesla Model S, and Nissan Leaf.

BENEFITS OF ELECTRIC VEHICLES

- **Equity and Environmental Justice**. ICEVs produce air pollution through tailpipe emissions, which adversely affects health outcomes. Low- and moderate-income populations are particularly vulnerable to air pollution stressors and often live closer to roadways than people in other communities.
- **Reduced Greenhouse Gas Emissions**. On a life-cycle basis, electric vehicles are superior to ICEVs in Alexandria. For example, according to the Union of Concerned Scientists' online calculator, a Chevrolet Bolt driven in Alexandria emits an estimated 112 grams of carbon dioxide equivalent per mile, while a similarly sized gasoline vehicle emits 381 grams per mile. As renewable electricity generation increases, the benefits of electric vehicles will further increase compared to gasoline and diesel vehicles.
- **Benefits to Electricity Grid**. Widespread transportation electrification increases the use rate of the grid, to the extent that charging can be shifted to off-peak periods. By strategically adding new electric load at the right times (such as when grid use is lowest), electric vehicle adoption in Alexandria can support an increased use of renewable wind energy.
- **Increased Local Fuels**. By transitioning toward greater numbers of electric vehicles, Alexandria can increase its dependence on locally produced fuels (electricity), thereby pushing jobs and economic benefits to its citizens rather than outside the state.
- **Saving Households Money**. Electric vehicles have much lower costs for fuel and maintenance, resulting in hundreds of dollars of savings each year for the average household.

[5] Fuel cell electric vehicles—another type of electric vehicle—use energy stored in hydrogen onboard the vehicle in a fuel cell. Fuel cell electric vehicles are not discussed further in this report.

What is Electric Vehicle Charging Infrastructure?

Charging infrastructure includes both the equipment used to charge electric vehicles as well as the wiring, conduits, substations, and transformers needed to provide electricity supply to the charger. Electric vehicle charging stations are typically either categorized by the power level or by the location type. There are three groups of chargers by power level: Level 1, Level 2, and DCFC stations (also sometimes called Level 3). Classification by location type is typically public, workplace, and home. The greatest amount of information is known about the publicly accessible chargers, which are tracked by data aggregators like the U.S. DOE (DOE, 2020) and Plugshare.com (Plugshare, 2020).

Level 1 chargers include standard 120 V outlets or lamppost connectors with input power levels of 1.3 to 2.4 kW. Though the slowest charging option, Level 1 chargers offer the least expensive costs in terms of installation since no permits or supplemental equipment are typically needed beyond an electrical outlet. Due to the slow charge rate, Level 1 chargers are good for vehicles with long dwell times and relatively low daily mileage, such as for vehicles driven 30 miles or less per day and parked at work for most of the workday and at home at night. Level 1 chargers provide three to five miles per hour of charge.

Level 2 chargers require a 208 V to 240 V electrical circuit (similar to common household clothing dryers) and have a faster charge speed than a Level 1 charger, with input power levels up to 22 kW. Level 2 chargers require an electrical permit and a certified electrician for installation. Level 2 chargers comprise the vast majority of chargers in the United States and in Alexandria. Tesla Level 2 chargers have a unique connector that can only be used by Tesla vehicles.

DCFCs are currently rated at power levels of 50 kW to 350 kW and are the fastest chargers available today. Due to the infrastructure requirements, these are also the most expensive. Only BEV models are currently capable of using DCFCs.[6] Additionally, because of limitations in the battery management system in vehicles, 50 kW is the highest charging power that most vehicles can accept today (except Tesla vehicles, which can charge up to 250 kW). The next generation of electric vehicles in the United States will charge at power levels up to 350 kW. Electrify America and EVgo, both major providers of DCFC stations in the United States, primarily build DCFCs (DOE, 2020). The newest chargers are backward compatible with the older, slower charging vehicles (DCFCs have three different charger connectors). DCFCs provide 200 miles per hour of charge.

[6] The only exception is the PHEV model, Mitsubishi Outlander, which can use a DCFC.

What are Common Locations for Chargers?

Electric vehicle charging infrastructure can be sited in several different types of locations in Alexandria. Each charging typology has a different set of considerations for installation, power level, operations, fees, and equipment type. The bullet list below briefly describes each type that are available for public us or public access.

- **Residential chargers.** Residential chargers can be broadly categorized into chargers at single-family homes (in a garage, carport, or driveway) and chargers at multifamily dwellings (in parking garages or surface lots). Multifamily dwelling chargers can be either shared between multiple residents or dedicated for a single resident.
- **Workplace chargers.** These chargers are located in employee parking lots. Sometimes referred to as at-work chargers, these chargers include commuter park-and-ride lots or daily public parking at transit hubs. Electric vehicle drivers can use workplace charging as a replacement or supplement for residential charging. Workplace chargers are typically owned and operated by the employer and (less commonly) by EVSPs (Botsford, 2018). Level 1 chargers are appropriate when the parking is assigned, and Level 2 chargers work well for parking that is not assigned or where valet service is available. Most electric vehicle drivers will not need a Level 2 charger for an entire workday, and employers should consider ways to ensure turnover of the parking spot during the day to avoid idle charging and to maximize charger use.

  ### MATCHING DWELL TIMES WITH CHARGING SPEED

  Residential parking in single-family homes can use slower chargers since residents typically spend each night at home and can charge the car slowly. Level 1 chargers are appropriate when average daily miles are relatively low (less than 30 miles per day), while Level 2 chargers work well for vehicles with higher daily mileage. For this typology, electric vehicle chargers are typically owned by the household.

- **Publicly accessible chargers.** These chargers include any publicly available or shared-use charging station. Key categories of locations include attractions (like shopping centers, cafes, libraries, and parks), public right-of-way, interstate off ramps, and community charging hubs. Commercial parking areas can vary widely in the amount of time that cars sit dormant. Level 1 chargers are typically not appropriate for publicly accessible chargers unless a site has a long (e.g., 8 hours or more) dwell time. Best practice is to network these chargers, as they may be accessed by many unique users (see next section). Further, DCFC can be installed in parking areas that are publicly owned and publicly available (such as park-and-ride lots, public library parking lots, and on-street parking) or that are privately owned but publicly available (such as shopping center parking lots and commercial office parking garages). Commercial sites that are a good fit for DCFCs are areas where people spend 20 to 30 minutes, such as grocery stores, pharmacies, and convenience stores. Sites that are a good fit for Level 2 chargers are areas

where people spend around one to four hours, such as movie theaters, libraries, museums, and sit-down restaurants.

What are Networked or Smart Stations?

Charging stations can be smart, where they are networked with a connection to a central backend system via wireless internet, or they may not be networked, where they are not connected to an IT system. All levels of chargers can be networked. Depending on the business model being used, networked chargers also typically require an ongoing monthly, per session, or annual networking fee to the user, site host, or both. The levels of communication available for a networked charger can include communication with the site host, utility grid, internet, and user.

Charging stations usually connect to a network by cellular, ethernet, or Wi-Fi. Garages can have network connection complications, and repeaters may need to be installed to ensure communication capabilities. Networked chargers can communicate between and connect the following:

- Electric vehicle to parking space
- Electric vehicle to charging station
- User to payment network
- Charging station to site host
- User to vehicle

A high degree of information can be provided to the user via smart phone, radio-frequency identification tag, or computer. Many networked chargers use an application on a smartphone, though there is not one common platform for electric vehicle charging at this time.

What Types of Connectors are Used at Charging Stations?

Table 7 was developed by the U.S. DOE and shows the types of connectors associated with each charger level. Most chargers and electric vehicles use a standard SAE J1772 connector and inlet that is compatible with Level 1 and Level 2 chargers. The standardization of cords and connectors is an ongoing issue for DCFC. The combined charging system connector is used by American- and European-made electric vehicles. The CHAdeMO connector is used by Japanese- and Korean-made electric vehicles. Tesla superchargers are only capable of charging Tesla vehicles. However, Tesla vehicles are capable of charging at CHAdeMO connectors (but require a $450 adapter).

The National Electric Code states that cords can be no longer than 25 feet, unless equipped with a retraction or other control device. However, best practice is to design charging stations with no more than three to five feet of cord distance from the vehicle to the charging station. This prevents cords from interfering with pedestrian routes and creating a tripping hazard.

Table 7. Summary of Charger Types

Charger Type	Maximum Charging Power	Charging Rate	Connector Name
AC Level 1	1.9 kW AC power, 120 V up to 16 A	2 to 5 miles of range per hour	J1772
AC Level 2	19.2 kW AC power 208 V or 240 V at up to 80 A	10 to 20 miles of range per hour	J1772
DC Level 1	80 kW DC power 50 to 1,000 V up to 80A	60 to 80 miles of range in 20 minutes	J1772 Combo
DC Level 2	400 kW DC power 50 to 1,000 V at up to 400 A	Up to 200 miles of range in 20 minutes	J1772 Combo
CHAdeMO v2.0	400 kW DC power 120 to 1,000 V, up to 400 A	60 to 80 miles of range in 20 minutes	CHAdeMO
Tesla	250 kW DC power	Up to 75 miles of range in 5 minutes	Tesla

Who Develops and Operates Public Electric Vehicle Charging Stations?

Several possible entities can own, manage, and operate publicly accessible charging stations, as described below.

Landowner or site host. Residential chargers are usually owned by the homeowner or building owner, while employers typically own workplace chargers. The landowner of a publicly-accessible charger can vary, and may be the government, a business, or a private resident. If the City is the landowner, it can provide the land free or for lease. The City can use its leverage to require a certain standard of infrastructure, to set maximum pricing or use certain pricing models, to share or make public usage data, to include city branding, or to implement specific design requirements. The City should require a high-quality station design, smart charging capability, and the sharing of usage data. Under a leasing agreement, the City should not require the charge point operator to pay for the parking spaces, but only for the land where the charger sits.

CHARGING-AS-A-SERVICE

Some EVSPs—such as Chargepoint, SemaConnect, and Greenlots—provide charging-as-a-service. This service is designed for property owners who want a turnkey solution to charging, including at a workplace, apartment, or new development. Charging as a service offers flexibility to commercial property owners, allowing them to pay for charging from their operating costs rather than capital budgets.

Equipment owner: The equipment owner typically oversees equipment installation. Residential chargers are typically owned by the homeowner or building owner. Workplace chargers are typically owned by the business or employer. Publicly accessible chargers are owned by private citizens, businesses, municipal governments, utilities, or EVSPs such as Electrify America or Tesla.

Station plaza operator: The City may operate the charging infrastructure itself, though this is uncommon.

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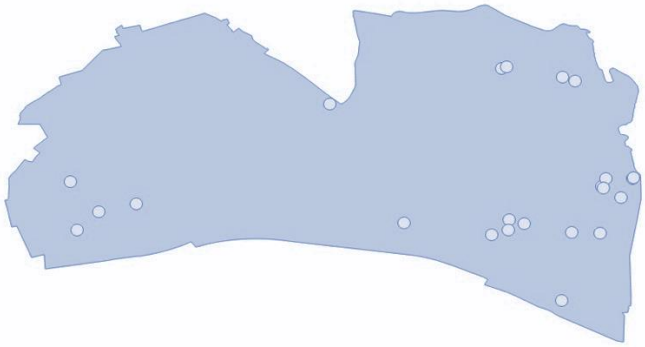
CHAPTER 4. CURRENT AND FUTURE CHARGING NEEDS

This chapter provides context on Alexandria's charger deployment and describes charging needs in the future. It first describes the City's existing electric vehicle charging infrastructure and housing stock, and then provides three scenarios for charging deployment to the year 2050.

Charging Infrastructure

There are 23 sites within Alexandria that have shared electric vehicle charging stations and a total of 64 plugs in the city. Shared charging includes publicly accessible chargers and shared, restricted access chargers. Level 2 plugs account for all but one of these 64 plugs (there is a single DCFC plug). As shown in Figure 14, shared charging stations are concentrated in a few key locations of the city, such as in Old Town. Table 8 below provides summary information about all the stations. The most common location for a station is at multifamily dwelling (such as an apartment or condominium).

Figure 14. Map of Shared EV Charging Stations in Alexandria



Note: These include both publicly available and restricted access plugs.

Of the 64 shared plugs in Alexandria, only 24 are truly publicly accessible, while 40 are restricted to residents of a multifamily dwelling, customers of a store, or patrons of a hotel. Tesla is the most common electric vehicle service provider for publicly accessible stations in Alexandria, offering charging at several hotels in Old Town. Charging is free at 15 of the stations and pricing varies at the other stations and can be based on time or electricity usage. The fees are determined by the station owner or the EVSP. Pricing at some of the stations is the same as the generic price of nonelectric vehicle parking for the lot, typically in increments of an hour.

Table 8. Summary of 23 Publicly Accessible Charging Sites in Alexandria (as of August 2020)

Location Type	Access	EV Network	ZIP	Level 2 Plugs	DCFC Plugs	Station Pricing
Auto dealership	24 hours daily	ChargePoint Network	22304	2	0	Free
	24 hours daily	ChargePoint Network	22304	1	0	Charging fee
	24 hours daily	ChargePoint Network	22314	2	0	Charging fee
	Open to public during business hours	Non-Networked	22304	3	1	Free

Location Type	Access	EV Network	ZIP	Level 2 Plugs	DCFC Plugs	Station Pricing
Grocery store	24 hours daily	Non-Networked	23301	5	0	Free
	24 hours daily	SemaCharge Network	22305	1	0	Free
	Open to public during business hours	Volta	22302	2	0	Free
Hotel	Restricted to hotel customers	Tesla Destination	22314	2	0	Free
		Tesla Destination	22314	2	0	Free
		Tesla Destination	22314	5	0	Free
		Tesla Destination	22314	2	0	Free
		Tesla Destination	22314	3	0	Free
		Tesla Destination	22314	3	0	Free
Multifamily dwelling	Restricted to residents	Blink Network	22303	1	0	Charging fee
		ChargePoint Network	22305	2	0	Charging fee
		ChargePoint Network	22314	4	0	Charging fee
		SemaCharge Network	22304	4	0	Charging fee
		SemaCharge Network	22314	1	0	Charging fee
		SemaCharge Network	22314	1	0	Free
		SemaCharge Network	22314	9	0	Free
Public parking	24 hours daily	ChargePoint Network	22314	2	0	Free
		ChargePoint Network	22314	2	0	Charging fee
		SemaCharge Network	22315	4	0	Free

In addition to the 64 plugs noted above, Alexandria also has workplace and residential charging sites. There is no way of knowing the exact number of workplace or residential chargers in Alexandria since these chargers are not publicly reported.

Influence of Housing Stock

Across the United States, the vast majority of charging among early electric vehicle owners occurs at home with a Level 1 or (more often) Level 2 plug (per the U.S. DOE "Charging at Home" website). One of the largest surveys on electric vehicle charging behavior was conducted in California. It showed that 83% of 2,831 electric vehicle owners primarily charge their vehicle at home (ICCT January 2019). At the same time, the survey also showed that well over 50% of electric vehicle drivers in multifamily dwellings—such as an apartment or condominium—rely primarily on publicly accessible charging.

A community's housing stock can be a barrier to greater electric vehicle ownership. According to the 2017 American Housing Survey, 47% of homes in the Washington DC metropolitan area are single-family houses with access to a garage or carport, compared to 57% nationally (U.S. Census Bureau 2020b). The other 53% of homes in the Washington DC metropolitan area are either multifamily dwellings or single-family detached homes without a driveway. Multifamily charging faces the additional challenge of determining who should install and maintain the charger (CEC 2019). Multifamily dwellings can be inhabited by renters who may be reluctant to invest in a charging station because they do not own the

unit or the parking spot. Similarly, the building owner might be reluctant to invest in a charging station for their tenants because of the perception that charging does not add rental value.

Table 9 is an analysis of the 2014-2019 American Community Survey for the City of Alexandria, which shows the fraction of residents by building type and household income category. The data shows that 49% of residents live in single-family homes and 51% live in multifamily dwellings. Higher income households are much more likely to be in single-family homes.

Table 9. Alexandria Housing Stock by Income Category

Income Range	Single-Family Homes	Multifamily Dwelling
<$50,000	5%	20%
$50,000-$100,000	7%	17%
$100,000-$150,000	6%	14%
$150,000+	31%	0.1%
Total	49%	51%

An additional unique aspect of Alexandria's housing stock is the lack of driveways and garages in detached homes. Many areas in Alexandria have limited off-street parking for residents due to the dense and old vintage housing stock or other space restrictions. This means that—unlike in most other jurisdictions—residents sometimes lack the ability to install electric vehicle chargers at their home.

Scenarios of Future Electric Vehicle Ownership

This report uses three scenarios, outlined in Table 10, to describe potential trajectories of future electric vehicle growth in Alexandria. The objective in developing these scenarios is to bound potential electric vehicle adoption within Alexandria to better understand future charging infrastructure needs and to facilitate effective planning.

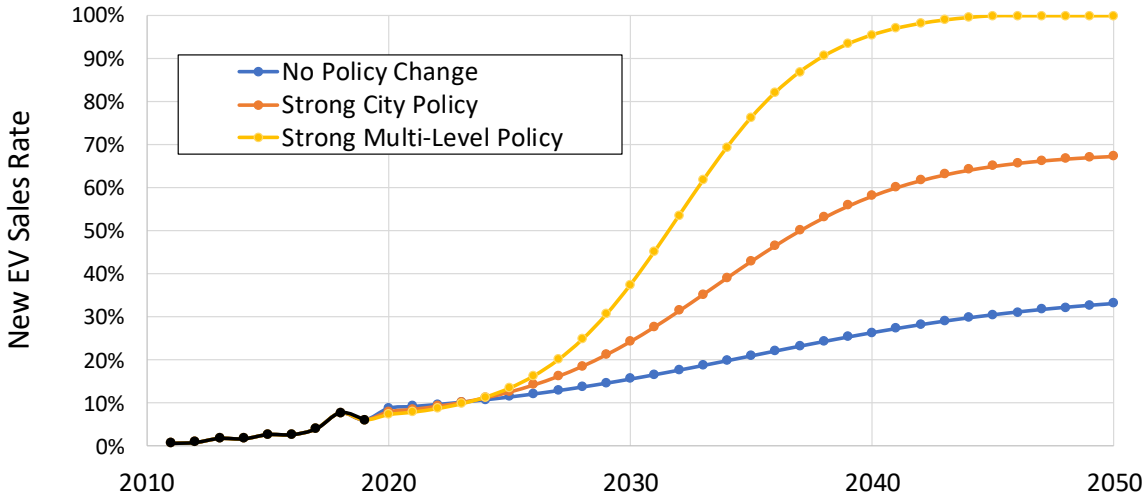
Table 10. Description of Three Electric Vehicle Trajectory Scenarios

Scenario	Description	Why Scenario is Feasible
No Policy Change	Growth in electric vehicle adoption continues at historical rates.	Battery costs continue to decline and vehicles are nearing cost parity with ICEVs, suggesting that electric vehicle adoption will continue on its own, even without policy intervention.
Strong City Policy	The City implements a strong set of policies to support adoption of electric vehicles.	As witnessed in other cities, a strong role by municipal governments can impact electric vehicle ownership. The extent of the impact is highly uncertain.
Strong Multilevel Policy	In addition to the City, federal and state governments are deeply involved in incentivizing electric vehicle adoption.	A strong environmental policy by all levels of government and by utilities could result in high levels of electric vehicle adoption.

Figure 15 shows the rate of electric vehicle sales among new vehicle sales under the three scenarios. The curves were designed to align with prior modeling work in other geographies (Williams et al. 2012).

Note that new vehicle sales share is used for the y-axis rather than share of vehicle stock because it is the most widely reported and widely understood metric for electric vehicle adoption rates. Note that all calculations below assume the number of light-duty vehicles in Alexandria stays constant over time (even as the share of electric vehicles increases). Additionally, the vehicle miles traveled in Alexandria stay constant over time.

Figure 15. Three Possible Pathways for Electric Vehicle Adoption



Future Charging Needs

Several organizations have created models to estimate the number of chargers needed in future years. The most widely used models today are the EVI-Pro and EVI-Pro Lite tools developed by the National Renewable Energy Laboratory in collaboration with the California Energy Commission (U.S. DOE n.d.). These tools use detailed data on personal vehicle travel patterns, electric vehicle attributes, and charging station characteristics in bottom-up simulations to estimate the quantity and type of charging infrastructure necessary to support regional adoption of electric vehicles. These models have served as the basis for several recent analyses, including a national infrastructure analysis (U.S. DOE 2017) and a state-level planning analyses for California (CEC 2018). EVI-Pro Lite was used for Alexandria's analysis below.

Other models assess other aspects of charging infrastructure, including workplace charging and the relative gap in necessary charging to support electric vehicle market growth. The University of California–Davis (2015) created the GIS Infrastructure Planning Toolbox to estimate the market distribution of electric vehicles and site workplace and fast charging in California at a highly spatially resolved level. The Red Line/Blue Line model created by the Electric Power Research Institute (2014) calculates the number and locations of public and workplace charging stations to enable additional electric vehicle miles traveled. Electrify America (2020) identifies a supply-demand gap based on a driver behavior analysis in a metropolitan area.

Although uncertainty remains about the ratio of vehicles to chargers that will ultimately support the expected electric vehicle population in Alexandria, estimates are needed to most efficiently allocate City resources and ensure partnerships and planning. Below, this document quantifies the amount of charging infrastructure required to serve the growing Alexandria electric vehicle market at a local level through 2050.

Methodology

The three adoption scenarios outlined in Figure 15 were used to estimate the number of residential, workplace, and publicly accessible chargers, as well as the cumulative cost of the chargers and the electricity load from electric vehicles using those chargers. The number of residential Level 1 and Level 2 chargers is determined by an equation:

$$Res_{j,y} = EV_y * L * H$$

Where:

- $Res_{j,y}$ = The number of residential chargers of Level *j* in year *y.* Level *j* can be either Level 1 or Level 2 chargers.
- EV_y = The electric vehicle population in year *y* in Alexandria (taken from Figure 15).
- L = The fraction of residential chargers that are either Level 1 or Level 2. The default value for *L* is set at 33% for Level 1 chargers and 67% for Level 2 chargers.
- H = The number of owner-occupied households that have access to a garage or carport per vehicle in Alexandria, as determined using the American Housing Survey (U.S. Census Bureau 2020b). A simplifying assumption is that Alexandria has the same ratio of housing stock with a garage or carport as the entire Washington DC area, by housing type (renter versus owner occupied, detached versus multifamily; U.S. Census Bureau 2020a).

The number of workplace Level 2 chargers, public Level 2 chargers, and DCFCs were estimated using EVI-Pro Lite. Because Alexandria is not listed in the EVI-Pro default database, this study used the Washington DC metropolitan area as a proxy. For each charger type—residential Level 1, residential Level 2, workplace Level 2, public Level 2, and DCFC—this study developed curves to show the relationship between electric vehicle population and number of chargers.

The energy consumption (in kilowatt-hours) for each charger type was estimated using a set of assumptions outlined in Table 11. The bottom row of each section in the table gives the calculated daily kilowatt-hours based on these assumptions. All other values in Table 11 are averages consistent with measured data of charging stations (U.S. DOE 2018). Residential chargers have constant daily energy consumption whereas publicly accessible and workplace chargers increase in daily energy consumption over time as station utilization increases in the future. Actual charging use may vary depending on a number of factors not considered in this analysis. Note that all values shown in the table are from the perspective of a single charger and are multiplied by the number of chargers to estimate an aggregate

energy consumption from all light-duty vehicles in Alexandria (see section below *Future Electricity Load from Electric Vehicles*).

Table 11. Assumptions and Calculated Daily Energy Consumption (kWh), by Charger Type and Year

Charger Type	Energy Consumption by Year				
Residential Level 2 Charger Use Inputs	**2015**	**2020**	**2030**	**2040**	**2050**
Annual Growth Rate Sessions/Day	0%				
Sessions Per Day (#)	1	1	1	1	1
Average Charging Power (kW)	5	5	5	5	5
Time of Sessions (hrs.)	3.5	3.5	3.5	3.5	3.5
Daily Energy Consumption (kWh)	17.5	17.5	17.5	17.5	17.5
Residential Level 1 Charger Use Inputs	**2015**	**2020**	**2030**	**2040**	**2050**
Annual Growth Rate Sessions/Day	0%				
Sessions Per Day (#)	1	1	1	1	1
Average Charging Power (kW)	1.9	1.9	1.9	1.9	1.9
Time of Sessions (hrs.)	8	8	8	8	8
Daily Energy Consumption (kWh)	15.2	15.2	15.2	15.2	15.2
Workplace Level 2 Charger Use Inputs	**2015**	**2020**	**2030**	**2040**	**2050**
Annual Growth Rate Sessions/Day	2%				
Sessions Per Day (#)	1.2	1.3	1.6	1.9	2.2
Average Charging Power (kW)	5	5	5	5	5
Time of Sessions (hrs.)	4	4	4	4	4
Daily Energy Consumption (kWh)	24.0	26.2	31.4	37.5	44.8
Public Level 2 Charger Use Inputs	**2015**	**2020**	**2030**	**2040**	**2050**
Annual Growth Rate Sessions/Day	2%				
Sessions Per Day (#)	4	4.4	5.4	6.6	8.0
Average Charging Power (kW)	5	5	5	5	5
Time of Sessions (hrs.)	2	2	2	2	2
Daily Energy Consumption (kWh)	40.0	44.2	53.8	65.6	80.0
Public DCFC Use Inputs	**2015**	**2020**	**2030**	**2040**	**2050**
Annual Growth Rate Sessions/Day	11%				
Annual Growth in Average Power	5%				
Annual Reduction in Time of Session	-3%				
First Year Sessions Per Day (#)	6	10.1	28.7	81.5	231.4
Average Charging Power (kW)	45	63.3	103.3	143.3	183.3
Time of Sessions (hrs.)	0.25	0.21	0.16	0.12	0.09
Daily Energy Consumption (kWh)	67.5	137.3	469.2	1,363.2	3,651.3

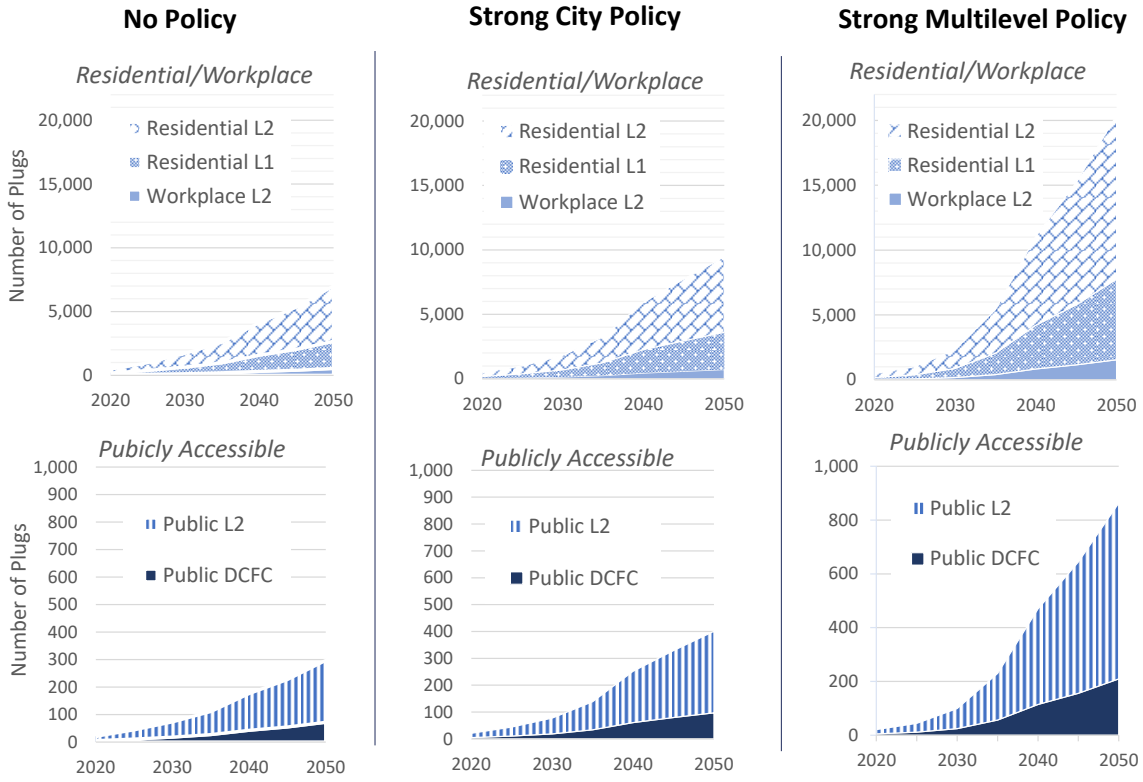
Note that several factors about expected future shifts in charging behavior and charging technology were incorporated into the assumptions in Table 11:

- **More public and workplace charging.** As electric vehicle adopters shift from innovators to early adopters to early majorities, the share of electric vehicle owners who charge at home will likely decline and the share of electric vehicle owners who charge at public and workplace chargers will increase.
- **Greater station usage.** The number of electric vehicles supported by each charger is anticipated to increase as electric vehicle drivers grow accustomed to stations. ICCT (2019) estimates that by 2025, public Level 2 chargers will be used 35% more than in 2020 and DCFCs will be used 65% more.
- **Larger stations.** There are 2.7 plugs per publicly accessible station on average in Alexandria (see Table 8). As electric vehicle adoption grows, charging stations will likely get larger. This trend is already evident in leading U.S. cities. For example, in San Jose—the U.S. city with the highest electric vehicle sales share—the estimate is 6 plugs per station, more than twice that of Alexandria. In California as a whole, there are 3.9 plugs per station.
- **Faster charging.** The majority of current DCFCs are rated at a power output of 50 kW. This is the maximum power level accepted by the majority of electric vehicles. In the future, charging speeds are expected to increase. Electrify America, one of the largest charging station providers in the country, is building stations rated up to 350 kW.

Results: Charging Gap in Alexandria

Figure 16 shows the estimated charging needs in Alexandria for the three adoption scenarios from today until 2050. The majority of future chargers are expected to be residential Level 2, and to a lesser extent residential Level 1. Workplace Level 2 chargers comprise the next largest group, followed by public Level 2 and finally DCFCs, which are not visible in the figure due to the scale. Numerical values from Figure 16 are shown in a table in Appendix E.

Figure 16. Needed Number of Plugs to Support Electric Vehicles in Three Scenarios



Note: See Appendix E for numerical values in graph.

This gap analysis provides several insights:

- **Charging gap today**. This study suggests a need for 16 public Level 2 and five public DCFC chargers based on today's electric vehicle population. As noted earlier in this chapter, Alexandria currently has 24 publicly accessible chargers (23 Level 2 plugs and one DCFC plug). Thus, Alexandria has a comfortable number of public Level 2 but fewer DCFC plugs than needed.
- **Gap in 2025**. By 2025, Alexandria needs approximately 33 public Level 2 plugs and 11 DCFC plugs (i.e., the City should add 9 additional Level 2 plugs and 10 DCFC plugs). This suggests a need to focus on the deployment of Level 2 and DCFC chargers as a near-term objective.
- **Residential charging priority.** Electric vehicle owners have and will likely continue to prefer to charge at home. As shown in Figure 16, residential charging infrastructure is the most important type of infrastructure across all scenarios. This result is driven partly by assumptions used in this study and partly by the housing stock within Alexandria. For some who have a dedicated garage or a driveway attached to their home where a standard 120 V outlet already exists, already have access to Level 1 charging. Moreover, Virginia's Uniform Statewide Building Code requires a single 120 V outlet to be installed in any new single-family or townhomes which an attached garage which may offer sufficient Level 1 charging. As such, for those residences without access

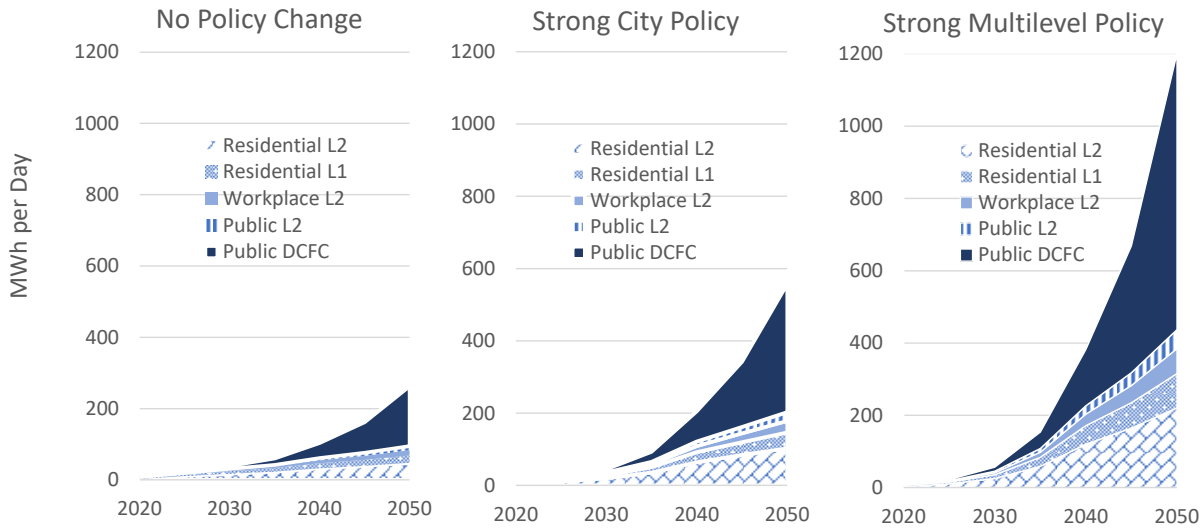
to a standard 120 V outlet for Level 1 charging or electric vehicle drivers with Level 2 charging needs may be the focus for prioritizing residential charging needs.

- **Gap in 2050.** In the long-term, the need for publicly accessible charging in Alexandria is estimated to be between 225 to 650 public Level 2 chargers and 75 to 210 DCFC chargers.

Future Electricity Load from Electric Vehicles

Figure 17 presents estimates of the power consumption, by charger type, for the additional electricity needed to charge electric vehicles in the future. These estimates are in addition to existing community loads for other services such as buildings and industry (not shown). The figure uses assumptions shown above in Table 11. Also, the Alexandria's Mobility Plan and EAP 2040 promote reduction in vehicle mode share over time, which could reduce electric vehicle charging demand.

Figure 17. Estimated Power Consumption Per Day (MWh), by Scenario and Charger Type



The figure provides two key insights. First, although DCFCs are the rarest plug type now and projected into the future, they also provide the greatest power consumption. This finding is driven by the fact that DCFC stations supply power at much higher levels than Level 1 or Level 2 stations. The rated power level of DCFC stations is expected to increase substantially in the future above the 50 kW of most plugs today. Additionally, station use of DCFC plugs (the number of electric vehicles served per day) is currently higher than for most other plug types and is expected to grow much faster in the future. Second, the estimated overall level of electricity needed to serve electric vehicles in Alexandria. At the high end in the Strong Multilevel Policy scenario, the City could need an additional 1,200 MWh per day just for its light-duty electric vehicle population. This estimated increase in power consumption is consistent with projections established for transportation electrification increases across the United States as a whole through as modeled through the National Renewable Energy Laboratory's (NREL) (2017) Electrification Futures Study findings. If this load were left unmanaged and consumed evenly throughout the day, the City would need, at minimum, an estimated additional ~50 MW of power (1,200 MWh per day/24 hours per day).

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CHAPTER 5. COMMUNITY PERSPECTIVES ON CHARGING

This chapter summarizes results of two public engagement surveys performed to gauge community perspectives on electric vehicle charging infrastructure.

Methodology

Two public engagement surveys were administered to community members in Alexandria in May and July 2020, respectively. The first (Survey #1) was a brief survey to help set priorities for the project team and to gain directional insights about how community members thought about charging infrastructure. The second (Survey #2) was a more detailed survey aimed at eliciting specific ideas about where to locate chargers within Alexandria. For both surveys, an invitation to participate in the survey was sent to a stakeholder email list and posted on the City's website. In total, 32 individuals responded to the first survey and 74 individuals responded to the second survey. Questions in both surveys were a mix of multiple choice and open text format. Survey respondents remained anonymous.

Key questions of interest from Survey #1 and Survey #2 are shown in Table 12 and Table 13, respectively. The full survey questions and responses for Survey #1 are in Appendix A. The full survey questions and responses for Survey #2 are in Appendix B.

Table 12. Key Survey Questions in Survey #1

Abridged Question
What are your goals and vision for the Electric Vehicle Charging Infrastructure Readiness Strategy plan?
What types of locations should be the highest priority for future electric vehicle charging infrastructure in Alexandria?
What are the unique barriers for Alexandria with regards to installing electric vehicle charging infrastructure?
Who are the right stakeholders to engage and provide further input on electric vehicle charging infrastructure in Alexandria?

Table 13. Key Survey Questions in Survey #2

Abridged Question
On a map of Alexandria, place a pin on your desired charging location. Briefly describe your primary rationale for selecting this location.
Suppose the City of Alexandria or a partner has limited funding to spend on publicly accessible electric vehicle charging stations. Where should that money be spent? Briefly describe the rationale for your answer.
Assume you drive an electric vehicle in two years. Other than your home or workplace, what is your preferred location to charge the vehicle?
Please provide any additional thoughts on how the city can accelerate publicly accessible charging infrastructure and the adoption of electric vehicles.

Survey Results

As noted, Survey #1 was used to set priorities in the project. Figure 18 shows a word cloud that summarizes responses to the question on goals and vision. As shown, several respondents were interested in topics such as Old Town charging, on-street charging, and multifamily building charging. Using these responses, the project team honed questions in the more detailed Survey #2. Note both surveys were not representative samples of the Alexandria population.

Figure 18. Word Cloud of Survey Responses: Vision for EVRS

Survey Question: What are your goals and vision for the Electric Vehicle Charging Infrastructure Readiness Strategy plan?

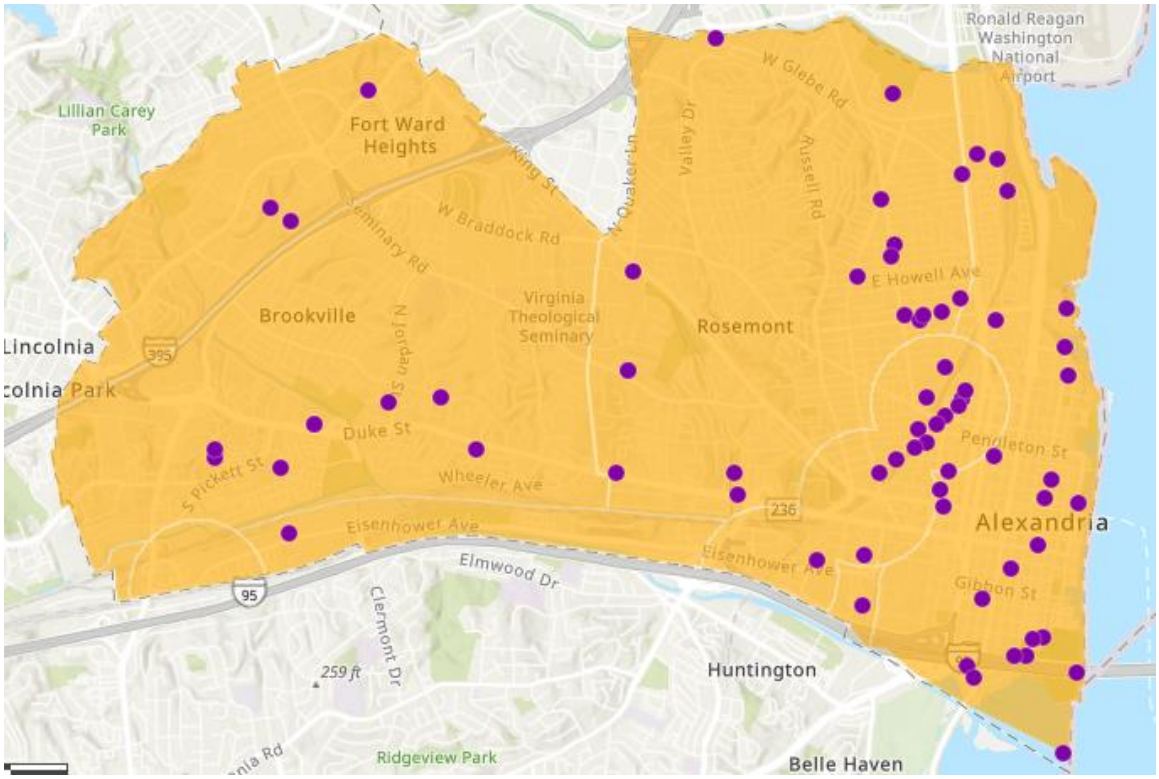
For Survey #2, responses were disaggregated by several other categorical variables. Table 14 provides summary statistics of Survey #2 respondents. As shown, survey respondents were not a representative sample of residents in Alexandria. For example, 100% of respondents currently own a car. To avoid privacy concerns and to maximize the response rate, the survey did not ask socio-economic questions. These descriptive qualities are used below to segment responses and generate useful insights.

Table 14. Results of Descriptive Questions

Category	Summary
Neighborhood location	96% of respondents live in Alexandria. The most common neighborhood location is Old Town (22%). See Appendix B for a breakdown of other responses.
Type of home	70% live in a detached home and 30% live in an apartment or condominium.
Home ownership	86% own, 11% rent, and 3% declined to answer.
Parking type	39% use on-street parking, 23% have a driveway at a detached home, 14% have a garage at a detached home, 13% park under the building, and 11% park in a detached parking area.
Current electric vehicle ownership	34% currently own an electric vehicle and 66% do not.
Future electric vehicle ownership	81% plan to own an electric vehicle in the next five years and 19% do not.
Car ownership	100% own a car.
Typical miles driven per weekday (pre-COVID-19)	46% drive less than 10 miles per day and 54% drive more than 10 miles per day. See Appendix B for a breakdown of responses.
Primary workplace location	62% work outside Alexandria and 38% work in the city limits.

Figure 19 shows results of the first locational question. Preferred charging locations are relatively evenly distributed throughout the city and align with population density.

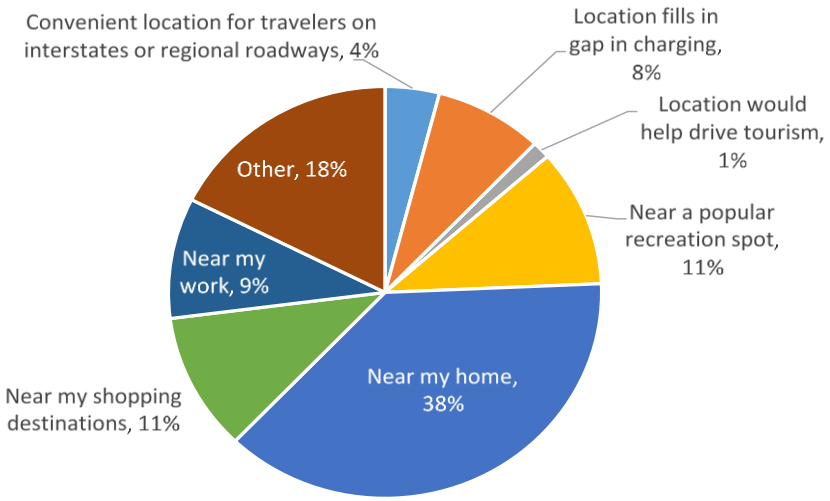
Figure 19. Survey Results for Desired Charging Locations



Survey Question: Place a pin on desired charging location and a brief description of primary rationale for selecting that location.

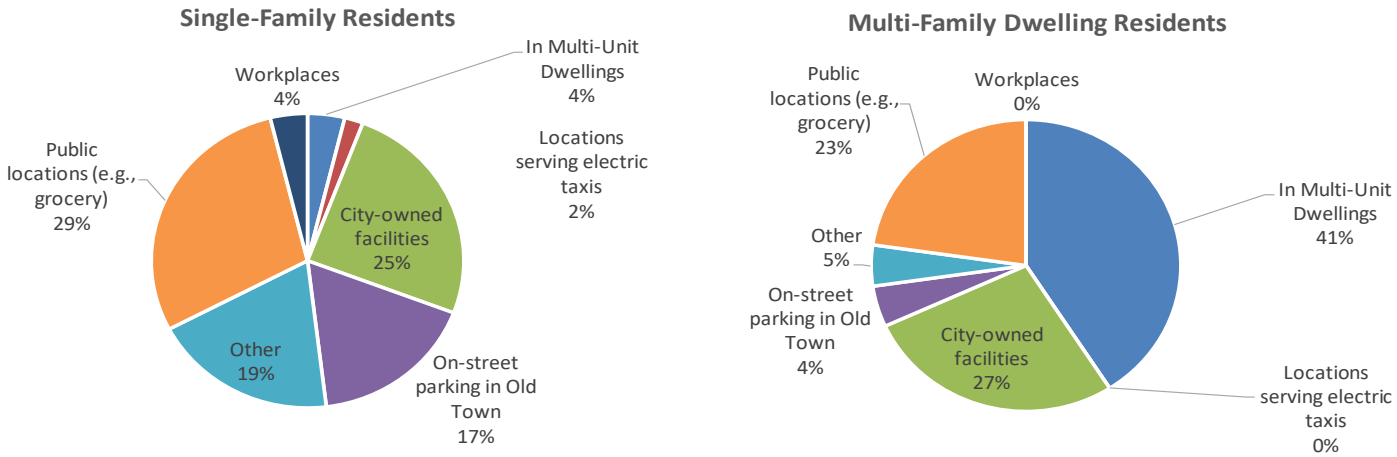
Respondents were asked for the rationale for choosing a given location. These results are shown in Figure 20. Of any location, respondents were most interested in placing publicly accessible charging near their home (38%). This fraction was much higher for individuals who live in a multifamily dwelling (55%) compared to a detached home (30%). Similarly, the fraction who prefer chargers near their home is much higher for respondents who use on-street parking (59%) than for those who park in a driveway or garage of a detached home (6%).

Figure 20. Why Respondents Chose Charging Location



Some additional survey questions asked respondents about preferred charging locations. Respondents were asked, supposing the City or a partner has limited funding to spend on publicly accessible electric vehicle charging infrastructure, where that money should be spent. Figure 21 shows responses segmented by people who live in single-family homes (n=52) versus multifamily dwellings (n=22). As shown, responses differed substantially by the respondents' type of housing.

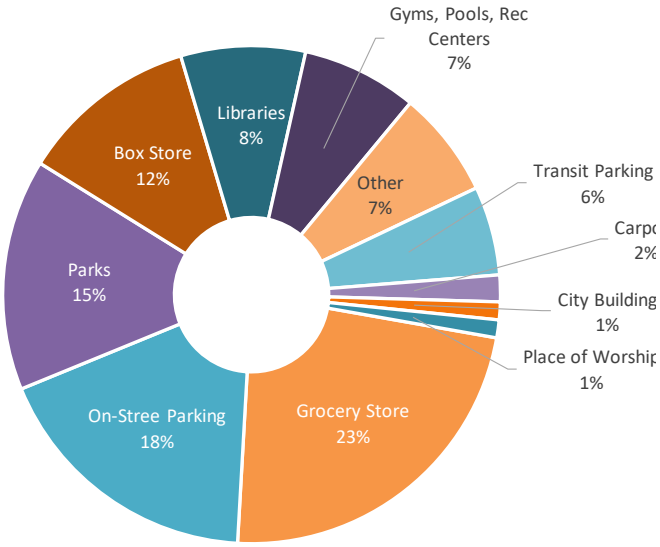
Figure 21. Survey Results: Where to Spend Money on Chargers



As shown in Figure 21, 17% of respondents in single-family homes want charging at on-street parking in Old Town, compared to only 4% of those in multifamily dwellings. Unsurprisingly, only 4% of respondents who live in a single-family home want charging in a multifamily dwelling, compared to 41% of multifamily dwelling respondents. Only a single respondent wanted charging at workplaces. This is somewhat surprising since most experts consider workplace charging as the second most important location (after residential charging; Hardman et al. 2017). The most consensus across responses is to locate chargers at public locations such as grocery stores.

Another question pertaining to station location asked respondents to **select up to three preferred locations for charging other than home.** This question was unique in requiring respondents to choose public locations. The results shown in Figure 22 reflect all choices selected by respondents. The locations of greatest interest coincide with those above, although percentages differ. Clear favorites included grocery stores (23%), on-street parking (18%), and parks (15%). Surprisingly, only 6% of respondents favored locating charging at transit stations. This fraction will likely increase as electric vehicle adoption moves from early adopters to the early majorities and late majorities segments.

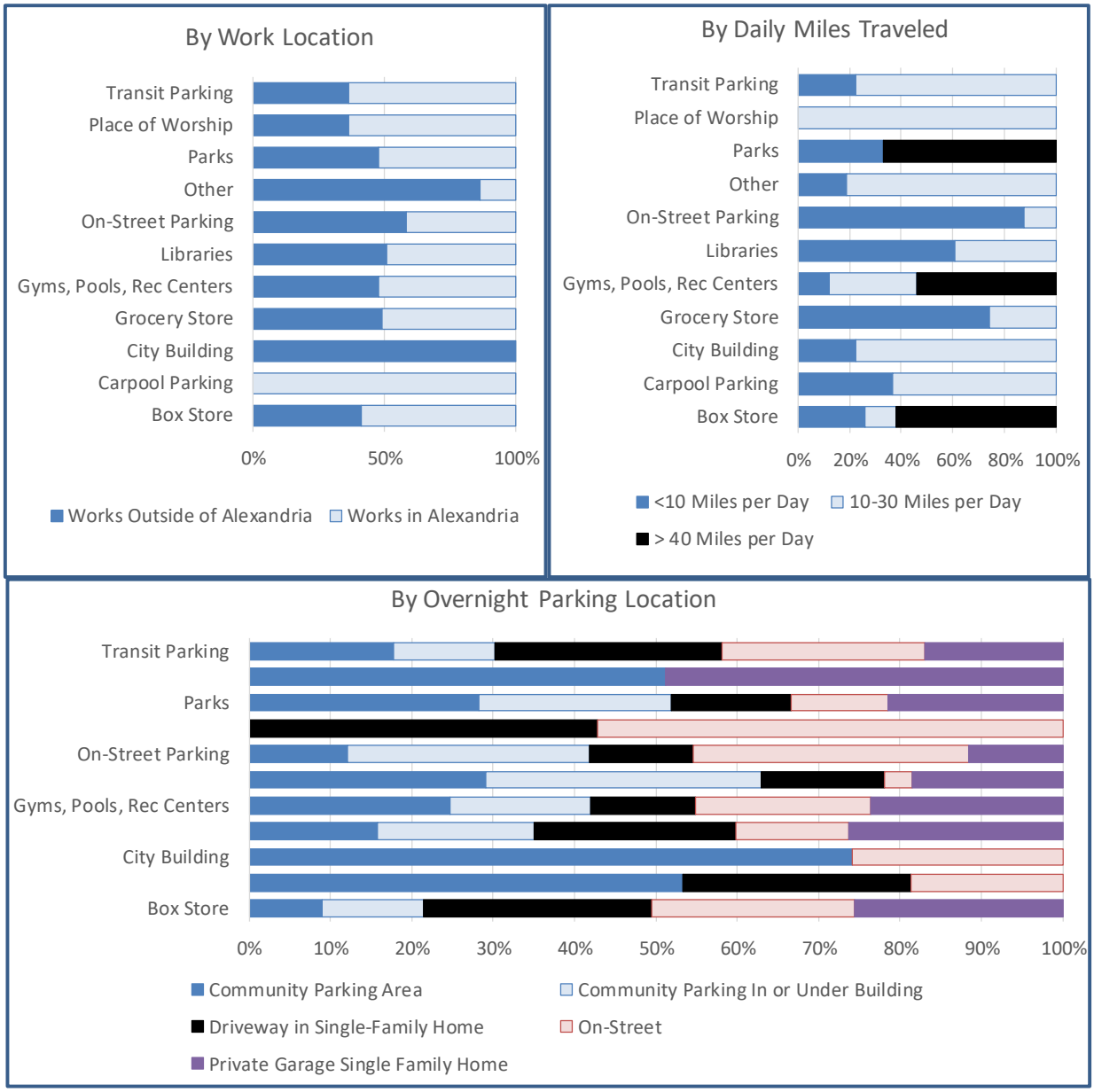
Figure 22. Preferred Charging Location Other than Home.



This study also segmented this locational question by those living in **single-family homes versus multifamily dwellings**; compared to the questions above, there was a much greater consistency between respondents from single-family homes and those from multifamily dwellings.

Figure 23 shows responses to the locational question broken out by three other questions related to **work location, daily miles traveled during an average weekday, and overnight parking location**. Note that because of the relatively small sample size (74 responses), these figures should be interpreted with caution.

Figure 23. Survey Results: Preferred Charging Station Location



Note: Responses are disaggregated by three segments.

CHAPTER 6. PRIORITY CHARGING LOCATIONS

To better understand areas of Alexandria with the highest need for publicly accessible chargers, this chapter uses a spatial analysis, which combines several factors into a single, weighted score. When paired with responses to the public engagement surveys in the previous chapter, this analysis helps elucidate priority charging locations.

Methodology

This study identified six factors that drive the need for public electric vehicle charging: (1) density of apartments and condominiums, (2) density of renters, (3) density of car commuters, (4) density of early adopters, (5) density of existing electric vehicle charger access, and (6) density of single-family housing with no access to a driveway or alley for overnight parking. Table 15 shows the rationale for each factor. As indicated in the call-out box to the right, similar factors were used to locate electric vehicle charging infrastructure in other jurisdictions. As annotated in Table 15, block group-level data on each factor was collected from U.S. Census data, real estate parcels provided by the City, zoning codes from the City's Open Data Hub, and the U.S. DOE's Alternative Fuel Data Center. Next, these data were weighted and compiled into four composite score options. The composite scoring system results in a unique weight for each block group that represents the charging need, as shown in the four composite score maps in Figure 24.

CITIES THAT USED A SIMILAR EV SCORING PROCESS

- San Antonio, TX
- Contra Costa County, CA
- Somerville, MA
- Berkeley, CA

Table 15. Weights and Rationales to Develop Four Composite Score Maps.

Density Factor	Rationale for Factor	Most Weighted Factor			All Weighted Equally
		Multi-family Dwellings	No Off-Street Parking	Charger Access	
Multifamily Dwellings [a]	Residents of multifamily dwellings have less access to at-home charging. These "garage orphans" are a relatively large segment of potential electric vehicle adopters who are locked out of the market.	50%	10%	10%	17%
Renters [a]	As with garage orphans, renters are less likely to have access to at-home charging than owners.	10%	10%	10%	17%
Car Commuters [a]	Areas with more car commuters have a higher need for charging than areas with a lower density of car commuters.	10%	10%	10%	17%
Early Adopters [a]	Electric vehicle chargers should be located in areas with more electric vehicles to help ensure charger use.	10%	10%	10%	17%
Existing Electric Vehicle Charger Access [b]	Areas with low publicly-accessible charging access should be higher scoring than areas with high charging access.	10%	10%	50%	17%
Homes with No Off-Street Parking Access [c]	Areas of single-family homes with low driveway or alley access should be higher scoring than areas of single-family homes with high driveway or alley access.	10%	50%	10%	17%

[a] U.S. Census Bureau 2020c

[b] U.S. DOE Station Locator

[c] City of Alexandria 2020

Results

Figure 24 shows six maps that display each individual factor. Colors are grouped into five shades using the Jenks natural breaks classification method (ESRI 2020), with the highest scoring 20% of block groups shown as the darkest shade and the lowest scoring 20% of block groups shown as the lightest shade.

Figure 24. Maps Showing Individual Factors that Build Up to Four Composite Score Options

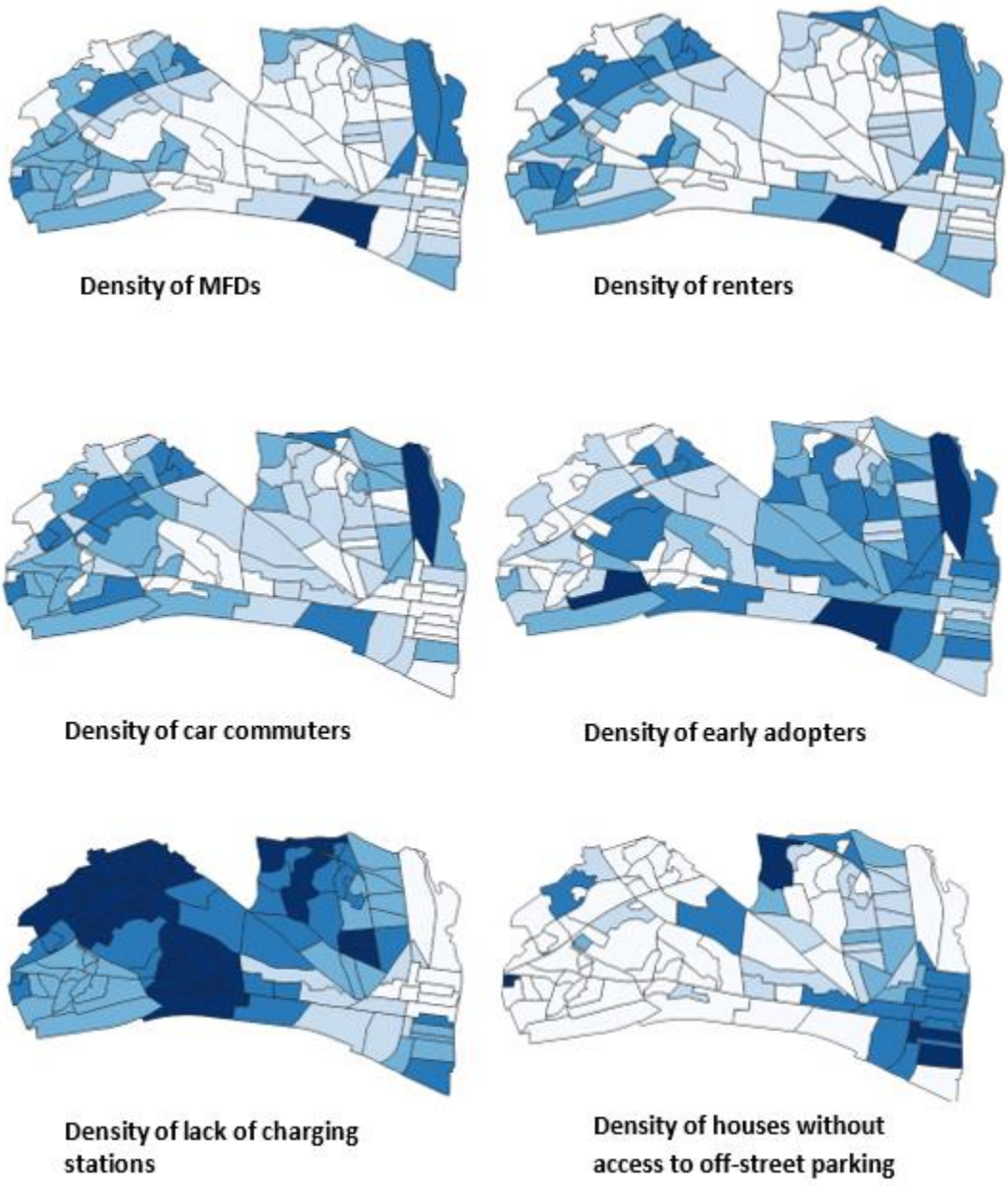
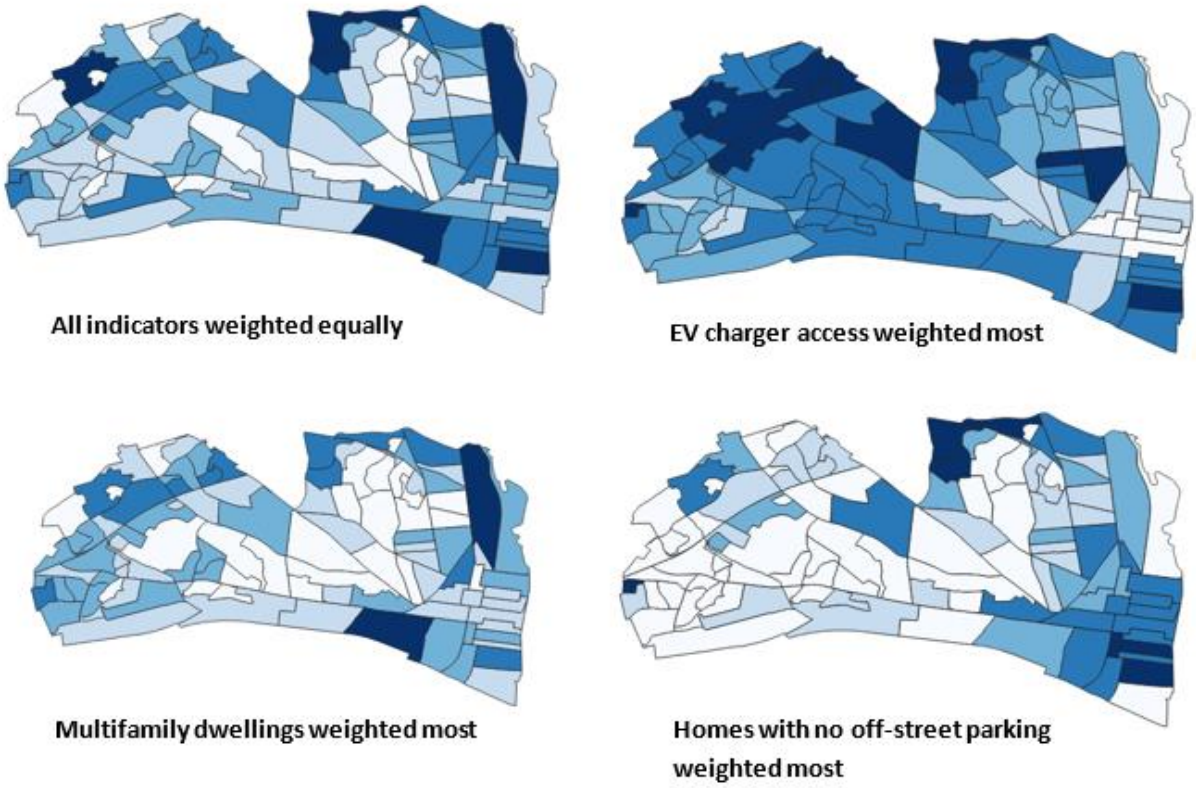


Figure 25 shows four composite score maps. These composite scores were developed for each block group after summing the six factors: they enable the City to choose which factor it considers most important to determine block groups of highest priority for electric vehicle charging infrastructure. The four maps below reveal that a handful of block groups appear consistently higher-ranking across weighting scenarios. These block groups could be good candidates for identifying Alexandria's greatest electric vehicle charging infrastructure needs.

Figure 25. Composite Electric Vehicle Charging Prioritization for Alexandria



Notes: These four maps depict four composite scores. All factors (shown in Figure 25) were normalized to 0 and 1 and multiplied by the weights in Table 15. Finally, the weighted scores were summed and normalized again to obtain the composite score. Darker shaded block groups indicate higher need for public electric vehicle charging. Lighter block groups indicate lower need for public electric vehicle charging.

Example of Using Heat Maps

This study identified 240 specific locations (with addresses) in Alexandria that could potentially be considered for public electric vehicle charging infrastructure. These potential locations were determined through expert judgement by the project team, and include grocery stores, farmer's markets, box stores, shopping centers, pharmacies, a movie theater, parks, recreation centers, nature centers, pools, places of worship, public schools, tourist attractions, post offices, and parking garages. See Figure 26 below for these possible sites of interest. These sites are not necessarily where electric vehicle charging stations are needed or will be built, but they offer some options for consideration. While visually there appear to be more sites in the southeast section of Alexandria than in other areas, this is a reflection of the density of certain types of attractions that are listed above.

Red points indicate sites of interest in Alexandria that could be considered for electric vehicle charging infrastructure. This does not imply that one area of the city will receive closer consideration for electric vehicle infrastructure than any other. In fact, there is an opportunity to install larger stations with more plugs on the west end of Alexandria. Additionally, Alexandria will work to ensure the distribution of electric vehicle charging infrastructure is as equitable as possible throughout the city, including to prioritize equity and access for low- to moderate- income and underserved residents of Alexandria. These maps can be updated using indices that prioritize equity, such as the Climate Vulnerability Index or Social Vulnerability Index. See Appendix F for the sites of interest by block group in Alexandria. Note that each row of the table in Appendix F represents one site, so there may be multiple rows of sites for each block group.

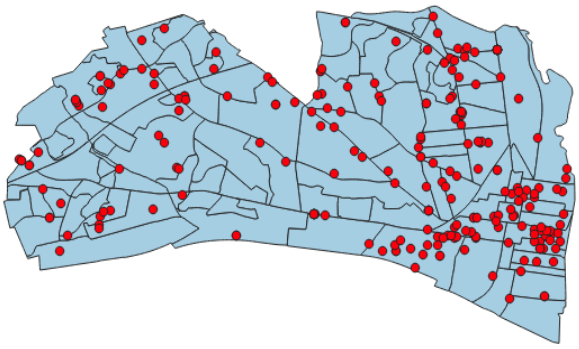
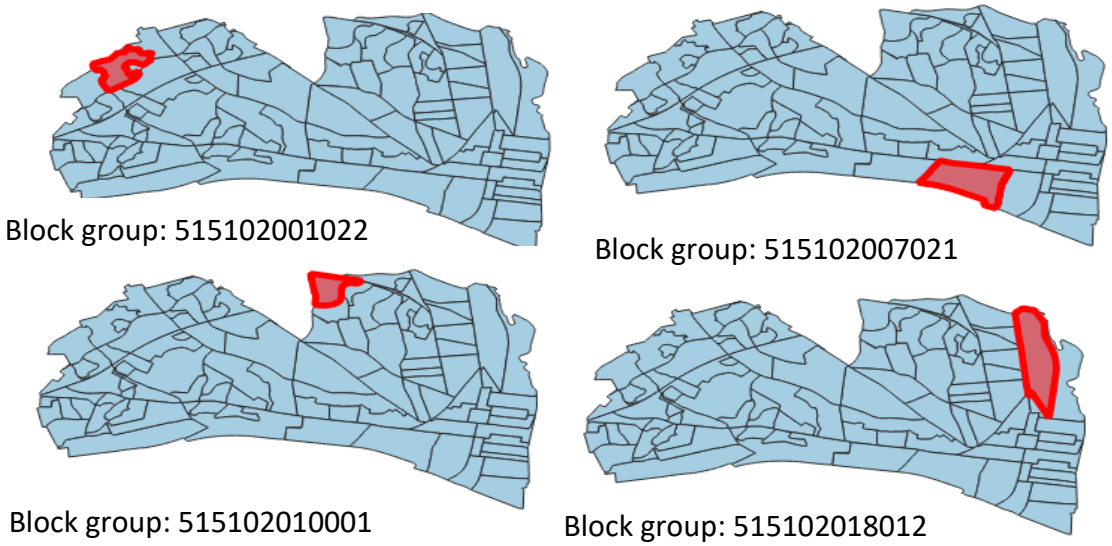


Figure 26. Charging Sites of Interest

When considering optimal locations for future electric vehicle charging infrastructure, the City may wish to consult the four composite score maps above and compare block groups that consistently rank higher with the sites of interest identified in Appendix F. Figure 27 shows an example of the way that Alexandria could identify four block groups that consistently rank high across the composite maps in Figure 25.

Figure 27. Four Highest-Ranking Block Groups in Alexandria



These block groups emerged as the highest ranking when the composite scores were examined side by side. Note that these four block groups are among several block groups that could be good candidates for electric vehicle charging infrastructure selection.

Using four example block groups and the sites of interest within those block groups, the City can identify locations that may be of interest to the public and optimal for siting electric vehicle charging infrastructure. In an example of selecting top block groups and sites of interest within those, as identified in Figure 27 and Table 16, public input from EVRS survey was also incorporated into a selection of top 10 sites (Table 16). Public input in the survey responses identified City-owned and public facility locations as most desirable for electric vehicle charging infrastructure. The survey responses indicated that the Potomac Yard shopping center was of interest to some respondents. City planners can use this method of site selection to identify high-priority block groups and site locations, while also incorporating input from the public.

Table 16. Example of Top 10 Potential Sites of Interest in the Top Four Scoring Block Groups

Category	Type of Location	Street Address
Grocery Store	Whole Foods	1700 Duke Street, Alexandria, VA 22314
Shopping Center	Hoffman Town Center	Eisenhower Avenue, Alexandria, VA 22331
Shopping Center	Potomac Yard Center	3671 Richmond Hwy, Alexandria, VA 22305
Pharmacy	CVS Pharmacy	2441 Eisenhower Avenue, Alexandria, VA 22331
Public School	Charles Barrett Elementary School	1115 Martha Custis Drive, Alexandria, VA 22302
Park	Potomac Yard Park	2501 Potomac Avenue, Alexandria, VA 22305
Nature Center	Jerome “Buddie” Ford Nature Center	5750 Sanger Avenue, Alexandria, VA 22311
Recreation Center	The Mark Center Pavilion	5708 Merton Court, Alexandria, VA 22311
Public School	John Adams Elementary School	5651 Rayburn Avenue, Alexandria, VA 22311
Public School	William Ramsay Elementary School	5700 Sanger Avenue, Alexandria, VA 22311

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APPENDIX A. SURVEY #1: DETAILED QUESTIONS AND RESULTS FROM FIRST PUBLIC ENGAGEMENT SURVEY

Figure 28 through Figure 31 present word clouds that summarize responses to the first public engagement survey.

Figure 28. Goals and Vision for the EVRS

Survey Question: What are your goals and vision for the Electric Vehicle Charging Infrastructure Readiness Strategy plan?

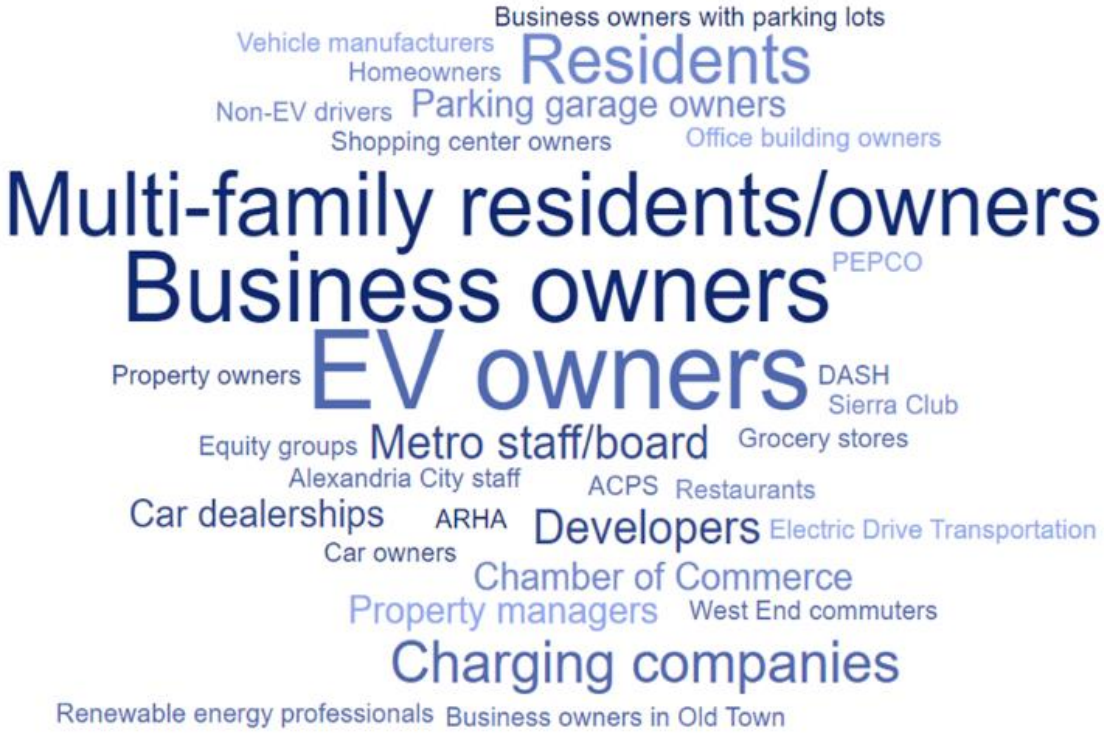
Figure 29. Priority Locations for EV Charging Infrastructure

Survey Question: What types of locations should be the highest priority for future electric vehicle charging infrastructure in Alexandria?

Figure 30. Barriers to Installing EV Charging Infrastructure

Survey Question: What are the unique barriers for Alexandria with regards to installing electric vehicle charging infrastructure?

Figure 31. The Right Stakeholders to Provide Input on Charging Infrastructure



Survey Question: Who are the right stakeholders to engage and provide further input on electric vehicle charging infrastructure in Alexandria?

APPENDIX B. SURVEY #2: DETAILED QUESTIONS AND RESULTS FROM SECOND PUBLIC ENGAGEMENT SURVEY

Alexandria administered a second EVRS public engagement survey to gauge community perspectives on electric vehicle charging infrastructure needs in the city. The survey was administered in July 2020.

Table 17 shows the specific questions and answer options used in the Alexandria public engagement survey.

Table 17. Questions and Options for Responses from Public Engagement Survey

Number	Question
1	The heat map of the city below shows areas identified as high priority (dark shades) and low priority (light shades) for new, publicly accessible electric vehicle charging stations. This map was developed using a scoring system that combines multiple factors into a single score for each area. Use your mouse to select a location on the map with your ideal location for a future charging station. Because we are searching for sites for publicly accessible electric vehicle chargers, please do not select a home residence that already has easy access to an electric outlet (such as a home with a garage).
2	Briefly describe your primary rationale for selecting this location. 1. Near my home 2. Near my shopping destinations 3. Near my work 4. Near a popular recreation spot 5. Convenient location for travelers on interstates or regional roadways 6. Location fills in gap in charging network 7. Location would help drive tourism 8. Other (open text)
3	Where in the City of Alexandria do you live? 1. Alexandria West 2. Arlandria 3. Carlyle 4. Del Ray 5. Eisenhower-East 6. Landmark 7. Old Town 8. Old Town North 9. Potomac Yard 10. Lynhaven 11. North Ridge 12. Rosemont 13. West End 14. Other Alexandria neighborhood 15. I do not live in Alexandria
4	Do you live in an apartment building or multi-unit condominium unit? 1. Yes 2. No

Number	Question
5	Do you own or rent your residence? 1. Own 2. Rent 3. Decline to specify 4. Other (please specify)
6	Which of the following best describes the type of parking available at your residence? 1. Private garage at a single-family home 2. Driveway at a single-family home 3. Community parking area in or under the building 4. Community parking area detached from residence 5. On-street parking
7	The City of Alexandria is interested in supporting publicly accessible charging for residents who cannot currently charge at home in a garage or driveway. Suppose the City of Alexandria or a partner has limited funding to spend on publicly accessible electric vehicle charging stations. Where should that money be spent? 1. City facilities (including recreation centers, libraries, and parks) 2. On-street parking in Old Town 3. Workplaces 4. Public locations (such as grocery store) 5. Apartments and condominiums 6. At locations that serve electric taxis or electric ride-hailing services (such as Uber) 7. Other (open text)
8	Briefly describe the rationale for your previous answer.
9	Do you own an electric vehicle? 1. Yes 2. No
10	Do you plan to own an electric vehicle in the next five years? 1. Yes 2. No
11	Do you own a car or are you considering purchasing a car? 1. Yes 2. No
12	Prior to COVID-19, about how many miles did you drive on a typical weekday (one day between Monday and Friday)? 1. Less than 10 miles per day 2. 11 to 20 miles per day 3. 21 to 30 miles per day 4. 31 to 40 miles per day 5. More than 40 miles per day 6. Not applicable

Number	Question
13	Assume you drive an electric vehicle two years from now. Other than your home or workplace, what is your preferred location to charge the vehicle? (select top three choices) 1. Parks 2. Libraries 3. On-street parking spot 4. Transit parking lot 5. Carpool parking 6. Grocery store 7. Box store (such as Walmart or Best Buy) 8. City building 9. Gyms, pool, recreation centers 10. Place of worship 11. Other (open text)
14	Is your workplace located within the City of Alexandria? 1. Yes 2. No
15	Please provide any additional thoughts on how the city can accelerate publicly accessible charging infrastructure and adoption of electric vehicles.

Figure 32 shows the results from Question 1 of the EVRS survey. This question asked respondents to add a pin on the "ideal location for a future charging station." The question asked respondence not to select a home residence. Most respondents indicated sites in the eastern or southern sections of the city, with some clusters in downtown Alexandria.

Figure 32. What is the Ideal Location for a Future Charging Station?

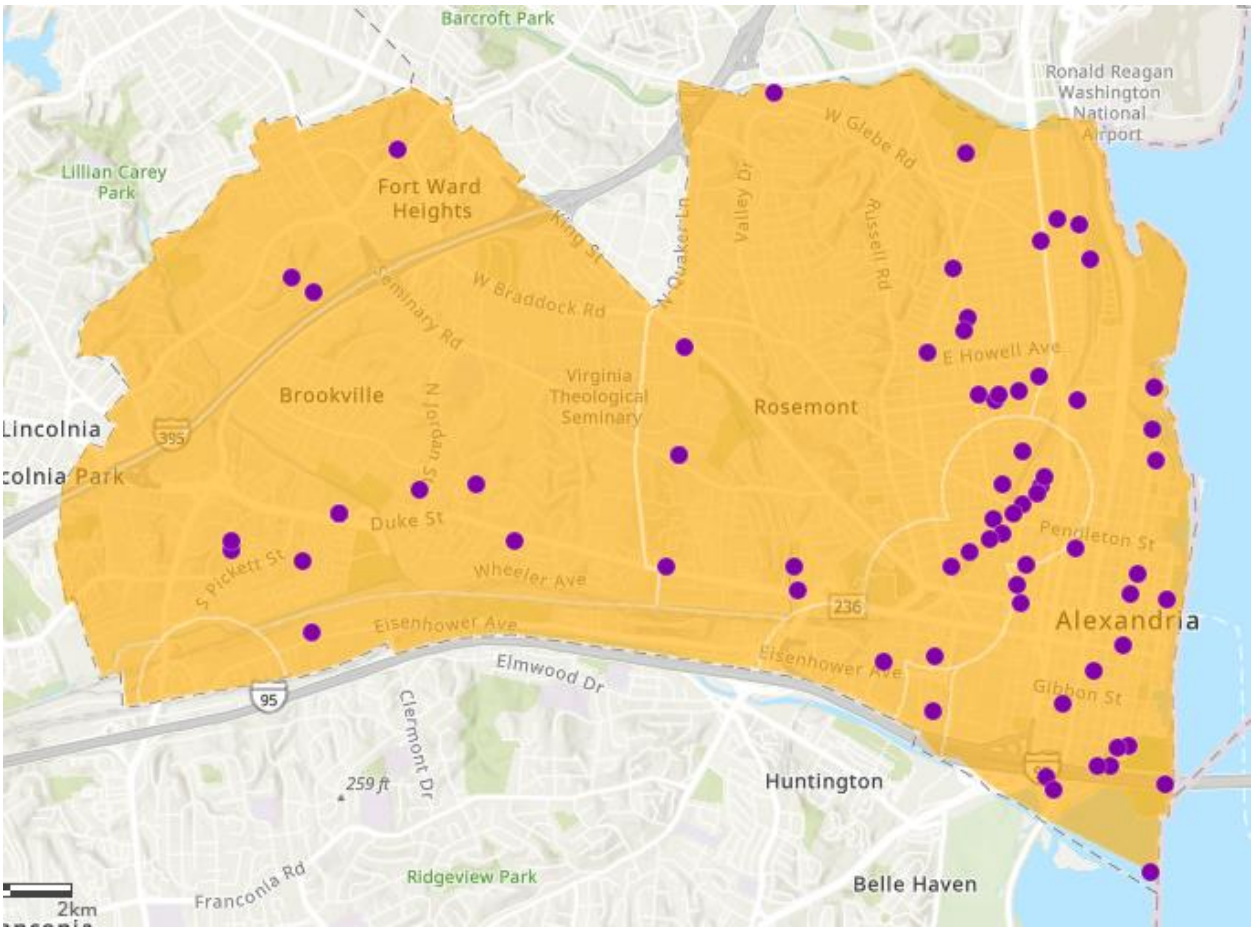


Figure 33 shows the results from Question 2 of the EVRS survey. This question asked respondents to explain their primary rationale for the location they selected in Question 1. Respondents most frequently indicated that they would like electric vehicle charging infrastructure near their home.

Figure 33. What was the Rationale for Selecting the Above Charging Location? (N=74)

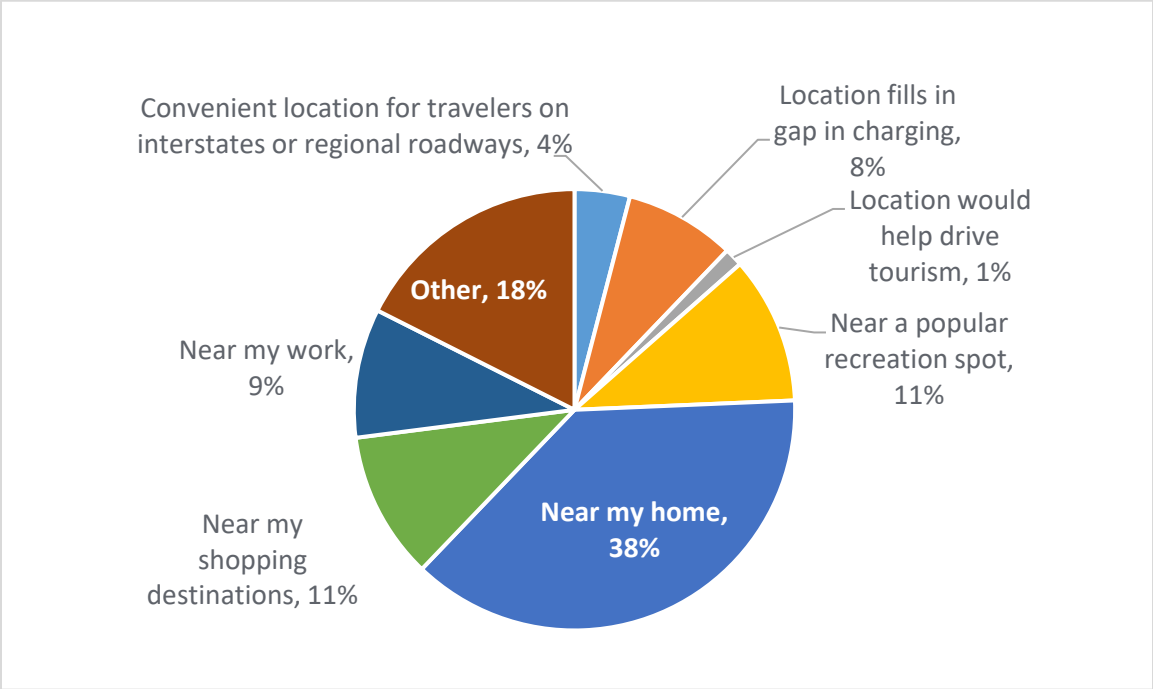


Figure 34 shows the results from Question 3 of the EVRS survey. This question asked respondents to indicate where in Alexandria they live. There was a wide range of locations selected by respondents.

Figure 34. Where Do You Live in Alexandra? (N=74)

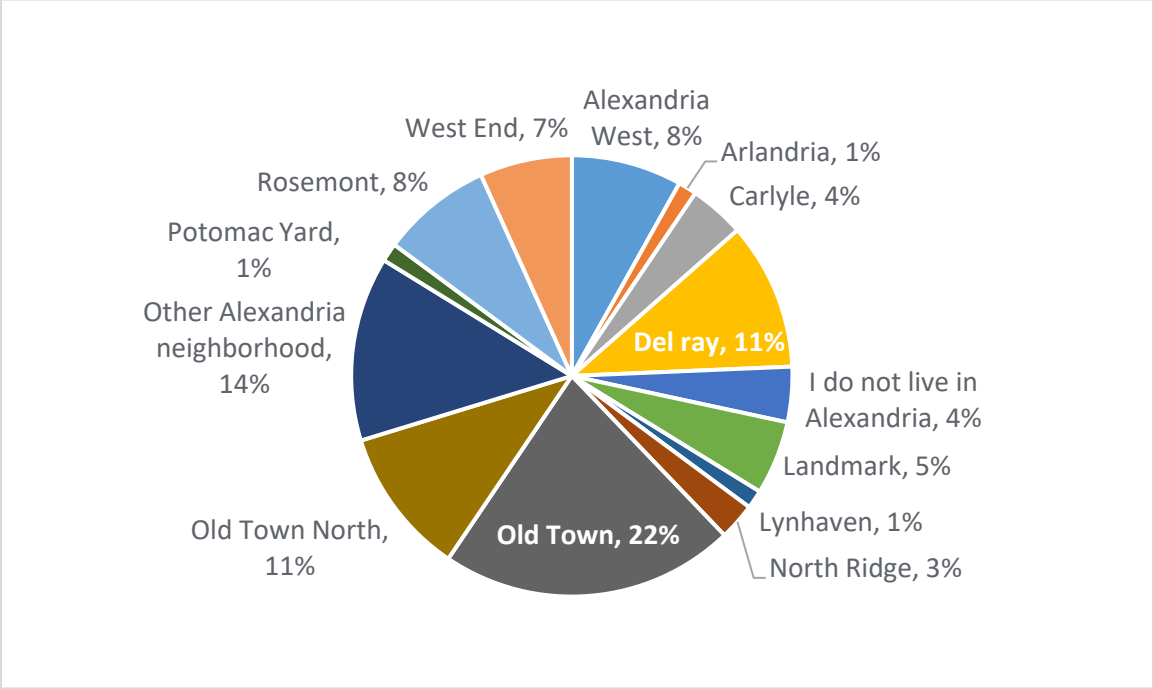


Figure 35 shows the results from Question 4 of the EVRS survey. This question asked if respondents live in an apartment building or multi-unit condominium unit. Survey respondents overwhelmingly said they do not live in an apartment building or multi-unit condominium unit.

Figure 36. Do You Live in an Apartment or Condominium? (N=74)

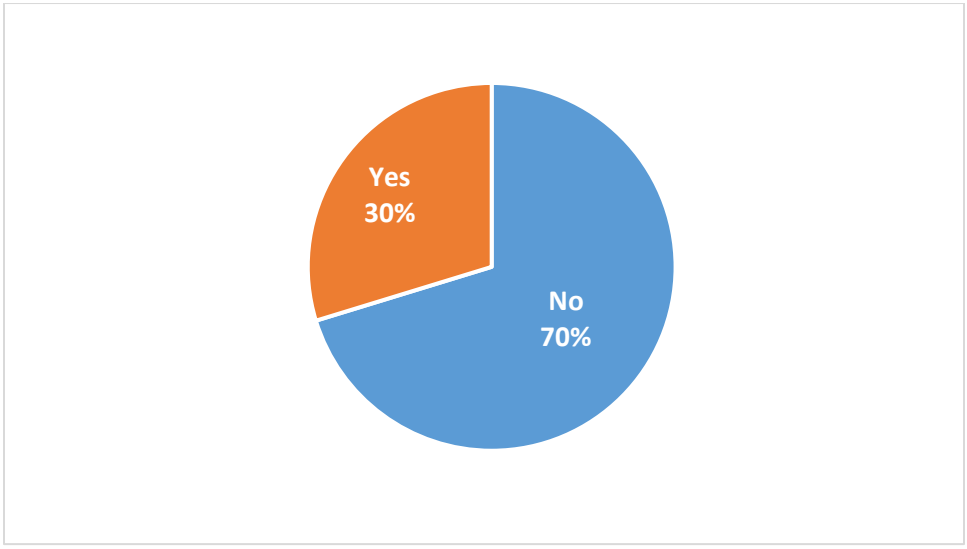


Figure 37 shows the results from Question 5 of the EVRS survey. The question asked respondents whether they own or rent their place of residence: 86% of respondents own their residence, 11% rent, and 3% declined to specify.

Figure 37. Do You Own or Rent Your Residence? (N=74)

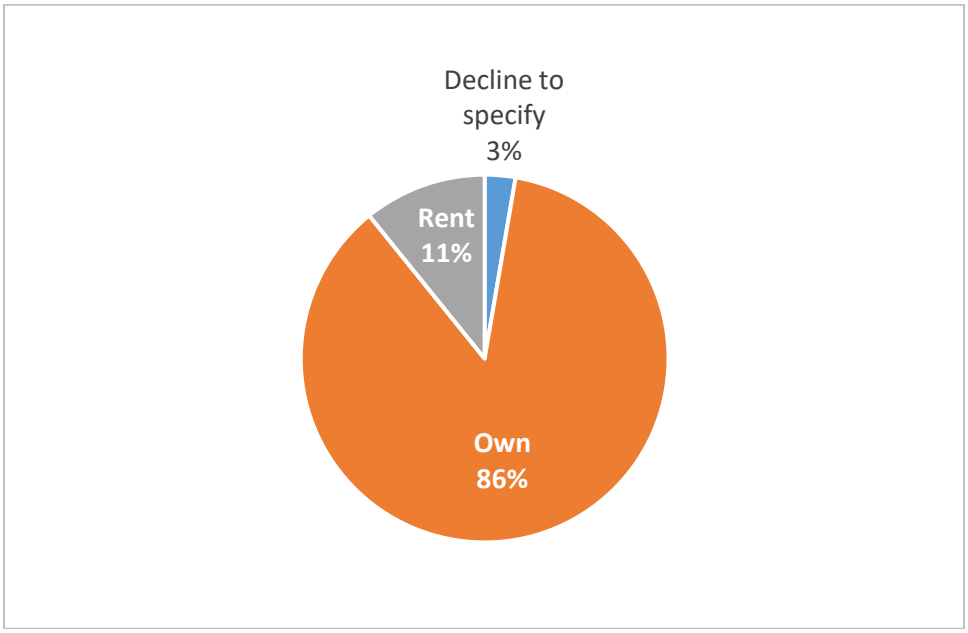


Figure 38 shows the results from Question 6 of the EVRS survey. This question asked respondents to describe the type of parking available at their residence. The category with the most responses was on-street parking, followed by driveway at a single-family home.

Figure 38. The Type of Parking Available at Respondents' Residences, N=74

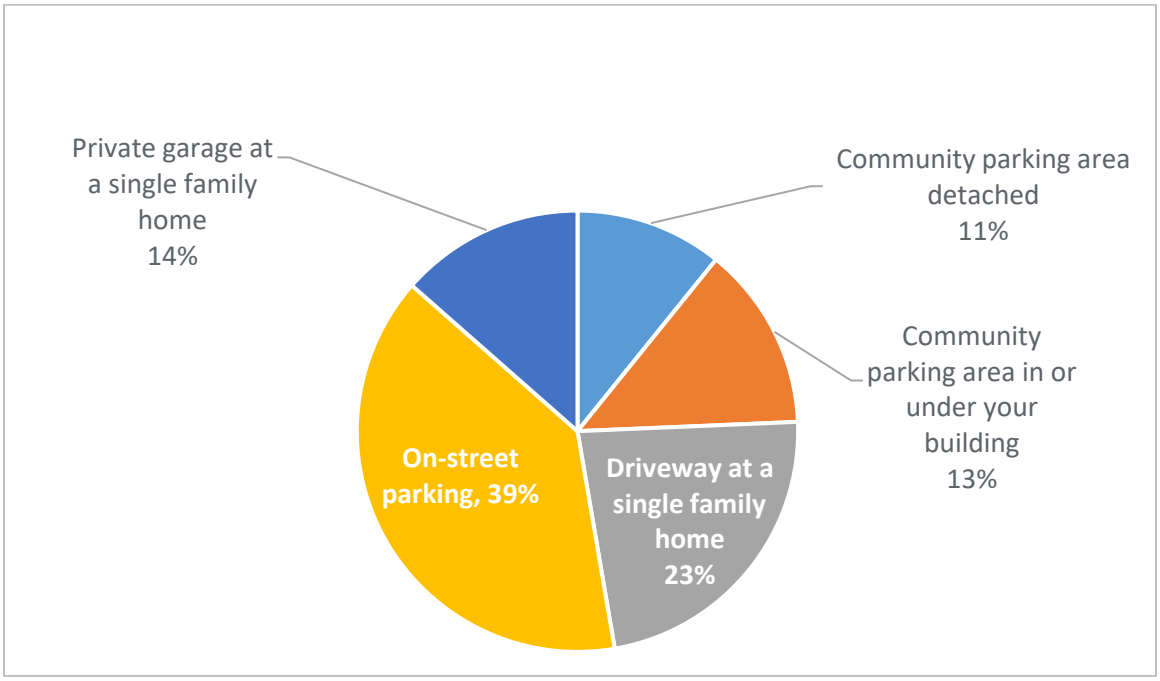


Figure 39 shows the results from Question 7 of the EVRS survey. This question asked respondents where funding toward electric vehicles should be spent by the City of Alexandria. About half of respondents indicated public locations or city facilities (such as recreation centers, libraries, and parks). Only 1% indicated locations that serve electric taxis or electric ride-hailing services.

Figure 39. How EV Funding Should Be Spent, N=74

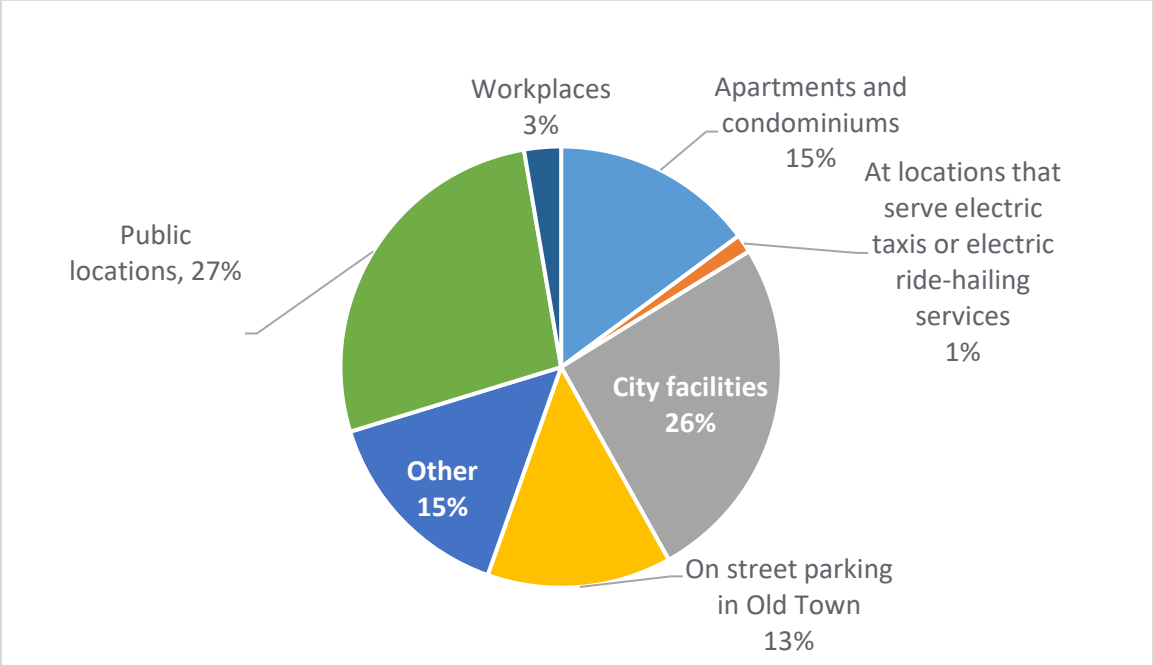


Figure 40 shows the results from Question 9 of the EVRS survey. The question asked survey respondents whether they own an electric vehicle: 66% do not, while 34% do.

Figure 40. Do Respondents Own an Electric Vehicle, N=74

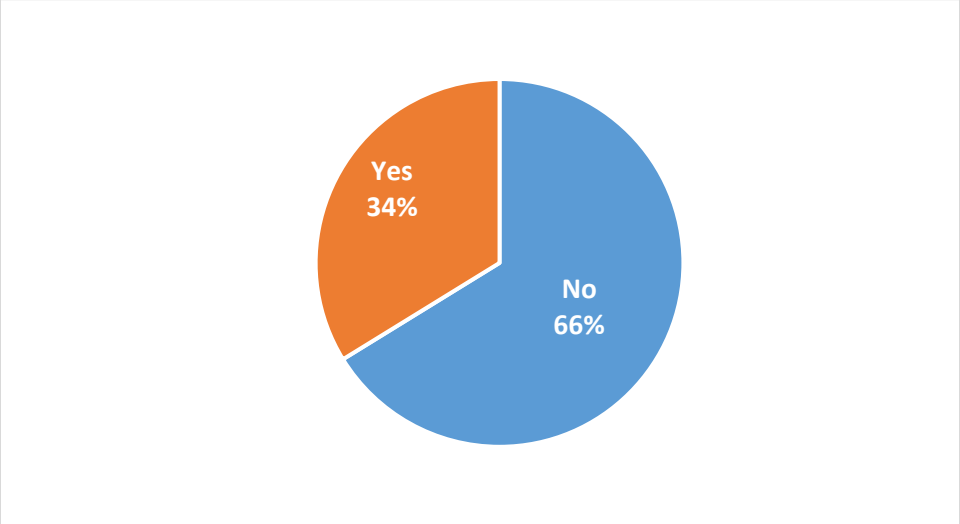


Figure 41 shows the results from Question 10 of the EVRS survey. This question asked survey respondents whether they plan to own an electric vehicle in the next five years, and 81% indicated they do.

Figure 41. Do You Plan to Own an Electric Vehicle in the Next Five Years? (N=74)

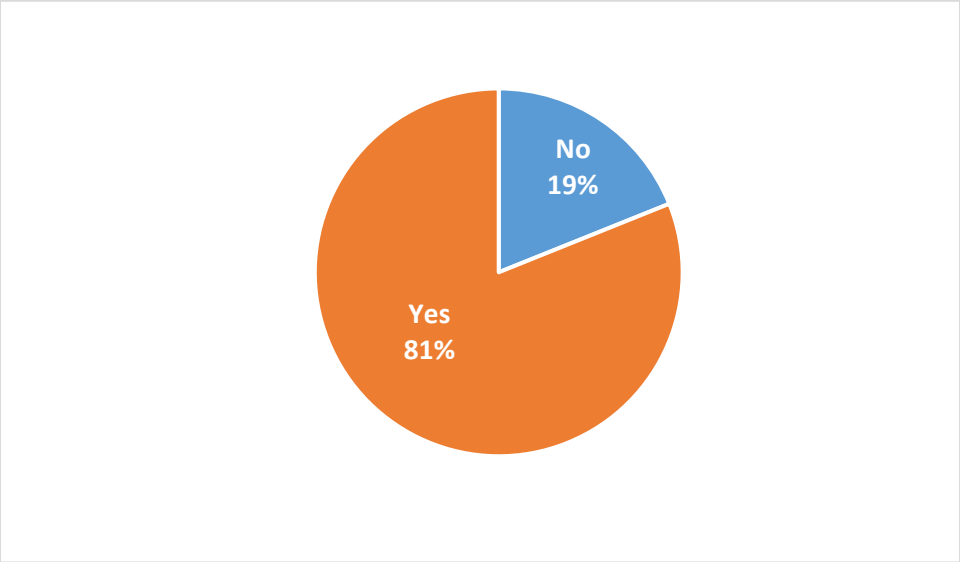


Figure 42 shows the results from Question 11 of the EVRS survey. This question asked survey respondents whether they own or plan to purchase a car. All respondents answered affirmatively.

Figure 42. Do You Own a Car or Are You Considering Purchasing a Car? (N=74)

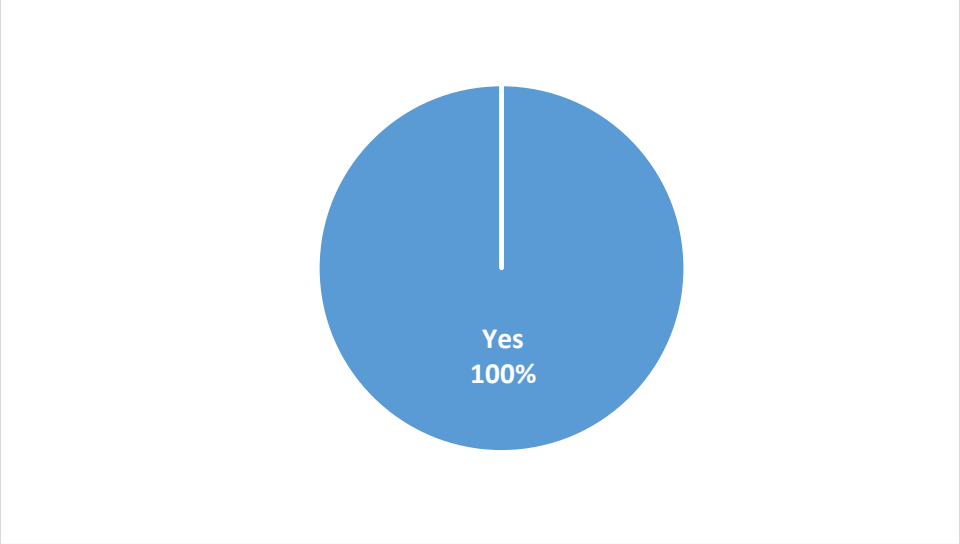


Figure 43 shows the results from Question 12 of the EVRS survey. This question asked survey respondents how many miles they drive on a typical weekday. Almost half of respondents travel less than 10 miles per day, while one-third travel 11 to 20 miles per day. Only 1% drive more than 40 miles per day.

Figure 43. How Many Miles Do You Drive on a Typical Weekday? (N=74)

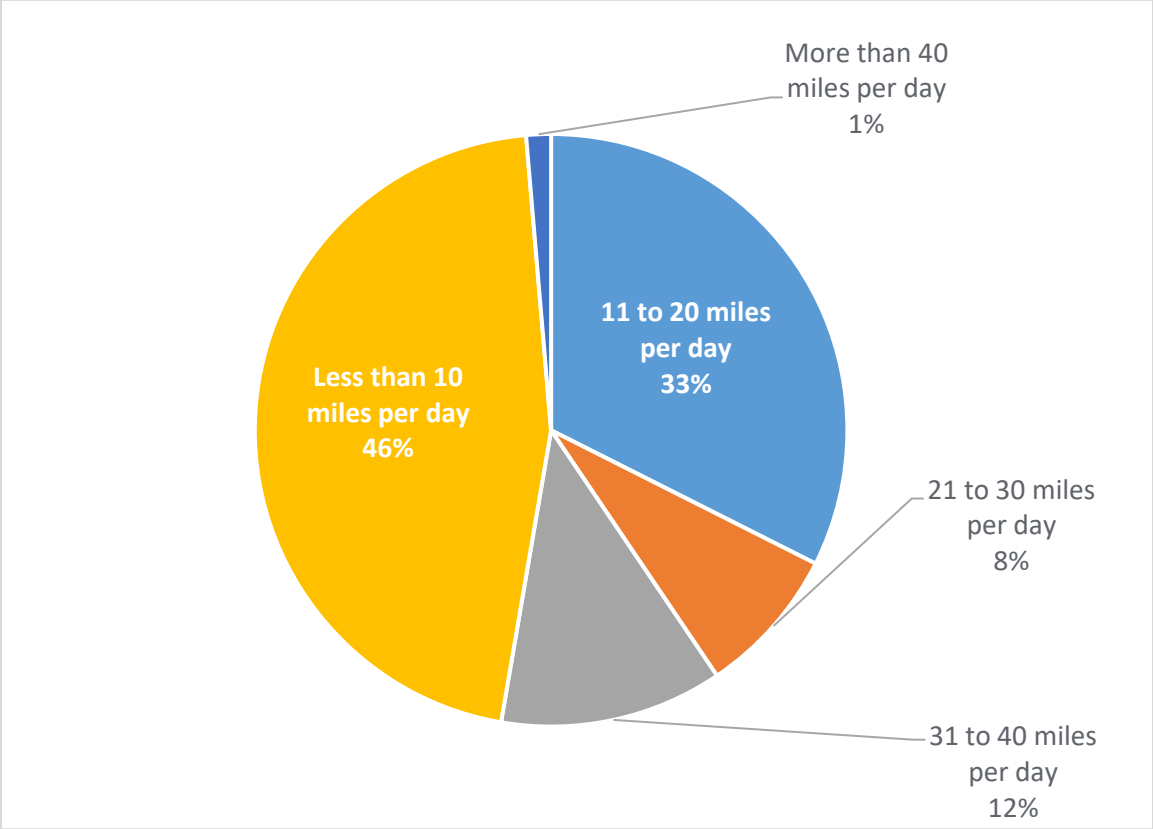


Figure 44 shows the results from Question 14 of the EVRS survey. This question asked survey respondents whether their workplace is within the City of Alexandria: 62% responded no, while 38% responded yes.

Figure 44. Is Your Workplace Located within the City of Alexandria? (N=74)

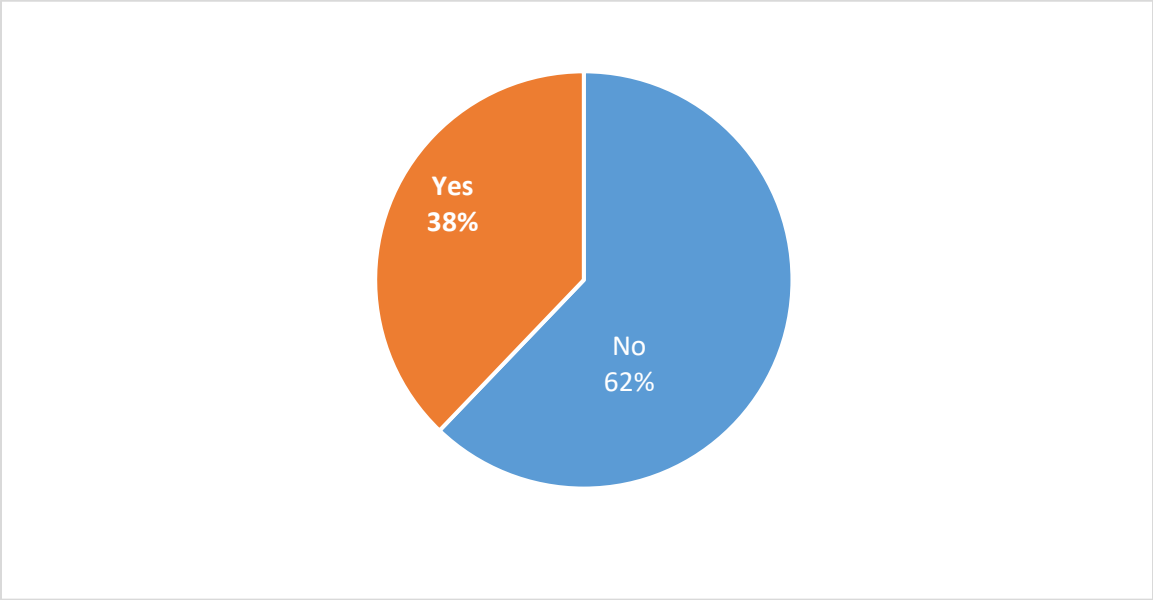


Table 18 presents the results to survey Question 15: Please provide any additional thoughts on how the city can accelerate publicly accessible charging infrastructure and the adoption of electric vehicles.

Table 18. Respondents' Additional Thoughts to Accelerate Publicly Charing Infrastructure

Question Responses
Instead of municipal stations, I recommend easing permits and regulations, or incentives for commercial/private charging stations at areas with significant parking such as malls or grocery stores.
Ensure you charge enough to cover *ALL* the costs to the city, including construction, maintenance, greening, personnel, billing/accounting, etc.
In order to transition as many people as possible to electric vehicles, chargers must be as easy to access as gas stations. Fast charging options should be available as well. Multi-unit housing with and without indoor parking should be a priority.
City should consider placing chargers at or around all its public parks, encourage apartment building and strip mall owners (through tax incentives) to install chargers, and work with charger companies to streamline the process of installation.
Charge lower city tax on electric vehicles.
It would be helpful if the parking spots did not require us to pay for parking (I am fine with paying for the charging). Right now we have to drive to National Harbor or Arlington to charge the car, I would rather spend my money closer to home.
Provide business incentives to install EV charging in addition to publicity available spaces.
Thank you for sending out this survey. I appreciate the city looking into this matter.

Question Responses
New apartment buildings should be required to have EV parking spots. They don't have to be free—and could be easily metered so the electricity used is charged to the tenant—but they should be available. Otherwise, if you rent, you can't have an EV
Adoption of electric vehicles, lower the property tax or give some type of incentive. Get rid of the ugly plant on Slaters Lane.
Offer free parking in city garages/lots for folks who charge and spend locally. Reduce vehicle property taxes for plug-in EVs and redirect a percentage to funding public charging. Raise vehicle taxes for high-emitting vehicles to fund public chargers.
Consider equity. Maintenance and "fuel costs" for an EV could benefit families that need a car to get to and from work and would benefit their monthly budget. EVs are not just for those that can afford a new one.
Find suitable places on or near King; require new construction or renovations to consider incorporating EV charging.
Would be amazing to have on-street free parking reserved for EVs.
Special parking spots for EVs.
Given Alexandria wants to reduce VMT [vehicle miles traveled], the trend of decreased car ownership, and uptake of ride sharing, consideration should be given to having DCFC to service ride-hailing vehicles. Lyft has committed to all EVs by 2030, others will.
What is not clear is if/how users will pay for charging, or if it will be free to them. If they will not have to pay anything I am not in favor of building the stations with taxpayer money.
Consider multiple Level 2 chargers versus one very expensive DCFC. Consider future adoption of city EVs and create central, city EV charging with available public charging spaces. Locate near existing electrified features, like pay parking kiosks.
Allow people who park on the street in front of their house to span the sidewalk with an electric charging cable and a rubber/plastic ramp cover. Even allowing this in the evening and overnight would greatly increase the ability to charge at home.
Do NOT for any reason on GOD'S green earth offer "free" charging on public property for any reason. And, stop smoking pot, I did.
Do not steal more parking spaces from the local residents or in front of the restaurants and public places. Owners of electric vehicles do not deserve to displace other residents and those who come to spend money in Alexandria Old Town.
Don't consume on-street parking for this.
Like the bikes, leave this to the private sector—do not use my money to pay for something that benefits only a few. Maybe spend your time and our money fixing the roads?????
Tax break!
Permitting homeowners with on-street parking the ability to run cables from their homes to their EVs. Obviously, the safety of those using sidewalks needs to be considered. A potential solution is permitting cable covers on the sidewalk.
EV charging is needed desperately. Please help with this: I want to charge my EV. Since I have not been going to work due to COVID I have not been able to charge my EV since I used to charge at work and I do not have a driveway or garage to park at.
I would buy an electric vehicle now if charging was convenient. Because I can't charge at home, the whole proposition is difficult. If I could charge nearby regularly and conveniently, I would own an electric vehicle.

Question Responses
There should be a process under which residents (or cooperative groups of neighbors) can be permitted to install, at their own cost, simple charge points at the curb outside their houses, powered from their own house(s).
Adopt a program where residents can install them [charging stations] in front of their houses with subsidies, or where residents can invest in them. Enable ability for residents to charge payments for use, or earn local currency tokens/credits that can be spent locally.
I think the city should work with homeowners with street parking only to self-fund charging. Give a dedicated space for "x" number of years if homeowners foot bill for charging station.
Charging station should follow international standards (for combined charging system chargers), allowing a three-phase option and universal fitment. On-street charging would need to accommodate "free form" parking for streets without marked parking space dividers.
Continuing partnerships with other places like MOMs [grocery store] to think about this.
Encourage employers and landlords to offer EV charging as an amenity to employees and tenants and to improve air quality. Utilize renewable energy to power charging stations. Study measures taken by other cities (such as Salt Lake City).
Moving to electric transportation is critical to sustaining our environment and our health. I hope that Old Town Alexandria takes the lead and shows the rest of the country what is possible when a municipality cares about its citizens.
Hep those who cannot charge at home. Not being able to easily charge an EV at home (townhouse with street parking) is the only thing stopping us from purchasing one.
I think the priority should be ensuring Alexandria residents can install their own private charging infrastructure, even if they only have access to on-street parking. I say this because I suspect many people share my disinterest in public charging.
Deployment of charging technology near people without off-street parking is very important.
Provide chargers in residential neighborhoods. For example, a space near the high-rise apartment/condo building in Landmark. Make sure the charger provide both high speed DCFC (Level 3) charging (at 150 kW) as well as J-Plug (Level 2) chargers.
Dominion has a lot to gain from EV adoption so perhaps work regionally or at the state level to press them to invest more in public charging locations. Good public charging in "main street" areas (such as Del Ray) would help support local businesses.
Why is the city trying to accelerate publicly accessible charging infrastructure? Why is the city trying to promote the adoption of electric vehicles? Why doesn't the City of Alexandria focus on improving the quality of existing services?
Seek out existing, underutilized parking lots or structures, especially if slated for renovation or redevelopment. Group charging facilities with bike share and bus access locations to aid with charging wait times if there are no nearby amenities.
I have land but the city won't allow access. Make it easier for residents to put in driveways, or even charging stations in front if their houses. Maybe the right answer is a cooperative partnership between the city and residential investment.
Give a tax credit to owners of electric vehicles. Cancel the affordable housing donation from developers and require them to use that money to add charging stations to any new or retrofit structure both commercial and residential.
Yon Lambert and City Manager Jinks are worthless overpaid tool bags!

Question Responses
A solid PR campaign showing the long-term savings of electric vehicles versus combustion engines to make ownership feel more relatable. The city can support long-term savings through infrastructure investment for ALX [Alexandria] citizen benefits.
Adoption of electric vehicles could be increased if you lowered the property taxes on them. Provide a financial incentive for consumers and they will react accordingly.
Have charging stations in grocery store parking lots.
Consider on-street charging stations.
Tax incentives for buying Tesla's since the federal tax credit is gone. Tesla's battery technology is the best and other car manufacturers are way behind. It would also be great to have discounts or rebates to install faster chargers at home.
Tax incentives for purchase. Publicized, easy to find and use charging stations.
Don't make it free. Safeway and My Organic Market already have commuters stopping to use the free charging without shopping at the store. As an EV owner and customer, it infuriates me, as I like to charge while I shop. Home charging takes 12 hours.
Incentivize installations of Level 2 chargers.

APPENDIX C. ELECTRIC VEHICLE REGISTRATIONS

Table 19 shows cumulative electric vehicle registrations between 2011 and 2020 within Alexandria.

Table 19. Cumulative Electric Vehicle Registrations Over Time in Alexandria

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Audi E-Tron	0	0	0	0	0	2	2	3	4	4
BMW 4d	0	1	1	1	1	1	1	1	1	1
BMW I3	0	0	0	7	17	17	24	30	31	31
Chevrolet Bolt	0	0	0	0	0	0	12	17	17	17
Chevrolet Volt	5	7	11	14	16	18	25	32	32	32
Chrysler Pacifica	0	0	0	0	0	0	4	12	19	19
Fiat 500e	0	0	0	2	3	3	4	4	4	4
Ford Energi	0	0	10	16	27	42	51	52	52	52
Ford Focus	0	0	0	0	1	1	1	1	1	1
Honda Clarity	0	0	0	0	0	0	0	7	9	9
Hyundai Ioniq	0	0	0	0	0	0	0	1	6	6
Hyundai Kona	0	0	0	0	0	0	0	0	4	4
Hyundai Sonata	0	0	0	0	0	1	1	1	1	1
Kia Niro	0	0	0	0	0	0	0	4	8	8
Kia Soul	0	0	0	0	0	1	2	2	2	2
Mercedes-Benz S-Class	0	0	0	0	2	2	2	2	2	2
Mini Cooper	0	0	0	0	0	0	0	1	2	2
Nissan Leaf	1	7	13	14	21	35	36	40	45	45
Porsche Cayenne	0	0	0	1	1	2	5	5	6	6
Smart Fortwo	0	0	0	1	2	2	2	2	2	2
Tesla Model 3	0	0	0	0	0	0	0	84	131	132
Tesla Model S	0	0	0	5	24	43	56	75	80	80
Tesla Roadster	2	2	2	2	2	2	2	2	2	2
Toyota Prime	0	0	12	17	19	19	39	48	50	51
Toyota Prius Plug-in	0	5	5	5	5	5	5	5	5	5
Volkswagen E-Golf	0	0	0	0	1	4	4	4	4	4

APPENDIX D. CHARGER COST ESTIMATES

Using the three charging scenarios presented in Chapter 4 as a starting point, a rough estimate of charger costs can be made by multiplying the number of chargers by the cost per plug. Table 20 provides the assumed per plug cost between 2020 and 2050. These costs are based on a variety of data collected from conversations with electric vehicle charging service providers and from examining the literature (ICCT August 2019; NY DEC 2020).

Several important notes about Table 20 are warranted:

- Costs described are the upfront and operational costs associated with chargers. These costs would be paid for by the site hosts and charging equipment owner-operator. These costs are NOT expected to be borne by the City of Alexandria.
- Table 20 only describes costs, not revenues. To understand expected profitability at a given charging location, assumptions about the station revenues are needed. Online calculators are available to help estimate these costs (GPI 2020).
- Incentives from the state and utility are expected to help defray some or all of these costs.
- The costs presented Table 20 do not include soft costs. As shown by Nelder and Rogers (2019), these soft costs sometimes account for a larger fraction of total station costs.

Table 20. Net Present Value Costs for Public and Workplace Level 2 Chargers and Public DCFCS (Rated At 150 Kw).

	2020	2025	2030	2035	2040	2045	2050
Public and Workplace Level 2 Charger (total)	$39,948	$39,945	$37,923	$36,185	$34,694	$33,413	$32,313
Make ready	$11,672	$10,023	$8,607	$7,391	$6,347	$5,451	$4,681
Equipment	$5,002	$4,296	$3,689	$3,168	$2,720	$2,336	$2,006
Electricity	$17,119	$18,930	$18,930	$18,930	$18,930	$18,930	$18,930
Other	$6,155	$6,697	$6,697	$6,697	$6,697	$6,697	$6,697
Public DCFC (150 kW) (total)	$702,979	$691,201	$681,087	$672,402	$664,944	$658,539	$653,040
Make ready	$41,686	$35,797	$30,740	$26,398	$22,669	$19,466	$16,716
Equipment	$41,686	$35,797	$30,740	$26,398	$22,669	$19,466	$16,716
Electricity	$582,339	$582,339	$582,339	$582,339	$582,339	$582,339	$582,339
Other	$37,268	$37,268	$37,268	$37,268	$37,268	$37,268	$37,268

Note: Costs do not include sources of revenue from the charging station, such as a per minute fee or advertisement placement.

Table 21 provides cumulative costs for the workplace and for owners of publicly accessible charging stations from the three scenarios from the station owner-operator perspective. Costs for residential chargers were not included since they are borne by the homeowner. Note that the costs in this table were estimated by multiplying the total net present value for a single charging plug by the number of plugs needed (as shown in Figure 16). In addition, the costs shown in the table do not include revenue generated at the station through charging fees.

Table 21. Cumulative Net Present Value Costs (Millions 2020 $USD) of Publicly Accessible and Workplace Charging Stations from Owner-Operator Perspective

Year	Strong Multi-Level Policy			Strong City Policy			No Policy Change		
	Work-Level 2	Public-Level 2	Public-DCFC	Work-Level 2	Public-Level 2	Public-DCFC	Work-Level 2	Public-Level 2	Public-DCFC
2020	$1	$1	$3	$1	$1	$3	$1	$1	$3
2030	$7	$3	$16	$5	$2	$13	$5	$2	$12
2040	$29	$12	$76	$16	$7	$41	$11	$5	$29
2050	$50	$21	$136	$23	$10	$63	$17	$7	$47

Note: Costs include make-ready, charging equipment, electricity, and other costs such as permitting and networking. Values do not include revenue from station users.

As shown in the table, the cumulative cost by 2050 could be as low as $71 million and as high as over $200 million. While the cumulative costs in each scenario increase over time, the cost per plug decreases over time due to assumptions about technological learning and an increased station size.

APPENDIX E. DETAILED RESULTS OF CHARGING NEEDS ASSESSMENT

Table 22 shows the number of plugs needed to support the electric vehicle populations in each scenario developed in Chapter 4. Note that these charging needs should be compared to the current number of plugs deployed in the city: 24 publicly accessible Level 2 chargers and one DCFC.

Table 22. Number of Plugs by Charger Type as Estimated in Chapter 3

	Residential Level 2	Residential Level 1	Workplace Level 2	Public Level 2	DCFC
Strong Multi-Level Policy					
2015	89	44	11	5	2
2020	294	145	37	16	5
2025	621	306	77	33	11
2030	1,430	704	176	75	24
2035	3,351	1,651	411	174	56
2040	6,860	3,379	841	356	114
2045	9,412	4,636	1,154	488	156
2050	12,626	6,219	1,548	654	209
Strong City Policy					
2015	89	44	11	5	2
2020	294	145	37	16	5
2025	621	306	77	33	11
2030	1,132	557	139	59	19
2035	2,019	994	248	105	34
2040	3,679	1,812	451	191	61
2045	4,799	2,364	588	249	80
2050	5,861	2,887	719	304	97
No Policy Change					
2015	89	44	11	5	2
2020	294	145	37	16	5
2025	621	306	77	33	11
2030	1,061	523	130	55	18
2035	1,605	790	197	84	27
2040	2,556	1,259	314	133	43
2045	3,309	1,630	406	172	55
2050	4,341	2,138	532	225	72

APPENDIX F. HIGH PRIORITY LOCATIONS IN ALEXANDRIA

Table 23 lists the top 240 sites of interest by block group and also includes the points that were suggested by survey respondents in the second EVRS public engagement survey.

Table 23. Sites of Interest

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102009003	Place of Worship	Westminster Presbyterian Church	2701 Cameron Mills Road, Alexandria, VA 22302
515102009003	Place of Worship	Emmanuel Episcopal Church	1608 Russell Road, Alexandria, VA 22301
515102009003	Place of Worship	Community Praise Church	1400 Russell Road, Alexandria, VA 22301
515102009003	Place of Worship	Antsokia Ethiopian Evangelical Church	1400 Russell Road, Alexandria, VA 22301
515102009003	Public School	George Mason Elementary School	2601 Cameron Mills Road, Alexandria, VA 22302
515102008011	Recreation Center	Chinquapin Park Recreation Center & Aquatics Facility	3210 King Street, Alexandria, VA 2230
515102008011	Place of Worship	First Baptist Church of Alexandria	2932 King Street, Alexandria, VA 22302
515102008011	Place of Worship	Oakland Baptist Church	3408 King Street, Alexandria, VA 22302
515102008011	Place of Worship	King Street Church	2912 King Street, Alexandria, VA 22302
515102008011	Public School	T.C. Williams High School King Street Campus	3330 King Street, Alexandria, VA 22302
515102008011	Public School	Douglas MacArthur Elementary School	1101 Janneys Lane, Alexandria, VA 22302
515102008011	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.08508, 38.82448
515102008011	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.08560016, 38.81669148
515102008011	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.08560016, 38.81669148
515102008021	Grocery Store	Giant Food	3131 Duke Street, Alexandria, VA 22314
515102008021	Shopping Center	Alexandria Commons	3233 Duke Street, Alexandria, VA 22314
515102008021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.08665014, 38.808513
515102008023	Tourist Attraction	The George Washington Masonic National Memorial	Callahan Drive, Alexandria, VA 22301
515102008023	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.07439925, 38.8066929
515102008023	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.07473945, 38.80849537
515102009001	Shopping Center	Fairlington Centre	1700 Fern Street, Alexandria, VA 22302
515102009001	Pharmacy	CVS Pharmacy	1521 North Quaker Lane, Alexandria, VA 22302
515102009001	Place of Worship	Bethel Evangelical Church	1701 North Quaker Lane, Alexandria, VA 22302
515102009001	Place of Worship	Church of Saint Clement	1701 North Quaker Lane, Alexandria, VA 22302

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102009001	Place of Worship	Blessed Sacrament Catholic Church	1427 West Braddock Road, Alexandria, VA 22302
515102009001	Place of Worship	Agudas Achim Congregation	2908 Valley Drive, Alexandria, VA 22302
515102007032	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05109622, 38.79310283
515102007032	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05040958, 38.79221087
515102004031	Shopping Center	Van Dorn Plaza	249 South Van Dorn Street, Alexandria, VA 22304
515102004031	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.12007055, 38.80363247
515102020011	Park	Armory Tot Lot	208 South Royal Street, Alexandria, VA 22314
515102020011	Place of Worship	St. Paul's Episcopal Church	228 South Pitt Street, Alexandria, VA 22314
515102020011	Place of Worship	Old Presbyterian Meeting House	323 South Fairfax Street, Alexandria, VA 22314
515102020011	Place of Worship	Basilica of Saint Mary	310 South Royal Street, Alexandria, VA 22314
515102020011	Tourist Attraction	Basilica of Saint Mary	310 South Royal Street, Alexandria, VA 22314
515102020011	Parking Garage	Solo Parking	101 Duke Street, Alexandria, VA 22314
515102020011	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04385425, 38.80278978
515102003021	Recreation Center	Patrick Henry Recreation Center	4653 Taney Avenue, Alexandria, VA 22304
515102003021	Place of Worship	Alexandria Free Methodist Church	4901 Polk Avenue, Alexandria, VA 22304
515102003021	Public School	Patrick Henry K-8 School	4643 Taney Avenue, Alexandria, VA 22304
515102003021	Public School	James K. Polk Elementary School	5000 Polk Avenue, Alexandria, VA 22304
515102007021	Grocery Store	Whole Foods	1700 Duke Street, Alexandria, VA 22314
515102007021	Shopping Center	Hoffman Town Center	Eisenhower Avenue, Alexandria, VA 22331
515102007021	Pharmacy	CVS Pharmacy	1680 Duke Street, Alexandria, VA 22314
515102007021	Pharmacy	CVS Pharmacy	2441 Eisenhower Avenue, Alexandria, VA 22331
515102007021	Movie Theater	AMC Hoffman Center 22	206 Swamp Fox Road, Alexandria, VA 22314
515102007021	Public School	Alexandria City Detention Center	2003 Mill Road, Alexandria, VA 22314
515102007021	Parking Garage	USPTO East Parking Garage	551 John Carlyle Street, Alexandria, VA 22314
515102007021	Parking Garage	Colonial Parking	1925 Ballenger Avenue, Alexandria, VA 22314
515102007021	Parking Garage	Colonial Parking	2050 Ballenger Avenue, Alexandria, VA 22314
515102007021	Parking Garage	Colonial Parking	1800 Duke Street, Alexandria, VA 22314
515102007021	Parking Garage	Hoffman Town Center Parking Garage	Mandeville Lane, Alexandria, VA 22314
515102007021	Parking Garage	Colonial Parking	551 John Carlyle Street, Alexandria, VA 22314
515102007021	Parking Garage	USPTO West Parking Garage	Elizabeth Lane, Alexandria, VA 22314
515102007021	Parking Garage	1940 Duke Street Garage	1940 Duke Street, Alexandria, VA 22314
515102007021	Parking Garage	Colonial Parking	333 John Carlyle Street, Alexandria, VA 22314
515102007021	Parking Garage	Impark (Carlyle Overlook Parking Garage)	2318 Mill Road, Alexandria, VA 22314
515102007021	Parking Garage	Colonial Parking	1701 Duke Street, Alexandria, VA 22314

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102007021	Parking Garage	2424-2428 Eisenhower Avenue Parking	2426 Eisenhower Avenue, Alexandria, VA 22314
515102007021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.06158098, 38.80199799
515102007021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.06633425, 38.80159192
515102007021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.06172498, 38.79795502
515102006005	Grocery Store	ALDI	4580 Duke Street, Alexandria, VA 22304
515102006002	Pool	Great Waves Waterpark	4001 Eisenhower Avenue, Alexandria, VA 22304
515102006002	Park	Cameron Run Regional Park	4001 Eisenhower Avenue, Alexandria, VA 22304
515102006003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.10091236, 38.81036478
515102010001	Recreation Center	Charles Barrett Recreation Center	1115 Martha Custis Drive, Alexandria, VA 22302
515102010001	Public School	Charles Barrett Elementary School	1115 Martha Custis Drive, Alexandria, VA 22302
515102010002	Place of Worship	Christ the King Anglican Church	1801 North Quaker Lane, Alexandria, VA 22302
515102011002	Park	Beverley Park	620 North Overlook Drive, Alexandria, VA 22305
515102011002	Place of Worship	Trinity United Methodist Church	2911 Cameron Mills Road, Alexandria, VA 22302
515102012023	Public School	Mount Vernon Community School	2601 Commonwealth Avenue, Alexandria, VA 22305
515102012033	Grocery Store	La Feria Grocery Store	3840 Mount Vernon Avenue, Alexandria, VA 22305
515102012033	Grocery Store	El Paisa Grocery and Takeout	3414 Mount Vernon Avenue, Alexandria, VA 22305
515102012034	Farmers Market	Four Mile Run Farmers & Artisans Market	4109 Mount Vernon Avenue, Alexandria, VA 22305
515102012034	Box Store	Target	3101 Richmond Highway, Alexandria, VA 22305
515102012034	Box Store	Target	6600 Richmond Highway, Alexandria, VA 22306
515102012034	Box Store	Walmart	6303 Richmond Highway, Alexandria, VA 22306
515102012034	Box Store	Walmart	7910 Richmond Highway, Alexandria, VA 22306
515102012034	Box Store	The Home Depot	7710 Richmond Highway, Alexandria, VA 22306
515102012034	Shopping Center	Potomac Yard Center	3671 Richmond Highway, Alexandria, VA 22305
515102012034	Pharmacy	CVS Pharmacy	3101 Richmond Highway, Alexandria, VA 22305
515102012034	Park	Hume Springs Park	100 Dale Street, Alexandria, VA 22305
515102012034	Recreation Center	Leonard “Chick” Armstrong Recreation Center	25 West Reed Avenue, Alexandria, VA 22305
515102012034	Place of Worship	The WELL Worship Center	6065 Richmond Highway, Alexandria, VA 22303
515102012034	Public School	Cora Kelly School for Math, Science and Technology	3600 Commonwealth Avenue, Alexandria, VA 22305
515102012034	Post Office	United States Postal Service	7676 Richmond Highway, Alexandria, VA 22306
515102012034	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05860641, 38.83870682
515102013001	Park	Mount Jefferson Park and Greenway	301 Hume Avenue, Alexandria, VA 22301
515102014001	Shopping Center	Shops at Del Ray LLC	2308 Mount Vernon Avenue, Alexandria, VA 22301

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102014001	Pharmacy	Neighborhood Pharmacy-Del Ray	2204 Mount Vernon Avenue, Alexandria, VA 22301
515102014001	Recreation Center	Mount Vernon Recreation Center	2701 Commonwealth Avenue, Alexandria, VA 22305
515102014001	Place of Worship	Alexandria Presbyterian Church	2405 Russell Road, Alexandria, VA 22301
515102014001	Place of Worship	Del Ray Baptist Church	2405 Russell Road, Alexandria, VA 22301
515102014001	Place of Worship	Del Ray United Methodist Church	100 East Windsor Avenue, Alexandria, VA 22301
515102014001	Post Office	United States Postal Service	1908 Mount Vernon Avenue, Alexandria, VA 22301
515102014001	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.06222764, 38.82413216
515102014001	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05869299, 38.82571299
515102014002	Place of Worship	First Church of Christ, Scientist	1709 Russell Road, Alexandria, VA 22301
515102014002	Place of Worship	Immanuel Lutheran Church	1801 Russell Road, Alexandria, VA 22301
515102014004	Place of Worship	Good Shepherd Lutheran Church	100 West Luray Avenue #2032, Alexandria, VA 22301
515102014004	Place of Worship	Alexandria Church-The Nazarene	20 East Braddock Road, Alexandria, VA 22301
515102015001	Place of Worship	First Christian Church of Alexandria	2723 King Street, Alexandria, VA 22302
515102015001	Place of Worship	Fairlington Presbyterian Church	3846 King Street #1993, Alexandria, VA 22302
515102015001	Public School	Matthew Maury Elementary School	600 Russell Road, Alexandria, VA 22301
515102015002	Place of Worship	Commonwealth Baptist Church	700 Commonwealth Avenue, Alexandria, VA 22301
515102015003	Park	Hooffs Run Park and Greenway	18 East Linden Street, Alexandria, VA 22301
515102015003	Place of Worship	Alexandria Church of Christ	111 East Braddock Road, Alexandria, VA 22301
515102015003	Place of Worship	Redeemed Church of Christ	4 East Oak Street, Alexandria, VA 22301
515102015003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.056092, 38.81202501
515102015003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05829309, 38.80960991
515102015003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05991774, 38.80842861
515102016003	Recreation Center	Charles Houston Recreation Center	901 Wythe Street, Alexandria, VA 22314
515102016003	Place of Worship	Church of God & Saints-Christ	634 North Patrick Street, Alexandria, VA 22314
515102016003	Place of Worship	Russell Temple CME Church	507 North Alfred Street, Alexandria, VA 22314
515102016003	Tourist Attraction	Alexandria Black History Museum	902 Wythe Street, Alexandria, VA 22314
515102016004	Place of Worship	Meade Memorial Episcopal Church	322 North Alfred Street, Alexandria, VA 22314
515102016004	Place of Worship	Ebenezer Baptist Church	909 Queen Street, Alexandria, VA 22314
515102016004	Place of Worship	Antioch Church of Christ	1120 Queen Street, Alexandria, VA 22314
515102016004	Place of Worship	Third Baptist Church	917 Princess Street, Alexandria, VA 22314
515102016004	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04829088, 38.80980698
515102018022	Tourist Attraction	Founders Park	351 North Union Street, Alexandria, VA 22314
515102018022	Parking Garage	220 North Union Street Garage	220 North Union Street, Alexandria, VA 22314
515102018022	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04239695, 38.80790605

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102018022	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.03962441, 38.8060941
515102018022	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04306073, 38.80643829
515102019001	Farmers Market	Old Town Farmers Market	301 King Street, Alexandria, VA 22314
515102019001	Pharmacy	CVS Pharmacy	503 King Street, Alexandria, VA 22314
515102019001	Place of Worship	Christ Church	118 North Washington Street, Alexandria, VA 22314
515102019001	Place of Worship	Alexandria Methodist Church	223 King Street, Alexandria, VA 22314
515102019001	Tourist Attraction	Stabler-Leadbeater Apothecary Museum	105-107 South Fairfax Street, Alexandria, VA 22314
515102019001	Tourist Attraction	Carlyle House Historic Park	121 North Fairfax Street, Alexandria, VA 22314
515102019001	Tourist Attraction	Old Town Alexandria Waterfront	1 Prince Street, Alexandria, VA 22314
515102019001	Tourist Attraction	Gadsby's Tavern Museum	134 North Royal Street, Alexandria, VA 22314
515102019001	Tourist Attraction	Athenaeum	201 Prince Street, Alexandria, VA 22314
515102019001	Parking Garage	Colonial Parking	102 North Union Street, Alexandria, VA 22314
515102019001	Parking Garage	Republic Parking (Market Square Parking Garage)	110-198 North Fairfax Street, Alexandria, VA 22314
515102019001	Parking Garage	Republic Parking System	111 South Pitt Street, Alexandria, VA 22314
515102019001	Parking Garage	Tavern Square Garage	418 Cameron Street, Alexandria, VA 22314
515102019002	Pharmacy	MedPlus Pharmacy	5130 Duke Street #2, Alexandria, VA 22304
515102019002	Place of Worship	Shiloh Baptist Church	1429 Duke Street, Alexandria, VA 22314
515102019002	Public School	Chance for Change Academy	216 South Peyton Street, Alexandria, VA 22314
515102019002	Parking Garage	King Street Garage	1115 King Street, Alexandria, VA 22314
515102019002	Parking Garage	One Parking	1800 Diagonal Road, Alexandria, VA 22314
515102019002	Parking Garage	Colonial Parking	1620 Prince Street, Alexandria, VA 22314
515102019002	Parking Garage	1700 Diagonal Road Garage	1700 Diagonal Road, Alexandria, VA 22314
515102019002	Parking Garage	113-199 North Fayette Street Parking	113-199 North Fayette Street, Alexandria, VA 22314
515102019002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05346076, 38.80587135
515102020012	Grocery Store	Safeway	500 South Royal Street, Alexandria, VA 22314
515102020012	Park	Windmill Hill Park	501 South Union Street, Alexandria, VA 22314
515102020012	Public School	Lyles-Crouch Traditional Academy	530 South Asaph Street, Alexandria, VA 22314
515102020012	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04656203, 38.80083399
515102020013	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04939731, 38.798437
515102020021	Grocery Store	Balducci's	600 Franklin Street, Alexandria, VA 22314
515102020021	Park	Jones Point Park	Jones Point Drive, Alexandria, VA 23242
515102020021	Tourist Attraction	Jones Point Park	Jones Point Drive, Alexandria, VA 23242
515102020021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04500224, 38.79384986

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102020021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04321924, 38.79539161
515102020021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04616096, 38.79391676
515102020021	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04440143, 38.79528813
515102020022	Park	Mount Vernon Trail	1198 George Washington Memorial Parkway, Alexandria, VA 22314
515102020022	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04124287, 38.78616297
515102020022	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.03993823, 38.79261226
515102001034	Box Store	The Home Depot	6555 Little River Turnpike, Alexandria, VA 22312
515102001034	Place of Worship	Lincolnia United Methodist Church	6335 Little River Turnpike, Alexandria, VA 22312
515102001034	Post Office	United States Postal Service	6137 Lincolnia Road, Alexandria, VA 22312
515102001041	Grocery Store	Global Food	1476 North Beauregard Street, Alexandria, VA 22311
515102001041	Farmers Market	Farmers Market at Southern Towers	5067 Seminary Road #5061, Alexandria, VA 22311
515102001041	Public School	Ferdinand T. Day Elementary School	1701 North Beauregard Street, Alexandria, VA 22311
515102001041	Tourist Attraction	Winkler Botanical Preserve	5400 Roanoke Avenue, Alexandria, VA 22311
515102001041	Parking Garage	Colonial Parking	4825 Mark Center Drive, Alexandria, VA 22311
515102001041	Parking Garage	Colonial Parking	2001 N Beauregard Street, Alexandria, VA 22311
515102001041	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.11993243, 38.82859432
515102001041	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.12185504, 38.82957053
515102002012	Grocery Store	Safeway	3526 King Street, Alexandria, VA 22302
515102002012	Place of Worship	Elevate Church	3801 West Braddock Road, Alexandria, VA 22302
515102002012	Place of Worship	Covenant Life Church	3846 King Street, Alexandria, VA 22302
515102002012	Public School	T.C. Williams High School Minnie Howard Campus	3801 West Braddock Road, Alexandria, VA 22302
515102002013	Grocery Store	ALDI	4602 Kenmore Avenue, Alexandria, VA 22304
515102002013	Shopping Center	Seminary Plaza	4550-4600 Kenmore Avenue, Alexandria, VA 22304
515102002013	Pharmacy	CVS Pharmacy	4606 Kenmore Avenue, Alexandria, VA 22304
515102002013	Parking Garage	Colonial Parking	4900 Seminary Road, Alexandria, VA 22311
515102002013	Parking Garage	Colonial Parking	4660 Kenmore Avenue, Alexandria, VA 22304
515102002022	Place of Worship	Zabriskie Chapel - Immanuel Church-on-the-Hill	3606 Seminary Road, Alexandria, VA 22304
515102002022	Place of Worship	Beth El Hebrew Congregation	3830 Seminary Road, Alexandria, VA 22304
515102003034	Recreation Center	Dowden Terrace Recreation Pool	6300 Holmes Run Pkwy, Alexandria, VA 22311
515102003034	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.11750101, 38.81237701
515102003034	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.11750101, 38.81237701

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102003034	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.11750101, 38.81237701
515102005003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.10455326, 38.81454996
515102001021	Shopping Center	The Shops at Mark Center	1458-1480 North Beauregard Street, Alexandria, VA
515102001071	Valet Service Lots	Mid Atlantic Parking Services Inc (MAPS PARKING)	4401 Ford Avenue #510, Alexandria, VA 22302
515102003011	Public School	Francis C. Hammond Middle School	4646 Seminary Road, Alexandria, VA 22304
515102005002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.10995246, 38.81406618
515102007011	Grocery Store	Harris Teeter	4641 Duke Street, Alexandria, VA 22304
515102007011	Shopping Center	Shoppes of Foxchase	4513 Duke Street, Alexandria, VA 22304
515102007011	Pharmacy	CVS Pharmacy	5101 Duke Street, Alexandria, VA 22304
515102007011	Park	Chessie's Big Backyard	6624 Telegraph Road, Alexandria, VA 22310
515102007011	Place of Worship	Victory Temple	2762 Duke Street, Alexandria, VA 22314
515102007011	Post Office	US Post Office Business Branch	2226 Duke Street, Alexandria, VA 22314
515102004055	Box Store	The Home Depot	400 South Pickett Street, Alexandria, VA 22304
515102004055	Shopping Center	Pickett Street Plaza	660 South Pickett Street, Alexandria, VA 22304
515102004055	Place of Worship	Iqra Learning Center	5703 South Pickett Street, Alexandria, VA 22304
515102004055	Post Office	United States Postal Service	368 South Pickett Street, Alexandria, VA 22304
515102018012	Park	Potomac Yard Park	2501 Potomac Avenue, Alexandria, VA 22305
515102018012	Parking Garage	Atlantic Parking	605 Slaters Lane, Alexandria, VA 22314
515102018012	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04697635, 38.83100139
515102018012	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04807227, 38.82061619
515102018012	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04791971, 38.83352621
515102018012	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05006, 38.83389
515102004041	Farmers Market	West End Farmers Market	4800 Brenman Park Drive, Alexandria, VA 22304
515102004041	Park	Armistead Boothe Park	520 Cameron Station Boulevard, Alexandria, VA 22304
515102004041	Public School	Samuel West Tucker Elementary School	435 Ferdinand Day Drive, Alexandria, VA 22304
515102004041	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.12088101, 38.808846
515102004063	Pool	Bren Mar Swimming Pool	6324 Edsall Road, Alexandria, VA 22312
515102004063	Place of Sorship	Muslim American Society	6408 Edsall Road, Alexandria, VA 22312
515102018013	Park	Tide Lock Park	1 Canal Center Plaza, Alexandria, VA 22314
515102018013	Parking Garage	Colonial Parking	44 Canal Center Plaza, Alexandria, VA 22314
515102018013	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04113553, 38.81858021
515102018013	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.04079654, 38.81629023
515102018013	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.0409079, 38.82161491

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102018014	Grocery Store	Harris Teeter	735 North Asaph Street, Alexandria, VA 22314
515102018014	Grocery Store	Trader Joe's	612 North Asaph Street, Alexandria, VA 22314
515102018014	Place of Worship	St. Joseph Catholic Church	711 North Columbus Street, Alexandria, VA 22314
515102018014	Place of Worship	New Pentecostal Church	600 North Columbus Street, Alexandria, VA 22314
515102018014	Tourist Attraction	Oronoco Bay Park	100 Madison Street, Alexandria, VA 22314
515102018014	Parking Garage	Lot 267 - Waterfront at Old Town	801 North Fairfax Street, Alexandria, VA 22314
515102018014	Parking Garage	Colonial Parking	652 Wythe Street, Alexandria, VA 22314
515102007033	Place of Worship	Alfred Street Baptist Church	301 South Alfred Street, Alexandria, VA 22314
515102004062	Grocery Store	Safeway	299 South Van Dorn Street, Alexandria, VA 22304
515102004062	Public School	Northern Virginia Juvenile Detention Center School	200 South Whiting Street, Alexandria, VA 22304
515102013002	Farmers Market	Del Ray Farmers Market	2311 Mount Vernon Avenue, Alexandria, VA 22301
515102013002	Place of Worship	Korean Presbyterian Church	201-299 East Del Ray Avenue Alexandria, VA 22301
515102013002	Parking Garage	2411 Mount Vernon Avenue Parking	2311 Mount Vernon Avenue, Alexandria, VA 22301
515102013002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05849, 38.82671
515102012041	Grocery Store	Giant Food	621 East Glebe Road, Alexandria, VA 22305
515102012041	Park	Lynhaven Park	5 East Reed Avenue, Alexandria, VA 22305
515102012041	Place of Sorship	Freedom Way Baptist Church	1 West Glebe Road, Alexandria, VA 22305
515102001062	Parking Garage	Beauregard Street Park G Garage	Netherton Drive, Alexandria, VA 22302
515102001062	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.112, 38.83904
515102001022	Recreation Center	William Ramsay Recreation Center	5650 Sanger Avenue, Alexandria, VA 22311
515102001022	Nature Center	Jerome "Buddie" Ford Nature Center	5750 Sanger Avenue, Alexandria, VA 22311
515102001022	Recreation Center	The Mark Center Pavilion	5708 Merton Court, Alexandria, VA 22311
515102001022	Place of Worship	NOVA Church	5700 Sanger Avenue #3104, Alexandria, VA 22311
515102001022	Public School	Early Childhood Center	5651 Rayburn Avenue, Alexandria, VA 22311
515102001022	Public School	John Adams Elementary School	5651 Rayburn Avenue, Alexandria, VA 22311
515102001022	Public School	William Ramsay Elementary School	5700 Sanger Avenue, Alexandria, VA 22311
515102001022	Park	Dora Kelley Nature Park	5750 Sanger Avenue, Alexandria, VA 22311
515102002011	Place of Worship	Fairlington United Methodist Church	3900 King Street, Alexandria, VA 22302
515102002011	Tourist Attraction	Fort Ward Museum & Historic Site	4301 West Braddock Road, Alexandria, VA 22304
515102009004	Place of Worship	Alexandria Presbyterian Church	1302 West Braddock Road, Alexandria, VA 22302
515102012042	Park	Four Mile Park	3700 Commonwealth Avenue, Alexandria, VA 22305
515102012042	Place of Worship	Love of Christ Church	101 Leadbeater Street, Alexandria, VA 22305
515102012042	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05160057, 38.83235572

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102016001	Park	Helen Miller/Bernard Hunter Park	224 North Fayette Street, Alexandria, VA 22314
515102016001	Arts Center	Oswald Durant Arts Center	1605 Cameron Street, Alexandria, VA 22314
515102016001	Pool	Old Town Pool	1609 Cameron Street, Alexandria, VA 22314
515102016001	Public School	Jefferson-Houston Pre-K-8 IB School	1501 Cameron Street, Alexandria, VA 22314
515102016001	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05296633, 38.80863216
515102016001	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05643298, 38.81044898
515102016001	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05375739, 38.80711896
515102012031	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.07658232, 38.84313539
515102018021	Tourist Attraction	Lee-Fendall House Museum	614 Oronoco Street, Alexandria, VA 22314
515102001073	Parking Garage	G Park Inc	2701 Park Center Drive, Alexandria, VA 22302
515102004054	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.12750531, 38.80966014
515102004054	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.12755502, 38.81040701
515102016002	Public School	T.C. Satellite Campus at ACPS Central Office	1340 Braddock Place, 2nd Floor, Alexandria, VA 22314
515102016002	Public School	Adult Learning Center Braddock Place Campus	1340 Braddock Place, 7th Floor, Alexandria, VA 22314
515102016002	Post Office	United States Postal Service	1100 Wythe Street, Alexandria, VA 22314
515102016002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.0532734, 38.81300666
515102016002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05148246, 38.81436752
515102016002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.054092, 38.81234901
515102016002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.0551578, 38.81090954
515102016002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.0511196, 38.81506372
515102016002	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05185318, 38.81383966
515102013003	Grocery Store	ALDI	425 East Monroe Avenue, Alexandria, VA 22301
515102013003	Pharmacy	Walgreens Pharmacy	1517 Mount Vernon Avenue, Alexandria, VA 22301
515102013003	Pharmacy	CVS Pharmacy	415 East Monroe Avenue, Alexandria, VA 22301
515102013003	Park	Eugene Simpson Stadium Park	426 East Monroe Avenue, Alexandria, VA 22301
515102013003	Place of Worship	St. Andrew and St. Margaret of Scotland Anglican Catholic Church	402 East Monroe Avenue, Alexandria, VA 22301
515102013003	Public School	George Washington Middle School	1005 Mount Vernon Avenue, Alexandria, VA 22301
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05738801, 38.82100286
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05586695, 38.82066092
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05172897, 38.8224398
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05332781, 38.8169483
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05362589, 38.82131677

Block Group ID	Category	Type of Location	Street Address / Latitude-Longitude
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.055502, 38.82100898
515102013003	EVRS Survey Respondent Suggestion	EVRS Survey Respondent Suggestion	-77.05517318, 38.81452246
515102007031	Recreation Center	Nannie J Lee Memorial Recreation Center	1108 Jefferson Street, Alexandria, VA 22314
515102007031	Tourist Attraction	Alexandria National Cemetery	1450 Wilkes Street, Alexandria, VA 22314
515102001023	Parking Garage	Colonial Parking	1851 North Beauregard Street, Alexandria, VA 22311
515102012021	Place of Worship	Grace Episcopal Church	3601 Russell Road, Alexandria, VA 22305
515102012022	Grocery Store	Streets Market & Cafe	3108 Mount Vernon Avenue, Alexandria, VA 22305
515102012022	Pool	Warwick Pool	3301 Landover Street, Alexandria, VA 22305
515102001061	Place of Worship	Saint James United Methodist Church	5200 Fillmore Avenue, Alexandria, VA 22311