Presidential Interdisciplinary Seed Grant

Leading Georgia's E-Mobility and Innovation:
Informing Research and Decision making

Roadmap for Research and Outreach

May 2025

Executive Summary

The *report represents the findings and outcomes from Leading Georgia's E-Mobility Innovation: Informing Research and Decision Making*, a Presidential Seed Grant to develop a foundational framework for research, outreach, and data-informed decision-making on electric mobility (e-mobility) at the University of Georgia. The project brought together faculty, staff, and students from multiple academic units to generate actionable knowledge and identify pathways for future work in this rapidly evolving domain.

This report captures key findings from the grant team. It documents baseline data collection, early-stage modeling, applied research outputs, and the development of outreach programs designed to support Georgia communities navigating transportation electrification. It also outlines research gaps, opportunities for multi-disciplinary collaboration, and alignment with state and national funding priorities.

The effort was organized into five collaborative research subgroups:

- **Electric Infrastructure**: Energy demand modeling and scenario simulations were conducted to assess the campus's grid readiness and inform future EV charging installations. The analysis found that the site could support EV charging but would likely require managed charging to avoid peak-demand periods and mitigate impacts to the grid. The analysis could be expanded to support a campus wide electric mobility strategy.
- **Driving Behavior**: Real-world single-pedal EV driving dynamics were captured to improve modeling for traffic flow, regenerative braking, and policy impacts. Single-pedal driving was found to follow different driving patterns than traditional two-pedal driving. This initial analysis provides a foundation for further scenario testing and research.
- **Commuter Survey**: UGA parking permit holders were surveyed to assess current and latent demand for EV charging, revealing behavioral insights, equity challenges, and infrastructure priorities. Respondents reported a desire for increased charging station availability, with cost and access identified as key barriers to EV adoption.
- **Lessons Learned**: Operational case studies are being compiled from UGA's e-mobility transition to support peer institutions in implementation planning. UGA's adoption of EVs into their fleet have resulted in cost efficiencies and informed the development of a step-by-step strategy for fleet electrification.
- **Public Safety Literature Review**: Analyzed risks and regulatory gaps across EV batteries, infrastructure, and emergency response, highlighting areas for continued investigation. While EV fires are significantly less frequent than internal combustion engine fires, they present unique challenges for first responders and government planning. These challenges are being addressed through a continued move toward standardization, increased access to training, and innovation by industry.

Parallel to the research, the Carl Vinson Institute of Government developed *Plug Into Georgia*, a statewide outreach program that provides educational resources, workshops, and technical assistance to local governments. This initiative has been instrumental in translating campus research into practical applications across Georgia.

Funding strategies are outlined to prepare for upcoming opportunities, including federal grants under NEVI, CFI, EPA programs, and utility-led initiatives. The report includes a detailed review of these sources and identifies strategic entry points for campus-led proposals.

In sum, this Roadmap offers both a retrospective on accomplishments and a forward-looking framework. It positions the University of Georgia to lead in interdisciplinary electric mobility research and applied public service across the state. The findings support the need for sustained data collection, broader faculty engagement, and coordinated funding strategies to build upon this foundation.

Introduction

The Interdisciplinary Seed Grant project, *Leading Georgia's E-Mobility and Innovation: Informing Research and Decision Making,* was designed to promote interdisciplinary engagement and innovation in E-Mobility on the University of Georgia campus. This project set out to identify key data sources in which to develop additional interdisciplinary research questions, such as how to improve driving behavior, how to address emerging safety and cybersecurity issues, how to incorporate charging into user-friendly planning and design, and how to model energy demand and capacity in novel ways.

UGA's campus offers unique opportunities to analyze these research questions by analyzing charging demand, charging supply, and energy infrastructure. This project's goal was to gather baseline data from both the demand and supply side of electric mobility and development assessments that are useful to UGA's E-Mobility transition. One of the ways in which this study worked to accomplish this goal was by creating a Roadmap for Research and Outreach. This Roadmap serves as a guide to understand the existing research being conducted by faculty across the University and future research needs and questions identified by those faculty. The Roadmap also summarizes outreach efforts and needs, as well as discusses past funding opportunities that can inform the pursuit of future funding proposals.

This Roadmap was produced by the Carl Vinson Institute of Government with input from the entire Interdisciplinary Seed Grant team. The primary authors of this Roadmap from the Institute were Julia Dietz, Asher Dozier, Natalie Bock, and McKenna Eavenson.

The Interdisciplinary Seed Grant team was comprised and supported by faculty, staff, and students across campus, including:

Carl Vinson Institute of Government: Shana Jones, Asher Dozier, Julia Dietz, Natalie Bock, McKenna Eavenson, Harrison Stang, Donavan Arnold

College of Engineering: Tianqi Hong, Fred R Beyette Jr., Wenzhan Song, Jin Ye, Handong Yao, Lynn M Abdouni, Qianwen Li, Tianle Zhu

Office of Sustainability: Justin Ellis

Parking & Transportation Services: Tim Cearley, Tysen deDufour, Virgina Hamilton

School of Public and International Affairs: Heewon Lee, Leticia Baquerizo

Terry College of Business: John Rios, Maric Boudreau, Ali Shirzadibabakan, Jiyong Park

Existing Research on Campus & Future Needs

The Interdisciplinary Seed Grant team self-organized into several subgroups of faculty, staff, and students across the University. These subgroups have worked to conduct initial research projects to test existing research questions and identify opportunities to build on those initial projects, as well as identify new research questions and needs. Beyond the immediate Seed Grant team, faculty across the University are engaged in electric mobility research and collaboration.

Interdisciplinary Seed Grant Subgroups

The projects conducted by the subgroups, as well as the future research needs and questions are summarized below. Any work products or initial reports from the subgroups are included as Addendums at the end of this Roadmap.

Electric Infrastructure Subgroup

Lead: Tianqi Hong (College of Engineering)

Subgroup Members: Fred R Beyette Jr. (College of Engineering), Justin Ellis (Office of Sustainability), Wenzhan Song (College of Engineering), Jin Ye (College of Engineering)
Students: Shibo Zhou

Installation of electric vehicle charging requires adequate utility infrastructure to support the increased draw of electricity. Often, seemingly appropriate sites for a charger may actually be quite expensive to achieve when the utility infrastructure upgrades are taken into account. Identifying areas on campus where EV charging would be useful for drivers and comparing that to existing utility infrastructure capacity is a key step to identifying where and how UGA can continue to support the transition to electric mobility across campus.

A valuable tool within this effort to establish foundational metrics and baseline data for further research questions, is the analysis of UGA's current energy infrastructure as well as the integration of analysis with existing project demand. With this need for foundational data, the completion of a study using one building-level system of the CHICOPEE FMD Section as an example for EV charging impact analysis- and ultimately as a test bed for this overarching analysis-was proposed.

The study focused on illustrating a quantitative analysis process of evaluating the impact of electric vehicle charging from the grid perspective. To achieve this objective, the study needed to first convert descriptive data or graphs to corresponding physical models, including EV charging models and grid models. Then, build various scenarios to perform a corresponding simulation study. Finally, the group performed data analysis based on the simulated results to identify the potential impacts and benefits from a technical and economic point of view. A more detailed report on this analysis is included in the Appendix.

Future opportunities within the scope of this study include expanding it to the whole campus in support of a campus wide electric mobility strategy. A similar approach can easily be expanded to the entire state of Georgia. The major challenge to this study is the lack of data or models.

EV Driving Behavior Subgroup

Lead: Handong Yao (College of Engineering)
Team Members: Justin Ellis (Office of Sustainability), Qianwen Li (College of Engineering),
Students: Tianle Zhu (GRA)

With the rise of electric vehicles reshaping driver behavior and energy consumption, studying EV driving behavior can be critical to addressing how certain dynamics of these vehicles may affect energy consumption and/or traffic flow. EVs often feature single pedal driving with regenerative braking, enabling smoother deceleration and energy recovery. Accurately calibrated models for EV single-pedal behavior help to simulate realistic flow under future EV dominant scenarios, support infrastructure decisions, evaluate energy-saving policies, and enable bottom-up modeling by using real behavior to inform.

With overarching project goals in mind, the team completed a study to collect real-world data for EV driving behavior. By creating a car-following model using four cars, one gas and three electrics, they were able to observe some of these behaviors. The leading vehicle is a Lexus S350, the second vehicle is a Ford Mustang Mech-E, and the last two vehicles are both Kia Niros. The leading vehicle was driven using adaptive cruise control (ACC) while all three electric vehicles are equipped with both ACC and regenerative braking. After dividing the experiment by eight groups under ACC controlled driving and four groups under human control findings, they observed that single-pedal mode responds more gently during the deceleration phase and that regular pedal mode consistently maintains larger spacing from the lead vehicle compared to single pedal mode. A more detailed summary of this study and the results is included in the Appendix.

While this study is helpful in observing certain braking and spacing behaviors in EVs, there are still gaps in this research. To fill these gaps, there is a need to conduct more field experiments to include various scenarios, such as interactions with traffic signs and vulnerable road users. There must also be an effort to find a method of connecting this with social behavior insights. Further research opens opportunities for journal paper publishing, NSF proposals, or even releasing the data for public access.

Commuter Survey Subgroup

Lead: John Rios (Terry College of Business)
Team Members: Maric Boudreau (Terry College of Business), Ali Shirzadibabakan (Terry College of Business), Jiyong Park (Terry College of Business)

This project aims to assess the charging needs of electric vehicle (EV) users at UGA. A targeted commuter survey was distributed to campus parking permit holders to better understand the charging behaviors of the university's commuting population. Two tailored versions were developed—one for students and one for faculty and staff—based on anticipated differences in commuting patterns, home charging access, and potential impact on campus energy demand. The survey gathered data on vehicle type, daily commuting distance, home charging capabilities, and interest in several types and locations of on-campus charging infrastructure.

Of the faculty and staff that responded, 12 percent reported owning a fully-electric or plug-in hybrid car, meanwhile that figure was less than four percent of the students that responded. The overall response rate was higher among faculty and staff than students.

Preliminary results show that survey respondents desired increased charging station availability, particularly in high-demand areas and in underserved locations such as Health Sciences, Gwinnett, and South Campus. In addition to the current Level 2 chargers, respondents also expressed a desire for a mix of Level 1 (long-term) and Level 3 (fast) chargers to accommodate diverse usage needs. Among non-EV owners, the survey identified cost and limited charging access as primary barriers to EV adoption. Multiple non-EV owner participants also emphasized that multimodal strategies, such as public transportation, bike lanes, and walkable options, should be prioritized. A more detailed summary of the survey response and results is included in the Appendix.

A separate follow-up survey will be administered specifically to current EV owners to capture more detailed usage patterns not addressed in the general commuter survey. To ensure responsive infrastructure planning, UGA's Facilities and Maintenance Division (FMD) plans to repeat this data collection regularly to monitor trends and refine strategies for supporting the university's evolving EV commuter population.

Lessons Learned Subgroup

Lead: Natalie Bock (Carl Vinson Institute of Government)
Team Members: Justin Ellis (Office of Sustainability), Julia Dietz (Carl Vinson Institute of Government)

A key goal of this project was to utilize UGA's campus and operations as a case study for EV implementation identifying the strategies and baseline data necessary to accelerate EV adoption and infrastructure both at UGA and other higher education institutions across the state.

UGA's Facilities Management Division (FMD) committed to exploring fleet electrification beginning in 2022 and expanded its EV fleet from 5 to 29 vehicles over 3 years, an increase of 625% bringing the total FMD EV fleet to 8% of all vehicles. In addition to forming a Fleet Electrification Working Group to guide these efforts, FMD implemented a series of steps that provide key insights and replicability to other units, universities, and EV fleet adopters across the state. These steps constitute the core of FMDs Fleet Electrification Strategy.

- Step 1 is a Vehicle Inventory Analysis which establishes the vehicle class types in a fleet, utilization patterns such as mileage, and fuel consumption, vehicle age, maintenance, and replacement schedules.

- Step 2 is Right Size, Right Type Planning via survey and interviews with managers which ensures each fleet vehicle is appropriately matched to its actual daily use and needs, optimizing efficiency and cost effectiveness. This strategy achieves correct "fit to task" minimizing underutilization and under- or over-specifying vehicles, and supports data-driven vehicle selection decisions aligned with operational needs.

- Step 3 is Vehicle Vetting, Demos and Procurement which evaluates right-size, right-type criteria through a structured vetting process including stakeholder hands-on demos to ensure operational fit. Final decisions consider performance, task alignment, total cost of ownership and broader institutional goals. EV selections automatically trigger an Engineering work order to assess charging infrastructure needs.

- Step 4 is Charging Infrastructure Planning which ensures adequate power, site readiness, and alignment with fleet deployment timelines. This step considers charger type, location, electrical capacity, and future scalability to support long-term fleet electrification goals.

- Step 5 is Vehicle Data Analysis Systems via automated analysis and visualization dashboards that enable maximum visibility of ongoing tracking of vehicle usage, fuel and energy consumption, and maintenance trends. These insights support continuous improvement, help validate right-size decisions, and guide future procurement and infrastructure planning.

- Step 6 is Vehicle Replacement Budget Strategy completing the strategy with a proactive replacement strategy that aligns fleet renewal with right-size planning. Budgeting would be based on vehicle lifecycle data, total cost of ownership, evolving operational needs, and broader institutional goals.

In addition to this Fleet Electrification Strategy Flow Chart, additional one-page case studies sharing key insights from UGA's e-mobility efforts are being tailored for other UGA adopting units, USG sister schools, and community planners across the state.

These resources focus on practical takeaways and strategic recommendations to accelerate campus and community electrification. Some examples include:

- Leveraging Parking Registration to Guide EV Charging Expansion for Commuters
- Key Considerations for Deploying Low-Speed Electric Vehicles (LSVs) on Campus
- Early Lessons in Campus E-bike and Micro-Mobility Integration
- Quiet, Clean and Capable: A Practical Approach to Electric Grounds Equipment Deployment

These will be featured in an online case study repository compiled with support from a GNEM seed grant received by Heewon Lee and Julia Dietz.

Public Safety Lit Review Subgroup

Lead: Julia Dietz (Carl Vinson Institute of Government)
Team Members: Heewon Lee (School of Public & International Affairs), Handong Yao (College of Engineering)
Students: Leticia Baquerizo (GRA, School of Public & International Affairs), Harrison Stang (GRA, Carl Vinson Institute of Government), Donavan Arnold (PSO Scholar, Carl Vinson Institute of Government)

In response to increasing questions from consumers and governments about the safety of electric vehicles and infrastructure, a team completed a literature review to address the following topics: battery management, charging infrastructure design and operation, chemical content, emergency response and safety standards, disaster evacuation concerns, frequency of fires, cybersecurity, and electric micromobility behavior. Within these topics, there were also sub-topics of risk identified. These sub-topics include, but are not limited to, battery malfunction, overheating, overcharging, and electric shocks. For emergency response and safety standards, the sub-issues of inadequate emergency guidelines and lack of charger infrastructure and behavioral limitations were identified.

While conducting this literature review, there were also multiple areas where additional research is needed including, but not limited to, social science research such as citizens' concerns and perceptions, planning and guidelines for general EV charging, safety concerns about EV behavior and collisions, and safety of charging infrastructure in parking decks. Further, the research indicates a need for improved access to education and training for first responders, drivers, and the public; support for local government and campuses to integrate electric mobility into planning; standardized response and safety protocols; and continued safety enhancements through industry innovation.

This literature review is included in the Appendix and will be used to inform other research and outreach projects, including a GNEM seed grant led by Heewon Lee (School of Public & International Affairs) studying public perceptions about EVs and the Carl Vinson Institute's Plug Into Georgia initiative.

Beyond the Seed Grant

Georgia Network for Electric Mobility

Founded in 2022, the Georgia Network for Electric Mobility (GNEM) is a pan-university initiative housed at the University of Georgia focused on electric mobility and transportation innovation, research, and economic development around the state and beyond. GNEM's mission is to accelerate electric mobility innovation and adoption in Georgia. GNEM will achieve this mission by convening key academic, business, government, and community partners to develop strategic frameworks, inspire multidisciplinary research and foster collaboration and workforce development.

GNEM is in the process of developing white papers to highlight research from faculty across UGA related to electric mobility and has provided additional seed grants to faculty, including members of the Interdisciplinary Seed Grant team.

One such seed grant award was received by Heewon Lee (School of International and Public Affairs), Julia Dietz (Carl Vinson Institute of Government), and Mengqi Liao (Grady College of Journalism and Mass Communications) to evaluate public perceptions around electric vehicles and create a case study library to share best practices.

Existing Outreach Efforts & Needs

Members of the Interdisciplinary Seed Grant team from the Institute of Government have also launched an outreach program for local governments, bring the research, expertise, and real-world experiences of electric mobility on UGA's campus to communities across the state.

Plug Into Georgia

The Carl Vinson Institute of Government, as a partner in UGA's Georgia Network for Electric Mobility, is leading public service and outreach efforts to enhance the economic competitiveness of the state through informing, educating, and supporting communities as they navigate emerging electric mobility technologies. Specifically, the Institute, with collaboration and support from Southern Company, is engaging local governments through the Plug into Georgia initiative.

This initiative provides user-friendly tools, educational opportunities, outreach, engagement, and technical assistance to help communities navigate the transition to electric transportation. By convening subject matter experts and partnerships, offering neutral, data-driven education, and providing technical support, Plug Into Georgia aims to strengthen connections between the University of Georgia and local communities while helping leaders make informed decisions.

One way in which Plug Into Georgia has worked to foster connections with local communities is through our regional E-Mobility Local Government & Community workshops. These workshops are designed to create an environment where local governmental and community leaders are encouraged to attend and connect with regional peers, exchange ideas, and take actionable steps toward shaping the future of transportation in Georgia. Along with these workshops, communities have also found value in our E-Mobility webinars that range in topic from EV charging funding 101 to EV community case studies around the state of Georgia. These webinars provide an informative environment for communities to listen and ask questions regarding any of their electric mobility needs.

With an emphasis on creating tools that are user-friendly to communities across the state, the Plug Into Georgia team has also had the opportunity to design and distribute multiple printed and digital resources such as our EV 101: A Georgia Guide for Public Charger Success Guidebook and our Georgia Electric Mobility Snapshot. Grounded in applied research and practical experience, the guidebook is designed to assist local policymakers and staff with best practices and strategies for planning, acquiring, and installing EV charging stations in their communities.

The Electric Mobility and Energy team at the Institute is planning additional workshops, guidebooks, webinars, strategic planning support, and technical assistance to help local governments make informed decisions around electric mobility.

Outreach Needs on Campus

UGA has established itself as one of the earliest adopters of electric mobility in the Southeast, beginning with electric campus transit buses in 2018 and continuing over the last three years into facilities management fleet vehicles. The integration of UGA's fleet electrification efforts and charging infrastructure planning with research, teaching, and public service outreach strengthens the university's role as a land-grant institution by transforming campus into a living laboratory, providing students with hands-on learning opportunities, and enabling statewide technology transfer through the Carl Vinson Institute of Government and other Public Service and Outreach units.

An E-mobility Outreach Strategy for campus operations is critical to the success of UGA's overall electrification efforts because it builds awareness, fosters buy-in, and accelerates adoption across departments, users, and decision-makers. This strategy should focus both internally, proactively engaging campus stakeholders, and externally, targeting peer institutions in the University System of Georgia. Essential components of this strategy include the following:

- UGA operations pilots and case studies – Document and share UGA's lessons learned with EVs, LSVs, micro-e-mobility, electric grounds equipment, charging infrastructure and data systems can be developed and improved with student and faculty support, and disseminated to both internal and external audiences. One-pagers and short videos would be effective tools for broad and accessible communication.

- Demonstration events and networking site visits - Seeing UGA deployments in action is the single best form of outreach. UGA will feature its operational electrification efforts to facilities managers at the annual SRAPPA event held at the Classic Center in October and a USG fleet manager gathering is proposed as an extension of the energy professionals CERG (Campus Energy & Resiliency Group) Network.

- A Public Facing Campus E-Mobility website and Dashboard would highlight UGA's growing e-mobility assets on campus with maps and data summaries as well as provide a location to disseminate UGA's operational standard operating procedures (SOPs) for fleet electrification.

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Potential Funding Opportunities & Strategies

Funding Opportunities

While many current and future funding opportunities for electric mobility research are ambiguous and under review by the federal government, having a strategy and knowledge of past funding is still pertinent to our project goals and being prepared to pursue future funding opportunities. The Seed Grant team is actively evaluating new and creative funding opportunities, including through private funders to continue the work completed thus far.

Multiple federal and state programs have provided funding in recent years to support the deployment of electric vehicle infrastructure, clean transportation technologies, and emissions reduction initiatives. Federally, programs such as the National Electric Vehicle Infrastructure (NEVI) Formula Program and the Charging and Fueling Infrastructure (CFI) Discretionary Grant Program were established under the Bipartisan Infrastructure Law to fund the installation of EV chargers across the country. The U.S. Environmental Protection Agency (EPA) has also administered initiatives such as the Clean School Bus Program, Clean Heavy-Duty Vehicle Program, Environmental and Climate Justice Block Grants, and the Diesel Emissions Reduction Act (DERA), all of which support the transition to lower-emission vehicle technologies through various forms of grants and rebates. Additionally, the Federal Transit Administration's Low or No Emission (Low-No) Grant Program offers funding for transit agencies to acquire low- or zero-emission vehicles and related infrastructure.

Several programs continue to offer financial incentives, including federal tax credits for the purchase of clean vehicles and installation of EV charging equipment. These credits vary based on income thresholds, vehicle criteria, and installation specifics. Some utility companies and local entities, such as Georgia Power and Cobb EMC, have developed incentive programs to assist with EV infrastructure development in their service areas. The Georgia Environmental Finance Authority (GEFA) has also provided grants for local energy efficiency and renewable energy projects.

State-level programs such as the Congestion Mitigation and Air Quality (CMAQ) Improvement Program and the Carbon Reduction Program are administered by the Georgia Department of Transportation to support emissions reduction projects. These include funding for EV infrastructure, public transit, and non-motorized transportation improvements. Other state-level policies and exemptions, such as alternative fuel vehicle access to high-occupancy lanes and state tax credits, have supported clean transportation efforts. Application windows and eligibility requirements vary by program, and some opportunities are subject to federal or administrative changes. A full list of past and ongoing programs is included in the Appendix.

Approach to Funding

While the federal funding landscape for electric mobility remains dynamic, the strategic path forward is clear. The University of Georgia is well-positioned to lead multi-institutional and multi-agency proposals by aligning its research strengths with pressing state and federal priorities. Going forward, proposals should emphasize interdisciplinary integration, applied impact, and community relevance - especially where infrastructure, behavior, safety, and workforce development intersect. The foundation laid by this Seed Grant enables scalable pilots, data collection systems, and outreach models that can be rapidly adapted to meet the criteria of programs within the focus of large funders in the private and government arenas. To remain competitive, the team should monitor upcoming rounds of federal and state solicitations, engage early with agencies and utilities, and prepare modular project concepts that can be tailored to specific opportunities. Developing co-investment from campus units and external partners will be critical to signal institutional commitment. Strategic use of faculty release time, graduate research assistants, and data-sharing infrastructure should be incorporated into future proposals. A focused funding strategy will allow UGA to transition from exploratory research to sustained leadership in electric mobility innovation.

Conclusion

This Roadmap captures the early outcomes of a coordinated, interdisciplinary effort to establish the University of Georgia as a leader in electric mobility research and outreach. The work completed this year demonstrates clear institutional capacity in technical modeling, behavioral analysis, campus-based piloting, and public engagement. More importantly, it confirms that UGA is uniquely positioned to connect rigorous academic research with the practical needs of Georgia communities navigating the transition to electric transportation.

Across all subgroups, common themes have emerged—most notably, the need for shared data, scalable modeling frameworks, and applied social science to complement technical advancements. These insights underscore the importance of continued collaboration across disciplines, and between researchers and practitioners, to inform infrastructure investments, policy design, and workforce preparation.

Looking ahead, the University must leverage this momentum to secure multi-year funding, expand faculty participation, and formalize partnerships with state agencies, utilities, and industry leaders. Priority should be given to developing a campus-wide data infrastructure, deepening community-based pilot projects, and pursuing aligned funding opportunities through federal and philanthropic channels.

This first phase has validated the interdisciplinary approach. The next step is to scale it—strategically, collaboratively, and with the full backing of the institution.

Appendix

1. Report on electric infrastructure analysis of Chicopee facility
2. PowerPoint presentation on EV driving behavior test
3. PowerPoint presentation on initial results from commuter survey
4. Public safety literature review
5. Detailed summary of past funding opportunities

Electric Infrastructure Subgroup – Interdisciplinary Seed Grant
T. Hong, F. Beyette, Jr., J. Ellis, W. Song, J. Ye, & S. Zhou

Electrical Vehicle Charging Impact Analysis – A Case Study from Grid Perspective

I. Introduction

This report focuses on illustrating the regular process of evaluating the impact of electric vehicle charging from the grid perspective. To quantitatively model and study such impact, we generally need to convert descriptive data to physical models, including EV charging and grid models. Then, we build various scenarios to perform a corresponding simulation study. Finally, we can perform data analysis based on the simulated results to identify the potential impacts and benefits from an economic point of view.

II. Grid Modeling

The common descriptive grid data is usually presented as a one-line diagram, as shown in Fig. 1, which we received from the FMD department. The one-line diagram represents one building-level power system of the CHICOPEE FMD SECTION. The detailed specs and abbreviations represent the actual physical models of each component.

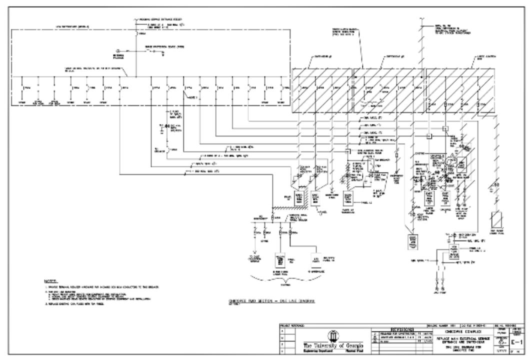


Fig. 1. CHICOPEE FMD grid.

Clearly, the one-line diagram shown in Fig. 1 cannot be directly applied to compute the system status. Hence, we usually need to convert this representative model into a model that can be simulated using software. In this project, we use a popular open-source tool, OpenDSS, as the platform for power system simulation. Other popular power flow analysis tools can also be applied here, if necessary, in the future. Some conversion examples are shown below for reference.

Electric Cable Modeling: One of the cable specifications shown in Fig. 1 is 4#4/0, 1#4G, 2½"C, indicating the cable uses four 4/0 AWG specification conductors and one 4 AWG grounding wire, which are installed in a 2½ inch conduit. Based on this specification, the corresponding electrical resistance is 0.055 Ω/kft , and the reactance is approximately 0.08 Ω/kft. We can then model such a line in OpenDSS as

```
New Line.Branch8_Cable phases=3 bus1=Branch8_Start bus2=Panel_H1
~ rmatrix=(0.055 0.0 0.0 | 0.0 0.055 0.0 | 0.0 0.0 0.055)
~ xmatrix=(0.08 0.0 0.0 | 0.0 0.08 0.0 | 0.0 0.0 0.08)
~ length=0.1 units=kft
```

Following a similar procedure, we can build models for a network transformer, breakers, and building loads to complete the circuits.

III. EV Charging Facility Modeling

Generally, electric vehicle (EV) charging facilities can be classified as Level 1, Level 2, and DC Fast Charging (DCFC). Different types of charging equipment are suitable for different scenarios and demands. The table summarizes the major parameters of different charging equipment:

Type	Voltage	Power	Estimated Charging Rate
Level 1	120 V (AC)	1.4 – 1.9 kW	3-5 miles/h
Level 2	240 V (AC)	3.3 – 19.2 kW	10-60 miles/h
DCFC	200 – 1000 V (DC)	50 – 350 kW	60% to 80% within 15 to 20 minutes.

In power system steady-state analysis, we usually model EV charging facilities as time-varying power loads, in which their input powers are assumed to be constant between two observations. In this study, we are not modeling different types of EV charging facilities individually. Instead, we aim to identify the maximum EV charging facility capacity. As a result, we group all potential EV charging systems as a lumped power load. Similar to the line modeling procedure in the previous section, the EV charging facilities are modeled in OpenDSS as:

```
New Load.GourpedEV Bus1=bus1 Phases=3 kV=0.48 kW=40 kVAR=10 Model=1
```

Note that the active power and reactive power for this grouped EV load are set to 40 kW and 10 kVar, respectively, for illustration purposes. They are time-varying inputs based on the actual scenarios considered during the simulation study.

In the studied Chicopee FMD system, we assume there is a dedicated branch line of 225A for the EV charging facilities. According to the electrical design calculation, under the condition of a power factor of 0.95, the theoretical maximum power capacity of this branch line is approximately 178.7 kW. This capacity design allows the charging station to have considerable flexibility and support different types and quantities of charging equipment. Based on the above analysis, we can consider adding five Level 2 electric vehicle charging systems with a power of 20 kW.

IV. Case Study

The EV charging impact analysis requires detailed information regarding the target areas, including network models, EV charging models, load profiles, and upstream feeder information. For this study, we are missing the length of the electric lines, upstream feeder information, and load profiles. Hence, we make necessary assumptions about that information to finish the whole study. In the following study, we will convert most of the physical quantities to per unit (short as p.u.) value (a kind of normalization process in power system analysis).

1. Base Case Analysis (without EV charging facility)

Based on the OpenDSS model established using circuit diagrams, the power grid simulation adopts the "daily mode", with a time span of 24 hours and a step size of 1 hour. The usage of the power grid at different times of the day was simulated (such as a small load in the early morning and a large load at noon). The parameters are as follows:

```
New Loadshape.LS_24h npts=24 interval=1
~ mult=(0.20, 0.20, 0.20, 0.20, 0.20, 0.25, 0.35, 0.60, 0.80, 0.90, 0.95, 1.00, 0.95, 0.90, 0.85, 0.80,
        0.70, 0.50, 0.40, 0.35, 0.30, 0.25, 0.22, 0.20)
```

where "npts" represents the number of hours considered in this load profile. For example, the first "0.2" means the operating power of the load is 0.2 times the rated power at 1 a.m. The corresponding load profile is shown in Fig. 2.

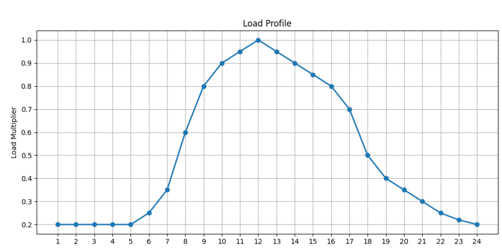


Fig. 2. Typical load profile for commercial buildings.

For feeder level information, we assume we have a network transformer which is modeled as:

```
New Transformer.XFMmain Phases=3 Windings=2 XHL=1.91
~ wdg=1 bus=SourceBus conn=wye kV= 12.47 kVA=2000 %R=0.25
~ wdg=2 bus=XfmrSecBus conn=wye kV=0.48 kVA=2000 %R=0.25
```

As mentioned previously, certain information is missing to complete the EV charging impact analysis, we select the necessary parameters based on engineering practices. We first calculate the total rated current of all branch circuit breakers, then divide the capacity of each branch circuit breaker by the total to obtain the proportion of that branch in the entire system. Finally, multiply this proportion by the main busbar's capacity to estimate that branch's maximum available current without exceeding the total capacity. This can ensure that the load configuration of the entire system does not exceed the backbone capacity limit and provides a benchmark case for EV-related studies.

For representation purposes, we only select the minimum voltage and maximum voltage to describe the operation status of the target system. During the daily operation, the voltages of all nodes were maintained within the range from 0.95 to 1.05 p.u. The maximum voltage is 1.004 p.u., which occurs at the primary side of the network transformer, and the minimum voltage is 0.974 p.u. at the load side. The average daily active power of the system is 0.372 MW, the maximum active power is 0.728 MW at 1 p.m., and the average active loss is 0.011 MW (≈ 1.5%). The voltage profile for the target system with a 24-hour simulation study is shown in Fig. 3.

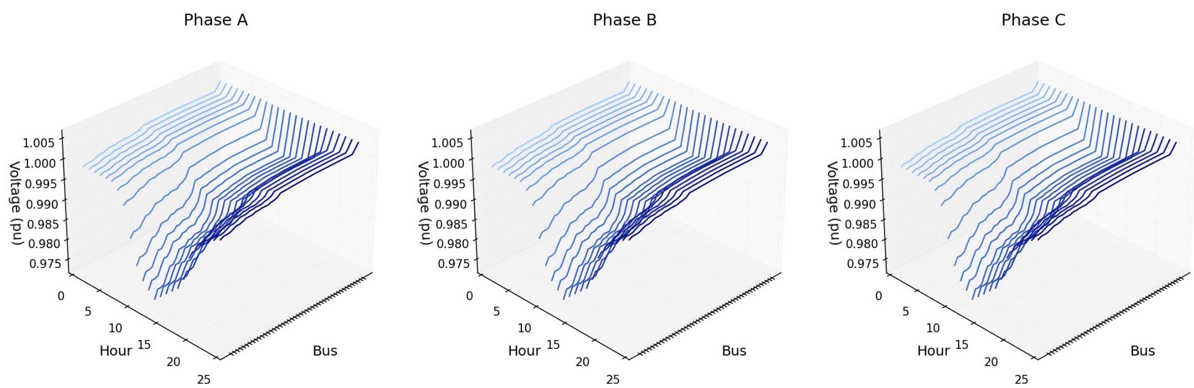


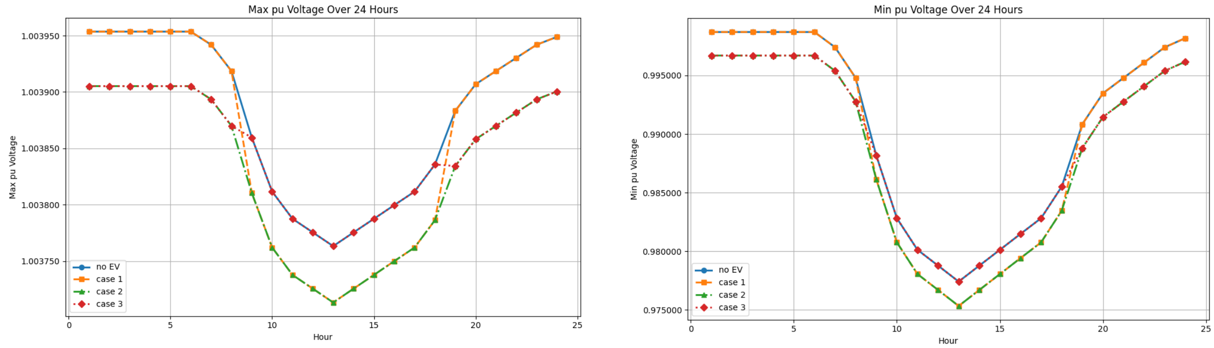
Fig. 3. 24-hour simulation for the understudied Chicopee FMD system.

2. EV Charging Impact Analysis

In the second study, we consider three types of EV charging scenarios.

- Case 1, the EV charging facility operates at full power from 8 a.m. to 5 p.m., assuming that the charging facilities are fully loaded during working hours.
- Case 2, the EV charging facility operates at full power throughout the day (extreme condition).
- Case 3, the EV charging facilities operate at full power for the rest of the day (off-peak operation).

For all cases, the maximum power of the EV charge station is 170 kW, the difference lies in the time of access. The following are the operational data curves under different scenarios compared with the base case.



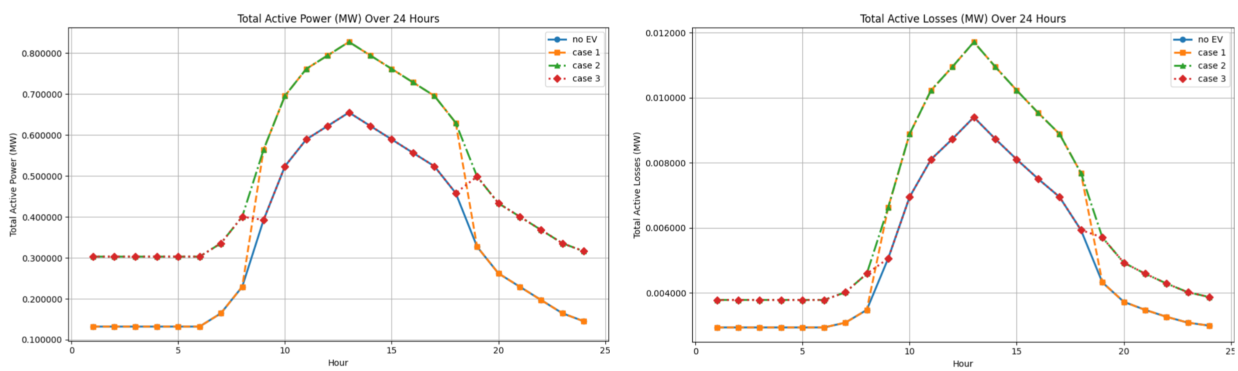
(a) (b)

Fig. 4. Maximum and minimum voltage over a day.

The maximum and minimum voltages of the power system during daily operations are shown in the following table, respectively:

	Max Voltage [p.u.]	Min Voltage [p.u.]
No EV	1.004	0.9777
Case 1	1.004	0.975
Case 2	1.004	0.975
Case 3	1.004	0.977

Due to the new EV charging load, the minimum voltages of both Case 1 and Case 2 have slightly decreased compared with the base case (no EV). Clearly, more EV charging facilities can be added to this existing system without additional infrastructure investment. In Case 3, since the EV working time avoids the peak period of the original load in the building, it has almost no impact on the system minimum voltage, which means the off-peak charging strategy can minimize grid impacts. The updated system load profile comparison under different cases can be found in Fig. 5(a).



(a) (b)

Fig. 5. Load and losses profiles.

Compared to the base case (No EV), the power demand in Case 1 and Case 2 significantly increases between 10 a.m. and 4 p.m., coinciding with the original load peak of the building. This overlap raises line currents, exacerbates voltage drops, increases grid stress, and potentially leads to voltage instability, higher losses, and greater economic costs. In contrast, Case 3 shifts EV operation away from peak building load periods, effectively utilizing idle grid capacity, thus enhancing grid stability and economic benefits.

3. Better Charging Plan

Based on the above analysis of Case 3, after adding EV charging facilities, the off-peak use with the original load of the building is better for the stability and economy of the power grid. The following analysis will use all the relatively idle time of the power grid to start the EV charging stations.

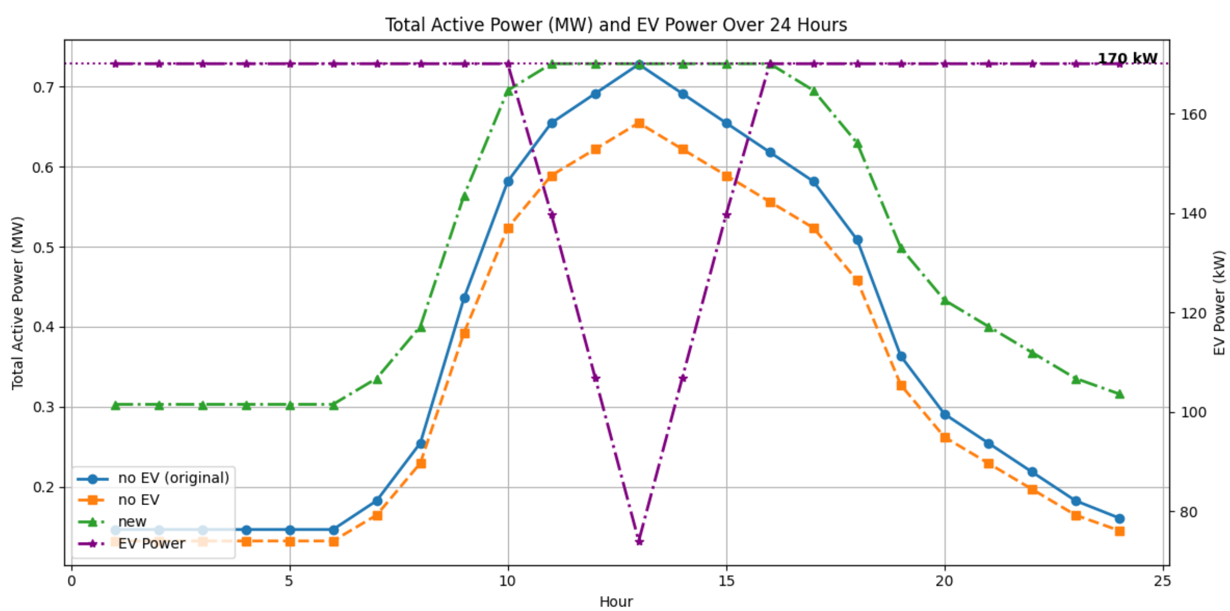
Based on the above calculation, the maximum power of the EV charging line is 178.7 kW, and we can assume the installation capacity for EV charging to be 170 kW (Reserve a certain amount of redundancy). To maximize the efficiency of electric vehicle (EV) charging without exceeding the total power limit of the grid, this study proposes a power allocation strategy based on the system's residual load capacity. Since a certain amount of base load already exists in the system, simply adding EV charging power during peak demand periods may lead to overload. To address this, we dynamically adjust EV charging power: when the base load is low, higher EV charging is allowed; conversely, when the base load is high and near the capacity limit, the EV charging power is reduced accordingly. This approach ensures that off-peak periods are fully utilized while preventing system overload, thereby maximizing the amount of energy delivered to EVs and improving overall power system efficiency. To quantify the power allocation each hour, we define a "charging coefficient" as the ratio of the actual EV charging power to the maximum allowed power of 170 kW, i.e.,

$$Charging\ Coefficient = \frac{Actual\ EV\ Power}{Installation\ Capacity} \times 100\%$$

The energy charged each hour is the coefficient multiplied by 170 kW and 1 hour. Accumulating over 24 hours gives total charging energy:

$$E_{total} = Installation\ Capacity \times \sum_{i=1}^{24} Charging\ Coefficient_i \quad [\text{kWh}]$$

According to the analysis results, the EV charging facilities can charge 3797.12 kWh daily, which is enough to fully charge more than 42 electric vehicles. Since the electricity cost is not available at this moment, we are not considering the hourly price difference in the above analysis.



- "no EV (original)" refers to the baseline condition where no EV charging station is connected, and the original loads operate at their full power levels. Since no EV load is present, there is no need to reserve capacity, so the system can run at maximum load levels.
- "no EV" represents a scenario without EV charging, but the load operation follows the same reduced profile as the EV-connected case. This allows for a fair comparison with the "new" curve by isolating EV power's impact.
- "new" shows the actual system behavior after adding EV charging stations. The original load levels are reduced to prevent system overload, and EV charging power is added on top.
- "EV Power" displays the 24-hour EV charging load profile, in kilowatts (kW), corresponding to the right vertical axis, with a peak of 170 kW.

Conclusion

This study examined the impact of integrating electric vehicle (EV) charging facilities into the CHICOPEE FMD section power distribution system using detailed simulation modeling with OpenDSS. Results indicate that adding EV charging infrastructure can cause modest reductions in node voltage and increased line losses, particularly when EV charging coincides with peak building load periods. And more EV charging facilities can be installed. Although these changes remain within acceptable operational limits, careful consideration is essential to avoid potential impacts on sensitive equipment and economic efficiency.

Among the analyzed scenarios, scheduling EV charging during off-peak periods emerged as the most beneficial strategy, significantly enhancing grid stability and economic performance. Utilizing available idle grid capacity during low-demand hours reduces the risk of voltage instability and excessive losses.

Therefore, strategically managing EV charging schedules to avoid peak demand periods is recommended for similar distribution systems, facilitating scalable EV adoption while maintaining optimal grid performance. Future analyses should incorporate detailed component specifications and more precise load profiles to refine these recommendations further.

EV Behavior with Regenerative Braking

Tianle Zhu, Handong Yao, Qianwen Li

Background: EV Driving Behavior

EV Adoption and Driving Innovation

- The rise of electric vehicles (EVs) is reshaping driving behavior and energy consumption.
- EVs often feature single-pedal driving with regenerative braking, enabling smoother deceleration and energy recovery.

Motivation for This Study

- Most existing car-following models focus on adaptive cruise control (ACC) in traditional internal combustion vehicles.
- However, EVs with single-pedal driving under ACC present distinct dynamics in acceleration, deceleration, and headway behavior.
- There is limited research addressing how these dynamics impact longitudinal traffic flow and spacing behavior.

Implications of EV Car-Following Models for Traffic Planning

Accurately calibrated models for EV single-pedal behavior help:

- Simulate realistic flow under future EV-dominant scenarios
- Support infrastructure decisions (e.g., intersection spacing, speed limit design)
- Evaluate energy-saving policies and AV lane planning based on regenerative performance

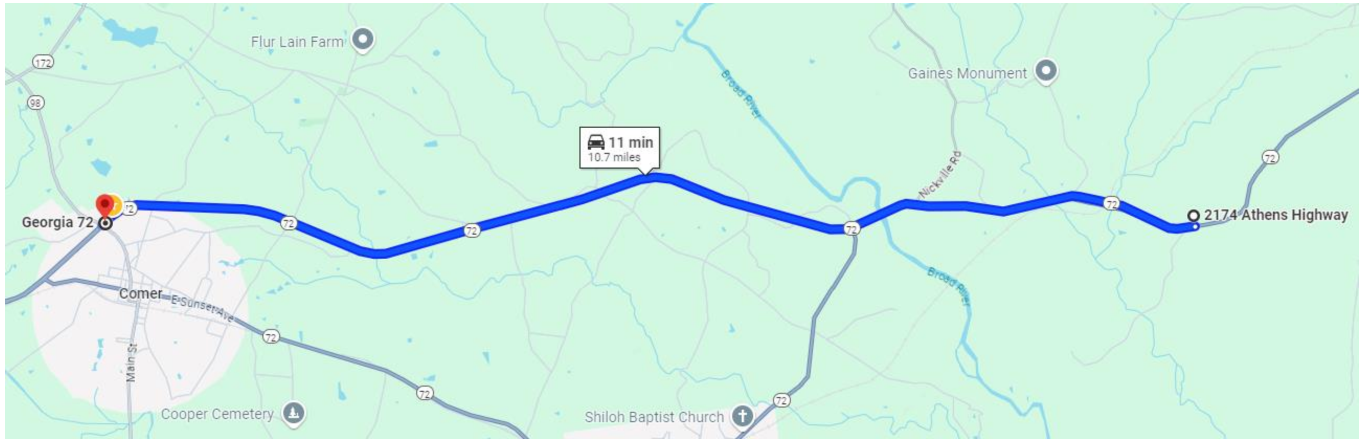
Enables bottom-up modeling, where real behavior informs corridor and network-level design.

Real-World Data Collection for EV Driving Behavior

Experimental Details:

- Vehicles:
  - Leading vehicle (Lexus S350)
  - 2nd vehicle (Ford Mustang Mach-E)
  - 3rd and 4th vehicles (Kia Niro)

- Testing area:
  - GA-72 between Comer and 2174 Athens Highway
  - Two-way four-lane roads
  - No signals
  - Light traffic



Real-World Data Collection for EV Driving Behavior

Experimental Details:

- The leading vehicle is driven with Adaptive Cruise Control (ACC) to regulate the experiment speed profile.
- All following vehicles are electric vehicles (EVs) equipped with both ACC and regenerative braking (single-pedal or regular-pedal mode).
- Each vehicle is equipped with a GPS device to accurately record the location and speed of the ego vehicle.
- The experiment is divided into 12 groups:
  - 8 groups under ACC-controlled driving
  - 4 groups under human driver control
- The detailed scenario settings are shown below.

Mode	Headway Setting	Acceleration Level	Description
Single-Pedal	Longest	Low / High	Regenerative braking with ACC
Regular-Pedal	Longest	Low / High	Traditional two-pedal with ACC
Single-Pedal	Shortest	Low / High	Tight headway with ACC
Regular-Pedal	Shortest	Low / High	Tight headway with ACC

Real-World Data Collection for EV Driving Behavior

Data Collection Details

- **Data Format:** Vehicle trajectory data from onboard GPS and sensor logs.
- **Key Variables:**
    - Vehicle speed (m/s)
    - Inter-vehicle spacing (m)
    - Time-stamped positional data
- **File Sources:**
    - experiment_1.csv, experiment_2.csv… -> Longest headway
    - experiment_5.csv, experiment_6.csv…-> Shortest headway

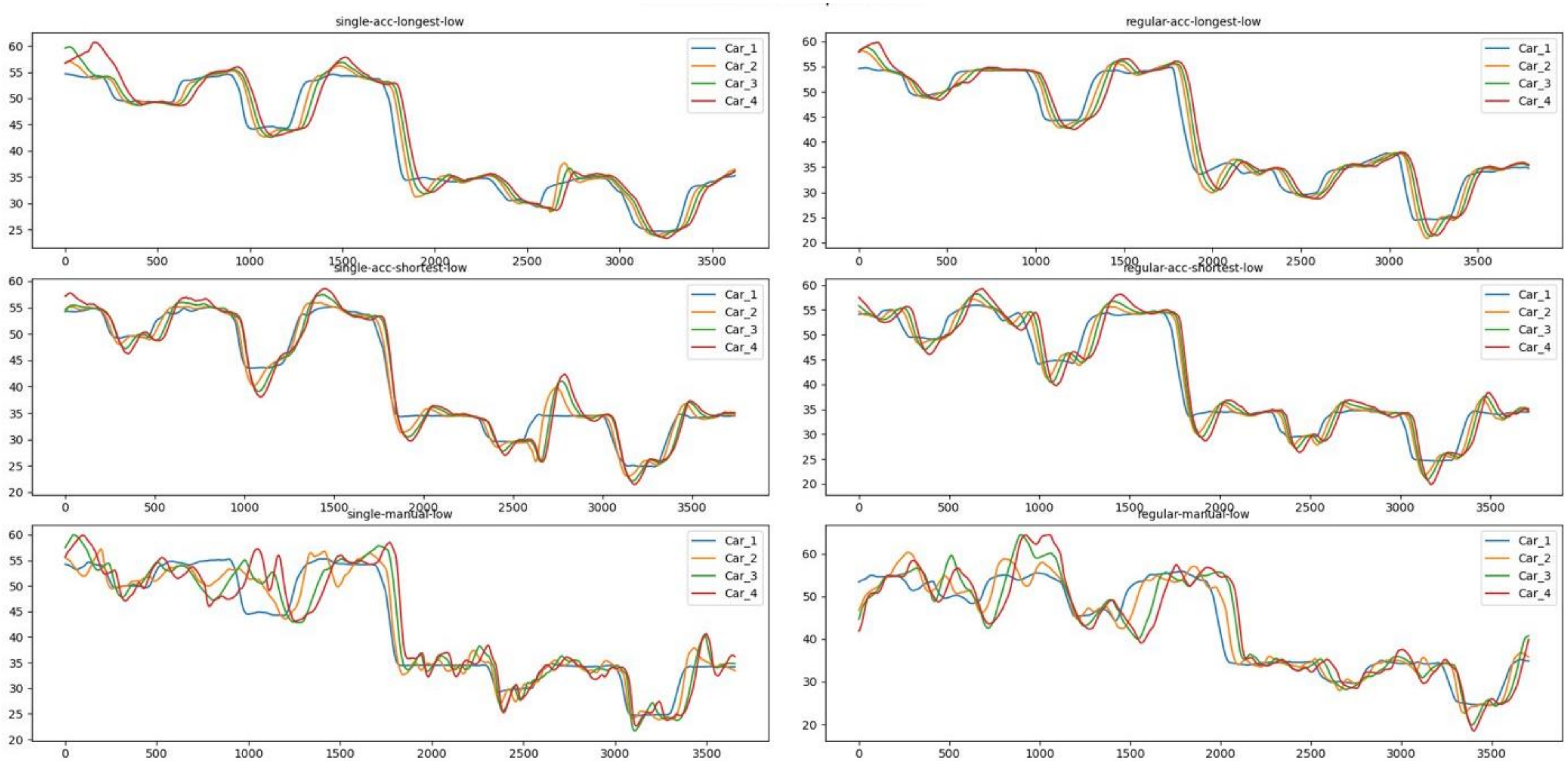
Usage

- **Data used for:**
    - Behavioral comparison (e.g., speed, spacing)
    - Car following model parameter calibration in SUMO
    - Downstream statistical validation (t-test, ANOVA)
    - Simulation-based traffic planning scenarios

experiment_data	
Record	integer
Time	timestamp
Car_1_Speed	float
Car_1_X	float
Car_1_Y	float
Car_1_Z	float
Car_2_Speed	float
Car_2_X	float
Car_2_Y	float
Car_2_Z	float
Car_3_Speed	float
Car_3_X	float
Car_3_Y	float
Car_3_Z	float
Car_4_Speed	float
Car_4_X	float
Car_4_Y	float
Car_4_Z	float

Data Validation: Behavioral Differences Between Single-Pedal and Regular-Pedal EV Driving

- **Visualization**



Data Validation: Behavioral Differences Between Single-Pedal and Regular-Pedal EV Driving

- **Objective**
  - To determine whether EVs exhibit statistically significant behavioral differences under different pedal settings
    - Single-pedal driving (regenerative braking).
    - Regular-pedal driving
- **Methodology**
  - Statistical Tests Used:
    - Independent Samples T-Test to compare means
    - One-way ANOVA for group variance assessment

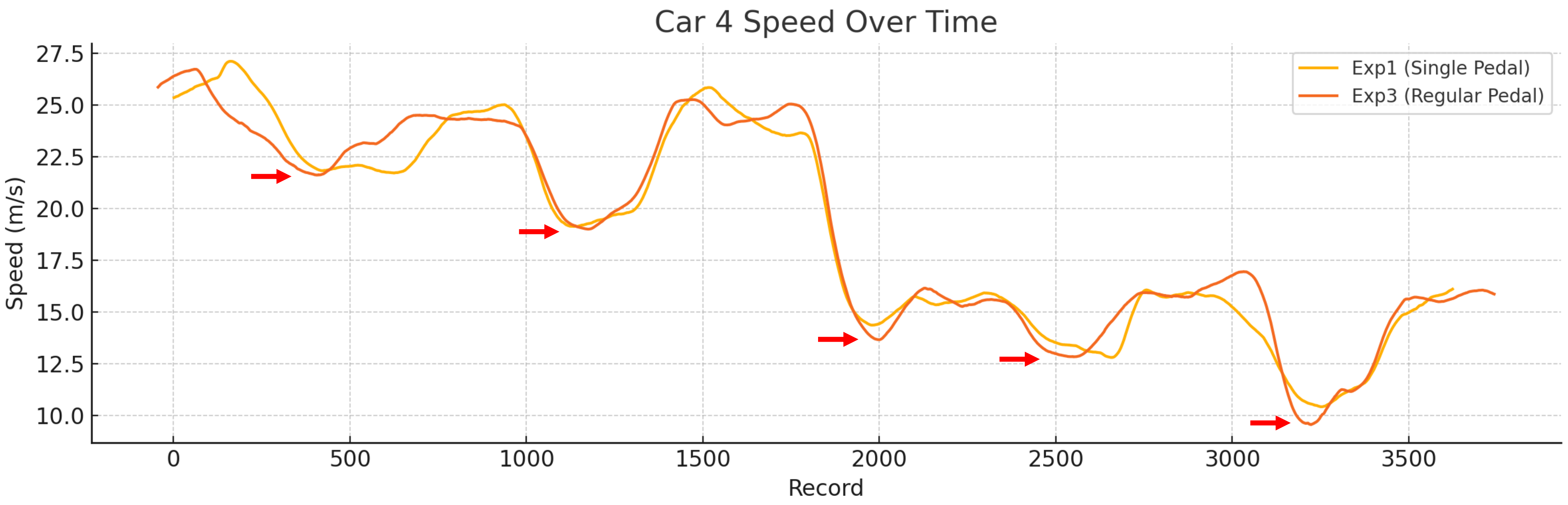
Metric	T-Test p-value	ANOVA F-Value	ANOVA p-value
Speed	0.09594	9.2360	0.0025
Spacing	9.156×10^{-6}	6.9658	0.0085

*Statistical significance threshold set at **$p < 0.05$, significant difference.***

Data Analysis: Behavioral Comparison

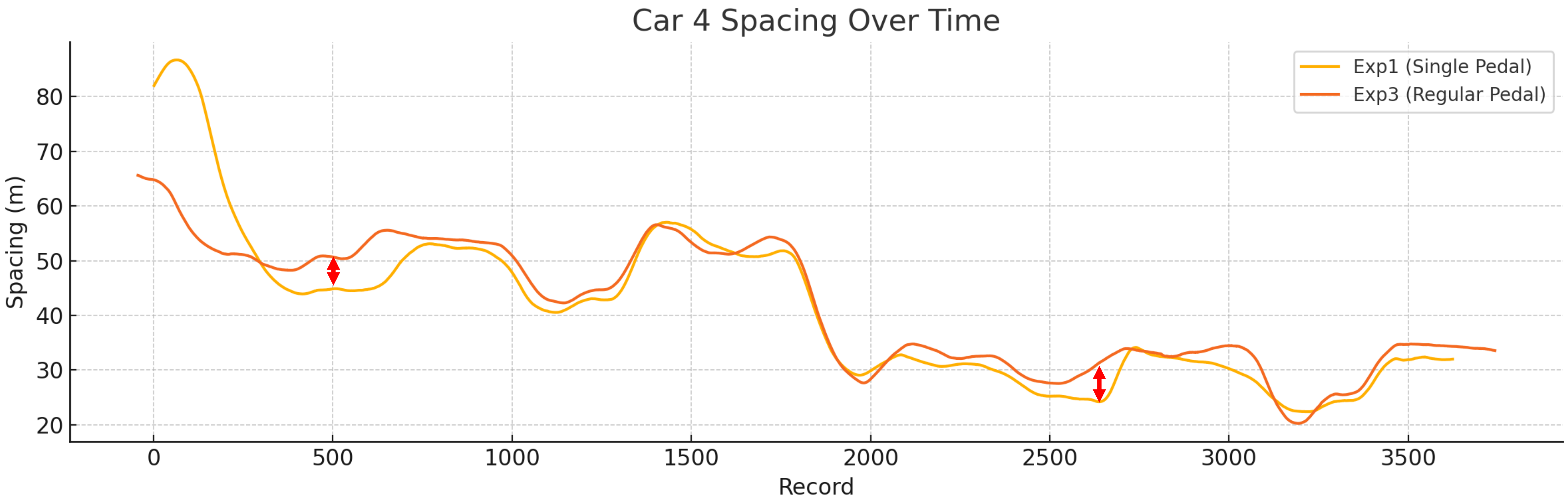
- **Objective**
  - To investigate how pedal mode (single-pedal vs. regular-pedal) affects the speed and spacing of Car 4, the last vehicle in the platoon.
- **Why Car 4?**
  - Furthest from the lead vehicle → amplifies following dynamics
  - Captures deceleration ripple effects more clearly
  - Sensitive to braking behavior differences from regenerative vs. friction braking
- **Analysis Methods**
  - Time-Series Curve Plot
    - Shows dynamic evolution of speed and spacing over time
    - Captures transient behavior during acceleration or braking segments
    - Useful for identifying response delays or oscillation patterns

Data Analysis: Behavioral Comparison



While the difference is not visually drastic, we can observe that the **single-pedal mode responds more gently** during the deceleration phase, which aligns with the nature of regenerative braking. This smoother deceleration behavior highlights how energy recovery systems influence following dynamics under ACC control.

Data Analysis: Behavioral Comparison



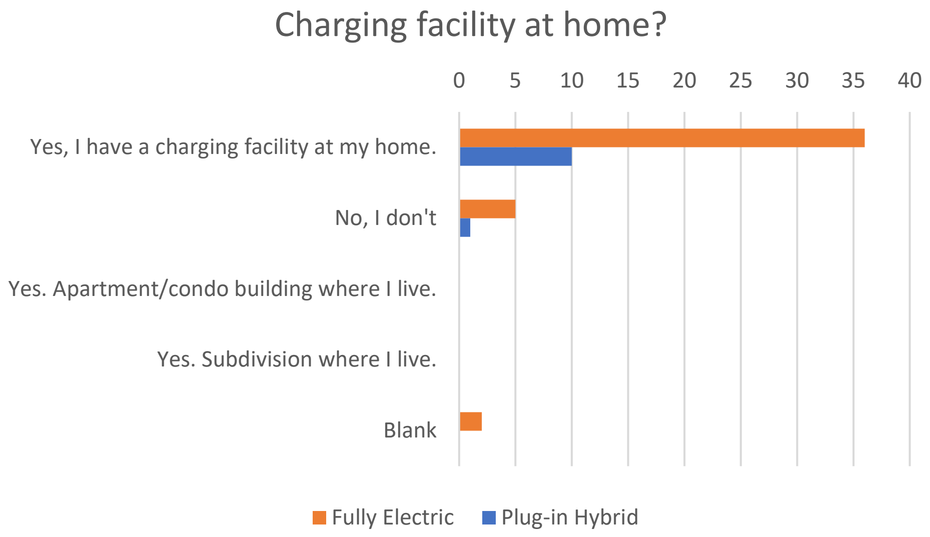
An interesting observation emerges from the analysis:
Despite identical headway settings under ACC control, the **regular-pedal mode consistently maintains a larger spacing** from the lead vehicle compared to the single-pedal mode.
This may be due to how regenerative braking in single-pedal mode encourages earlier and smoother deceleration, allowing the vehicle to follow more closely without abrupt braking. In contrast, regular-pedal vehicles may exhibit delayed or sharper deceleration, leading to a more conservative following distance even under the same ACC configuration.

J. Rios, M. Boudreau, A. Shirzadibabakan, & J. Park

Survey on EV Charging at UGA
Early Insights

Faculty & Staff

Participate in a follow-up survey/focus group?	Not at this time	Yes, I'm interested	Blank	**Grand Total**
Fully-electric car	11	30	2	**43**
Plug-in hybrid car	3	8	0	**11**
Gas/Diesel/Hybrid Car	244	99	10	**353**
Bus	2	2	0	**4**
Walking	5	2	2	**9**
Other	14	13	1	**28**
Grand Total	**279**	**154**	**15**	**449**



Fully-electric car

UGA Charging	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
South Campus	3	2	2	2	2	1	1
Noth Campus	0	0	0	0	0	0	0
East Campus	2	0	2	0	2	1	1
I-STEM	0	1	0	1	0	0	0
Hull St.	1	0	1	1	0	0	0

Plug-in hybrid car

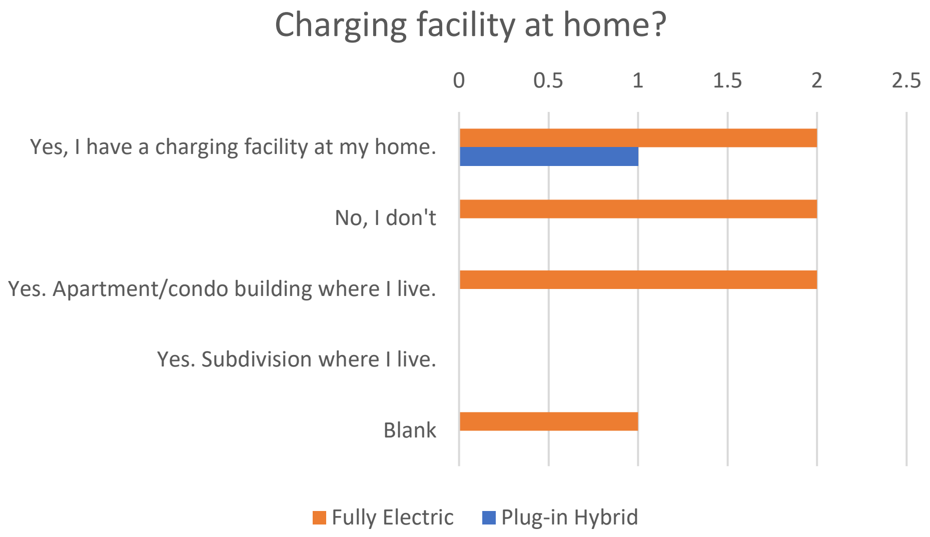
UGA Charging	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
South Campus	1	1	1	1	1	0	0
Noth Campus	0	0	0	0	0	0	0
East Campus	0	0	0	0	0	0	0
I-STEM	0	0	0	0	0	0	0
Hull St	0	0	0	0	0	0	0

Comments summarized with ChatGPT

- Add **more EV charging stations**, especially at high-demand areas.
- Install chargers at underserved locations like **Health Sciences**, **Gwinnett**, and **South Campus**.
- Improve **signage and discoverability** of chargers.
- Consider offering **incentives**: discounted parking or charging rates, avoiding double-charging.
- Maintain and **upgrade charger hardware**.
- Consider both **Level 1 (long-term)** and **Level 3 (quick turnaround)** chargers.

Students

Participate in a follow-up survey/focus group?	Not at this time	Yes, I'm interested	Blank	**Grand Total**
Fully-electric car	5	1	1	**7**
Plug-in hybrid car	0	1	0	**1**
Gas/Diesel/Hybrid Car	74	32	3	**109**
Bus	17	9	3	**29**
Walking	11	12	1	**24**
Other	29	8	4	**41**
Grand Total	**136**	**63**	**12**	**211**



Fully-electric car

UGA Charging	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
South Campus	2	2	2	1	2	1	1
Noth Campus	0	0	0	0	0	0	0
East Campus	1	1	1	1	1	2	2
I-STEM	0	0	0	1	0	0	0
Hull St.	1	1	0	1	0	0	0

Plug-in hybrid car

UGA Charging	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
South Campus	0	0	0	0	0	0	0
Noth Campus	0	1	0	1	0	0	0
East Campus	0	0	0	0	0	0	0
I-STEM	0	0	0	0	0	0	0
Hull St	0	0	0	0	0	0	0

Comments summarized with ChatGPT

- **Chargers are often occupied**, making it difficult to find available spots.
- Paying for **both parking and charging is a deterrent** for many users. Add free charging options.
- Charging costs **increase unfairly after two hours**, despite slow charging speeds (~6 kW).
- **Add fast (Level 3) chargers** near campus for quick top-ups.
- Support for electric buses as a clean and efficient campus transportation option.

Non-EV Drivers' Comments – Faculty & Staff

- **Cost is the primary barrier** to EV adoption, including purchase price, battery replacement, and charging equipment.
- **Charging infrastructure is insufficient**, especially in rural areas, at apartments, and on the Health Sciences Campus.
- **Charging availability concerns** deter potential buyers—stations are often full or require additional fees.
- **Skepticism about environmental benefits**, citing fossil fuel–powered electricity and battery production concerns.
- **Equity concerns**: EV incentives may benefit higher-income individuals more than others.
- **Hybrid vehicles are preferred** by some as a practical middle ground.
- **Desire for public transportation, bike lanes, and walkable options** is strong—many see these as higher priorities than EV support.
- **Electric buses and fleet vehicles are praised**, especially for reducing noise and pollution.
- **Safety concerns** with e-bikes, scooters, and EVs on roads, especially near campus; calls for helmet rules and clearer regulations.
- **Support for alternative commuting incentives**, including free charging, reduced parking fees, and limited freshman vehicle access.
- **Appreciation for UGA's sustainability efforts**, but calls for **more comprehensive and multimodal strategies**.

Non-EV Drivers’ Comments – Students

- **EVs are unaffordable** for most students due to high upfront cost, battery replacement, and limited income.
- **EV adoption is seen as a luxury**, benefiting higher-income individuals more than typical students.
- **Charging access is unrealistic for students**, especially for those living in apartments or commuting long distances.
- **Parking access is a major concern**, with frustration about EV-only spots in already limited decks.
- **Campus priorities should shift** away from cars—focus on **bikes, buses, walkability, and public transit** instead.
- **Students want safer cycling infrastructure**, better pedestrian zones, and rules for scooters and e-bikes.
- **Skepticism about EV sustainability**, citing battery production, grid dependence, and mining impacts.
- **Electric buses are popular**, with calls to **restore or expand the fleet**.
- Some support **infrastructure expansion** if funded equitably and placed in **underutilized lots**.
- **Range anxiety and lack of chargers** deter students from seriously considering EVs.
- **Preference for hybrids or gas vehicles** due to flexibility, cost, and current infrastructure gaps.

Public Safety and Electric Mobility Systems: A Literature Review on Operational, Emergency, and Technological Considerations

An outcome of the Leading Georgia's E-Mobility and Innovation: Informing Research and Decision-making Interdisciplinary Presidential Seed Grant

May 2025

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INTRODUCTION

The transition to electric vehicles (EVs) and broader electric mobility offers many economic, environmental, and public health benefits. However, recent data suggests that the pace of EV adoption in the United States has slowed. Among the contributing factors may be concerns, both real and perceived, about safety of EVs, particularly in the context of battery-related incidents, charging infrastructure, and emergency response.

Despite the heightened attention that EV-related fires and accidents have received in media and public discourse, current research indicates that the overall likelihood of vehicle fires is lower for EVs than for internal combustion engine (ICE) vehicles. This contrast between public perception and empirical evidence points to the importance of clarifying where legitimate safety concerns exist, where perception diverges from data, and how risks compare between different vehicle types. It also highlights the need for coordinated sharing of information from industry, government, and researchers.

This white paper aims to provide a research-grounded overview of public safety considerations related to electric mobility, particularly as they affect local governments, emergency responders, infrastructure providers, and members of the public. It reviews existing academic and industry research to identify key safety considerations associated with EVs and electric micromobility, such as emergency response protocols, infrastructure planning, and cybersecurity. It also examines steps already taken by industry or regulatory agencies to mitigate safety concerns and enhance standards.

The paper outlines several areas where additional action may be needed, ranging from education to planning and additional research. The goal of this review is to provide a clear, fact-based understanding of the existing literature and research regarding public safety of EVs. As electric mobility technologies continue to evolve, ongoing research and policy adaptation will be critical. Reassessing safety performance and preparedness strategies in light of new data and innovations will help ensure that transportation systems remain both resilient and responsive to community needs.

LITERATURE REVIEW

Based on a review of the literature and a categorization of identified safety questions around EVs, we identify six primary dimensions and their respective subdimensions, as Table 1 summarizes.

Table 1: Categorization of EV Public Safety Dimensions

Dimension	**Subdimension**	**Author**
	Comparison with ICE Vehicle Fires	Guzek et al., (2024)
		Sun et al. (2020)
1. Fires & Battery Management	Thermal Runaway	Guzek et al., (2024)
		Dorsz & Lewandowski (2022)
	Internal Short Circuits	Gao et al. (2020)
		Dorsz & Lewandowski (2022)
		Kim & Shin (2023)
		Wikner & T. Thiringer (2018)
		O'Brien (1993)
		Geisbauer et al. (2021)
		Bisschop et al. (2020)
	External Short Circuits	Yang et al. (2020)
2. Chemical Safety Consideration	Toxic Substance Release	Guzek et al. (2024)
		Geisbauer et al. (2021)
		Krol & Krol (2022)
		Truchot et al. (2018)
3. Incident Emergency Response	Limitations in Guidelines for Emergency Response	Guzek et al. (2024)
		Dorsz & Lewandowski (2022)
	Emergency Response Training	Fechtner et al. (2016)
		Liu (2022)
		Liu et al. (2023)

		Balcombe (2023)
		Krol & Krol (2022)
		Stave & Carlson (2017)
4. Disaster Evacuation & Response	Evacuation Routes and Charging Station Coverage	Adderly et al. (2018)
		Feng et al. (2020)
		Torkey et al. (2024)
	Power Grid Interactions	Adderly et al. (2018)
		Feng et al. (2020)
		Yang et al. (2020)
	Energy Storage Capacity of EVs	Adderly et al. (2018)
	Driver Behavior Considerations	Adderly et al. (2018)
		Feng et al. (2020)
		Torkey et al. (2024)
5. E-Micromobility	Risky Riding Behavior	Useche (2022)
		Dozza (2022)
		Dozza (2023)
		He (2021)
		della Mura (2022)
		Ma (2024)
		Brunner (2020)
		Walton (2012)
		Kegalle (2025)
	Pedestrian Interaction	Sikka (2018)
		*Jafari (2024)
		Liu (2022)
		Kuo (2019)
		*Maiti (2022)
	Mode Shifts	Reck (2022)
		Asensio (2022)

	Lane Limitations	*Zhang (2021)
		*Bridge (2023)
		Weiss (2024)
	Road Geometry Constraints	He (2024)
	Nighttime Riding	Currans (2022)
6. Cybersecurity	Vulnerabilities	Ronanki (2024)
		Hamdare (2023)
		Hodge (2019)
		Stine (2023)
		Johnson (2022)
		Acharya (2020)

Note: Studies marked with an asterisk (*) primarily focus on campus environments.

1. Fires & Battery Management

Fires in electric vehicles (EVs) are documented to have the lowest fire rate, with approximately 25.1 fires per 100,000 vehicle sales, compared to 1,529.9 for internal combustion engine vehicles (ICEs) (Guzek et al., 2024). While EV fires are significantly less likely to occur, they require different methods to extinguish them. EVs with lithium-ion batteries often require large quantities of suppressants and may reignite even after the fire appears extinguished (Sun et al., 2020.) One factor that exacerbates this difficulty is a lack of access to first responder training on how to extinguish battery fires properly and safely.

EV fires are typically related to battery failures, which could be internally or externally caused. It is important to understand the cause of and chemical components of battery fires in order to accurately inform safety measures and protocols.

Thermal Runaway:

One of the primary hazards related to lithium-ion batteries is thermal runaway, a phenomenon in which the lithium-ion cell enters an uncontrollable, self-heating state. This state can result in high temperatures, cell venting, and fires. According to Guzek et al. (2024), extinguishing a fire caused by thermal runaway in an electric vehicle is more complex than in internal combustion vehicles, due to the fact that lithium-ion batteries can burn for hours, generate heat after being turned off, and reignite the fire even after appearing to be extinguished. Moreover, Dorsz and Lewandowski (2022) highlight that battery design and the limited capacity of cooling systems in electric vehicles increase the likelihood of thermal runaway. These studies indicate that battery overheating, and the resulting thermal runaway can be determining factors in the occurrence of fires or explosions. Faults caused by internal or external conditions within these lithium-ion cells can result in this overheating. These internal or external hazards include internal short circuits, external short circuits, and high or low temperature environments.

Internal Short Circuits:

Gao et al. (2021) identified that one of the most common issues is the internal short-circuit (ISC), a result of the battery's internal connections shorting due to overcharging. Causes of these internal short circuits can also be excessive discharging and electric shocks. The causes of ISCs have been largely addressed by technological innovations and usage guidelines, including managed charging and changes in design.

Overcharging[1] and excessive discharging[2] are two situations capable of compromising both the safety and longevity of these energy storage systems. Dorsz and Lewandowski (2022) observed that lithium-ion batteries, when exposed to various charging levels could elevate the risk of fires or functional failures; however, additional research is necessary to determine the validity of this finding in practice. When a battery is charged beyond its maximum capacity, it may suffer damage. Kim & Shin (2023) share that experts advise maintaining the battery’s state of charge (SOC) within a moderate range, typically between 20 and 80 percent, to safeguard the system from unnecessary stress. Further, according to E. Wikner & T. Thiringer (2018), charging within these percentages also limits aging and

[1] Overcharging occurs when the battery is already fully charged (100%) but continues to receive charging current, which can significantly reduce its lifespan. Even if the current is low, continuously supplying energy to a fully charged battery can lead to long-term damage (Hong et al., 2022).

[2] Discharging occurs when an EV battery releases energy to power the vehicle. Excessive discharging below 25% SOC accelerates degradation, causing lithium loss and material damage (Chowdhury et al., 2024).

avoids stress from battery overcharging, and potentially helps the battery maintain functional range for a longer time.

When EVs were initially released to the public, electric shock in electric vehicles was a primary concern, due to the high voltage of batteries and additional components that had the potential to increase risk of fires in the event of an accident (O'Brien, 1993). To mitigate this risk, EVs are currently designed to ensure electrical safety by automatically disconnecting power system and isolating the battery after a severe impact, which prevents responders from contacting cables and high-voltage components (Geisbauer et al., 2021).

This design is required by the Federal Motor Vehicle Safety Standards[3]. Also, many recent EV models are equipped with electrical insulation monitoring that detects faults in the insulation of battery storage systems in order to prevent electrical hazards such as short circuits or electric shocks. These automatic disconnection systems and electrical insulation monitoring help protect both users and first responders. Still, it is important to note that the deterioration of insulation materials over time could expose active parts of the electrical system, which could pose a risk of potential electric shock (Bisschop et al., 2020), but more research is needed to determine if this is a substantiated concern.

External Short Circuits:

In contrast, an external short-circuit (ESC), as described by Yang et al. (2020), is an electrical failure caused by external factors, such as a collision, vibrations, or crushing forces that compresses the battery pack or its connections. These disruptions allow direct contact between the battery's positive and negative terminals, producing a powerful surge of energy. Unlike internal faults, an ESC may rapidly propagate across multiple cells,

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[3] [3] Federal Motor Vehicle Safety Standards; Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection, Department of Transportation, National Highway Traffic Safety Administration, 49 CFR Part 571. "Under FMVSS No. 305's current post-crash safety requirements, vehicles must meet either electrical isolation requirements or low voltage requirements. The current requirements for electrical isolation are that the electrical isolation of the high voltage source must be greater than or equal to 500 ohms/volt for an AC high voltage source; 500 ohms/volt for a DC high voltage source without electrical isolation monitoring during vehicle operation; or 100 ohms/volt for a DC high voltage source with an electrical isolation monitoring system during vehicle operation."

escalating a localized incident into a broader system failure, thereby compromising the overall safety and performance of the battery.

To address and reduce these hazards, the Federal Motor Vehicle Safety Standards[4] have introduced an optional compliance approach centered on the use of physical barriers to meet post-collision safety requirements. Under this framework, high-voltage components must be enclosed within protective structures that prevent direct human contact.

2. Chemical Safey Considerations

While electric vehicle battery fires can release hazardous substances, these incidents are rare and typically manageable with proper protocols. Studies show that the toxic gases produced by EV fires are comparable to those from ICE vehicle fires. As with any vehicle fire, appropriate protective gear, ventilation, and early hazard recognition are key to reducing exposure risks. This section summarizes current research on chemical hazards and outlines recommended safety measures for responders and the public.

Toxic Substance Release:

Under certain conditions, electric vehicle battery fires can release toxic substances that pose serious health and safety concerns. Several studies have shown that when an electric vehicle battery catches fire, it can release substances that are hazardous through inhalation and skin contact (Guzek et al., 2024; Geisbauer et al., 2021). Guzek et al. (2024) further caution that the delayed release of toxic vapors or flammable gases may increase risks during post-accident handling or vehicle repairs. A study by Krol and Krol (2022) demonstrated that a lithium-ion battery fire in an underground garage can generate hydrogen fluoride (HF) concentrations high enough to endanger emergency services and occupants. Underground parking garages are more common in Europe, where this study was done, and the authors recommended exhaust fans to alleviate the risks; thus, it is likely that risks of HF build up would be significantly less in above ground parking garages which

[4] Federal Motor Vehicle Safety Standards; Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection, Department of Transportation, National Highway Traffic Safety Administration, 49 CFR Part 571, 82 Fed. Reg. 44945, 44945 (Sept. 27, 2017).

have open air flow. However, the literature does not address any specific concerns related to above-ground parking garages and EVs.

While certain conditions of an electric vehicle battery fire can cause the release of toxic substances, a study done in 2018 by the Fire Safety Journal compared the toxins of ICE vehicle fires and EV vehicle fires. The study found that in the burning ICE vehicles observed, there was a release of toxins such as Hydrogen Chloride, Hydrogen Cyanide, Carbon Monoxide, Sulfur Dioxide, and multiple others (Truchot et al., 2018). In comparison to EVs, this study found that toxic gas production between ICE cars and electric ones is similar (Truchot et al., 2018). Given these concerns, experts recommend that users stay alert for early signs of battery distress—such as fluid leakage, unusual gurgling sounds, visible sparks, or smoke (Geisbauer et al., 2021). Because chemical hazards, especially those involving compromised high-voltage systems, can escalate quickly, responding with informed caution is critical to minimizing potential harm. However, these incidents are infrequent and highly situational. The risk of toxic exposure is comparable to or lower than other industrial and vehicular fire scenarios (Truchot et al., 2018). Proper protective equipment, ventilation protocols, and awareness of potential chemical hazards are the most effective risk management tools (Truchot et al., 2018).

3. Incident Emergency Response

As EVs become more common, emergency response systems must adapt to the distinct operational challenges they pose, in particular with lithium-ion batteries. While EV fires are less frequent than those involving ICE vehicles, they present unfamiliar challenges, including intense heat, risk of re-ignition, and toxic byproducts. This section explores gaps in current emergency response protocols and training and identifies opportunities to improve safety standards and preparedness.

Limitations in Guidelines for Emergency Response:

Emergency response concerns focus on the need for appropriate protocols for handling electric vehicle incidents. Guzek et al. (2024) point out the inadequacy of EV manufacturers' guidelines to minimize risks posed by lithium-ion battery fires to emergency responders, such as firefighters and roadside assistance providers. Dorsz and Lewandowski (2022) recommend fully standardizing the assessment of safety concerns to all people and structures in enclosed spaces. Establishing uniform regulations and guidelines could enable more accurate modeling of the heat release rate (HRR) throughout electric vehicle fires, contributing toward improved, standardized safety measures to support more effective emergency response strategies.

Lack of Emergency Response Training:

Structural modifications and manufacturer guidelines alone are not sufficient. Liu (2022) draws attention to a limitation in current fire response practices: traditional extinguishers are largely ineffective when confronted with lithium-ion battery fires. Dorsz and Lewandowski (2022) also argue the battery, once it is extinguished, may spontaneously reignite because the batteries can continue to store energy after the initial visible fire is extinguished. They also recommend that a thermal imaging camera be used to verify the absence of internal flames.

A recent study identified that more than 40 percent of first responders in the U.S. have not received training on EV emergencies, despite about 90% of them having reported receiving some kind of safety training (Liu et al., 2023). EV specific training is necessary to safely respond to the unique challenges that come with electrical fires, which is echoed by Balcombe (2023). According to a study that was conducted in Germany, emergency tasks involving EVs are perceived as more dangerous than those involving conventional vehicles by all occupational groups surveyed (Fechtner et al., 2016). That could be because firefighters face difficulty identifying EVs and locating high-voltage components without standardized tools (Stave & Carlson, 2017; Balcombe, 2023). Many responders are unaware of emergency response guides (ERGs) or how to access them quickly during incidents (Balcombe, 2023). This highlights the need to work on training, develop standards, and for safer vehicle design to ensure a better response. Also, mobile-accessible ERGs and Rescue Data Sheets (RDSs) could be useful for first respondents to safely handle EV incidents during extrication (Balcombe, 2023).

To address this need, first responder EV safety trainings have been developed and are being deployed, often sponsored by groups promoting the adoption of EVs including Clean Cities organizations and utility companies. The U.S. Department of Energy's Alternative Fuels Data Center hosts a resource library with guidelines and training resources for first responders to address fire and water related incidents with electric vehicles. While these safety knowledge bases and protocols do exist, there remains a need to improve access to and incorporate this into existing first responder training.

Furthermore, Krol and Krol (2022) identified additional challenges with fire response in underground parking garages, in particular highlighting that lithium-ion battery fires can leave hydrogen fluoride residue that is harmful to humans and could lead to significant ecological adverse impacts if washed into the municipal sewer system without proper treatment. Krol and Krol (2022) identify solutions such as proper water treatment response protocols and mechanical smoke exhaust ventilation in underground parking garages to mitigate ecological impacts and ensure safe working conditions for first responders. The literature did not document any risks specific to above-ground parking garages.

4. Disaster Evacuation & Response

In a natural disaster, nearly all infrastructure systems are disrupted, including transportation and the electrical grid. Since EVs drivers generally have more limited options to recharge than a traditional ICE vehicle has to refuel, any disruption to the electric grid or transportation system could pose challenges for EV drivers. However, there are also potential benefits that EVs can provide during disaster recovery. There are several factors that impact the severity of unique challenges for EV drivers, as well as several strategies already being deployed or that could be considered, to mitigate any additional challenges in a disaster scenario.

Evacuation routes and charging station coverage:

Evacuation routes and disaster plans were not initially designed with charging infrastructure for EVs in mind. Feng et al. (2020) showed that if all vehicles evacuating Florida in Hurricane Irma had been electric, six of the nine major electric operators would have exceeded their supply capacity, which in this hypothetical scenario may have caused cascading failures that would affect the evacuation process. In addition, Torkey et al. (2024) have observed that electricity infrastructure planning in cities has focused mainly on expanding the number of stations, without necessarily considering their operability or travel routes in disaster situations. As a result, many stations lack minimum conditions of accessibility, reliability, and interoperability at critical moments, which limits their effectiveness during disasters.

Adderly et al. (2018) highlighted four factors that could limit the functionality of charging stations during a disaster. First, the number of stations and the number of outlets available are insufficient to serve all users at the same time, especially in high-demand situations. Second, the time it takes for a vehicle to charge can range from minutes to hours depending on the level of the charger, and the number of vehicles that can be serviced depends on the type of charger available. Third, although fast charging options are available, most EV charging still occurs at home using slower chargers. Due to their high cost and technical requirements, in addition to revenue potential considerations, fast chargers are typically concentrated in commercial areas, which are not necessarily along evacuation routes. Finally, many stations require pre-registration or accounts linked to credit cards, which poses an additional obstacle for those looking to charge urgently, especially if they are unfamiliar with the area. Adderly et al. (2018) also recommended setting a minimum density of publicly accessible charging points, adjusted to the proportion of EVs per inhabitant in each region.

Feng et al. (2020) and Torkey et al. (2024) have raised how governments could offer incentives to promote the construction of charging infrastructure in and around major evacuation routes.

In the last several years, government incentives and the market have responded to address these factors. Incentive programs like the federal National Electric Vehicle Incentive (NEVI) program were created to install Level 3 fast chargers every 50 miles along Interstates, and hurricane-prone states focused their efforts on evacuation routes. As of this white paper's writing, most of NEVI funding is paused by the current Administration. In Georgia, funding for 4 charging sites approved during the first phase of NEVI are still moving forward, with 33 identified sites in Phase Two currently subject to the pause in federal funding. Regardless of federal funding, the number of public charging ports continues to increase, with ports in Georgia increasing tenfold over the last ten years (U.S. Department of Energy, 2024). Increasing installation of public ports, combined with increasing battery range and charging management, may alleviate the bottleneck for charging during emergency situations.

During natural disasters, it is common for the electric grid to experience service interruptions, therefore charging stations relying on that electric supply become inoperative (Feng et al., 2020). Feng et al. (2020) warn that if too many vehicles attempt to charge simultaneously along a specific evacuation corridor, it could exceed the local network capacity, which if not managed could trigger further failures of the grid (Yang et al., 2020). However, such cases have not been documented, and utility companies are looking at all demands on the system as they continuously revisit disaster planning.

Critical stations should be equipped with backup power systems—such as solar, wind, or emergency-use natural gas or diesel generators—to ensure continued operation during outages (Adderly et al., 2018; Feng et al., 2020; Torkey et al., 2024). Adderly et al. (2018) also recommend that evacuation plans include alternative routes to functional stations and that distributed energy resources like solar panels or battery storage be integrated to meet surges in demand from multiple simultaneous vehicle connections. Strategically placing these backups at congestion points can prevent network overload and enhance emergency response.

Faced with this scenario, the implementation of strategies for scheduling and prioritization has also been proposed. This would involve limiting concurrent use, prioritizing according to vulnerability level, and promoting partial loads (e.g., 40% or 80%) rather than full loads to avoid system congestion, which is similar to the gasoline refueling limits and prioritization during hurricane evacuations.

Despite there being a gap in research for optimal mass evacuation planning for electric vehicles, Li et al. (2022) attempts to address these challenges with a study that proposes a three-stage method to account for charging demand, limited facilities, and inefficient evacuation routes. Through a three-stage methodology, the model creates an evacuation plan with ideal routes and a departure schedule for EVs. The model highlights optimum routes, not real-time operations. Li et al. (2022) suggests this model could be incorporated into a mobile application in which EV drivers make reservations for different scheduled departures and routes, but notes that for this model to be employed effectively, the government would have to build public trust in the model for users to actually follow the evacuation departure routes and schedule.

Energy storage capacity in EVs:

In long evacuations, or when traffic jams occur, the distance required to evacuate could exceed the battery charge range. Adderly et al. (2018) point out the differences in fueling before and during disasters for ICE versus EV drivers. ICE drivers can stockpile fuel in advance of disasters and have access to a much broader network of gas stations, but may be subject to limited gasoline supplies on high demand travel routes. EV drivers cannot stockpile energy in the same way, but can proactively charge batteries fully before evacuations are ordered and have ample supply as long as the electric grid is functioning and ports are available.

This underscores the importance of incorporating smart charging techniques such as dynamic wireless charging, battery swapping, V2V (Vehicle-to-Vehicle) charging, and V2G (Vehicle-to-Grid) technology, as suggested by Torkey et al. (2024). V2V & V2G are both types of “two-way” charging. Vehicle-to-Grid or V2G allows energy to flow in both directions between an electric vehicle and the power grid. This method of charging not only provides energy to the vehicle but can send energy back into the grid during high demand periods or even in periods after a disaster when the electric grid is down (Electrly, n.d.).Vehicle to Vehicle or V2V charging allows energy to be passed from one EV to another through a dedicated V2V connector (Electrly, n.d). Both two-way charging methods are valuable for dealing with range anxiety and peak energy usage times. Smart Charging methods can provide solutions to improve charging system efficiency and provide more flexible and resilient energy management during emergencies.

The average battery range of electric vehicles has also increased significantly, rising from a median range of 90 miles in 2015 to 270 miles in 2023, and with continued increases in range and battery capacity expected, this concern may be mitigated (U.S. DOE et al. 2023).

Driver Behavior Considerations:

Studies show that drivers' decisions during disasters can significantly affect the efficiency of evacuations (Adderly et al., 2018; Torkey et al., 2024). Fear, anxiety, and the search for safety can lead to impulsive decisions such as fully charging vehicles even when a partial charge will get them to their destination, which extends the waiting time and increases the pressure on the electrical system. In this context, Torkey et al. (2024) propose promoting more agile and context-adapted loading practices, between 40% and 80% of their battery capacity, which allow space to be freed up quickly and cover reasonable distances to more distant stations or safe areas. They also highlight that the time it takes to charge the last 20% of a battery can increase drastically compared to the time it takes to charge from 0% to 80%, and that this inefficiency multiplies in the case of an emergency if charging is not managed. In addition, a lack of knowledge about the location of compatible charging stations, or a lack of interoperability between brands and suppliers, can lead to confusion, delays, and unnecessary congestion.

Adderly et al. (2018) and Torkey et al. (2024) propose that at the regulatory level, it is necessary to ensure interoperability between charging stations, unified charging protocols, and ease of access in critical situations. Likewise, progress has been made towards standardization of the design of charging ports through the adoption of the North American Charging Standard (NACS) by most car manufacturers going forward. This standardization would facilitate the use of chargers in emergency contexts without the need for adapters or additional technical verifications (Adderly et al., 2018; Torkey et al., 2024).

The widespread use of technologies such as mobile apps would support users to track in real-time the most suitable evacuation routes for their vehicles, including information on operating stations, power availability, and alternative routes in the event of outages (Adderly et al., 2018; Torkey et al., 2024). These measures can increase the likelihood of a smooth evacuation.

5. Electric Micromobility

Electric micromobility (e-micromobility) devices, such as electric scooters and e-bikes, are increasingly used for short trips across campuses and in urban environments. While these modes offer convenience and environmental benefits, their widespread use introduces safety challenges. Risk factors arise from rider behavior and infrastructure interaction. These risks are not inherently due to the devices being electric but rather stem from the way electric technology has enabled widespread motorization of traditionally human-powered modes of transportation.

Behavior Limitations:

The increasing use of e-micromobility devices introduces new safety challenges. Risky riding behaviors, pedestrian conflicts, and shifts in transportation modes contribute to higher crash risks, particularly as motorization enables faster, less predictable travel in shared spaces.

Risky Riding Behavior: E-micromobility users often exhibit risky riding behaviors, including speeding, abrupt maneuvers, sidewalk riding, and non-compliance with traffic rules. Useche (2022), Dozza (2022, 2023), and He (2021) observed that smaller wheel sizes and higher maneuverability of e-scooters contribute to sudden movements that drivers and pedestrians find difficult to predict. Studies by della Mura (2022) and Ma (2024) highlight that young male riders are particularly prone to risky behavior, often underestimating the dangers involved. Brunner (2020) and Walton (2012) also noted a strong link between sensation-seeking traits and e-micromobility risk-taking. Moreover, Kegalle (2025) emphasized that frequent users tend to normalize risky behaviors over time, further increasing crash risks.

Pedestrian Interaction: Conflicts between e-micromobility riders and pedestrians are a major concern, especially in shared spaces. Sikka (2018) and Jafari (2024) found that a considerable proportion of pedestrian injuries occur due to collisions with e-scooters, either from active riding or tripping over parked scooters. Liu (2022) demonstrated that pedestrian discomfort rises sharply with increasing e-scooter speeds and density. Kuo (2019) highlighted that the unpredictability of rider behavior leads pedestrians to perceive e-micromobility as a higher risk compared to bicycles. Maiti (2022) added that elderly pedestrians feel vulnerable when sharing sidewalks with fast-moving e-micromobility devices.

<u>Mode Shifts:</u> The rise of e-micromobility is altering traditional mode choice patterns. Reck (2022) found that shared e-scooters primarily displace walking, while Asensio (2022) showed that in certain urban environments, e-micromobility can partially substitute for short car trips, affecting both congestion and emission profiles. These mode shifts also impact exposure risk, as new riders unfamiliar with vehicle dynamics may behave unpredictably, contributing to higher crash rates.

Infrastructure Interaction:

Infrastructure limitations and environmental conditions affect e-micromobility safety. Inadequate or poorly designed lanes, challenging road geometry, and low visibility at night force riders into riskier behaviors and contribute to higher crash rates, particularly in dense campus settings and during peak travel times.

<u>Lane Limitations</u>: Inadequate lane types force e-micromobility users into unsafe behaviors. Zhang (2021) and Bridge (2023) reported that riders prefer bikeways and multi-use paths but are often forced onto sidewalks or mixed-traffic lanes due to missing or incomplete e-micromobility lanes. Weiss (2024) noted that lack of clear e-micromobility lanes increases both rider and pedestrian hazards, especially in high-demand areas where shared use paths are congested.

<u>Road Geometry Constraints</u>: Beyond the absence of dedicated infrastructure, road design features often present significant safety challenges for e-micromobility users. He (2024) observed that narrow lane widths, poor surface conditions, and abrupt elevation changes, such as curb cuts, can destabilize e-micromobility vehicles and increase crash risk. Intersections and turns designed primarily for larger vehicles often create low-visibility zones, making them especially hazardous for e-scooter riders navigating alongside or around larger traffic.

<u>Nighttime Riding</u>: Environmental conditions, particularly lighting, have a major influence on e-micromobility safety. Currans (2022) found that nighttime riding significantly increases crash risk, driven by reduced visibility for both riders and surrounding traffic.

Eight studies focusing on campus environments reveal consistent patterns in e-micromobility behavior and safety risks. Rider activity peaks during key pedestrian commuting periods—such as lunchtime, evening class transitions, and late-night hours—correlating with elevated crash risks. Survey and field studies emphasize the need to regulate e-scooter speeds on sidewalks and recommend redesigning pedestrian zones to accommodate e-micromobility while maintaining pedestrian safety. Nighttime riding is disproportionately associated with crash incidents, highlighting the importance of targeted nighttime regulations. Infrastructure analyses consistently show that bikeways and multi-use paths are the preferred facilities for e-scooter users; however, in their absence, sidewalk riding becomes significantly more frequent, increasing the potential for pedestrian conflicts.

6. Electric Mobility Cybersecurity

As EV adoption expands, the cybersecurity of EV charging infrastructure has emerged as a critical concern. The interconnected ecosystem of EV chargers, cloud platforms, and the power grid exposes numerous vulnerabilities due to the nature of their connection to the internet if cybersecurity protections are not established. If subject to a cyberattack, it could disrupt charging services, damage vehicles or infrastructure, and undermine grid stability.

According to the National Renewable Energy Lab (NREL), there are two types of cybersecurity risks: physical access and remote access. Physical access is when someone gains direct access to a vehicle, such as through a maintenance port or by physically tampering with the car, allowing them to interfere with the vehicle’s internal computer system. The NREL suggests that manufacturers may mitigate this physical access risk by installing network traffic monitoring and tampering alarms in vehicles that can detect unusual activity, implement fire walls, and employ secure code practices. Remote access involves someone gaining access to the vehicle’s systems without being physically present, such as through Bluetooth connections, smartphone apps for remote start, key fobs, or GPS directions. Manufacturers can mitigate the risk of remote access by ensuring infotainment systems operate on a different communication network than the operational and safety network, require user authorization, and encrypt firmware updates (Hodge, et al., 2019).

Vulnerabilities:

Device-Level Vulnerabilities: Physical and firmware-based vulnerabilities in EV charging stations present cybersecurity challenges. Ronanki (2024) emphasized that wireless and hybrid conductive–inductive chargers often lack robust firmware protections, leaving them vulnerable to remote exploitation. Cyber actors could tamper with firmware to disrupt operations, extract sensitive data, or damage hardware components. Similarly, Hamdare (2023) identified that many publicly accessible EV devices suffer from weak physical security, including unsecured ports, default configurations, and outdated firmware, which create easy entry points for cyber intrusions. These device-level weaknesses are particularly concerning because they could allow cyber actors to compromise charging infrastructure without requiring advanced technical capabilities.

System-Level Vulnerabilities: In addition to individual charger security, vulnerabilities at the system level could pose challenges to grid reliability. Acharya (2020) examined scenarios in which coordinated manipulation of EV charging loads, either through compromised communication channels or firmware backdoors, could induce rapid changes in power demand, voltage fluctuations, or localized disruptions. While such outcomes are hypothetical, the research underscores the importance of securing EV charging infrastructure as it becomes more integrated with the grid and internet.

Communication Vulnerabilities: Secure communication between EVs, chargers, and backend management systems is essential for operational integrity. However, Hamdare (2023) highlighted that many EV infrastructure systems still rely on protocols such as Open Charge Point Protocol (OCPP) and International Organization of Standardization (ISO) 15118, which are often deployed without full encryption or mutual authentication. These weaknesses expose systems to man-in-the-middle attacks, session hijacking, and unauthorized command injections, allowing attackers to manipulate charging commands, billing data, or user credentials during transmission. Additionally, Johnson (2022) reviewed vulnerabilities within cloud-based management platforms. Without rigorous access controls and threat detection mechanisms, cyber actors could remotely disable chargers, alter operational settings, or extract sensitive user information, posing systemic vulnerabilities to EV charging networks.

Leading EV charging companies are implementing a range of cybersecurity measures to protect their infrastructure and users. These efforts are guided by industry standards and frameworks, such as the National Institute of Standards and Technology (NIST) Cybersecurity Framework Profile for Electric Vehicle Extreme Fast Charging Infrastructure, which provides a risk-based approach for managing cybersecurity activities in the EV charging ecosystem (Stine et al., 2023).

CONCLUSION: GAPS AND RECOMMENDATIONS

The growth of electric vehicles and micromobility options is reshaping transportation systems, introducing new considerations for safety, emergency preparedness, and public understanding. While fires involving EVs are relatively rare, the nature of these incidents often differs from those involving internal combustion engine (ICE) vehicles, requiring specialized knowledge and procedures for effective response. Many of these protocols already exist, but access to relevant training—particularly for first responders—remains inconsistent.

A lack of standardized manufacturing guidelines and emergency response protocols contributes to variability in how EV-related incidents are managed. Additionally, the rapid expansion of EVs has not been fully integrated into disaster response or evacuation planning. For example, many current plans were developed prior to widespread EV adoption and may not account for the unique needs and capabilities of electric mobility. Similarly, urban spaces and campus environments were not originally designed for widespread use of motorized micromobility devices, leading to challenges around infrastructure compatibility, regulation, and public safety.

As electric mobility becomes more connected to digital networks, cybersecurity is also emerging as an area of operational concern. While current research does not indicate that EVs are inherently more dangerous than ICE vehicles, there are real differences in how incidents involving each type of vehicle unfold and how they should be managed. These differences highlight the need for transparency and clarity—both in how safety concerns are communicated and how planning and policy evolve in response.

Public understanding and perception of safety play a critical role in shaping both behavior and policy. While engineering research to date finds that EVs have comparable or lower safety concerns than ICE vehicles in many categories, this message is not always clearly conveyed to or understood by the public. Currently, there are no comprehensive tools for assessing public or official perceptions of EV safety. Existing studies tend to include public safety as a secondary topic within broader EV adoption surveys or focus on narrow demographic subsets. Developing better tools to measure these perceptions will enable more effective education and engagement and ensure communication strategies align with actual public needs.

Likewise, there is limited research that directly compares the safety profiles of EVs and ICE vehicles—particularly when it comes to incident causes, outcomes, and response protocols. Additional work is also needed to evaluate how safety concerns are currently being addressed by both government and industry, and whether those efforts are reaching the right audiences with the right information.

Finally, planning for resilient and safe electric mobility systems must evolve in parallel with the technology itself. This includes integrating energy, transportation, and emergency response systems and using shared modeling tools to identify high-demand scenarios, anticipate points of failure, and improve coordination between sectors. Participatory planning efforts that involve transportation officials, energy providers, emergency managers, and community members can also help build more informed infrastructure, communities, and governance.

Key needs moving forward include:

1. **Education and Training**
   Improved access to training and educational resources is essential for first responders, EV drivers, and the broader public. While specialized procedures exist for responding to EV-related incidents, barriers to accessing these trainings persist. Public-facing materials should also address safety topics like battery fires, evacuations, and toxic material exposure in clear, actionable ways.
2. **Coordinated and Participatory Planning**
   Local governments need support and guidance to develop cross-sector plans that integrate emergency management, transportation, and energy systems. Participatory approaches can improve planning outcomes and community trust.
3. **Standardized Response Protocols**
   The development and dissemination of clear, evidence-informed emergency procedures tailored to electric and micromobility technologies will support consistent and effective incident response across jurisdictions.

4. **Continued Safety Enhancements**

   As the EV industry evolves, there is an ongoing need for continued improvements in vehicle safety design and infrastructure resilience. Whether through updated regulations or voluntary industry efforts, maintaining and advancing safety backstops will help mitigate concerns and improve public confidence.

5. **Expanded Research Priorities**

   Key gaps include:

   a. Tools to measure public and official perceptions of EV safety;
   b. Direct comparisons of ICE and EV safety profiles;
   c. Evaluations of government and industry approaches to safety;
   d. Studies that clarify the difference between perceived and actual safety concerns, including EVs and infrastructure in above-ground parking decks;
   e. Research on access to emergency response training and public awareness of existing protocols.

Addressing these needs through transparent, interdisciplinary work can help ensure that public safety keeps pace with the rapid evolution of electric mobility—while equipping policymakers, planners, and the public with the tools and knowledge needed to navigate this transition with confidence and clarity.

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Detailed Summary of Past Funding Opportunities

Compiled by Harrison Stang, Graduate Research Assistant for the Carl Vinson Institute of Government, 2024-25

Federal Incentives:

National Electric Vehicle Infrastructure (NEVI) Formula Program:

- Description: The NEVI Formula Program, established under the Bipartisan Infrastructure Law, allocated $5 billion over five years to support the deployment of electric vehicle (EV) charging infrastructure across the United States. Georgia received $135 million of these funds. The program aimed to create a nationwide network of EV chargers to enhance accessibility and promote the adoption of electric vehicles.
- Eligibility: Eligible applicants included private entities, government agencies, and non-profit organizations capable of designing, constructing, installing, financing, operating, and maintaining NEVI-compliant EV charging infrastructure within Georgia. Applicants were required to demonstrate the ability to meet federal and state program requirements.
- Application: The Georgia Department of Transportation (GDOT) initiated the first round of solicitations in July 2023, with subsequent rounds planned to continue the buildout of the state's Alternative Fuel Corridors. However, as of February 2025, the federal administration suspended the NEVI program, halting further funding and implementation. The impact of this suspension on Georgia's EV infrastructure development is currently under assessment.

Charging and Fueling Infrastructure (CFI) Discretionary Grant Program

- Description: The Charging and Fueling Infrastructure (CFI) Discretionary Grant Program, established under the Bipartisan Infrastructure Law, provides $2.5 billion over five years to strategically deploy publicly accessible electric vehicle (EV) charging and alternative fueling infrastructure across the United States. The program focuses on both community and corridor projects to ensure comprehensive coverage in urban, rural, and underserved areas.
- Eligibility: Eligible applicants include states, local governments, metropolitan planning organizations, transportation authorities, and Indian tribes. The program emphasizes projects that expand access in rural areas, low- and moderate-income neighborhoods, and communities with limited private
- Application: The most recent funding opportunity was announced on May 30, 2024, with a submission deadline of September 11, 2024. Future funding rounds are anticipated, but specific dates have not been released. Applicants are encouraged to monitor the U.S. Department of Transportation's website for updates.

Clean School Bus Program

- Description: The U.S. Environmental Protection Agency's (EPA) Clean School Bus Program, established under the Bipartisan Infrastructure Law, allocates $5 billion over five years (FY 2022-2026) to replace existing school buses with zero-emission and low-

emission models. This initiative aims to reduce children's exposure to harmful diesel exhaust, thereby improving air quality and public health.
- Eligibility: Eligible applicants include state and local governmental entities, public school districts, tribal organizations, and non-profit school transportation associations. Priority is given to high-need local education agencies, rural and low-income areas, and districts serving tribal students.
- Application: The EPA periodically announces funding opportunities under this program. For instance, in September 2024, the agency made $965 million available to fund clean school buses. Applicants are encouraged to monitor the EPA's Clean School Bus Program website for the latest information on application periods and deadlines.

Clean Heavy-Duty Vehicle Program
- Description: The U.S. Environmental Protection Agency's (EPA) Clean Heavy-Duty Vehicles (CHDV) Grant Program, established under the Inflation Reduction Act, provides $1 billion in funding through 2031 to accelerate the replacement of internal combustion engine heavy-duty vehicles with zero-emission alternatives. The program also supports the development of necessary charging or refueling infrastructure and provides funding for workforce training to ensure effective deployment and maintenance of new technologies. The initiative prioritizes reducing emissions in communities disproportionately affected by air pollution.
- Eligibility: Eligible applicants include states, municipalities (including public school districts), Indian tribes, and nonprofit school transportation associations. The program focuses on replacing Class 6 and Class 7 heavy-duty vehicles, such as school buses, transit buses, and refuse trucks, with zero-emission models.
- Application: The initial Notice of Funding Opportunity was announced in April 2024, with applications due by July 25, 2024. In December 2024, the EPA selected 70 applicants across 27 states, three Tribal Nations, and one territory to receive approximately $735 million for the purchase of over 2,000 zero-emission vehicles. Future funding opportunities are anticipated, but specific dates have not been announced. Interested parties should monitor the EPA's official channels for updates.

Environmental and Climate Justice Block Grants
- Description: The Environmental and Climate Justice Block Grant Program, established under the Inflation Reduction Act, allocates $3 billion to support disadvantaged communities disproportionately affected by pollution and climate change. The program funds community-led projects aimed at reducing pollution, enhancing climate resilience, and addressing public health concerns.
- Eligibility: Eligible applicants include community-based nonprofit organizations, partnerships between such organizations and local or tribal governments, and higher education institutions. Projects must demonstrate a focus on environmental or climate justice initiatives within underserved communities.
- Application: The Environmental Protection Agency (EPA) announced the availability of approximately $2 billion for the Community Change Grants program, with applications accepted on a rolling basis until November 21, 2024. Funding opportunities are expected to continue through 2026.

National Diesel Emissions Reduction Act (DERA)

- Description: The Diesel Emissions Reduction Act (DERA), initially authorized under the Energy Policy Act of 2005 and reauthorized in 2010 and 2019, provides funding to reduce emissions from older diesel engines across the United States. In October 2024, the U.S. Environmental Protection Agency (EPA) announced the availability of $125 million to upgrade older diesel engines to cleaner and zero-emission solutions. The program offers grants and rebates to support projects that retrofit or replace diesel engines, aiming to improve air quality and public health.
- Eligibility: Eligible applicants include regional, state, local, tribal, or port agencies with jurisdiction over transportation or air quality, as well as nonprofit organizations or institutions that provide pollution reduction or educational services to diesel fleet owners. Projects may target various diesel-powered vehicles and equipment, including school buses, transit buses, medium- and heavy-duty trucks, marine engines, locomotives, and non-road engines used in construction, agriculture, or mining.
- Application: The most recent national DERA funding opportunity opened on August 2, 2023, with applications due by December 1, 2023. EPA anticipates awarding a total of approximately $115 million under this notice, with individual awards ranging up to $4 million. Future funding opportunities are expected, but specific dates have not been announced. Applicants are encouraged to monitor the EPA's DERA website for updates.

Low or No Emission Grant Program

- Description: The Federal Transit Administration's (FTA) Low or No Emission (Low-No) Grant Program provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses, as well as the acquisition, construction, and leasing of supporting facilities. In Fiscal Year (FY) 2024, approximately $1.1 billion was made available for this program.
- Eligibility: Eligible applicants include designated recipients of FTA grants, states, local governmental authorities, and Indian tribes. Projects must be directly related to the purchase or lease of low or no-emission vehicles and may include the construction or rehabilitation of facilities to support such vehicles.
- Application: The FY 2024 funding opportunity was announced on February 8, 2024, with applications due by April 12, 2024. Future funding opportunities are anticipated, but specific dates have not been announced. Applicants are encouraged to monitor the FTA's official website for updates.

Community Alternative Fuel Infrastructure Grants

- Description: The Community Charging and Fueling Grants, part of the Charging and Fueling Infrastructure (CFI) Discretionary Grant Program, aim to strategically deploy publicly accessible electric vehicle (EV) charging and alternative fueling infrastructure in urban and rural communities across the United States. Established under the Bipartisan Infrastructure Law, the program allocates $2.5 billion over five years (FY 2022-2026), with at least 50% of the funding dedicated to community grants.
- Eligibility: Eligible applicants include state or local governments, metropolitan planning organizations, special purpose districts or public authorities with a transportation

function, Indian tribes, and U.S. territories. The program prioritizes projects that expand access to EV charging and alternative fueling infrastructure within rural areas, low- and moderate-income neighborhoods, and communities with a low ratio of private parking spaces.

- Application: The most recent funding opportunity was announced on May 30, 2024, with a submission deadline of September 11, 2024. Future funding rounds are anticipated, but specific dates have not been released. Applicants are encouraged to monitor the U.S. Department of Transportation's website for updates.

Clean Vehicle Federal Tax Credit

- Description: The Clean Vehicle Federal Tax Credit, established under the Inflation Reduction Act, offers financial incentives to encourage the adoption of electric vehicles (EVs) and fuel cell vehicles (FCVs). As of 2025, purchasers of qualifying new clean vehicles may be eligible for a tax credit of up to $7,500, while those buying qualifying used clean vehicles may receive a credit of up to $4,000. These credits aim to make EVs more accessible and affordable, promoting environmental sustainability.
- Eligibility: Eligibility depends on income limits, vehicle price caps, and specific manufacturing and sourcing requirements. Used EVs must be purchased from a licensed dealer and meet price restrictions.
- Application: The credit can be claimed when filing federal taxes using IRS Form 8936. Starting in 2024, buyers can transfer the credit to dealers at the point of sale for an upfront discount. As of February 2025, discussions about repealing the federal EV tax credit are ongoing. Potential buyers should stay informed about policy changes.

EVSE Federal Tax Credit

- Description: The Alternative Fuel Vehicle Refueling Property Credit, extended through December 31, 2032, under the Inflation Reduction Act, offers a tax credit for the installation of electric vehicle supply equipment (EVSE). For individuals installing EV charging stations at their residences, the credit covers 30% of the installation cost, up to $1,000. Businesses are eligible for a credit of up to $100,000 per item of qualifying property.
- Eligibility: Individuals and businesses that install qualified EV charging equipment are eligible. For residential installations, the property must be used as the taxpayer's main home. Business installations must meet specific criteria, including location requirements in eligible census tracts.
- Application: To claim the credit, taxpayers should file IRS Form 8911 when submitting their federal income tax returns. It's important to retain all receipts and documentation related to the purchase and installation of the EVSE. Consulting a tax professional is advisable to ensure compliance with IRS requirements.

State Incentives:

Congestion Mitigation and Air Quality (CMAQ) Improvement Program

- Description: The Congestion Mitigation and Air Quality (CMAQ) Improvement Program provides federal funding to state and local governments for transportation projects that reduce traffic congestion and improve air quality. In Georgia, the Georgia Department of Transportation (GDOT) administers CMAQ funds, prioritizing projects in nonattainment and maintenance areas for air pollutants. Eligible projects include public transit expansion, electric vehicle infrastructure, traffic flow improvements, and active transportation enhancements.
- Eligibility: Eligible applicants include state and local government agencies, transit operators, and metropolitan planning organizations (MPOs). Projects must demonstrate a direct benefit to air quality and congestion reduction, with priority given to nonattainment and maintenance areas under the Clean Air Act.
- Application: Funding is allocated through GDOT and local MPOs. Interested applicants should monitor GDOT and Atlanta Regional Commission (ARC) announcements for upcoming funding opportunities.

Carbon Reduction Program

- Description: The Carbon Reduction Program (CRP), established under the 2021 Infrastructure Investment and Jobs Act, provides roughly $6.4 billion in funding over five years (2022-2026) to states for projects aimed at reducing transportation-related carbon emissions. In Georgia, the Department of Transportation (GDOT) administers CRP funds to support initiatives such as public transit expansion, traffic flow improvements, deployment of intelligent transportation systems, and development of pedestrian and bicycle infrastructure. The program emphasizes strategies that align with the state's priorities to enhance safety, equity, mobility, resilience, and air quality.
- Eligibility: Eligible applicants include state and local government agencies, metropolitan planning organizations (MPOs), regional transportation authorities, and other entities responsible for transportation planning and implementation within Georgia. Projects must demonstrate a capacity to reduce on-road carbon dioxide emissions and should align with the strategies outlined in Georgia's Carbon Reduction Strategy.
- Application: GDOT, in collaboration with MPOs, manages the selection and funding of CRP projects. Application procedures and timelines are established by GDOT and may vary based on project scope and regional priorities. Interested applicants should consult GDOT's Carbon Reduction Program webpage for detailed guidance on application requirements, submission deadlines, and evaluation criteria.

HOV & HOT Lane Exemption for Alternative Fuel Vehicles

- Description: To claim the tax credit, businesses must complete the Electric Vehicle Charger Certification Form provided by the Georgia Environmental Protection Division (EPD). The completed form, along with required documentation, should be submitted to the EPD for certification. Once certified, the tax credit can be applied to the business's state income taxes. Unused credits may be carried forward for up to five years; however, beginning January 1, 2025, the carryforward period will be reduced to three years.
- Eligibility: To claim the tax credit, businesses must complete the Electric Vehicle Charger Certification Form provided by the Georgia Environmental Protection Division (EPD). The completed form, along with required documentation, should be submitted to the EPD

for certification. Once certified, the tax credit can be applied to the business's state income taxes. Unused credits may be carried forward for up to five years; however, beginning January 1, 2025, the carryforward period will be reduced to three years.
- Application: Owners of eligible vehicles must first register their vehicle with the Georgia Department of Revenue (DOR) and apply for an Alternative Fuel Vehicle (AFV) license plate at their local county tag office. For HOT lane access, they must set up a Peach Pass account and request a non-toll designation.

Georgia Environmental Finance Authority Grants
- Description: The Georgia Environmental Finance Authority (GEFA) provides funding to local governments for energy efficiency, renewable energy, and infrastructure projects that reduce emissions and enhance sustainability. Recent opportunities include the Energy Efficiency and Conservation Block Grant (EECBG) Program, which awarded $2.6 million in September 2024 to 17 communities for energy-saving projects, and the Bipartisan Infrastructure Law (BIL) allocations, which include $10.8 million for the State Energy Program to support local energy initiatives.
- Eligibility: Eligible applicants include local governments, state agencies, and educational institutions. Specific eligibility requirements vary by program.
- Application: Application procedures and deadlines depend on the grant program. Local governments should check GEFA's website for open funding opportunities and submission details.

Utility Incentives:

Georgia Power Make-Ready Program
- Description: Georgia Power's Make Ready Infrastructure Program assists local governments in installing electric vehicle (EV) charging stations by covering the design, construction, and maintenance of the necessary electrical infrastructure up to the charging equipment. This initiative aims to reduce the financial barriers associated with EV charger installations, promoting the adoption of electric transportation across Georgia.
- Eligibility: Local governments are eligible if the proposed installation meets the following criteria:
  - Public Accessibility: Chargers must be installed in areas accessible to the general public or designated for public fleets serving the community.
  - Charger Quantity: A minimum of six Level 2 chargers or at least one DC fast charger is required.
- Application: Local governments must submit an online application through Georgia Power's website, providing project details and site information. Georgia Power will review eligibility, potentially conduct a site visit, and manage the infrastructure installation if approved.

Cobb EMC Commercial EV Charger Grants
- Description: Cobb EMC offers grants ranging from $500 to $5,000 to non-residential members—including businesses, commercial property owners, multifamily unit owners, and government agencies—to support the installation of Level 2 and Level 3 EV charging

stations. The program aims to expand EV infrastructure within Cobb EMC's service area, with a preference for projects that provide public access or benefit a significant number of EV users.

- Eligibility: Applicants must be non-residential Cobb EMC members with an active electric service meter. EV charger vendors and businesses primarily engaged in EV charging are not eligible. Installations must comply with state and local codes.
- Application: Applicants submit an online application with project details. After review, approved projects proceed with installation, followed by submission of final invoices and photos for verification. Grant payments are issued 8 to 12 weeks after approval.

Sumter EMC Commercial Charger Rebate

- Description: Sumter EMC offers a rebate of **$500** per charger to commercial members who install Level 2 or Level 3 electric vehicle (EV) charging stations at their businesses. This initiative aims to encourage the expansion of EV infrastructure within Sumter EMC's service area. Each business can receive rebates for up to three chargers.
- Eligibility: Applicants must be Sumter EMC commercial members and chargers must be installed and operational within Sumter EMC's service territory.
- Application: Members must submit a copy of the paid installation and charger invoice(s) within 60 days after the EV charger has been installed. The customer will fill out the application form available for Sumter EMC's website.

Private Incentives:

Georgia Research Alliance

- Description: The Georgia Research Alliance's Innovation & Entrepreneurship (I&E) Program supports the commercialization of research from Georgia's universities by providing funding and resources to help researchers and faculty turn their discoveries into viable startup companies. The program offers a structured funding pathway:
  Phase I Grants: Up to $50,000 to validate the market potential of a technology.

  Phase II Grants: Up to $100,000 to support company formation, requiring a dollar-for dollar match from a commercial entity or granting agency.

  Phase III Loans: Low-interest loans to qualified Georgia-based startups, repayable to a fund that supports future loans.

  Additionally, the GRA Venture Fund, LLC, provides early-stage investment capital to select companies, with state investments matched at least 3:1 by private investors.

- Eligibility: Researchers and faculty at accredited public or private universities in Georgia are eligible. Projects must involve university-owned intellectual property and aim to establish a Georgia-based startup.
- Application:

Pre-Proposal Submission: Complete a pre-proposal application to outline the project's commercialization plan.

Full Proposal: Upon approval, submit a detailed proposal using GRA's application forms, including milestones and budget.

Review and Funding: GRA evaluates proposals with input from industry advisors. Approved projects receive funding in tranches based on milestone achievement.