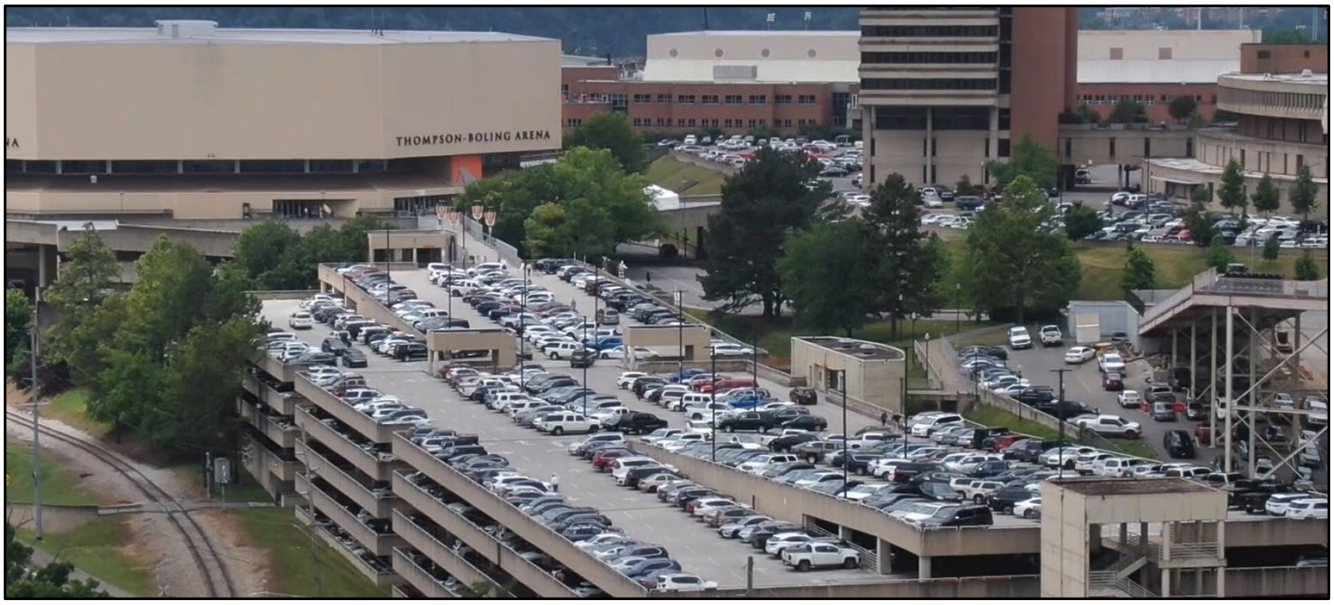
University of Tennessee at Knoxville

Campus EVSE Strategic Planning

Project Final Report

Written for the University of Tennessee at Knoxville by the East Tennessee Clean Fuels Coalition, which is housed in the UTK Institute for a Secure and Sustainable Environment.



Top – Photo of the G-10 parking garage; bottom – photo of the six Agricultural Campus EV charging stations.
Credits: top – WBIR Channel 10 News; bottom – PlugShare.com.

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Acronyms

7SPC	*Seven States Power Corporation*
BEV	*battery (all) electric vehicle*
CAAS	*Charging as a Service*
DCFC	*direct current fast charger*
DET	*Drive Electric Tennessee*
DOE	*US Department of Energy*
EAA	*Electric Auto Association*
EIA	*US Energy Information Administration*
ETCleanFuels	*East Tennessee Clean Fuels Coalition*
EV	*electric vehicle*
EVSE	*electric vehicle supply equipment (charging infrastructure/equipment)*
GHG	*greenhouse gas(es)*
ICE	*internal combustion engine*
IRA	*US Inflation Reduction Act (of 2021)*
ISSE	*UTK Institute for a Secure and Sustainable Environment*
KEVA	*Knoxville Electric Vehicle Association*
KUB	*Knoxville Utilities Board*
LD	*light duty*
LPC	*local power company (name of local electricity provider/utility in Tennessee)*
NOx	*nitrogen oxides*
OEM	*original equipment manufacturer (automaker)*
PEV	*plug-in electric vehicle; includes both BEVs and PHEVs*
PHEV	*plug-in hybrid electric vehicle*
PM	*particulate matter*
PTS	*UTK Parking & Transportation Services Division*
SBO	*Sustainable Business Organization*
SDGs	*UN Sustainable Development Goals*
TDEC	*Tennessee Department of Environment and Conservation*
TNTech	*Tennessee Technological University*
UT	*University of Tennessee System*
UTK	*University of Tennessee at Knoxville*

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June 2024

Executive Summary

The University of Tennessee (UT) System has a $1.9 billion expenditure impact on Tennessee's economy, and a $4.0 billion total economic impact (data from the UT System Impact Dashboard). The Knoxville campus is the flagship campus of the UT system, is responsible for far and away the largest of these impacts… and has over 36,000 students enrolled (roughly 60% of students enrolled throughout the University of Tennessee at Knoxville [UTK] system) and roughly 10,000 faculty, staff, and temporary employees, as of 2023. This large campus has just shy of 20,000 parking spots.

The campus has been active for years in providing access to electric vehicle (EV) charging on campus. Two main initiatives – adding 4-8 chargers at two select locations on campus, and an electrical engineering project that added six chargers on a different corner of campus – have provided charging at geographically diverse campus sites for over a decade (see the campus charging map, Figure 3 on p. 7). But students, staff, faculty, and visitors have had to procure a separate charging "permit" to use those locations for the majority of the past 13 years. While UTK has made recent changes, the leadership at the University recognized that it was time to think more critically about EV charging over the longer term.

Although the numbers were gathered in different ways, the best data that UTK has indicates that interest in charging on campus by EV drivers has increased from roughly 100 in 2020 to approaching 200 in 2023. To be a responsible caretaker to the growing community of drivers that will be utilizing an EV to get to and from campus, as well as serve appropriately in its position as an educational institution that needs to take a leading role in reducing the contribution of greenhouse gases to Earth's atmosphere, UTK should take a more proactive role in ramping up the number of EV charging options across campus parking locations. This report contains a) a description of our work to help the campus decide how to upgrade the current electric vehicle supply equipment (EVSE, "chargers") and utilize a payment system with fair pricing as UTK moves to almost exclusively networked chargers, and b) forecasting data and suggested future goals that UTK can consider for developing a written and publicized EVSE strategic plan. The UTK Torchbearer is symbolic of the Volunteer Creed – "One that beareth a torch shadoweth oneself to give light to others." Due to the enormous and wide-reaching greenhouse gas-reduction benefits that can be derived from transitioning to much greater use of EVs, lighting the way for all campus denizens towards transportation electrification is not just a worthy undertaking, but an imperative one.

We are recommending that UTK do the following.

1. **Set a goal of *at least* 400 parking spaces that offer charging by 2033.** Taking into account the many other considerations related to such a decision (see pp. 26-27 in the Recommendations section), planning for higher numbers of EV-charging spaces should generate numerous returns in various aspects of corporate and community sustainability.
2. **Form a working group of those who drive an EV to campus** to have a regular audience of drivers from which to gain data, input, and insights.
3. **Develop an EV Education Campaign** to regularly share the benefits of driving electric to all campus denizens through multiple channels, including the University website.

See the Recommendations section for additional ideas to consider towards developing a well thought-out, robust, long-term campus EVSE plan.

Background, Previous Efforts, and Goals

In Fall 2022, staff from UTK engaged in a discussion with East Tennessee Clean Fuels Coalition (ETCleanFuels) about their desire to create a campus EV charger strategic plan. ETCleanFuels was chosen to assist in the process and began work in February 2023 with an original end date of September 2023. During the project period, the end date was extended into late 2023.

The staff from UTK and ETCleanFuels that worked together on the project include:

- ✓ **Terry Ledford**, Energy Manager, Facilities Services
- ✓ **Mark Hairr**, Executive Director, Parking & Transit Services *
- ✓ **Ricky Whitted, Jr.**, Senior Transportation Manager, Parking & Transit Services *
- ✓ **Jay Price**, Sustainability Manager, UTK Office of Sustainability, Facilities Services
- ✓ **Jason Cottrell**, Director of Landscape Services, Facilities Services
- ✓ **Sammy Parcell**, Director of Fleet Management *, Department of Finance and Administration
- ✓ **Dr. Michael McKinney**, Professor in the Department of Earth and Planetary Sciences, and the Global Sustainable Development Faculty Fellow for 2023 (within the Center for Global Engagement's Global Research Office)
- ✓ **Dr. Vasileios Maroulas**, Professor of Mathematics with joint appointments at the Business Analytics and Statistics at the Haslam College of Business, and Data Science and Engineering at the Bredesen Center (helped with forecasting work)
- ✓ **Jonathan Overly**, Chief Executive Officer, ETCleanFuels *(UTK dual graduate)*
- ✓ **Valerie Farmer**, Project Assistant, ETCleanFuels *(UTK graduate)*
- ✓ **Savannah Robertson**, (former) Drive Electric TN Director *(UT Chattanooga graduate)*

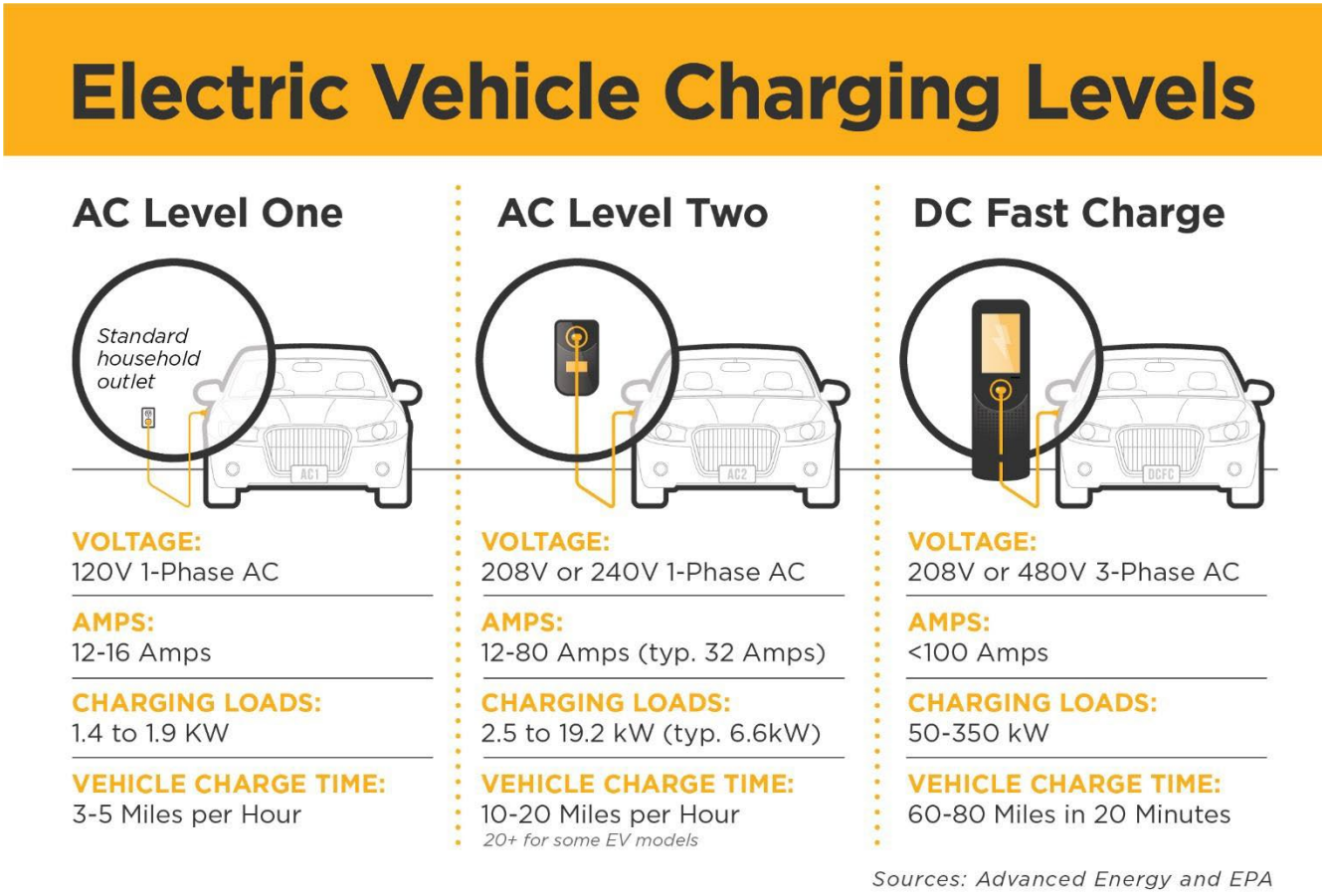
** The "Parking and Transit Services" and "Fleet Management" departments were reorganized into the "Parking and Transportation Services Department" in 2023.*

EV and EVSE Basics

Electric vehicles, or EVs, come in two types: a) full electric, or what are called "battery EVs" (or BEVs) that only operate on electricity, and b) "plug-in hybrid EVs," or what are called PHEVs. As a group, these vehicles are called "Plug-in EVs," or PEVs. For simplicity in this document, we refer to any vehicle that could plug in at a charging location as an EV. By comparison, a typical non-plug-in hybrid – while they use regenerated electricity as fuel to move the vehicle – are not commonly included in an "EV" category in industry discussions because they cannot get any of their fuel directly as electricity and thus must rely on petroleum for their primary fuel. For a more thorough explanation, see here.

"Chargers" are the equipment that allow an EV to plug in and receive electricity, or "fuel." This equipment is often called "Electric Vehicle Supply Equipment," or EVSE. In the US and most other countries, charging comes in three "levels"; Figure 1 below provides a visual explanation of these charging levels and the associated power, charging speeds and times. The primary focus of this effort was on adding alternating current (AC) Level 2 EVSE.

Figure 1. Electric Vehicle Charging Levels



Graphic credit: https://www.svalleyec.com/automotive-industry-goes-green-evs-101

Current State of Parking on Campus

As of the 2022–2023 school year, **UTK had 19,883 parking spots** for students, staff, faculty, and visitors across the campus, and they issued 24,221 parking permits for faculty/staff, commuters, and non-commuters. To provide a broader snapshot of campus – people, size, and impact – university student, staff/faculty, and campus data (as of fall 2023) are as follows.

- ✓ 36,304 students (28,883 undergraduates; 7,421 graduates)
- ✓ 18-to-1 student-to-faculty ratio
- ✓ 2,074 faculty
- ✓ 5,562 staff
- ✓ 3,410 temp employees
- ✓ 8,986 student employees
- ✓ 3,406 non-paid employees (volunteers)
- ✓ The campus covers 920 acres and includes 257 buildings

Here are the parking permits sold in fall 2023 (information from Parking & Transportation Services Department, October 2023):

- ✓ 13,518 commuter permits sold
- ✓ 5,001 non-commuter permits sold
- ✓ 5,471 faculty/staff permits sold

Total of 23,989 permits sold; slightly less than in the 2022-23 scholastic year.

Previous Environmental Efforts and Initiatives Undertaken at UTK

https://sustainability.utk.edu/impact/

UTK supports and encourages environmental initiatives, and has done so for a long time. Previous environmental efforts and initiatives undertaken at UTK have included foci on academics, green infrastructure, energy, food, transportation, zero waste, and more. The Office of Sustainability published an Environmental Impact Report for 2018-2019 that details how it has reduced the campus' environmental impact over the past decades, and a Sustainability Master Plan for 2020-2030 details current initiatives, future goals, actions needed to achieve carbon neutrality, and lays out plans to reduce the University's environmental impact as a whole. The University also has eight student groups promoting sustainability.

Current transportation initiatives include the following.

- ✓ 36 electric and hybrid vehicles, and plans to acquire more all-electric EVs
- ✓ UT Facilities Services has eight Nissan Leafs, according to Jason Cottrell (2023)
- ✓ Two electric Zero motorcycles for the campus Police Department
- ✓ Mass shuttle/transit services (T-link, KAT Bus, The Trolley)
- ✓ Alternative transportation – E-scooters, walkability (focusing on a more walkable campus), and bicycling
- ✓ Extension of the Pedestrian Walkway including dedicated bicycle lanes

Expanding beyond transportation, the below are some current environmental initiatives.

- ✓ Reusable to-go container pilot program
- ✓ Green infrastructure projects (green roof, stormwater garden, rain gardens, etc.)
- ✓ Campus Climate Change survey
- ✓ Numerous annual sustainability events and campaigns

Current State of Chargers on Campus

As of 2023, there were a total of 23 Level 2 chargers located at five different locations. Those locations are shown on the UTK campus map below (Figure 2), and include the Music Building (six chargers), the Agriculture Campus (six chargers), 11th Street Garage (six chargers, shown in Figure 3), Facilities Services (four chargers), and the Staff lot 7 (one dual-port charger).

Figure 2. Map of EV Charging Stations on UTK Campus, as of Summer 2023

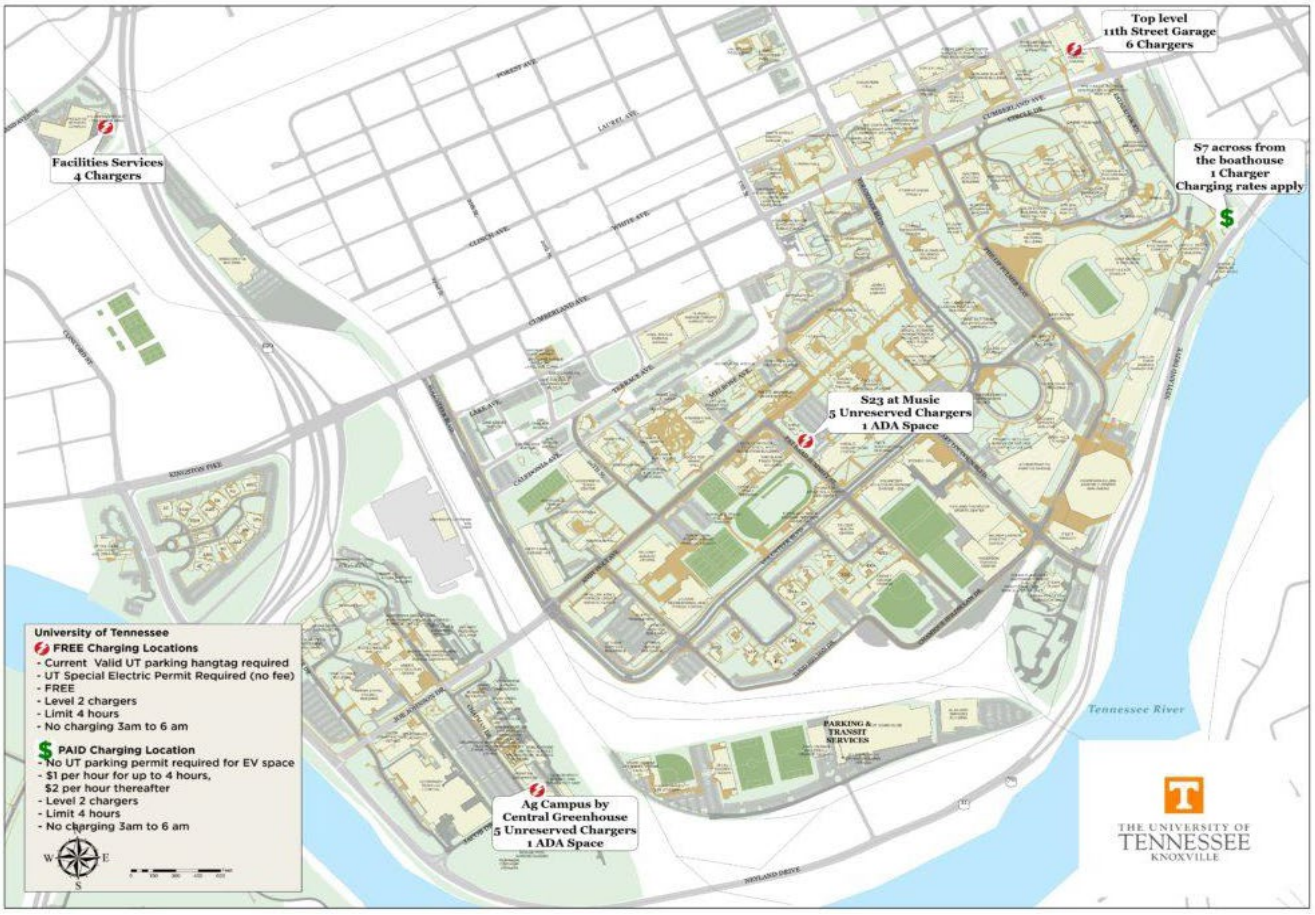
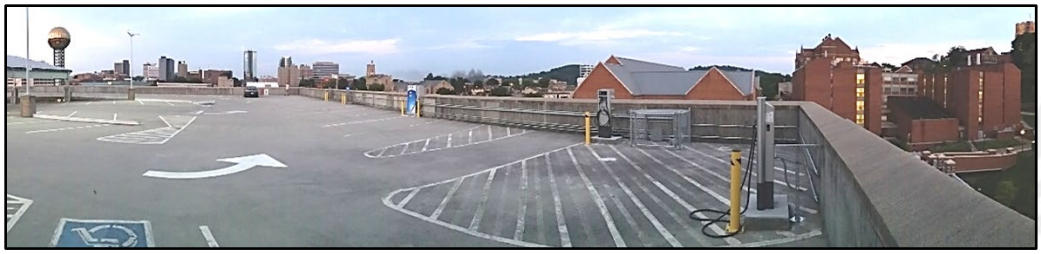


Figure 3. EV Chargers on top of the 11th Street Garage



Graphic credit: East Tennessee Clean Fuels.

All UTK's chargers – aside from the one located at Staff lot 7 – are non-networked and free to use for students, faculty, and staff. The charger at Staff lot 7 is networked, pay-to-use, and open to the public. Visitors may only access the one dual-port ChargePoint charger there as of 2022. Downtown Knoxville, which is just a few minutes' drive from UTK's campus, is actively pursuing adding DC fast chargers as an alternative option for visitor charging.

Twelve of these chargers (six at the Music Building and six at the Agriculture Campus) were installed in 2012 through a US Department of Energy grant as part of "The EV Project." The lone networked charger located at Staff lot 7 was donated to the University by Seven States Power Corp. (7SPC) in 2021. UTK Health Integrated Business & Engineering Program students worked in collaboration with 7SPC and the Knoxville Utilities Board (KUB) to add this charger to campus.

Past Efforts Related to Campus EV Charging

UTK had been providing one-time permits to students, staff, faculty, and visitors since they opened the first chargers in 2012. Individuals were required to go to the parking kiosk at Circle Park and request an EV permit that would be valid for four hours of charging/parking in one of those spaces. In early 2021, UTK changed its system to offer a full, scholastic-year permit to students, staff, and faculty that already had a parking permit for an assigned lot. Through that process, the following numbers resulted from the annual EV permits.

- ✓ 103 EV permits in 2021-22
- ✓ 108 EV permits in 2022-23

This does not quantify the total number of EVs that are on campus yet provides a glimpse into the desire to charge on campus (in addition to the use of campus chargers, which is covered and analyzed later in this report).

Through discussions in the project, Parking & Transportation Services (PTS) built a new online portal within the campus vehicle registration system in spring 2023 to collect information about those who own and drive an EV to campus. The portal can be seen in the screenshots shown in Figures 4 and 5.

Figure 4. UTK Parking Permit Portal

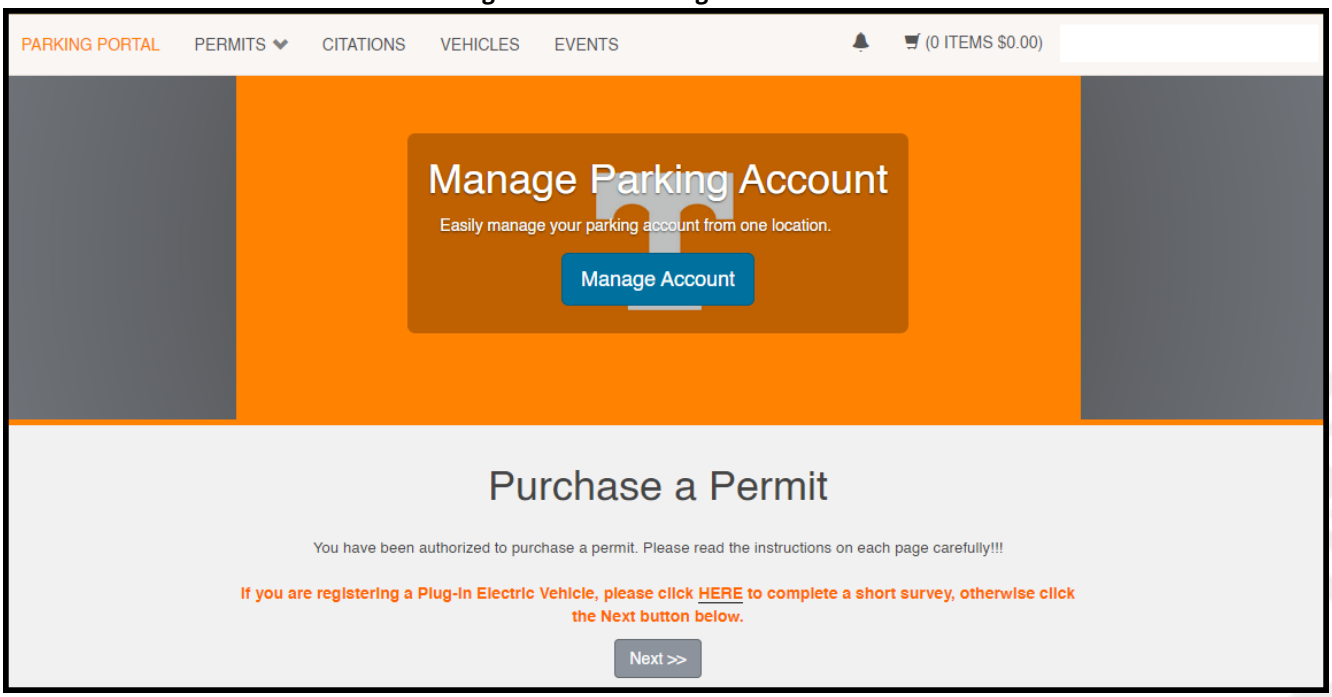
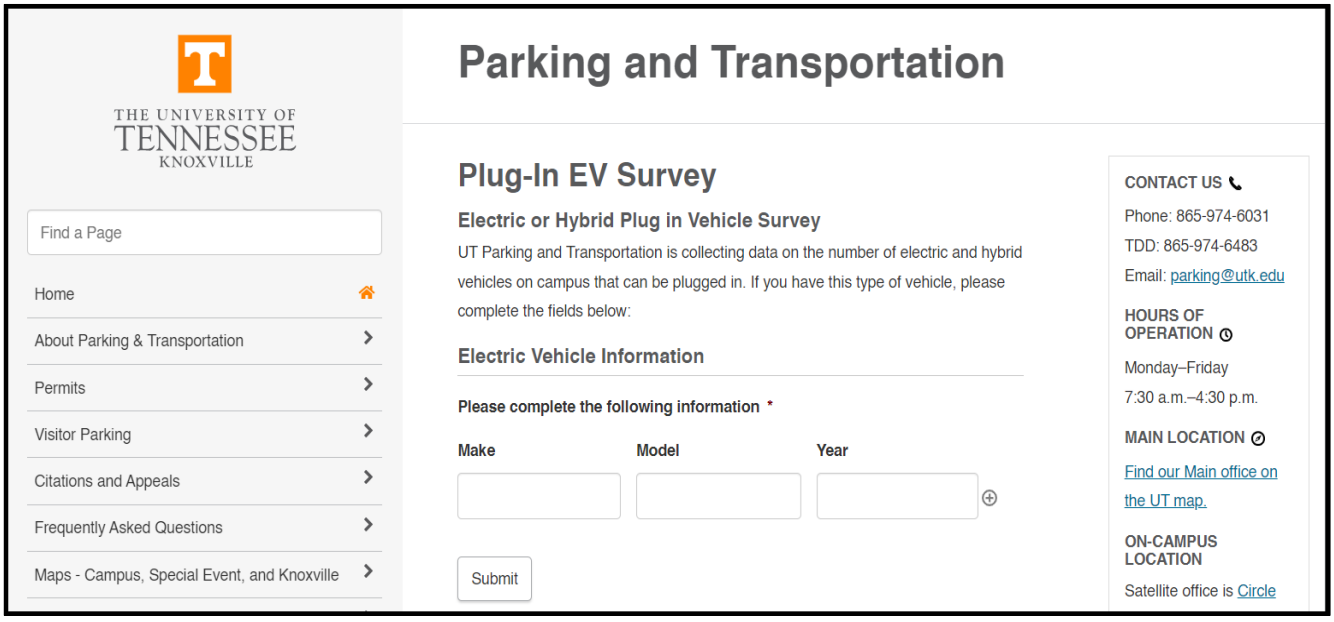


Figure 4 shows the parking portal, the place where students and staff/faculty go to purchase a parking permit. The words in orange at the bottom that read "If you are registering a Plug-in Electric Vehicle, please click here…" were added when the parking portal permit area was edited. Figure 5 shows the simple data

request survey that comes up for EV owners to fill out when they click the link. This addition to the parking portal makes it much easier for UTK to track how many EVs are on campus.

Figure 5. UTK Parking Permit EV Survey



From the data provided by PTS to ETCleanFuels as of mid-September 2023, 220 students, faculty, and staff responded and completed the questions in the portal. Some vehicles that were entered into the survey were not EVs – ETCleanFuels removed the non-EVs from the data – and resulted in **174** registered EVs. (It is not clear as to what caused the confusion in entering non-EVs.) By comparison to the 103 and 108 EV permits requested in 2021-22 and 2022-23, respectively, this is a large jump in year-over-year growth. Caution should be taken however when comparing these as the numbers were obtained in different ways. However, without better data, one can infer that this shows a substantial increase in interest in charging on campus by those that need parking on campus.

Prior EV Survey

In 2019, UTK Research Associate Professor Dr. Chien-fei Chen developed a survey with the help of one of her students. The lengthy survey obtained many comments from campus parkers about their thoughts, worries, and desires related to EVs and charging on campus. She released this survey to the UT general email list and received roughly 600 responses from UT staff, faculty, and students. Figure 6 shows how important respondents thought it was that UTK add more EV chargers on campus. With almost 100 responses, 51 percent responded that it was "very important" and an additional 27 percent responded that it was "somewhat important" – **a total of 78 percent stating that adding more chargers on campus was "important" to them.**

Figures 6, 7, and 8 show additional survey responses related to, respectively, the importance of adding more campus chargers, plans to purchase EVs, and willingness to pay for on-campus charging.

Figure 6. Respondents Important on Adding more Chargers on Campus

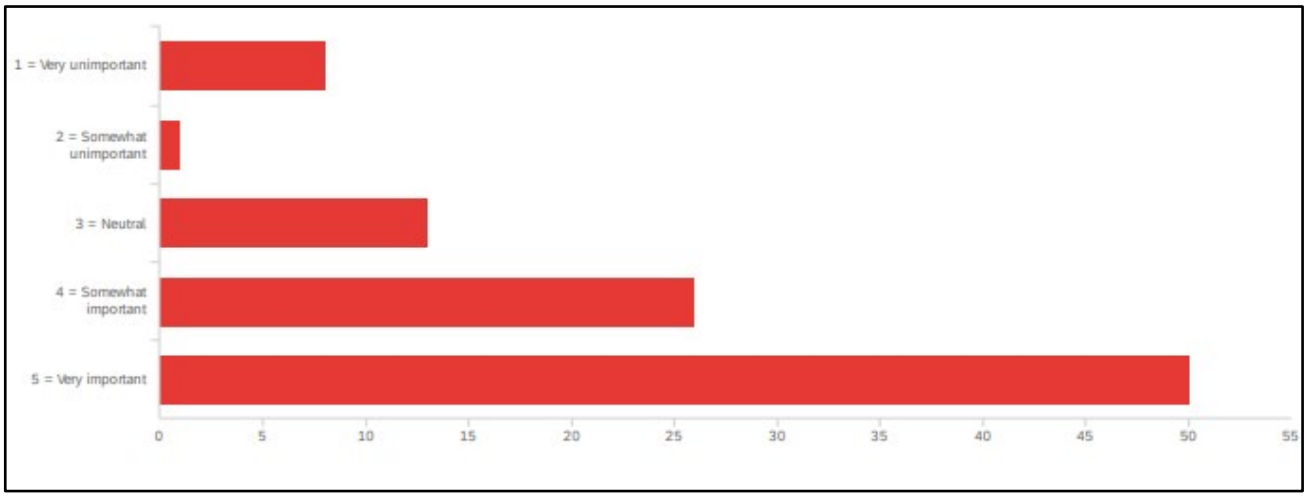


Figure 7. Respondents Planning on Buying or Leasing an EV in the Future

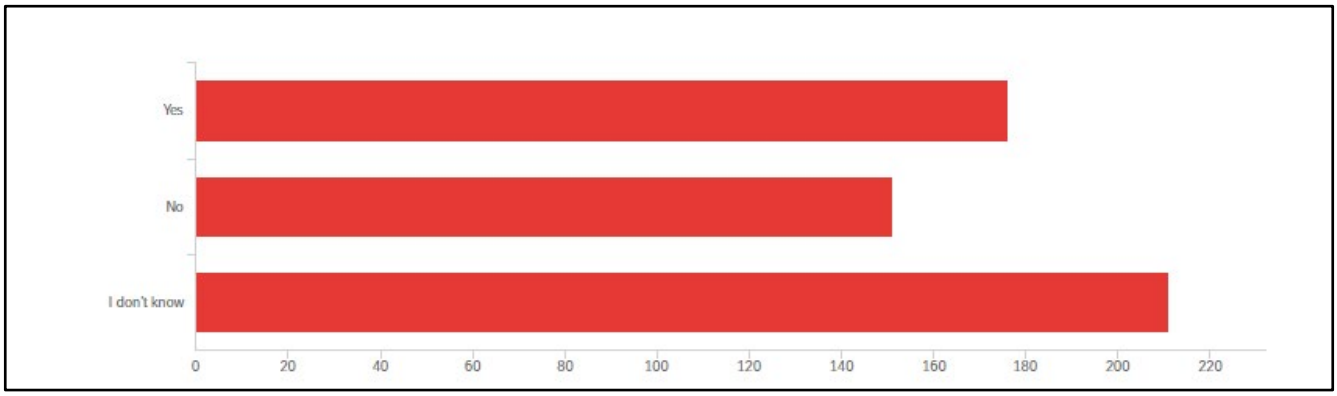
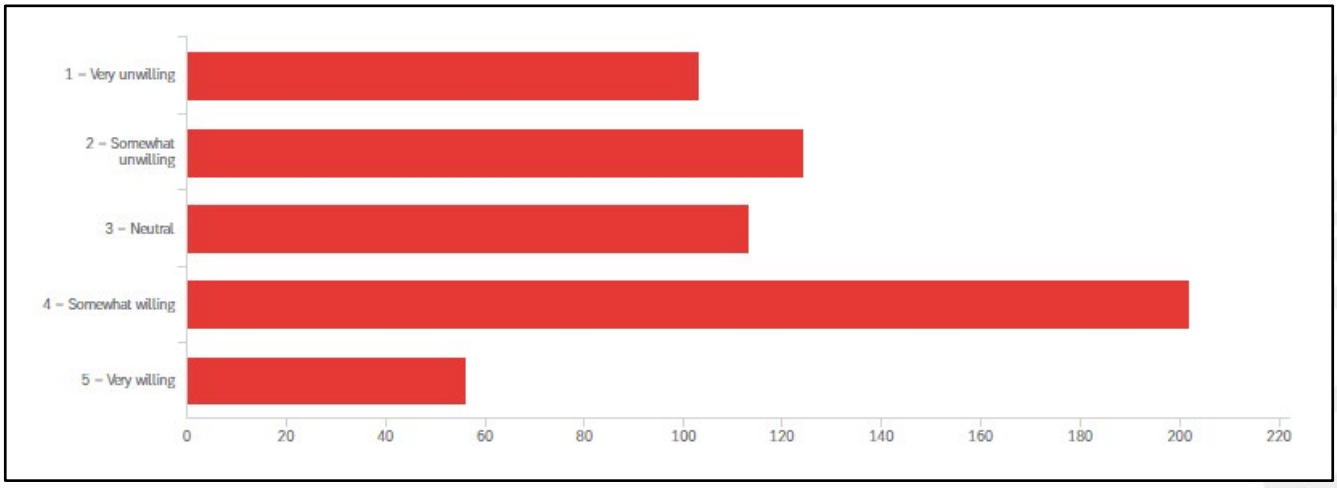


Figure 8. How Willing Respondents are to Pay for Charging on Campus



Some additional notes and comments from the survey included the following.

- ✓ 219 of 550 respondents said they drive between 5 and over 50 miles one way each day to get to campus, with the vast majority of those driving between 5-20 miles each day (which would equal 10-40 miles roundtrip). It should be noted that we do not know what percent were *well over* 50 miles in daily one-way driving (i.e., 70 to potentially over 100 miles).
- ✓ 30 different locations were suggested as additional places to add more chargers. Respondents were given the option to select a first, second, and third option. Those suggestions included choices like adding
    a) more at the 11th Street Garage; the #1 "first choice" answer;
    b) near "The Hill," the high point and relative center of the eastern end of the campus that has nearly no parking options now due to very limited parking space; and
    c) near the John C. Hodges Library, and the Student Union. The Library and Union have a few, close surface parking lots, and those lots could be incorporated into future UTK plans to better utilize that valuable inner-campus real estate.
- ✓ Some specific comments from the survey are included below.
    - There were numerous comments addressing the need to move their EV after four hours of charging and how that was difficult (e.g., "hard to find another spot after leaving EV spot") and created a disincentive; one example included "This summer I considered buying an EV. I liked the idea of charging on campus, until I realized I would have to move my car. I simply do not have time on a teaching day to search for more parking, especially at noon. This was a major factor in my choosing to buy a hybrid instead."
    - "Whether or not I buy an electric vehicle would be heavily influenced by the availability of charging stations close to (where I) work."
    - "In terms of moving my car after it is done charging, I would be much more likely to do this on time every time if there are charging stations near my work building."
    - "I own a plug-in hybrid and did not know that UTK had any chargers available to me until this survey. They are not available to see on the map within the UTK app." (UTK has since – in 2022 – added the chargers to several different online active and PDF maps).
    - "The factor that kept me away from electric was that a lot of our electrical power from TVA is created by coal-fired generators. I read that opting for electric cars can actually be (dirtier) environmentally than using gas. These factors led me to stay with gas. But afterwards, TVA announced it is closing (I believe) three of its coal-fired generators. Still, the point about analyzing how electricity is generated -- the electricity your car will require -- is very valid to me." (TVA's coal-based electricity production has dropped from roughly 60 percent in 2000 to roughly 20 percent in 2023, and this needs to be better relayed to campus citizens.)

The comments expressed a broad range of opinions from "charging should be free" to "charging should not be free;" that UTK should focus on other types of greener transportation (which they are, including encouraging the use of mass transit, moving to electric mass transit, and biking); some misunderstandings of the cleanliness of the TVA grid now and the associated powering of EVs by it; and how adding charging increases the already complex parking situation on campus. (Like many college campuses, many students and staff arrive and leave at different times of the day, so it is common that more parking permits are provided than parking spaces exist.)

Project Goals

The project team established the following goals:

1. research what other college campuses across the USA were doing offering charging, the types of charging available, and what the cost was to use the equipment;
2. get further insight into students, faculty, and/or staff current attitudes toward EVs on campus;
3. analyze relevant data to look forward and determine what the campus may need in the future regarding charging stations; and
4. provide UTK leadership with data and insights to help them develop a strategic, long-term plan for obtaining EVSE on campus.

As the project progressed, additional goals developed:

5. replace all the current non-networked chargers with networked chargers (for control, pay system management, and the ability to have all of the charging data [e.g., when, where, amperage rates]); and
6. to find the most cost-effective, best suited near-term provider of EVSE for UTK's needs.

Plan and Work Undertaken in Project

Meetings Scheduled

Throughout most of the project period, the team met once a month on the third Monday, with almost all those meetings being held in person. In addition to the regularly scheduled meetings, there were also separate, virtual meetings held for EVSE companies to present their charging equipment and services to members of the project team with a focus on near-term charger replacement.

Research on Charging at Universities in the USA

One of the first items on our to-do list was researching how other college universities and campuses have added and implemented EV chargers to their campus. Altogether, data from 39 universities was obtained, gathered, and inputted in a spreadsheet, including factors such as number of chargers, level (1, 2, DCFC), kW, amperage, voltage, price to charge, brand, and audience they served (that is students, faculty, staff, and/or visitors). Figure 9 below shows the locations of the universities that ETCleanFuels spoke with and the charging audience.

Figure 9: Map of EV Chargers and Audience(s) they Serve at Different Universities Across the United States

Link: https://www.google.com/maps/d/u/0/edit?hl=en&mid=1dZfranKjkmiV8Q4y4RRZz8xvqmdu5_0&ll=35.10083500467113%2C-92.21308918635421&z=5.

As part of the work, ETCleanFuels spoke with two universities in particular – the University of Michigan and University of Maine – to see what their future plans were regarding adding EVSE on campus. The University of Michigan is currently installing *150 L2 networked chargers and shared that their goal is to add 400-500*

chargers over a four-year period. One future problem they are anticipating is how to manage this very large number of chargers. The University of Maine did not have an official plan or goal yet, however they shared that they were pursuing grant funding to install DC fast chargers on campus. Table 1 below shows a subset of the information gathered from the researched campuses as an example of the data acquired.

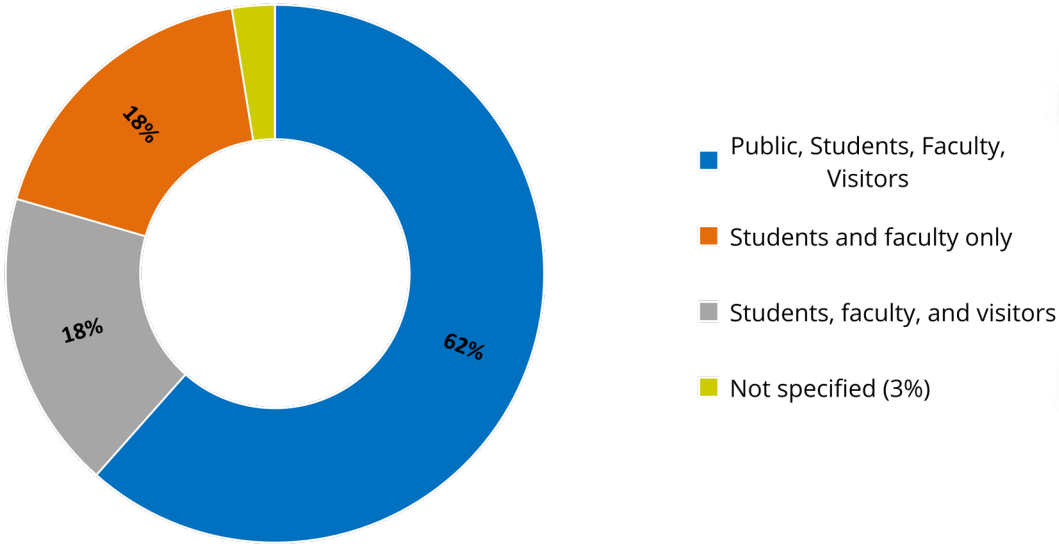
Table 1. Example Universities and EV Charger Specifics

Univ. #	#/Locations	Level	kW	Amps	Volts	Price	Brand	Audience
1	2	L2	X	30-40	240	Free	Clipper Creek	Faculty
1	28	L1	5	15	120	EV Permit	Eaton	Public
1	4	L2	X	40	208	$1.50/hour	X	Students, faculty, visitors, public
2	8	L2	6.6	30	240	All chargers are free for students Some chargers are free for all users while others are pay-to-use	ChargePoint	Faculty, visitors, public, students
3	15	L2	6.48	30	240	$1.50/hour	ChargePoint	Students, faculty, visitors, public
4	10	L2	7.2	30	240	Free	ChargePoint	Faculty, visitors, public, students
5	1 unit at 7 different locations	L2, DCFC	X	30, 200	240, 480	$0.34/kWh	ChargePoint	Faculty, visitors, public, students
6	1	L2	6.6	30	240	Free	ChargePoint	Students, faculty
6	1	L2	6.6	30	240	X	ChargePoint	Public

"X" represents specifics that were not known or provided by the campus staff we engaged.

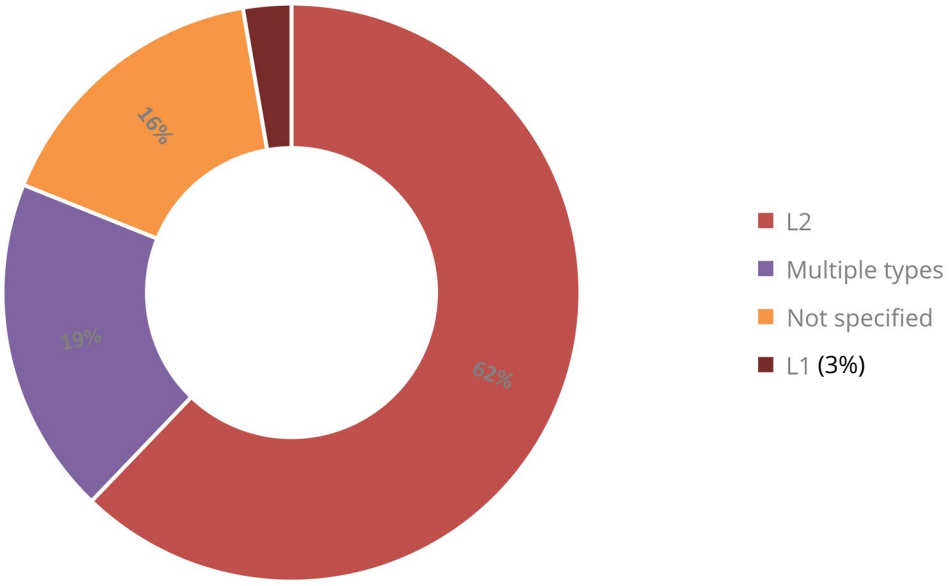
Delving into the acquired data resulted in the following insights. The most common audience that has access to chargers was a combination of all – students, faculty and staff, and visitors. The next most common audiences were evenly split between a) all but staff and b) student and faculty only (Figure 10).

Figure 10. Audience Type Access to Chargers, by University



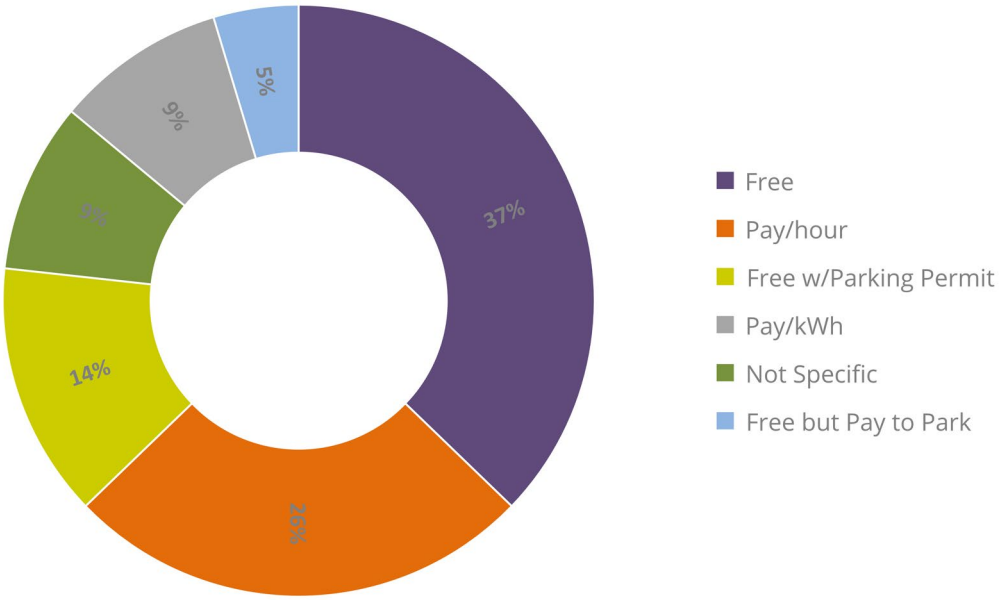
Level 2 chargers were the most popular level of charging offered, and level 1 was the least popular (Figure 11). This does not include DCFC as there was only one university with this type of charger (Ohio State).

Figure 11. Charger Level Type, by University



The largest faction of universities does not charge any fees to refuel their EV at this time, although there may be requirements to have a parking permit or pay to park in the lot. Of the universities that do require customers to pay, they use either a pay per hour or per kWh rate (Figure 12).

Figure 12. Price to Charge Categories, by University



Decision-making on What is Needed Now versus Future Needs

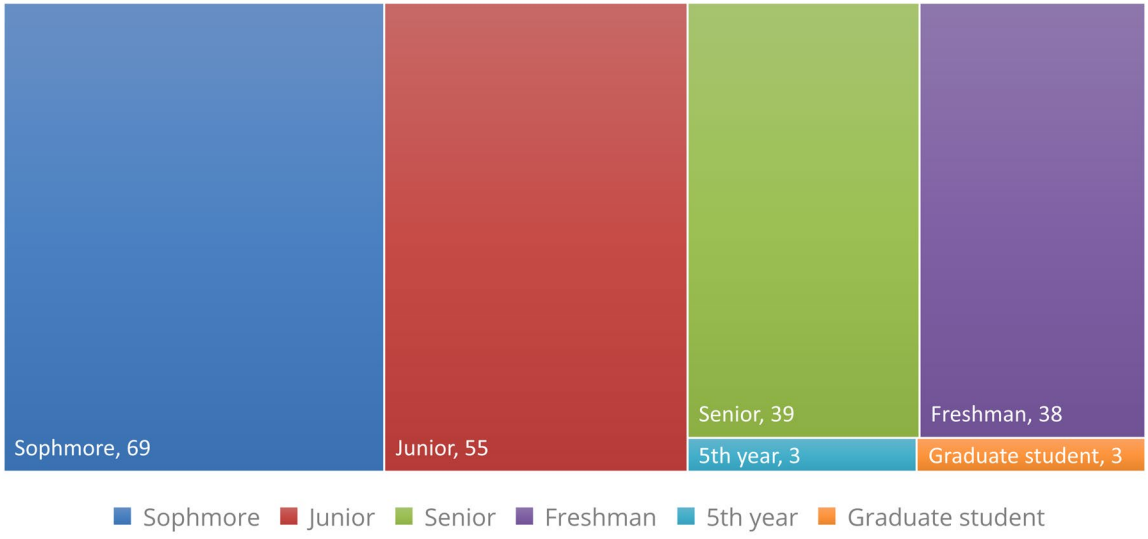
The project team decided that the top priority should be replacing the chargers already on campus before adding additional chargers, based on the current state of that equipment. This is due to the chargers being out-of-date/older and non-networked, as well as now including a variety of brands (over the past decade, staff found some deals on non-networked chargers over time as some needed replacing, and purchased those). After this phase is accomplished, the University wants to add additional chargers as the next step in its plan – the key questions are how many and where.

The team decided that Level 2 chargers would be the most practical based on the amount of time students and staff/faculty are typically parked on campus, the high costs of DCFC units and the impact they can have on campus electrical demand, and that Level 1 chargers provide electricity at a slower rate. It was also decided that a cable management system such as a reel or retractor would be the best option due to the problems that can result from unhung cables (where a simple loop system often does not encourage the user to put the cable back on the loop), including possible damage to the cables.

2023 EV and EVSE Survey

Dr. Michael McKinney has been heavily involved with student environmental initiatives on campus. He worked with students including Luke Cornelius, President of The Sustainable Business Organization (SBO), to develop a survey surrounding students' thoughts on EVs on campus. The survey was shared with UTK students of all classifications in early fall 2023 and gathered 207 responses in a short period of time. Cornelius shared the survey to a number of campus organizations and groups including the Sustainable Business Organization, Students Promoting Environmental Action in Knoxville (SPEAK), the Compost Coalition, Plastic Free UT, and Smokeys Cleanup; to several environmental/sustainability listservs; and to a number of classes. The results from the responses are as follows, and it is worth repeating that this is only *student* responses. To begin, Figure 13 shows the classification of all the respondents.

Figure 13. Breakdown of Respondents' Classifications



Several important details emerge from Figure 14, which are the results from posing two questions – "How likely are you to own an EV a) 'within the next year' and b) 'within the next 5-10 years'." The answer options ranged from 1 to 5 with 1 being "not likely" and 5 being "Very Likely."

- ✓ Students responded overwhelmingly that they are not likely to own an EV within the next year. However, a few students did state that they are *very likely* to own an EV within the next year (five) or *likely* (1).
- ✓ Looking just at the "Not Likely" answers between the 1 and 5-10 year options, a whopping 80 percent of those that said they are not likely to own an EV within 1 year migrated to another answer option, or a greater likelihood that they will own an EV (that is, 126 respondents selected another option).
- ✓ Reviewing the change in the answers along the "Likely" end, the number of respondents selecting either 4 or 5 went from just six to 81 as you switch from within "one year" to "5-10 years." That is a change of 2 percent to 39 percent. Additionally, that same group for the "5-10 year" question equals 81 people signaling their interest in owning and driving an EV on campus within 5-10 years, or between 2028 or 2033.

Figure 14. Likeliness of Owning an EV in the Future

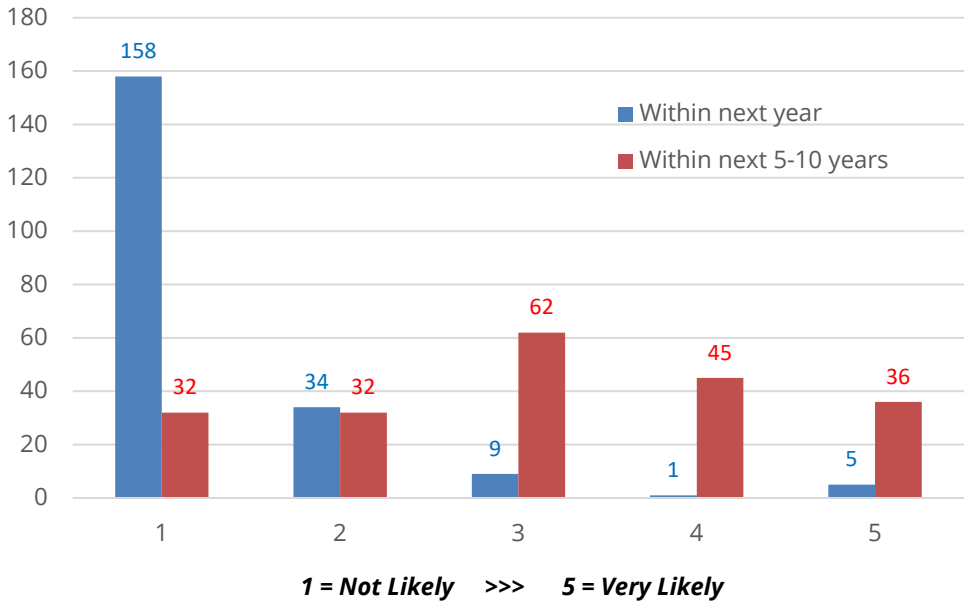


Figure 15 shows the results from posing the question, "What factor(s) could be preventing you from purchasing an EV?" With 207 respondents, 338 total options were checked – on average, students selected 1.6 options.

Initial Cost was the clear leader in keeping students from purchasing an EV. Lack of Infrastructure was the second most popular answer, and it should be noted that the question was not posed as "lack of infrastructure *on campus*," but in general (and so likely includes the US-wide general, known major hurdle of EV ownership of buyer's worry that there is not enough infrastructure period/everywhere).

Figure 15. Factors Affecting Students' EV Purchasing Decision Making

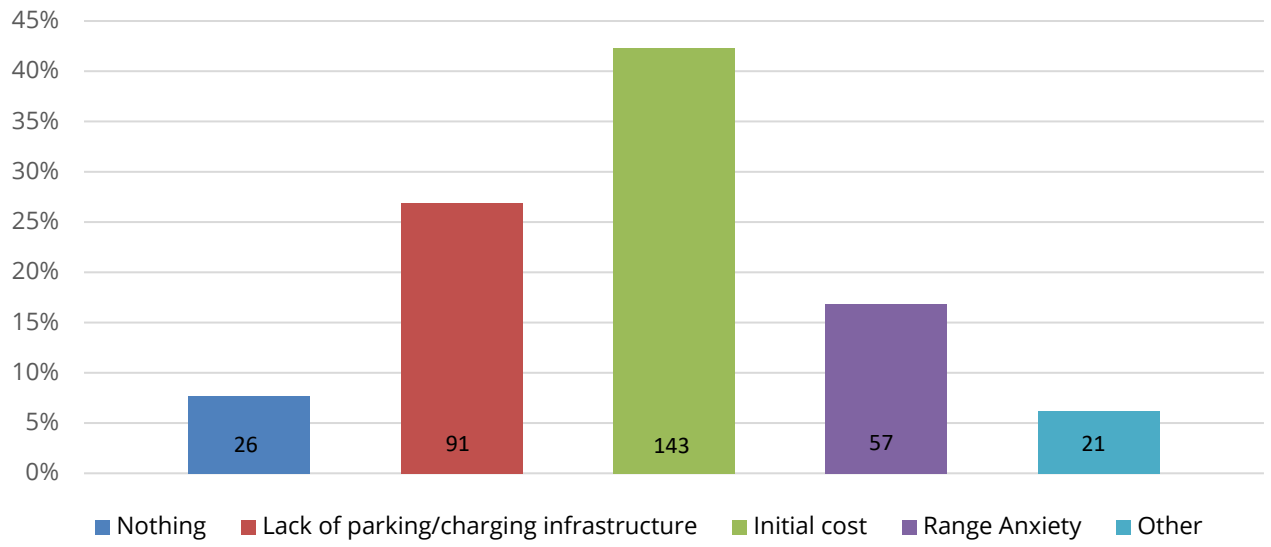


Figure 16 shows the results from asking the question, "What business model would you be most interested in seeing UT implement?" and offered three answer options. The Loss Leader business model (offering free charging to attract drivers) was the most popular business model, with the Cost Recovery model (setting a fair usage fee to cover UTK's costs of providing charging) following close behind. Just over 10 percent of student respondents selected the Profit Making model. As the need for more charging grows on campus, the associated annual costs of providing charging (electricity), the associated electrical demand impacts, and the need to replace equipment over time will grow, too. UTK will likely need to ensure that there is some kind of income to cover those costs.

Figure 16. Respondents Interest in a Specific Business Model

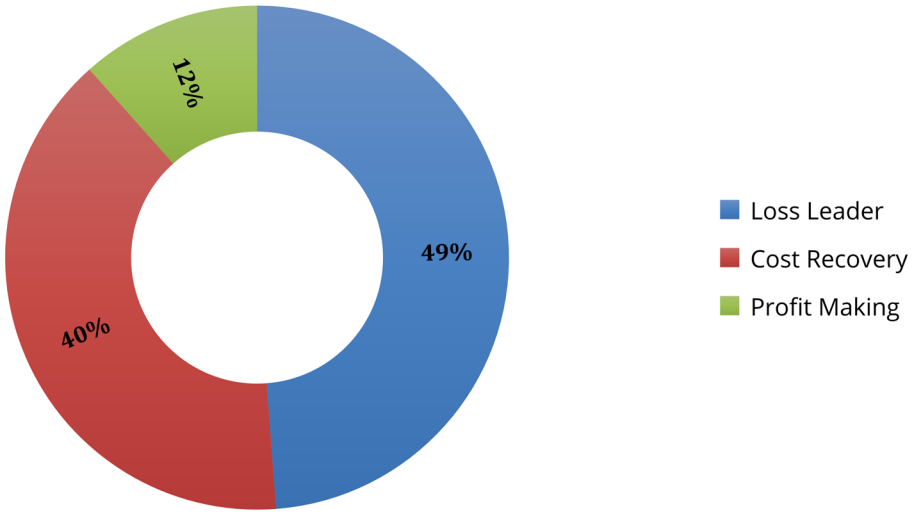
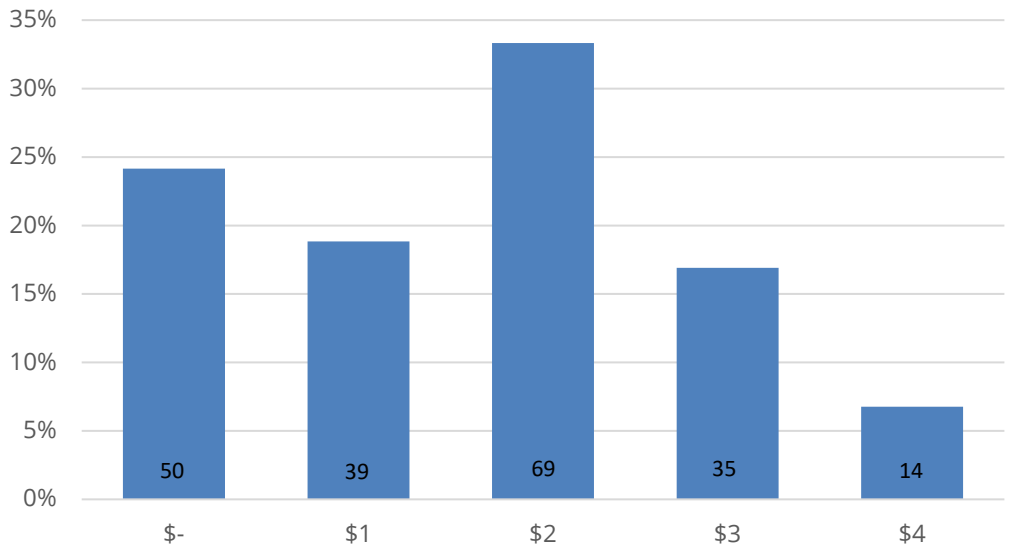


Figure 17 shows that answers to the question, “How much would you be willing to pay for EV charging on campus?” The first value is zero, and the numbers above the bars are the number of responses to that dollar value. Of the responses, 76 percent were willing to pay something to charge (not free) on campus, and 57 percent are willing to pay $2 an hour or more to charge.

Figure 17. Willingness to Pay for EV Charging



Level 2 Companies Engaged

As part of the work in the project, ETCleanFuels researched manufacturers and resellers of Level 2 units. This was beneficial on several fronts including providing current data on what kinds of features and options are available on commonly available units, as well as allowing UTK to see current pricing on such units for the plan to "rip and replace" the non-networked units across campus. Below are some details on the research conducted, and a table with unit features.

- ✓ We reached out to 27 companies that sell or manufacture Level 2 units, letting them know we were working with the campus on a potential near-future opportunity. (We also spoke with a couple of Level 1 unit manufacturers.) Some of those did not get back to us, and some had limitations or lacked features that UTK was interested in having in the future service on campus.
- ✓ We held virtual meetings with 12 companies to learn everything we could about their company and various Level 2 EVSE offerings.
- ✓ Some of the key data we wanted to acquire included capital and operating costs including information on warranties and service/connectivity fees, and collecting unit specifications and/or sales presentations that had technical data included.
- ✓ All data was aggregated into a workbook, and we collected numbers for a) buying and b) leasing units (or "Charging as a Service," or CAAS) from these companies, if the entity offered a CAAS option.
- ✓ We gradually removed companies that were not going to be the best option for UTK (the ones that only offered Level 1, did not have cable management, were too expensive, were only for fleets, etc.).
- ✓ Five companies were invited to speak to the project team and show the hardware and software that their company offers.

Table 2. Obtained Level 2 EVSE Company Data

Co. #	Level 1, 2	Single/ Dual Cable	Breaker Size (A)	Max Amp Draw (A)	Cable length(s)	Cord Manage-ment System	Bluetooth Capable	Protection
1	2	Single	40	32	25 ft	Reel	No	NEMA 4
2	2	Single	40	32	25 ft	Loop	Yes	NEMA 4
3	2	Dual	40	30	18 ft, 25ft	Reel	Yes	NEMA 3R
4	2	Dual	40	32	25 ft	Reel	No	IP 66
5	2	Single	50	40	25 ft	Loop	No	IP 66
6	2	Single	40	32	25 ft	Loop or Reel	Yes	NEMA 4
7	2	Single	40	32	25 ft	Loop or Reel	No	NEMA 4
8	2	Single	50	40	25 ft	Loop	Yes	NEMA 4
9	2	Dual	40	30	21 ft, 25 ft	Retractor	No	NEMA 4
10	1	Single		16	n/a	n/a	Yes	IP 66
11	1	Single		16	n/a	n/a	No	IP 66

The table above shows the 11 companies that were analyzed further after meeting with a member of the company. The Single/Dual Cable column refers to whether the unit has one port meaning it can only charge one vehicle at a time (single), or it has two ports and can charge two vehicles at the same time (dual). In some cases, the dual units provide two full connections to different breakers at the box while in others the

two cables/connectors must share a single breaker. The Breaker Size column refers to the required minimum breaker amperage. The Max Amps Draw column refers to the maximum amperage that the unit can deliver to a connected EV. The ones that show a Cord Management System of “loop” only were eliminated from final consideration. The data in the Protection column indicates that almost all of the units offer a high level of enclosure protection via the NEMA 4 (American) and IP 66 (European) standards, offering advanced degrees of protection against corrosion, windblown dust and rain, splashing water, and hose directed water (and undamaged by ice that can form on the enclosure) for NEMA 4, and more specifically indicating incoming liquid protection or waterproofness for IP 66.

Forecasting & Recommendations

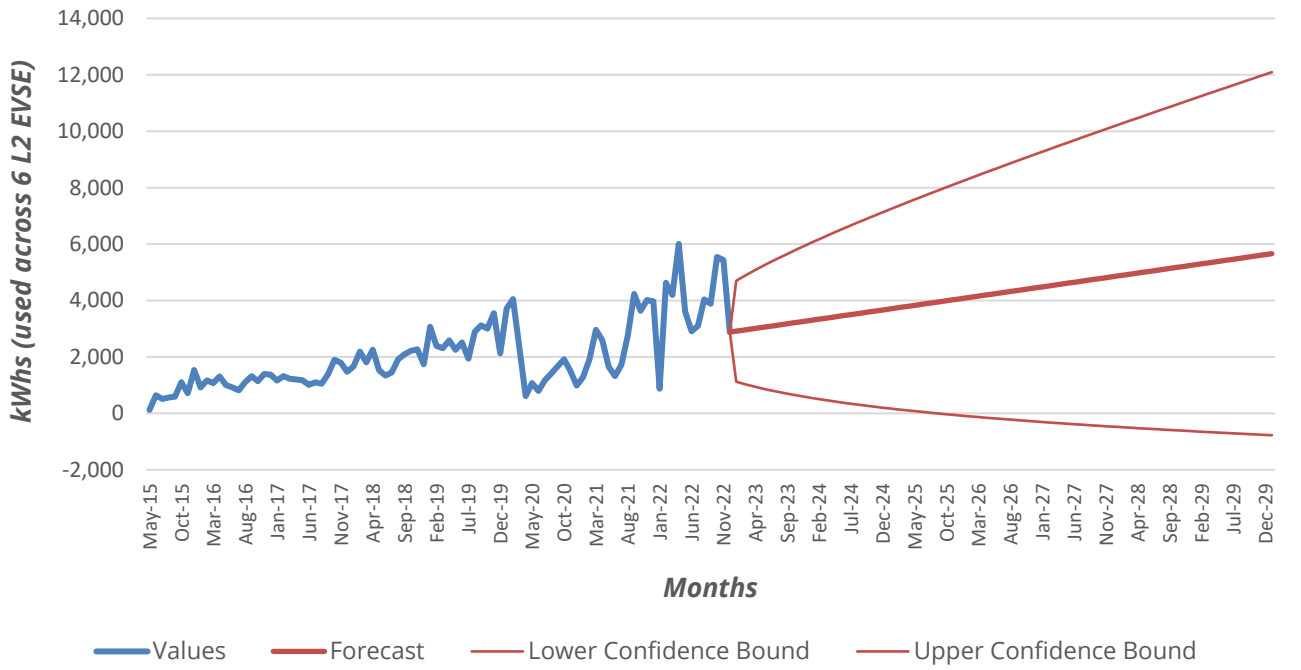
Data Utilized, and Process to Derive Forward-Looking Projections

One of the primary goals of this project was to look forward and determine what the campus may need in the future regarding charging stations. To do this, we looked at multiple sets of past data related to EVs.

Sustainability Manager Jay Price shared past usage data from the charging stations at the Music Building and Agriculture Campus. (There was no data for the 11th Street Garage, and the relatively new single dual-cable networked charger on campus only has a small time window of data.) Between the Music and Agriculture locations, the Music Building is a campus-centered location whereas the Agricultural site is on the edge of the entire UTK Campus. We produced graphs for both sites, but the Agricultural location showed no real growth over roughly seven years. We deduced that this site is not as desirable a charging site for those coming to campus except for those needing to visit that distant part of Campus. Thus, Figure 16 shows the Music Building site's usage from 2015 through the end of 2022, and then forecasting through 2030 (including lower and upper confidence bounds with a 95 percent confidence interval).

In the known data, there is a lag when COVID hit in 2020, yet the usage rate largely picks up where it left off in 2022-23. However, the forecast would likely be higher in future years without the charger use loss that occurred during the period. The forecast shows a roughly 100 percent increase in usage in 2030 – 6,000 kWhs/month consumed in EV charging there – from around 3,000 kWhs/month consumed during the 2021-2022 period. Using the forecasted escalation rate, that would equal roughly **7,600 kWhs/month** in use, or *an increase of 153 percent (from the ~3,000) in 2033*.

Figure 16. Music Building Charging Data Extrapolation



We also utilized numbers found from researching past national EV sales (Argonne National Laboratory) dating back to 2010, and Tennessee EV registrations (TN Dept. of Revenue) dating back to 2019. The Tennessee data was not collected by that department prior to 2019, and the data is not publicized by the department either. Currently, it is gathered by TDEC from the Department of Revenue, processed by TDEC's partner Atlas EV Hub, and then posted on the Drive Electric TN initiative website, here.

With these two sets of data, we did simple forecasting in Microsoft Excel to project numbers up until 2033 – 10 years out from the study work year. We included upper and lower confidence bounds in all our analysis for each of the datasets to account for variability (also referred to as low, middle, and high estimations, thus the middle or mid estimations are the main forecast). However, we had incomplete data for 2023 for both datasets as we were doing the work in the fourth quarter of 2023. We also know that the Inflation Reduction Act (IRA) will have a growing impact on near-future EV sales. The IRA was signed into law in 2022 and is the largest climate investment in US history, and is designed to mobilize private capital to achieve federal climate goals, and strengthen long-term, full-breadth EV sales, and support and hasten American EV industry growth. Numerous aspects of the IRA are widely expected to result in increased EV sales, and thus we wanted to take that near-term information into consideration as we filled out the 2023 numbers. Thus, we established three scenarios for forecasting the Q4-CY2023 national and Tennessee numbers:

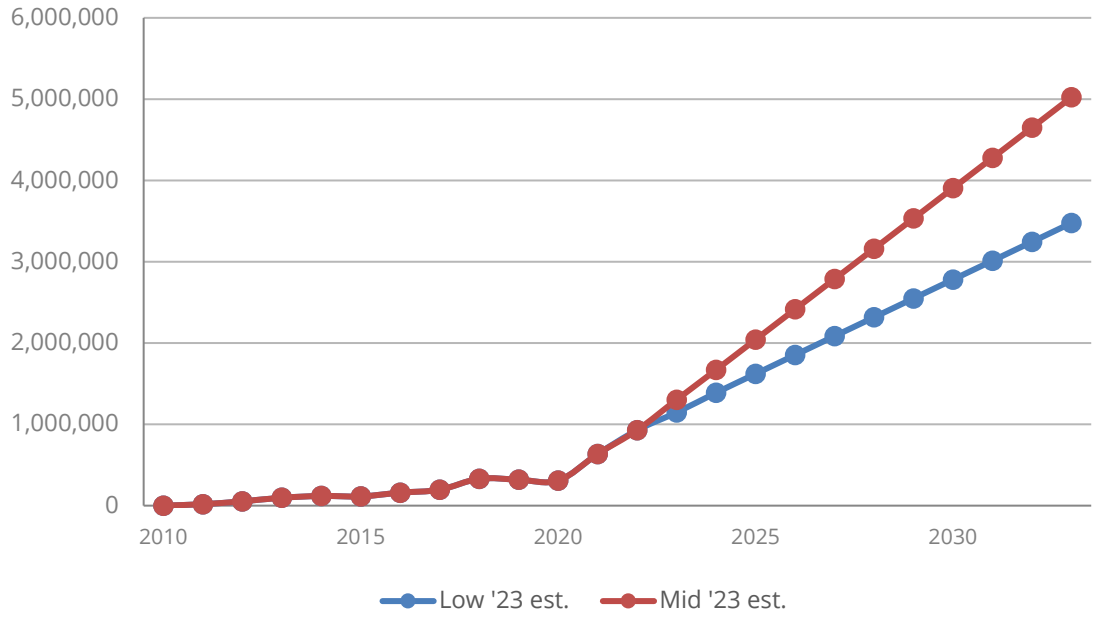
- ✓ LOW = 1.1x – Sales/registrations are lower than expected;
- ✓ MID = 1.25x – Slightly higher than average of what was sold in each of the recent previous quarters; and
- ✓ HIGH = 1.4x – Sales/registrations are higher and IRA impacts have been more substantial than expected.

Those factors were used only to complete the calendar year 2023 annual sales data forecast by taking the actual national sales data for the first three quarters of 2023 and multiplying that nine-month number times the value shown above. If the selected factor was consistent with what was seen over the previous four quarterly growth in national EV sales increases over nine-month periods, it would have been 1.11x to 1.32x. Those newly calculated numbers were then used to derive full-year 2023 data and added to the 2010-2022 data before finishing the forecast in Excel through 2033. The resulting graphs showing projected national sales numbers (Figure 17) and projected Tennessee EV registrations (Figure 18) are shown on the next page.

As future, national EV sales are a hot topic, we are providing below a selection of forecasted EV sales in the future from a variety of sources, for comparison to what was derived above.

- ✓ **4,719,375** in 2030 – From www.EVAdoption.com, and this analysis was done several years ago and thus excluded the known higher growth rates from 2022 and 2023. *They also noted that light-duty (LD) EVs sales as a percent of total light-duty vehicle sales in the US will rise from 3.4 percent in 2021 to 29.5 percent in 2030.*
- ✓ **3,691,784** in 2030 – From the International Energy Association.
- ✓ **4,600,000** in 2030 – From S&P Global Mobility via Green Car Reports; that includes the expected full impact of the Inflation Reduction Act (IRA).
- ✓ **5,600,000** in 2030 – Edison Electric Institute, with LD reaching over 32 percent of total LD vehicles sales in the US.

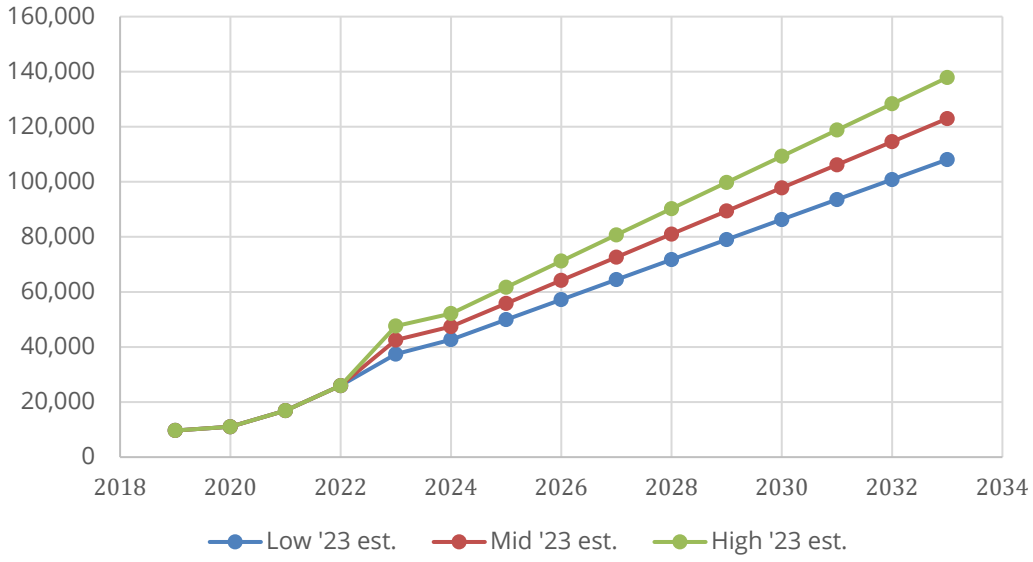
Figure 17. National EV Sales: Historic & Projections with L/M/H Numbers



The high estimate in the above graph was removed as it tracked unusually high. An assistant for Dr. Maroulas could not help us determine what was going on in the data, and with an expectation that we would not use it, it was removed.

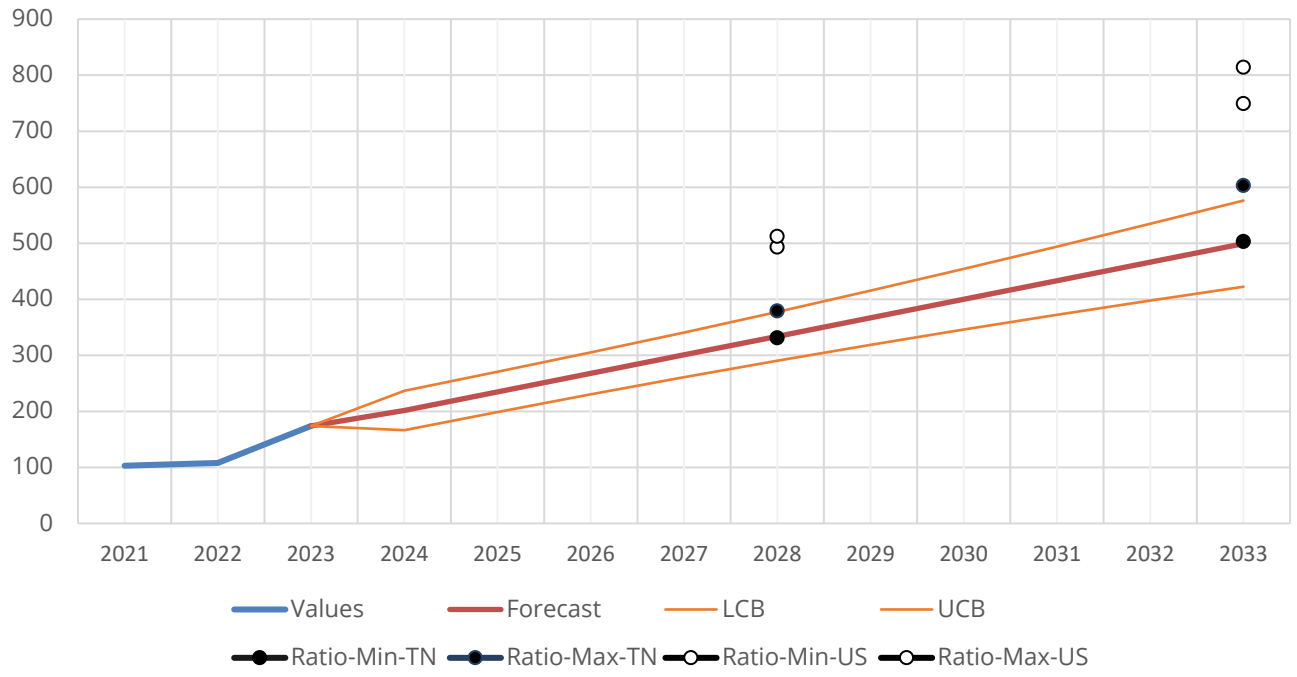
Note that all of the additional forecasting numbers shown in the bulleted list are *ending in 2030, not 2033.* With that in mind, the "middle" forecast from our analysis above seems close to most of those predictions. The national EV sales data resulted in a main forecast of just over 5 million EVs being sold in the USA in 2033 (Figure 17, 5,023,552 to be exact). On the Tennessee registrations side, see Figure 18 – the 2033 middle registrations hits 122,967 EVs being registered in Tennessee that year.

Figure 18. Tennessee EV Registrations: Historic & Projections with L/M/H Numbers



Along with the sales and registration datasets and as noted previously, we also obtained from UTK EV parking permit sales data for three scholastic years. The first two scholastic years of data ('21-'22 and '22-'23) were obtained in a different way by UTK than the third year's data ('23-'24). The first two numbers were the amount of people that requested annual permits to be able to park in EV charging spots; the third number was obtained through UTK's new self-selection process of "I have a plug-in EV" that drivers were encouraged to fill out when purchasing a parking permit on the PTS Division's website (and our removal of non-EVs in that data). It should also be stated that we do not know the percentage of people that either did not see the request, or chose not to complete it, which has the effect of reducing the true numbers. We used these three numbers (knowing we had very little data) to forecast how many parking permits may be requested in the future (Figure 19) using the same forecasting tool used for the other datasets.

Figure 19. UTK Parking Permit Registrations: Historic & Projections with L/M/H Numbers



After we produced these graphs, we reached out to Dr. Vasileios Maroulas to get advice on our analyses. Dr. Maroulas – a Professor of Mathematics at UTK with joint appointments at the Business Analytics and Statistics at the Haslam College of Business, and Data Science and Engineering at the Bredesen Center – suggested using ratios to get a more accurate projection of the parking permit numbers (since we had so few years of data to work with). We then created ratios using the parking pass numbers to the Tennessee EV registration and National EV sales data for years 2021-2023. After turning those ratios into percentages, we multiplied the percentages with the Tennessee EV registration and National EV sales data that we projected for 2028 and 2033 (using both the minimum and maximum numbers to account for variability). This gave us the minimum and maximum number of parking permits five years from now (2028) and 10 years from now (2033) and are shown in Figure 19 (black dots are TN-based numbers, white dots are US-based).

Reviewing Figure 19 provides the following highlights:

- ✓ the US numbers clearly provide higher estimates than the Tennessee numbers, and may be less relevant to Tennessee;
- ✓ the Tennessee numbers are more in line with the primary-forecast-to-upper-confidence boundaries in 2028 and 2033; thus,
- ✓ using only the high-end Tennessee numbers, **the number of UTK denizens requesting EV charging permits in 2028 would be 379, and in 2033 would be 603**.

Analytical Results

All the above was performed to provide the following Tables 3 and 4 of data.

Table 3. Resulting Analytical Data

Dataset	**Start #** *(2022)*	**End #** *(2033)*	***Units***	**Percent Increase ***	**Multiplier ***	**Relevance**
UTK Music Building EVSE Use (kWhs)	3,000	7,600	*kWhs*	153%	2.53	Local, on-campus electricity use by EVs
National EV Sales	929,074	5,023,552	*EVs sold*	441%	5.41	Overall nationwide # of EVs sold
TN EV Registrations	25,955	122,967	*EVs registered*	374%	4.74	Overall state # of EVs registered
UTK Parking Permit Requests	108	603	*Permits requested*	458%	5.58	Local, on-campus requests to access chargers

** The percentage provided is the percent increase over that period; the "multiplier" provided is the multiplication result moving from the 2022 number to the 2033 number.*

While the sales and registrations datasets are not directly indicative of charging needs, they are used here as a second best-available surrogate to indicate general American public and general Tennessean interest in EVs, *and the subsequent need and desire to charge*. Moreover, as we move beyond the earlier adopters of newer, more advanced and environmentally friendly technology, the next group of potential EV drivers in the US – the "Early Majority" or "Pragmatists" – will want easier access to charging and less problems along the way… including those that do not have home charging options, or those that live in multi-family housing (e.g., apartment and condominium complexes).

If we utilize the multipliers shown in Table 3 the following values result in Table 4 for the a) interest we have in charging on campus (2022 = 108) and the b) number of chargers there are on campus (2022 = 23).

Table 4. Potential Future UTK Charger Needs, 2022 to 2033

Dataset	Multiplier	Period Start	2033 (End) Value	
			Charging Interest	*# of Chargers*
Music Building EVSE Use	2.53	2022	274	58
National EV Sales	5.41	2022	584	124
TN EV Registrations	4.74	2022	512	109
UTK Perking Permit Requests	5.58	2022	603	128
Using all Four of the Above Values				
Average values			*493*	*105*
Median values			*548*	*117*
Removing the National EV Sales Values				
Average values			*463*	**99**
Median values			*512*	*109*

A median is better to use when extreme values exist in a dataset. However, in this case, there are no outliers, and the two values are not that far apart for this assessment.

Recommendations for Future EVSE Expansion

There is no question that there will be more EVs driving onto and around the UTK campus in the coming years, given the growth in sales across the US and in Tennessee over the last decade. *But the key questions are a) how many EVs will that be, b) how many of those EVs will need charging, and c) what role should UTK play in either being responsive to UTK denizen charging needs… or being proactive to stay ahead of the need?*

Keeping in mind that UTK has nearly 20,000 parking spots as of 2023, we are providing the following recommendation levels for the number of parking spaces that should have EV charging connections in the future. They take into account the above analysis but also the many further points elucidated below.

Table 5. Recommendation Opportunities for UTK on the Number of Parking Spaces Served by Level 2 Chargers

Year	Minimum		Suggested Minimum		Lighting the Way	
	#	%	#	%	#	%
2022	23	0.12%	---	---	---	---
2028	60	0.3%	120	0.5%	400	2.0%
2033	100	0.5%	200	1.0%	1,000	5.0%

The percents were all taken using 20,000 as the number of UTK parking spots, to enable round numbers.

These recommendations are for the number of parking *spaces* that have charging available in the future, **so the number of actual units (if dual-cable / dual-port units are selected) could be as much as half of that number.**

UTK should set a goal of having at least 400 EV charging spots by 2033. This is double the "suggested minimum," but in only a limited way does that take into account UTK setting an example for the larger

community – for the Knoxville area and for other universities and campuses across the state – and beyond. Moreover, if UTK genuinely wants to be a sustainability leader as compared to universities across the country, a much higher goal should be contemplated like between the "Lighting the Way" recommendations. However, data is king, and one of the first things that the University should do is determine better ways to get quality data and input from its driving-to-campus denizens: some new pathways for gathering data on EVs coming to campus already should be devised, and input should be garnered on a regular and ongoing basis so that the goals can *be ahead of* the need to and interest in charging on campus in future years. **As a part of this, UTK should consider working with ETCleanFuels to build a Campus EV Drivers Working Group**, beginning with some in-person and virtual meetings. Any interested campus staff could be part of the group and help plan what kind of input is most valuable from the group, as well as how that may change over time.

We also encourage UTK to include its chosen goals in any future updates to the Campus Sustainability Plan and Campus Master Plan. We also suggest – if not already being done – including Scope 3 total emissions and starting to count the GHG reductions that are occurring from those that drive EVs to campus, and ETCleanFuels can help with those calculations if needed.

We also recognize the following real-world consideration. GHG emissions reductions from campus denizens are Scope 3-related emissions; as such, they may not be the most important for UTK to tackle. However, they are connected and should not be dismissed. "… for many organizations, scope 3 emissions account for by far the highest proportion of total emissions. Unfortunately, these are also usually the hardest to reduce." In this case, every EV driver would likely be garnering reductions along the lines of 50-70 percent of their related transportation GHG emissions, which is massive on a per-car basis, and that percent reduction will grow in the coming years. **This could be the fastest way UTK could reduce Scope 3 GHG emissions related to all the students, staff, and faculty that drive to campus.**

Additional contributing factors to the decision to install more chargers on campus include the below.

1. We live in the Tennessee Valley, with TVA as our power producer. With TVA's continuing efforts to reduce the amount of carbon related to every kWh they produce, that makes the emissions (GHG and certain criteria pollutants) associated with any EV that charges on TVA-produced electricity *continue to decrease in the coming years.*

2. Every all-electric vehicle (BEV) that comes to campus removes *one more tailpipe from campus, and the associated particulate matter and nitrogen oxides emissions that come with ICE vehicles.* Gasoline- and diesel-powered vehicles get dirtier the longer they are kept; EVs are now getting cleaner the longer they are kept based on the growth in use of cleaner grid fuels.

3. There are several points related to the UTK 2020-2030 Sustainability Master Plan.
    - Within the Transportation sections, the following is mentioned: "All new parking structures and lots must include electric vehicle charging stations." **This is an important facet of offering charging on campus and should be followed**, even if Level 1 is chosen (see bullet #8).
    - The UN's Sustainable Development Goals (SDGs), and UTK as a signatory of the Declaration on University Global Engagement – As it notes in the Master Plan, "Through this declaration, the University has made a formal commitment to deepen our students'

understanding of 'the most pressing economic, social, and environmental challenges facing our world today,' as outlined in the SDGs." Climate Change and Global Warming are undisputed, pressing issues that all citizens of this planet face today. While the impacts of Climate Change are connected to almost all 17 of the SDGs, they are rooted and amplified in goals 7 (Affordable and Clean Energy), 11 (Sustainable Cities and Communities), and 13 (Climate Action). UTK sits essentially in the middle of the greater Knoxville community and has a responsibility to show community leadership (see more in #4 below).

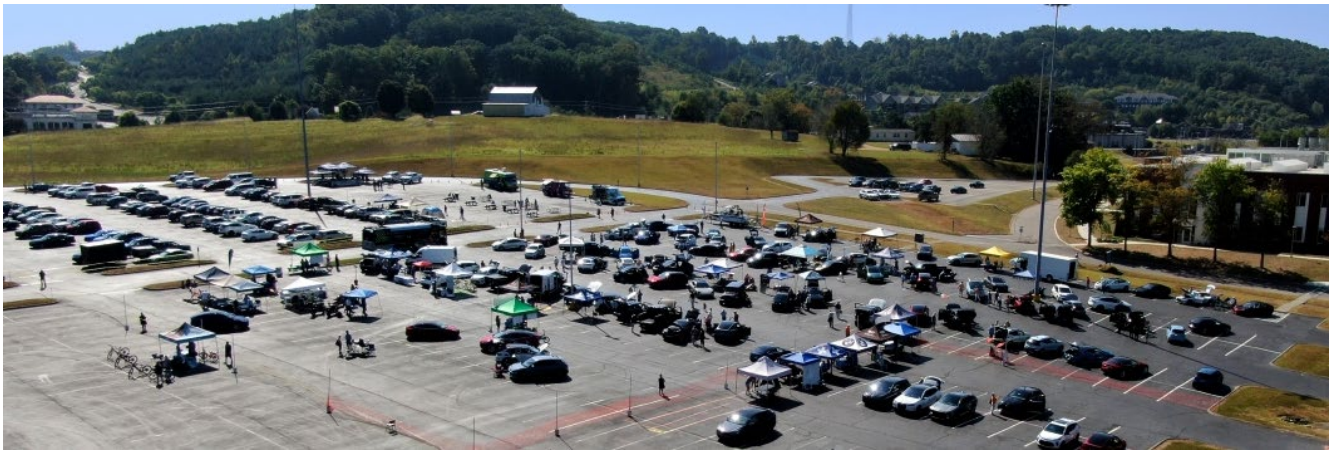
4. The UTK Campus Environmental Policy states that "UT will aspire to serve as a model of sustainability, stewardship, and inter-generational responsibility." If this aspiration is to be upheld, UTK should choose one or more EVSE goals that are closer to the "Lighting the Way" option shown in our recommendations above. GHG emissions are usually the greatest for individuals for either their home or transportation needs, and depend on home size and sharing (e.g., three plus people in an apartment or home) and the GHG footprint of their selected vehicles, driving distance, and style. By proactively encouraging the use of EVs, UTK will be helping its denizens reduce GHG emissions in their community.

5. The chargers used by the UTK fleet are included in the original 2022 numbers, so they are included in the recommended number of parking spaces that offer charging, or number of chargers on campus goals. If UTK is going to essentially double their acquisition and use of dedicated EVs (which will have the largest reductions in GHGs compared to PHEVs and ICE vehicles) and reach 10 percent of its total fleet as electric or alternative fuel by 2030, the alt-fuel that provides the greatest reductions in GHGs (for fleets utilizing the TVA grid) for light-duty vehicles… is electricity. If an ICE vehicle is replaced with a similar type and size BEV, the reductions using TVA grid power as of 2023 are on the order of 60 percent.

6. Drive Electric TN educational "chapters" provide first-hand driving and learning opportunities locally, and the number of them is growing. In 2020, there was only one functional chapter, the Knoxville EV Association (KEVA); as of the end of 2023, *there are now four functional chapters and another five in development*. That means more younger people across the state will be having chances to see and experience EVs in the coming years in their communities before they perhaps attend UTK to further their education and learn about their greater part in being a good US and worldly citizen by "lighting the way for others."

7. KEVA is in Knoxville! They are by far the strongest chapter and hold numerous events in the greater Knoxville and surrounding counties area that students can (and have) attended, including as volunteers. One of the largest events *in the United States* each year during Plug In America's "National Drive Electric Week" is KEVA's "Drive Electric Festival." The 2023 event had almost 140 EVs in one location and provided 311 rides or drives to community citizens (see Figure 20). KEVA also typically partners with ETCleanFuels to be at the "Knox Auto Show" and the main event for the "Dogwood Arts Show" that's held at World's Fair Park, both of which have thousands of visitors every year. KEVA has an outsized impact on local EV education compared to many other cities in Tennessee, the Southeastern US, and the country.

Figure 20. Drone Shot from KEVA's 2023 Drive Electric Festival



Graphic credit: Matthew Lawson.

8. Supporting the idea of continuing to offer only Level 2 (or Level 1) chargers on campus is the fact that DC fast charging is coming to downtown Knoxville. The City of Knoxville is working with KUB to bring a set of four DCFC units that will open in 2024. Visitors to campus, as well as students/staff/faculty, will soon be able to utilize nearby fast charging for their electric fueling needs. (Thanks to the recent addition of 24 Tesla Supercharger stalls in Powell, there are now three sites and 40 total Superchargers in Knoxville. There are seven total DCFC units that offer mostly CCS1 or but also the CHAdeMO ports at three locations in Knoxville, and that number should go up for four to 12 in 2024.)

9. Level 1 charging options are a) attractive to some campus EV drivers, b) much less expensive than Level 2 chargers, and c) come in networked models. It is suggested that UTK develop and plan a Level 1 installation in several parking areas, but not until greater input is gathered from current and potential future EV drivers to campus.

Appendices

Appendix A. Electric Vehicle Top 10 Benefits

Electric vehicles (EVs) provide many benefits to owners, drivers, the community, and the planet. Here is a quick Top 10 list.

1. EVs reduce carbon emissions as they run on cleaner electricity, not gasoline.
   (In Tennessee, this is due to the TVA's 60 percent carbon-free electricity production, and commonly yields ICE vehicle to EV reductions that range from 50-80 percent, depending on the type of ICE or electric vehicle moved from or to. You can see specific, example TN driver switch GHG results here.)

2. As the grid gets cleaner in the coming years, the emissions profile for EVs will get cleaner as well. Reference this excellent article from ElectrifyNow for good historical graphs and data.

3. EVs can be charged with as much as 100% renewable energy, while gasoline is derived from non-renewable resources. Even if something like renewable gasoline were to be widely available and used, the tailpipe pollution would not change and still be spread where the cars and people are. *(Depending on their LPC, EV owners can sometimes increase the amount of renewable energy they use beyond the utility's standard generation mix by participating in various LPC programs.)*

4. EVs charging can happen anywhere—even through an ordinary electric outlet.

5. EVs are less expensive to operate and maintain, as there are far fewer moving parts than in a vehicle with an ICE (on the order of 20 moving parts in an EV versus 2,000 in an ICE vehicle). Reference an Argonne National Lab report, and a CarGurus article.

6. EVs are fun to drive, with faster acceleration and an overall better driving experience than ICE vehicles.

7. EVs are quieter than vehicles with engines as they use a motor instead of an ICE to develop mechanical force. This allows the driver to hear more of what is going on around them.

8. EVs are becoming more prevalent and popular, as indicated by auto manufacturers' commitments to invest billions to convert from ICE to all electric models that they sell in the next 10-20 years.

9. Many models of EVs are eligible for federal or state tax credits.

10. Driving an EV virtually eliminates your use of petroleum for all your needs… not just transportation. Americans consume and use petroleum in products they use on a regular basis (e.g., plastic containers), but those amounts as petroleum are trivial compared to the amount of gasoline they use in a year (for the typical driver who goes over 10,000 miles per year).

Appendix B. Additional Results from Dr. Chien-Fei Chen's Campus EV Survey

The below are additional data/results that were pulled from the campus-wide EV and EVSE survey that was conducted by Dr. Chien-fei Chen in 2019.

Figure B-1. Participants who regularly drive to campus

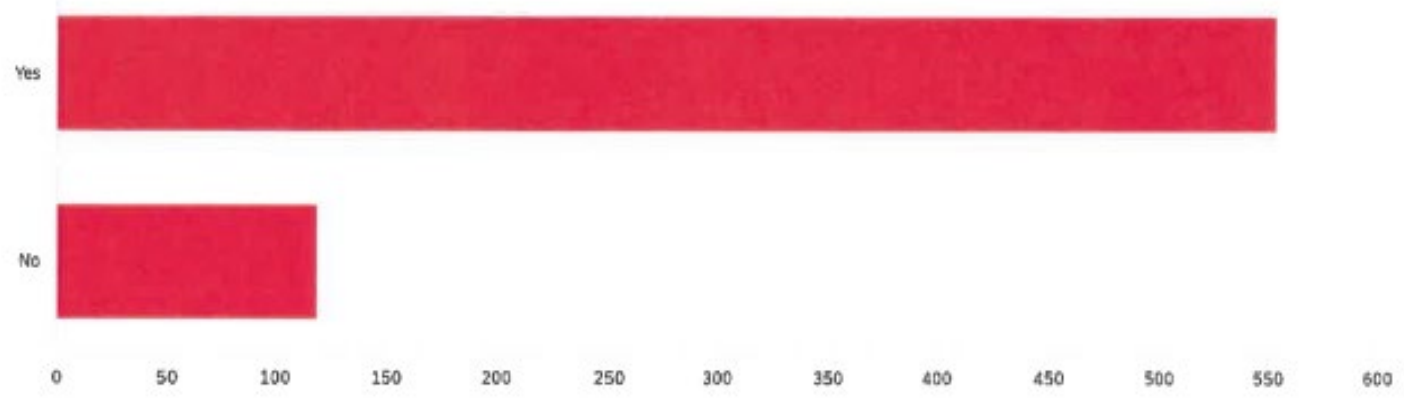


Figure B-2. How far people typically drive to campus

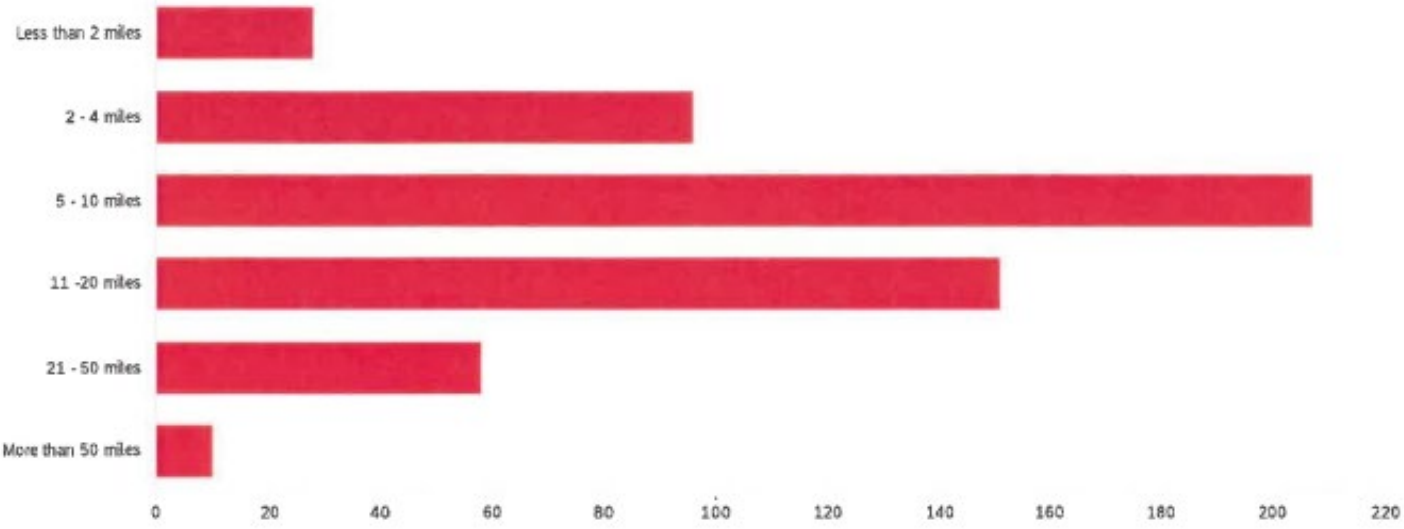


Figure B-3. Satisfaction of current chargers on campus

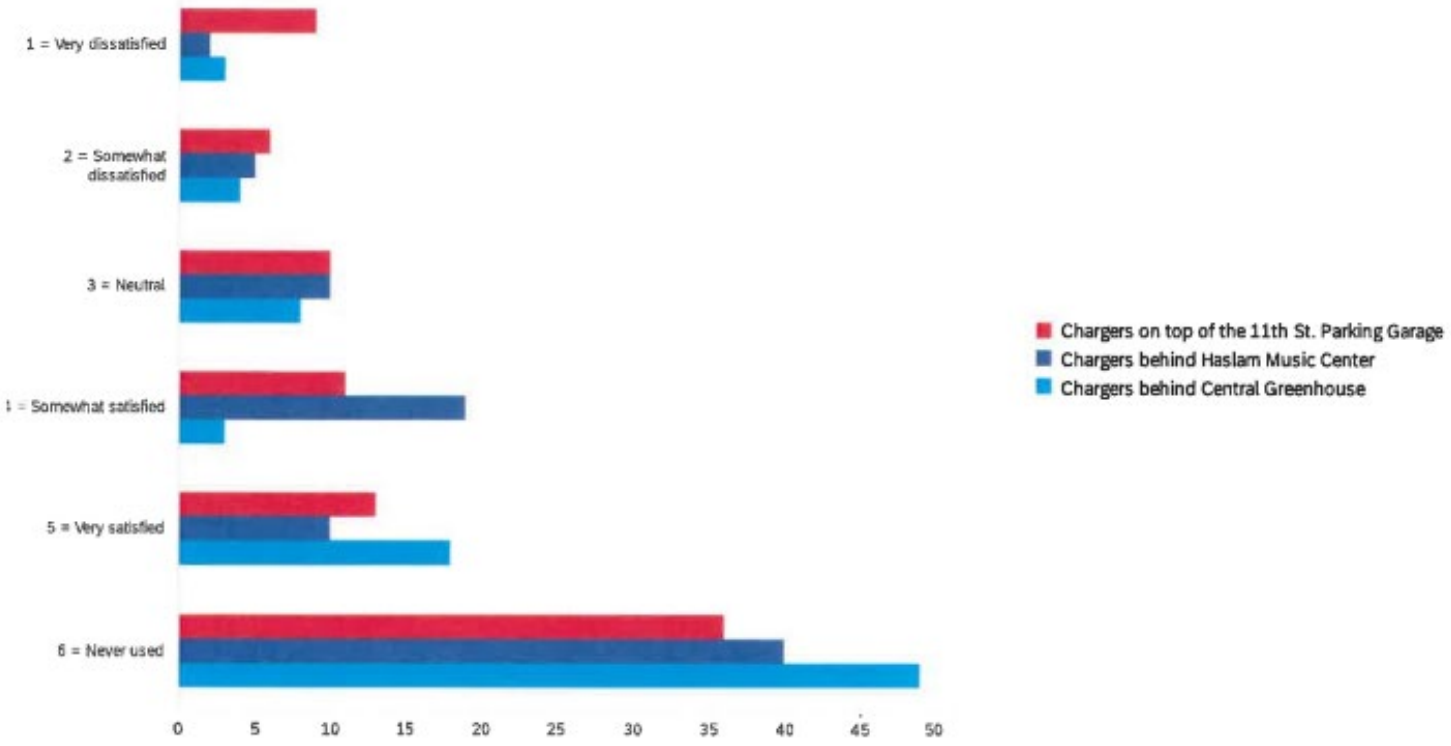
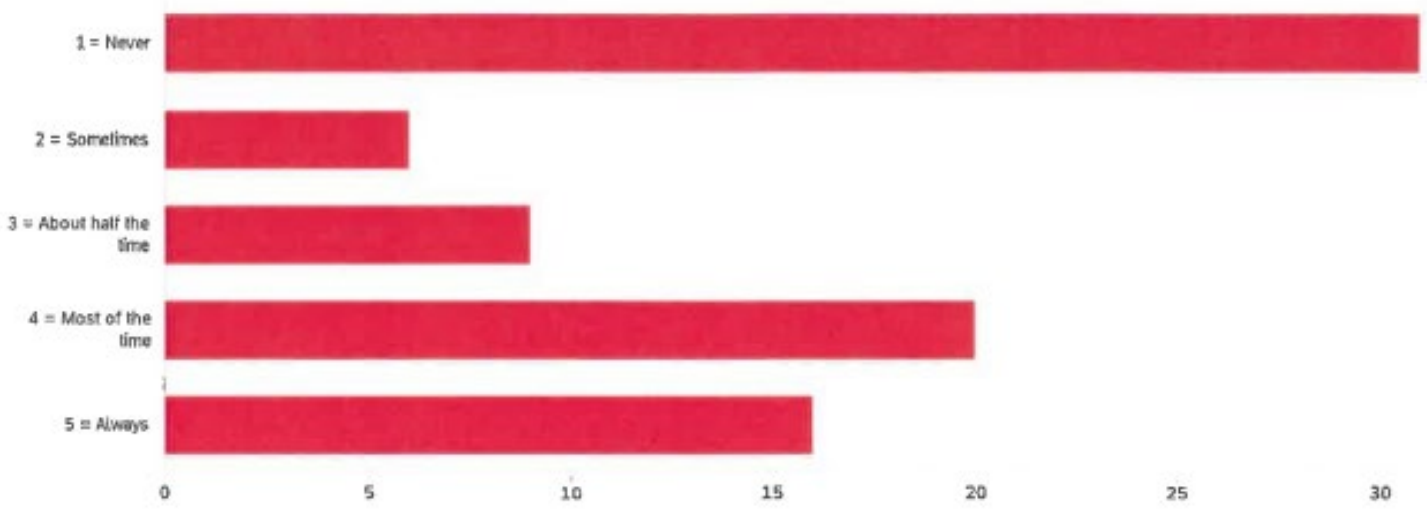



Figure B-4. How often users unplug their vehicle right after it is done charging (at 4-hour limit)