ITE DEVELOPING TREND EXPLORATION: ELECTRIFICATION

Executive Summary

Many government agencies and vehicle manufacturers around the world are collaborating on ways to move away from fossil fuel-based vehicles to slow the human impact on climate change, create new jobs, and reduce the number of materials necessary for vehicle manufacturing. The following is a list of recent legislation from around the world, that supports this goal:

- In April 2022, the Canadian Ministry of Transport announced plans to expand the country's national zero-emission vehicle purchase incentive program to reach a goal of 100 percent zero-emission cars by 2035, and medium and heavy-duty vehicles by 2040[1]
- In September 2022, the Australian Ministry for Climate Change and Energy announced plans to develop a strategy to reach zero vehicle emissions by 2050[2]
- By the end of 2022, state legislatures within the United States have enacted or considered a phase out of gas-powered car sales[3] in California, Connecticut, Delaware, Hawaii, Maine, Maryland, Massachusetts, Nevada, New Jersey, New Mexico, New York, North Carolina, Oregon, Rhode Island, Vermont, and Washington
- The Infrastructure Investment and Jobs Act (IIJA) Bill passed by the U.S. Congress in 2021 dedicated $7.5 billion[4] towards the development of electric vehicle infrastructure with further investments and incentives included in the Inflation Reduction Act of 2022[5]

As the proliferation of alternative fuel vehicles and electrification develops, ITE members will be called upon to advise on how these vehicles will impact our transportation system and communities. Historically, the type of advice likely to be sought from ITE members could include site design, roadway safety, funding impacts, workforce capacity, community equity, alternative fuel options, and electrical grid impacts; however, socioeconomic questions could arise. For example, would driving behavior of electric vehicle users change based on frequency, availability of charging stations, and the duration to charge? Further, what are some of the barriers for people considering adopting electric vehicles? While a lot of media attention is placed on electrification of the vehicle fleet, other emerging electric micromobility options such as e-Bikes, e-Scooters, and e-Carts create a new set of opportunities and challenges for transportation professionals.

[1] https://www.canada.ca/en/transport-canada/news/2022/04/minister-of-transport-announces-the-expansion-of-the-incentives-for-zero-emission-vehicles-program.html
[2] https://minister.dcceew.gov.au/bowen/media-releases/next-steps-national-electric-vehicle-strategy
[3] https://motorandwheels.com/what-states-banning-gas-cars/
[4] https://bipartisanpolicy.org/blog/a-status-update-on-ev-charging-infrastructure-investments-in-the-iija/
[5] https://home.treasury.gov/news/press-releases/jy0923

The ITE Electric Vehicle (EV)/Electrification Working Group was formed in August 2022 as part of the ITE Sustainability Standing Committee of the Transportation Planning Council. They have spent the last quarter discussing emerging electrification topics of interest that transportation professionals may become exposed to in the coming years. These briefs are meant to outline and highlight items where ITE members can play a role in expanding the dialogue and raising awareness of issues related to electrification.

With the completion of EV Infrastructure Deployment Plans for all 50 States, the District of Columbia, and Puerto Rico, all states within the United States now have access to fiscal years (FY) 2022 and 2023 formula funding to implement National Electric Vehicle Infrastructure (NEVI), totaling more than $1.5 billion funded by the Bipartisan Infrastructure Law (BIL). These funds are expected to help build and install EV chargers over approximately 75,000 miles of highway throughout the country. All approved plans are available on the Federal Highway Administration (FHWA) website[6] and funding tables for the full 5 years of the NEVI Formula program can be viewed here. Within these plans there are several common themes, including the following:

- Charging station implementation, corridor development, and future-proofing
- Customer service concepts (e.g., seamless travel, costs, reliability)
- Partnerships, particularly related to fast-charging stations
- Measures of effectiveness and monitoring
- Equity (geographic, economic, demographic)
- Seasonal weather and emergency preparedness

Understanding what influences current and future demand for EVs is vital to planning the future of transportation. The reasons that communities should support EVs should be clearly summarized and understood. Understanding fleet penetration rates through a study of the EV market is one way to accomplish this goal. Simply banning sales of gasoline powered motor vehicles will not necessarily lead to a swift transition given the average price of new EV sales is more than $60,000[7]. It is also important not to let new car sales information be conflated with the composition of the vehicle fleet. Optimistically, half of new vehicle sales could be electric by 2030, but realistically it will probably take longer. Since only about 5 percent of vehicles are replaced each year, it takes 15-20 years before the percentage of vehicle sales are reflected in the fleet. With current policies, it is unlikely that the fleet will be fully electric before 2050. No matter the EV fleet penetration forecast, we are currently entering the inflection point for the EV fleet size. Because of this, traditional transportation topics such as emissions, engine noise, energy security, school buses, consumer costs, equity, batteries, and vehicle inspection will be disrupted.

[6] Joint Office of Energy and Transportation, https://driveelectric.gov/

[7] https://b2b.kbb.com/news/view/new-vehicle-transaction-prices-end-2022-at-record-highs/

Emerging Electrification Issues of Interest to Transportation Professionals

The ITE EV/Electrification (EVE) Working Group discussed several issues of interest to transportation professionals related to electrification. The following sections have been identified in priority order as established by the EVE Working Group, relative to ITE. While this list is by no means exhaustive nor the priorities final, it forms the starting point for discussion. The intent of outlining these issues is to allow the EVE Working Group to advance a few of these ideas in greater detail this year, forming the basis for potential research problem statements to eventually be advanced with more data and analysis.

1. EV Planning – the number of charging stations and their locations in the public and private space

One of the questions ITE receives the most from jurisdictions is the following:

> *Based on my jurisdiction's characteristics, how can I plan for the number and location of EV charging stations for all types of chargers (public chargers, private workplace chargers, home chargers, truck chargers, micromobility chargers, etc.)?*

A compilation of existing resources and tools for EV infrastructure, planning, and implementations is needed to answer this question, along with local context. This could include a guide to find calculators, toolkits, datasets, maps, and references regarding planning of electric vehicle charging stations (EVCS). Some examples of tools and additional inquiries for consideration in siting EV infrastructure include the following:

A. Methods for estimating demand and how to prioritize locations of charging infrastructure, such as:
   a. US DOT EV Resources: Examples of what ITE could organize, a comprehensive resource hub:
      - https://www.transportation.gov/rural/ev/toolkit/planning-resources/implementation-installation-and-maintenance
      - https://www.transportation.gov/rural/ev/toolkit
      - https://www.nrel.gov/transportation/evi-x.html
      - https://theicct.org/publication/electric-vehicle-charging-guide-for-cities/

   b. City Plan Examples:
      - https://www.arcadis.com/en-us/knowledge-hub/perspectives/global/2020/resilience-to-recovery/electric-vehicle-charging-infrastructure-planning-for-the-city-of-cambridge-massachusetts
      - https://www.cityoffrederickmd.gov/DocumentCenter/View/10005/18-04-Concerning-the-Adoption-of-a-Plug-in-Electric-Vehicle-Charging-Infrastructure-Implementation-Plan?bidId=

B. An overview of charging station types (levels and connectors), including their constraints and demands. Information could include:
   a. Which e-vehicles require which types of connectors, and to what degree can they be compatible? For example, Teslas require different chargers than other e-vehicles. Can charging stations be designed to serve all e-vehicles to reduce duplication, waste, and user frustration?
   b. Ratio of Charging Stations to e-vehicles
   c. Charging time, costs, and integration with paid parking
   d. Portion of parking spaces that have charging stations, including turnover rate, particularly as it influences curbside management and on-street parking.

C. Understanding the optimum balance of EVCS provision between vehicle owner residence/fleet yard, work sites, commercial sites and corridors will require research.

D. Understanding the factors that affect the costs of installing, maintaining, and operating charging stations, and who should bear those costs.
   a. Home EVCS typically cost $500-1,500, plus installation which can cost an additional $500 to $2,000 for existing buildings, but less for new construction.
   b. Commercial EVCS cost much more but have a revenue recovery aspect from user fees which is not commonly understood. Many agencies are wary of possible maintenance costs and durability (how many years they typically last).

Guidance has yet to be developed for public versus private charging stations for vehicles, transit, freight, and other fleet vehicles. Considerations could include land use compatibility, including influencing land development codes for commercial and multi-family developments, including the provision to provide charging stations, overall charging demand, charging speed and time-of-day demands, and more. This would need to include consideration on who (e.g., agency or company) is responsible for owning/operating and maintaining the infrastructure, including coordination and operations agreement for temporal uses (e.g., office hours vs. overnight charging, public fleets vs private operators). Key considerations should include priorities for EVCS funding. For example, private funding might focus on new residential construction (single and multifamily), and long parking duration such as places of employment (e.g., offices). Examples of public funding might focus upon rural areas, energy deserts, long-distance corridor fast charging and light poles in urban areas where individual home charging is not possible.

Figure 1. Electric vehicle charging stations at a hotel and at a shopping mall (private). Source: ITE.

Transportation professionals routinely must weigh the cost of EV policies and land development mitigation measures. Understanding not only unit costs but total cost implication will help with understanding and implementation. The complete cost of EV charging includes equipment and the energy cost to the consumer or owner of charger. The national average in the United States for an at-home Level 2 electric car charging system (installed) is $1,300[8]. In addition, consideration needs to be given to other cost factors such as permits, garage or exterior modifications, wiring, plug-in vs. hardwired connections, and where the charger is located (indoors or outdoors). Having unit costs available to transportation professionals will help with decision making and timely implementation.

[8] https://www.jdpower.com/cars/shopping-guides/what-does-an-ev-home-charger-cost

A large majority of electric vehicle owners charge their units at home. However, homes are commonly built today without regard for the future of EVs. While there are numerous public and private issues associated with various development types, a simple consideration might be the idea of providing space and power in residential dwelling units (single or multi-family) for this need. This should consider vehicles and other mobility devices (for example, heavier e-Bikes). For multi-family residential, designing parking to be EV-ready with proper wiring for future EVCS is becoming common. Considering single-family examples, a simple consideration for electric passenger cars and pick-up trucks might be to add a 240V outlet in each newly constructed or renovated single-family garage. This would allow homeowners to easily install a Level 2 charging station (just mount and plug in). In the land use development review process, these types of transportation mitigation measures could become conditions of development or become part of local building codes/requirements. Other development types would also need exploration (such as curbside management) to assess how public/private responsibilities can be established equitably. ITE could help with developing uniform language for agencies when developing or promoting this new policy implementation.

2. *EV charging station accessibility*

With the transportation reauthorization (Infrastructure Investment and Jobs Act IIJA) placing an emphasis on electric vehicles and charging stations, consideration to accessibility to properly invest in the future is crucial. The Access Board has provided a technical assistance document (July 2022) that outlines how EVCS can be designed to be accessible to all users, including people with disabilities. ITE offered comments to the Access Board in October 2022 and can help practitioners become aware of these requirements and how they may be best applied.

In terms of accessibility, the ITE Equity Committee has a working definition as follows:

> *Accessibility - the provision of accommodations for all persons to fully approach, enter, operate, participate in, and/or use safely and with dignity, a site, facility, work environment, service, technology, activity, location and/or program. This includes a holistic approach to social and spatial elements, encompassing the reduction or elimination of physical and attitudinal barriers through universal design best practices, as everyone deserves the opportunity to reach their full potential.*

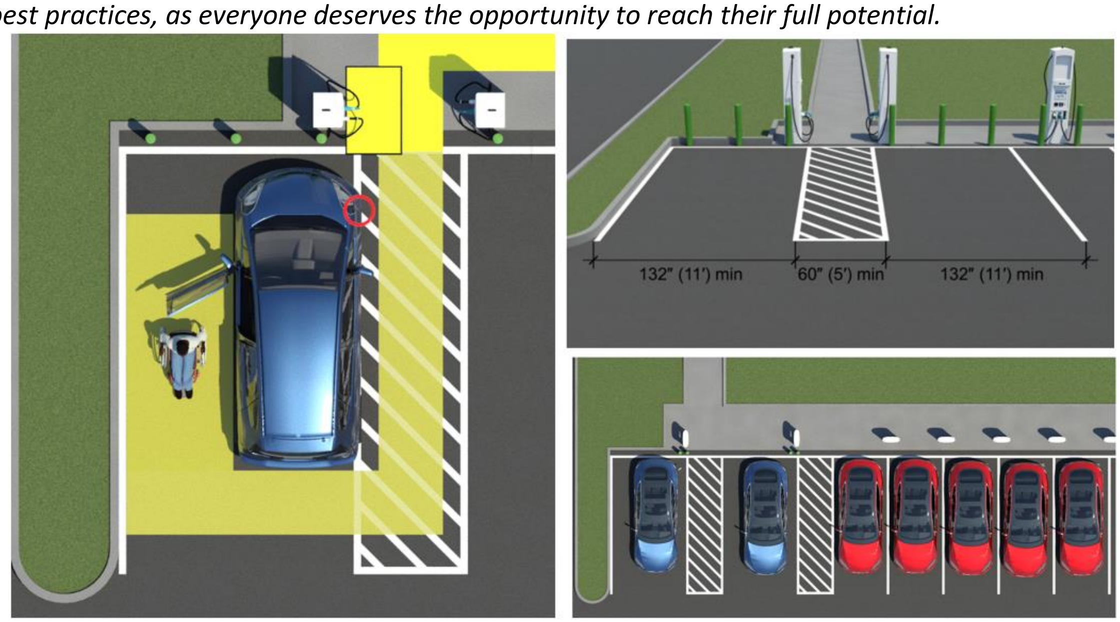

Figure 2. Accessible electric vehicle charging stations. Source: U.S. Access Board.

Simplistically speaking, placing curbs (barriers) between EVCS and users is not unlike revisiting the topic of accessible curb ramps for sidewalks. But the topic of accessibility goes beyond these aspects, including issues of e-Scooter and e-Bike accessibility at stairways as well as the implications of the quiet nature of EVs to all road users. Taking time to properly design accessibility of each site will require appropriate guidance.

3. *EV impacts on incident management*

With a small percentage of EVs in the vehicle population, battery issues associated with EVs, crashes, and first responders have yet to be fully understood. There are limited real life examples for protocols addressing extinguishing fires/the handling of hazardous materials, and EV batteries. Early experiences have noted excessive water needs to extinguish these fires using traditional methods. Case studies from state and metropolitan area corridor management teams should be consulted for incident crash management and EVCS best practices. Things as simple as outfitting corridor management crews with generators to address drivers who have run out of charge on highways and fire proof blankets to suffocate the fire are examples a few agencies are already deploying. Uniform and proven procedures for handling batteries in the event of major crash damage are also needed. The novel aspects of EVs and corridor management teams will likely require training that could be coordinated initially by ITE.

4. *EV impacts on transportation analysis*

There are aspects of EVs that affect fundamental transportation analysis and planning. Some issues which will require ITE consideration may include the following:

- Updates to acceleration and deceleration assumptions for things like change and clearance intervals, and synchronization of traffic control signals based upon the different engine type and increased weight of EVs
- Simulation model assumptions for things like gap acceptance on two-way stop-controlled intersections, AASHTO sight distance or roundabouts
- Curbside management where public streets are used for EVCS
- Effect on travel demand due to user perception of lower operating costs and clearer operation
- Concept of “fail-safe” at rail grade crossings in the event of an EV loss of charge
- Weight impacts for larger, longer distance vehicle battery types related to crash impact consequences and pavement/structure life
- Impact to long-term transportation funding as compared to traditional road user charges

5. *Micromobility Electrification: e-Bikes, e-Scooters, e-Carts, etc.*

Most EV policies and subsidies are directed toward electric vehicles, but micromodes (e-bikes and e-scooters) are much more affordable, cost effective, and vastly outsell vehicles today. They also impose much smaller external costs (road and parking infrastructure costs, traffic congestion, and traffic risk imposed on other people). To date, most EV subsidies are not directed toward support for e-micromobiity. For cases where it has been done, those examples would be helpful for professionals in understanding why and how this may be done and how this integrates with other strategic goals, such as efforts to create more affordable and healthy transportation systems (plus VMT reduction targets such as in California, Oregon, Washington State, and British Columbia). This can also be linked to land use entitlement mitigation measure consideration.

Figure 3. Micromobility electrification (e-Scooters). Source: ITE.

Electrification goes beyond cars and pick-up trucks. Other micromobility options (e-Bikes, e-Scooters, e-Carts, e-Skateboards) can provide urban mobility with greater affordability and lower external costs (road and parking infrastructure costs, congestion, and crash risk imposed on others). Charging for these e-micromobility modes can commonly be done with standard outlets, simplifying the need for charging. In urban areas especially, this can contribute to and enhance other non-vehicle, local-trip mobility choices. Accommodating street design for these electric options—which are significantly slower than cars—create new design consideration for how to best address the needs of existing bicycle and pedestrian users as these EV modes emerge. Additionally, electrification of various modes is leading to historically slower modes becoming faster (motorcycle-like) requiring new considerations. ITE can help practitioners with advance design guidance related to e-micromobility.

6. *EV Fleets and bus charging – considering adequate utilities and the need to support fleet requirements*

Figure 4. Zero emissions all electric bus. Source: FTA.

Electric vehicles provide significant benefits to the decarbonization of fleets and bus services, particularly when replacing older polluting diesel models that emit pollutants through particulate matter. However, the intense duty cycles of these vehicles and the large heavy batteries used to fuel electric trucks and buses mean that these models may require high-powered charging and may need to charge mid-shift to be able to meet current operational needs. A "green" assessment of the scale of transit vehicle battery needs and passenger delivery capabilities as compared to disaggregated personal EVs and batteries has yet to be performed. Other policies affected by fleet EVs include issues of environmental/emission studies, e-wheelchair charging at bus stops, urban/rural investment, battery disposal, and Buy America policies.

Other groups are exploring these topics in detail:

- https://electrificationcoalition.org/work/electric-vehicle-fleets/
- https://www.gsa.gov/buy-through-us/products-services/transportation-logistics-services/fleet-management/fleet-electrification
- https://www.duke-energy.com/energy-education/energy-savings-and-efficiency/fleet-electrification
- https://www.energy.gov/eere/femp/electric-vehicles-federal-fleets
- https://smart.columbus.gov/playbook-asset/electric-vehicle-ev-fleet-adoption/challenges-and-future-of-fleet-adoption

ITE can be a voice at the table, providing a high-level assessment of the benefits of electrifying commercial, transit, and school bus vehicles with considerations for the challenges posed by needed charging infrastructure.

7. *EV charging station best practices at rest areas*

Rest areas may become opportunities for photovoltaic energy production. Is it possible to eliminate barriers to EVCS concessions that include solar photovoltaic energy production, energy storage, and comfort facilities for drivers? These facilities can be provided in existing vehicle inspection and enforcement stations and in rest areas or through public-private partnerships. However, this may come into conflict with current Federal policies for rest areas. Opening motorway (Interstate, freeway, and toll road) rest areas to energy and EV charging partnerships has the potential to generate revenue for public agency DOTs while reducing the impacts of heavy vehicles on local road networks, providing opportunity for new discussions about rest areas of the future. An example of this could be developing charging station rating systems which indicate the types of stations (levels and connector type), prices, and access to nearby services that motorists can use while waiting for vehicles to recharge (e.g., whether there are coffee shops, stores, parks, dog walking area, etc. within walking distances). Case studies and best practices are lacking today and could be expanded in all these areas. In particular, agency roles in addressing long distance corridor and rural needs will need to be weighed against urban investments where homeowner/employer provision of EVCS is more plentiful and trips are shorter (averaging 10 to 20 miles). Priorities for EVCS investment in more expensive fast charging might focus upon rural areas/interstate corridors (e.g., rest areas) and high utilization fleets as compared to settings such as urban areas, residential uses, and long-duration parking settings (which may be deemed possibly lower public priority since a significant portion may be privately provided).

8. *EV charging station mapping – universal mapping and information sharing*

Now that EVs have become a substantial part of transportation, location of charging stations needs to continue to be a part of that planning and consideration. The same way fossil fuel vehicles can access multiple networks locating gas stations, there should be additional amenities for EV users. Not all EV motorists are aware of all public charging stations available. This may not only discourage the public from switching to EV vehicles but may also limit the distance traveled by EV users due to a lack of knowledge. Pointing users and ITE members to charging station maps will help decipher locations beyond just what is located on board the vehicle. One practical application would be for agency transportation plans to consider including an electrification element similar to other aspects of a transportation system plan (such as bicycles, freight, motor vehicles, pedestrian, transit, managed lanes, parking, airports, access management, pipelines, etc.) which would help with advanced community planning at a local level. Two examples of existing resources are the following:

a) National level: https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC
b) County level: https://ecosystems.azurewebsites.net/SantaClara/

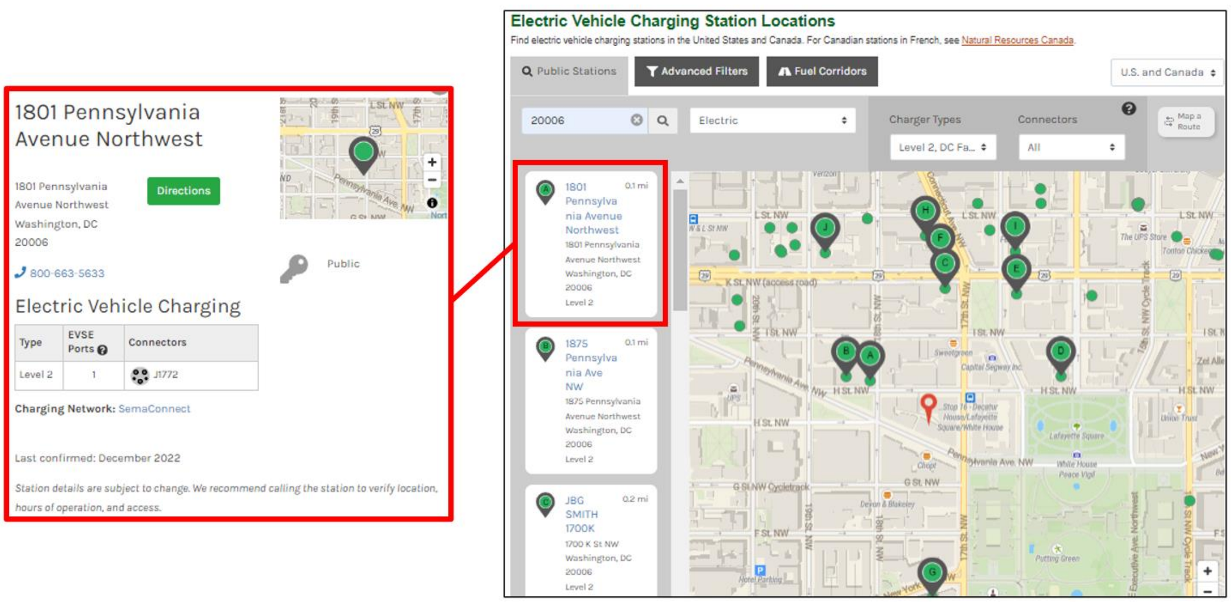

Figure 5. Electric vehicle charging station map with station details. Source: U.S. Department of Energy.

9. *EV charging station access – "energy deserts"*

Vehicles are an important mobility tool for individuals that do not have adequate access to mass transit, biking, or other sustainable modes. Electric vehicles have significant benefits through reduced emissions as compared to traditional fueled gas vehicles. People with disabilities, individuals living in multiunit dwellings and areas of cities that have experienced historical underinvestment have unique barriers to accessing charging infrastructure and electric vehicles. Considerations include partnerships with lighting companies/districts to jointly utilize light poles for EVCS in locations with limited charging opportunities. Agencies can play a role in partnerships and access to EVCS for charging opportunities for underserved communities. This is an opportunity where ITE could advance situational siting criterion for areas which have been underserved.

10. *EV truck charging needs, issues, and best practices*

EV charging for heavy vehicles varies by the application of the vehicle. Delivery vehicles that typically travel 100 to 150 miles per day will rely on depot charging. Over-the-road motor carrier operations will rely on pre-trip depot charging and interval charging along the long-haul route, anticipating 600 to 900 miles of travel during a duty period and the need for a high-speed charging. Reducing the impacts of heavy vehicles on interchange operations, pavements, and regional and local roads might be achieved through the construction of motorway wayside charging facilities.

11. *EV Park & Ride repurposing*

Changes in commute patterns with the impact of COVID-19 have persisted in many regions and the future of daily commutes into central cities has forever changed. Concomitantly, an increase in midday travel and motorway volumes indicates that the use of automobiles for flexible trips is one of many responses to a change in the workplace. In areas where mass transit park-n-ride facilities are experiencing ongoing excess capacity for parking, repurposing of one or more levels of a multistory carpark has the potential to create revenue streams for mass transit operators. This excess parking capacity may become a source of ridership, supporting an increase in the market share of mass transit.

The Mobility Marketplace concept includes offering a wide variety of mobility options, concessions, energy generation and storage, and EV charging for transportation in the unused parking spaces. It is a flexible model that can also support micrologistics, emerging logistics, and mobility needs, particularly related to driver comfort and dignity; the ongoing evolution of the transportation system in response to the applications of technology for transportation electrification, autonomous mobility and logistics, shared services, and the connectivity that will drive more choice and improved reliability in logistics and mobility services.

Due to the long duration of parking, Park& Ride lots provide a unique opportunity to support motorists who do not have access to charging stations. For example, rapid charging in these types of situations may not make much sense as Level 2 charging stations given the costs variations.

12. *EV in-motion charging opportunities and needs*

The concept of in-motion charging of EVs presents a new consideration in freeway, roadway, and corridor network planning. While efforts are ongoing in research to dynamic wireless charging in an electrified ecosystem, questions for transportation professionals exist around its role in providing a sustainable charging solution. Examples include the following:

- Locations
- Spacing
- Cyber security
- Vehicle interoperability
- Utility infrastructure
- Level of trip planning
- Reliability for longer trips
- Speeds at which vehicles would optimally be able to accomplish in-motion charging (e.g., freeway speed, local street speed, central business district activity, bus stops, traffic signal or stop signs)
- Effects to other users beyond simply charging an EV
- Rural and/or urban application – ability to accomplish door-to-door trips
- Managed lane use/corridor centric or metropolitan road network based

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