TAKEOFF!

Airports Are Electric Vehicle Ready

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Metropolitan ENERGY CENTER
Clean Cities
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About Metropolitan Energy Center and Clean Cities

Metropolitan Energy Center (MEC) is a nonprofit organization whose mission is to create resource efficiency, environmental health, and economic vitality in the Kansas City region and beyond. Since 1983 we have worked with residents, businesses, and municipalities to transform energy use in the building and transportation sectors. The cornerstone of our transportation programming lies in our Clean Cities partnership, which began in 1996. Clean Cities is a federal Department of Energy program that "advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum use in transportation." The national program is comprised of a network of more than 75 coalitions across the U.S. MEC has the honor of housing both the Kansas City Regional and Central Kansas Clean Cities Coalitions. Find out more at https://metroenergy.org.

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Project Summary

This deployment guide is intended to help aviation departments plan, deploy, and manage electric vehicles in their fleets and future-proof their infrastructure for electrification of additional fleet units for airlines and concierge services. This guide results from a larger alternative fuel project, Accelerating Alternative Fuel Adoptions in Mid-America, across Kansas and Missouri.

The project simultaneously fulfills aspects of Metropolitan Energy Center's (MEC) energy transformation strategy and meets the U.S. Department of Energy (U.S. DOE) objective to accelerate the deployment of commercially available alternative fuel and electric vehicles and supporting fueling infrastructure, through community-based partnerships among state and local governments and the private sector.

Working with nine fleets and fuel retailers, our approach is to deploy new alternative fuel vehicles (AFV), ranging from propane and compressed natural gas to electric vehicles, then use these local success stories as a focal point to generate further deployments. We strategically invite attendees to workshops focused on augmenting the host's AFV projects and use attendee feedback to plan further deployments with attendee organizations in a way that benefits the entire community.

In addition, this project will substantially increase access to biodiesel fueling and electric charging on major travel corridors across Kansas.

These projects reduce U.S. dependence on petroleum and fleet impact on climate change, increase local fuel diversification and resilience, and catalyze the adoption of clean transportation technologies in other

communities through the sharing of best practices and the collection and sharing of data. Planned outcomes include annual reduction of 1,645 metric tons of GHGs, and 20,175 barrels of petroleum.

Acknowledgments

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TABLE OF CONTENTS

Executive Summary

When you first step out of the airplane you experience sensory overload—travelers anxiously waiting to board their flights are chatting with one another, updates from airport personnel are booming over the intercom, aromas from the nearby coffee shop are lingering in the air, and family and friends are greeting their newly-arrived guests. You eventually make it outside and wait for the airport shuttle to arrive. As the massive vehicle pulls up, you are greeted with something unfamiliar … but refreshing. Instead of being inundated by the noise and smell of diesel exhaust chugging out of the tailpipe, an all-electric bus quietly comes to a stop. You hop on board and can finally gather your thoughts over the faint buzz of the electric motor smoothly zooming to your next destination.

Across the U.S., fleets of all types are increasingly deploying all-electric vehicles (EVs). With lower maintenance and fueling costs, zero-emission technology is marking commercialization milestones while continuing to dominate headlines. While EV adoption is increasing rapidly, as with any new technology there are still barriers to overcome. Challenges include high upfront costs, limited range, and charging infrastructure needs.[1] As the North American Council for Freight Efficiency describes it, we are in "the messy middle" of transitioning from a sector dominated by diesel powered internal combustion engines to one that will see multiple power options and increased collaboration among stakeholders.[2] However, some fleets will face fewer obstacles going electric than others. Due to their predictable routes, high fuel volumes and high award amounts under federal grants and incentive programs, transit for fleets to begin their electrification journey. Over the last five years, fleets have deployed, or initiated procurement of more than 2,000 battery electric transit and school buses.[3] Transit buses include airport shuttles which transport thousands of travelers and community members to and from, and within airports every day. Airports, the front doors to medium- and large-sized cities, are an ideal location for communities to showcase their dedication to innovation and a more sustainable future.

The goal of this guide is to help aviation departments plan, deploy, and manage electric vehicles in their fleets and future-proof their infrastructure for electrification of additional fleets. We have identified five phases that should be followed in order to implement a new fleet electrification plan, in order to have a successful and sustainable deployment.

Please note this guide does not contain information regarding aircraft fleets. For additional information regarding aircraft fleets, visit the U.S. Department of Energy Bioenergy Technologies Office.[4]

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[1] *https://cdn.stateofsustainablefleets.com/state-of-sustainable-fleets-2020-report.pdf?elqTrackId=a455d64d68154233afedfd9dbd9cb8a9&elq=183ac5a6ccc840af96eab06778331f4e&elqaid=2965&elqat=1&elqCampaignId=*

[2] *https://www.trucknews.com/transportation/nacfe-sees-messy-middle-ahead-of-zero-emission-freight/1003095618/*

[3] *https://cdn.stateofsustainablefleets.com/state-of-sustainable-fleets-2020-report.pdf?elqTrackId=a455d64d68154233afedfd9dbd9cb8a9&elq=183ac5a6ccc840af96eab06778331f4e&elqaid=2965&elqat=1&elqCampaignId=*

[4] *https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuels*

Phases of Deployment

Phase 1
Project Evaluation

Step 1: Identify airport, municipality, and statewide goals.
Step 2: Identify key decision makers.
Step 3: Assign project lead/champion.
Step 4: Develop fleet profile and estimated return on investment (ROI).
Step 5: Identify existing electricity capacity and utility rate structure.

Phase 2
Determine Project Scope

Step 1: Evaluate potential funding opportunities.
Step 2: Evaluate potential public and private partnerships.
Step 3: Complete modeling to determine energy use and needs.
Step 4: Create a list of ideal characteristics of vendors and technologies.
Step 5: Identify charging infrastructure requirements.

Phase 3
Pre-Deployment

Step 1: Develop and begin executing a communications plan.
Step 2: Develop infrastructure implementation schedule.
Step 3: Develop vehicle procurement schedule.
Step 4: Provide training to applicable stakeholders.
Step 5: Develop a resiliency plan.

Phase 4
Deployment

Step 1: Engage in maintenance best practices.
Step 2: Maintain an active feedback loop.
Step 3: Revisit communications plan.

Phase 5
Project Sustainability

Step 1: Document successes and share widely.
Step 2: Monitor technological advances.
Step 3: Create a sustainability plan.

Phase 1: Evaluation

Step 1: Identify airport, municipality, and statewide goals.

An important first step in airport fleet electrification is to investigate whether your airport, local municipality, and/or state has specific sustainability goals. These types of goals can be used as a tool when advocating for cleaner, more efficient transportation. Twenty-eight states already participate in the Federal Aviation Administration's (FAA) Airport Sustainability Plan, which includes initiatives to reduce emissions, address community needs, and maintain high, stable levels of economic growth.[5] Several states and individual airports are going beyond the FAA's plan and adopting more aggressive goals of their own, including mandates to shift to cleaner shuttle bus options.[6] Cities and states across the U.S. are also adopting Climate Protection and Resiliency Plans, including the City of Kansas City, MO.[7] These plans typically include specific greenhouse gas reduction targets for areas of operation, clean transportation goals, efforts to improve local air quality, and identifying communities where noise pollution needs to be addressed. While researching local sustainability initiatives, local allies, policymakers, and champions who support your electrification efforts should also be identified.

As transportation continues to electrify, fleets, businesses, and industry experts are utilizing telematics data, fleet interviews, and operational evaluation to quantify health benefits (to onsite workers and the local community) and reduction in fuel and maintenance costs associated with deploying cleaner transportation. For example, ICF conducted a comprehensive analysis for the American Lung Association quantifying the potential air quality, health, and climate benefits of ambitious vehicle electrification across the U.S. According to the report, swapping gas vehicles for zero-emission new cars and trucks in

Evaluation Best Practices

- Utilize a cross-divisional approach throughout the project, ensuring everyone is on board with the project from the beginning.
- Engage with your electric utility as soon as possible. Airports will have a utility account manager who can support you through this process.
- Contact your local Clean Cities Coalition for information and resources regarding evaluation tools, connections to industry experts, funding opportunities, and more.

[5] *https://www.faa.gov/airports/environmental/sustainability/*
[6] *https://www.act-news.com/news/electric-shuttles-are-taking-off-at-airports/*
[7] *https://www.kcmo.gov/Home/Components/News/News/1936/625*

the U.S. would lead to 110,000 fewer deaths, 2.8m fewer asthma attacks and avoid 13.4m sick days by 2050.[8] Nearly every city has health and economic goals, so both can also be used as a tool when advocating for the electrification of fleets.

Step 2: Identify key decision makers.

Next, identify the individuals, within and outside of your city's Aviation Department, who must support and ultimately approve the electrification project. Airports are essentially small cities, so it is crucial to utilize a cross-divisional approach throughout the project, ensuring everyone is on board—airport leadership, fleet managers, finance, sustainability, legal, ground transportation, operations and construction.[9] Completing this step in the early stages of the project will help you avoid internal delays and streamline the deployment process.

In 2017, the Kansas City International Airport (KCI) became the first U.S. airport to deploy all-electric shuttle buses. Kenny Williams, the former Fleet Manager at KCI who spearheaded the deployment, said he involved as many people as possible in the exploratory phase of the project, even his critics. He challenged them to think about what was possible with electric shuttle buses instead of focusing on what they could not do. To demonstrate the quieter, cleaner, and smoother ride of battery-electric shuttles, Williams had BYD (the vehicle manufacturer ultimately chosen by KCI) bring one of their buses to KCI so airport personnel could experience firsthand the benefits of electric vehicles. After that, he said they were hooked.[10] Williams also stressed that while drivers and technicians may not be part of the final decision process, their buy-in is critical. He communicated to his staff that working with electric vehicles would make them more valuable and provide them with the opportunity to gain experience with new technology. In addition, the quieter ride EV buses provide makes it easier for drivers to hear what's going on behind them.

Kansas City International Airport (2017)
AP Photo/Orlin Wagner *Topeka Capital – Journal*

[8] *https://www.lung.org/getmedia/9b396179-40ff-4b3b-9426-9ceea288575d/prior-research-zero-emission-technologies-2022.pdf#:~:text=Vehicle%20electrification%20has%20the%20potential%20to%20signifcantly%20reduce,comprehensive%20analysis%20for%20the%20American%20Lung%20Association%205*

[9] *Meyn, S. (2020). Seattle–Tacoma International Airport. (E. Wolfe, Interviewer).*

[10] *Williams, K. (2020). Kansas City International Airport. (E. Wolfe, Interviewer).*

For each decision maker it is also important to identify and communicate to them how they will benefit from fleet electrification. A few examples:

Airport Chief Financial Officer:

- Economic benefits with reduced lifetime operational costs due to lower maintenance and fuel expenses.

Airport Fleet Manager and Human Resources:

- Improved driver satisfaction and health with a cleaner ride and less driver
- Opportunity to deploy best-in-class vehicles.

Airport Drivers and Technicians:

- With a quieter ride, drivers can better hear what is going on in the rider/luggage
- It is also an opportunity to become an expert in a new technology.

Community Members:

- Better experience at the airport.
- Reductions in local air pollution.
- Spurring interest in additional sustainable practices and projects citywide.

Airport Marketing Department:

- New content for airport promotion and business development.

Mayor, City Council, City Manager, and other Policymakers:

- Proof of commitment to emerging technology, better air quality, and limiting dependence on fossil and foreign fuels.
- Resulting health and wellbeing of airport workers, constituents and citizens, and airport visitors.

Director of Aviation:

- Enabling the airport to stay ahead of federal emission reduction regulations.

Step 3: Assign project lead/champion.

As stated in the previous step, it is crucial to utilize a cross-divisional approach throughout the entire electrification project. However, to prevent any confusion among staff, a project lead should be identified as soon as possible, so they can begin to map out the project priorities and assign specific tasks and responsibilities to staff members. Proterra, an electric vehicle manufacturer, said they identify early on a potential lead/champion when working with airports.[11] The lead should schedule recurring meetings, so the project team and appropriate internal and external stakeholders stay up to date on the project and troubleshoot any issues. Tony Cademarti is Fleet Program Manager for City of Everett, Wash., who helped deploy seven electric buses in their transit fleet. He said deploying electric buses was not like purchasing another diesel bus—it required a comprehensive approach. Cademarti stated one of the lessons learned from their project was the need for a dedicated project manager throughout the entire process. For their project, they assigned one staff member to lead bus procurement, and another to implement the infrastructure, which caused some miscommunication. He said it is something they will change for future projects.[12]

Further, it should be clear to internal and external stakeholders who is leading the project, and the lead should have a hand in every aspect: communication with staff and project partners, infrastructure implementation, vehicle procurement, and enforcing necessary operational changes.

EVs typically require less maintenance than conventional vehicles for a variety of reasons including the following:

- The battery, motor, and associated electronics require little to no regular maintenance.
- There are fewer fluids, such as engine oil.
- Brake wear is significantly reduced due to regenerative braking.
- There are far fewer moving parts relative to a conventional fuel engine.

Step 4: Develop fleet profile and estimated return on investment (ROI).

Most fleets already collect data on their vehicles but developing a fleet profile goes deeper. Many Clean Cities Directors utilize the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool to analyze scenarios based on fleet profiles.[13] The Argonne National Laboratory developed AFLEET for Clean Cities stakeholders to estimate petroleum use, greenhouse gas emissions, air pollutant emissions, and cost of ownership of light-duty and heavy-duty vehicles using simple spreadsheet inputs. If you do not have all the data requested in the tool, defaults are available. These defaults are based on averages from collected data across the U.S. and can generate comparable estimates; however, local data inputs are always better.

This tool is also a great resource if you are unsure which fleet or group of vehicles to electrify first. By creating

[11] *Caplin, B. Williams, B. (2020). Proterra. (E. Wolfe, Interviewer).*
[12] *Cademarti, T. (2020). Transportation Services, City of Everett. (E. Wolfe, Interviewer).*
[13] *https://afleet.es.anl.gov/home/*

a profile of each fleet, you can make an informed decision for your airport. Overall, the return on investment for these vehicles will come from the savings they provide. Estimated amounts on the return on investment should be based on the following general fields:

- **Lifetime Fuel Savings:** The amount of money saved over a vehicle/fleet's lifespan by switching to electric.

- **Annual Fuel Cost Comparison:** Annual fuel consumption costs of the existing vehicle/fleet compared to the costs of the proposed EV/fleet.

- **Funds From Selling Vehicles:** Funds that can be secured by selling existing vehicles at their best time based off a procurement schedule.

- **Vehicle Maintenance Costs:** Lifespan maintenance costs on the current vehicle/fleet compared to the lifespan maintenance costs of the proposed EV/fleet.

Analyzing scenarios based on a fleet profile will help you determine electrification of which fleets makes the most sense for your budget and timeline.

Step 5: Identify existing electricity capacity and utility rate structure.

The most potentially complicated part of deploying EVs is ensuring adequate power to charge your fleet at a reasonable rate. Charging costs vary depending on multiple factors, including electricity price, charging equipment type, installation cost, time of day charging takes place, and miles driven.[14] Technology to manage charging and minimize demand fees exists and can be utilized in an overall charging strategy. As soon as possible, it is critical to meet with your utility to understand your current electricity capacity and rate structure.

The size and scope of an airport transportation system adds additional challenges when determining your electricity capacity. At airports there are several types of vehicles and infrastructure at different locations with varying owners and charging requirements. These include customer and employee parking, third party fleets, airline equipment, etc. It can be difficult to determine who owns and operates each element in the airport's electric grid. You must also consider the department and City's short-term and long-term transportation vision and meet the needs of the evolving customer.[15] As fleets continue to deploy EVs, utilities are applying various strategies

Clean Cities Coalitions work with stakeholders of all types—fleets, fuel providers, manufacturers, government agencies, fuel retailers, and community groups—to promote and implement clean fuels, fuel efficiency, and new transportation technology.

Each coalition has their unique strengths, and many can provide fleet scenario analysis services. They also keep a finger to the pulse of the alternative fuel industry and local events and resources.

Visit cleancities.energy.gov and contact your Clean Cities coalition today.

[14] *https://www.energy.gov/eere/vehicles/articles/fotw-1149-august-31-2020-cost-charging-electric-vehicle-united-states*
[15] *Hedges, E. Marine, W. (2020). Evergy. (E. Wolfe, Interviewer).*

to address these challenges. The Union of Concerned Scientists outlined incentives and programs (listed below) utilities are introducing to meet their customers' evolving needs.[16] By collaborating with your utility early on, you may help influence the type of strategies they utilize and the kilowatt/hour rate they charge.

- **Make-Ready Investments:** Utility invests in the infrastructure, including upgrading electrical panels, digging trenches, and laying wires, making the site ready for installing the charging equipment. Make-ready can be defined differently at each utility, so get details if this is offered by your provider.

- **End-to-End Utility Ownership:** Utility funds, owns, and operates all infrastructure, including the charger.

- **Utility Incentives:** The utility may provide full or partial rebates to the site host for the costs of installing the infrastructure, purchasing and installing the charger, or both.

- **In some cases, multiple approaches are offered within a single program:** For example, in the make-ready model, the utility may offer rebates to cover part of the charger and installation costs.

- **Financing options:** Under a financing arrangement, the utility may pay for the charger and other electrical equipment, and the customer repays the utility as part of its regular electric bill. Over time, the customer recovers the equipment cost through reduced fuel and maintenance expenses and can use these savings to pay the monthly installments.

Charging costs vary depending on multiple factors, including electricity price, charging equipment type, installation cost, time of day charging takes place, and miles driven. As soon as possible, it is critical to meet with your utility to understand your current electricity capacity and rate structure.

Identify the cost of electricity to charge vehicles per kilowatt-hour (kWh), paying special attention to utility peak demand rates. Stephanie Meyn, Climate Program Manager at Seattle–Tacoma International Airport (Sea-Tac), said it is critical for fleets to understand what causes demand charges and how they are inversely proportional to the monthly mileage of an electric fleet. An evaluation conducted in the King County Metro transit agency in Seattle, Wash., found the three electric buses in their fleet had an average fuel economy 2.5 to 3 times higher than their 23 hybrid, diesel, and trolley buses. Despite this large efficiency boost, the electric buses had higher per-mile fuel costs due to the large difference between diesel fuel and electricity prices. Demand charges made up a significant portion of their utility bills each month—between 34% and 54%. To decrease the relative cost of their demand charges, King County Metro needed to either increase their charger utilization by adding additional electric buses to their route, operate their current electric buses more frequently, or both.[17] The table below, from the 2020 State of Sustainable Fleets report provides a summary of factors that can add or save costs when charging fleets.[18] Discuss each factor, as well as those previously mentioned early on with your utility. For more information on energy usage considerations, see Phase 4, Step 1.

[16] *https://www.ucsusa.org/sites/default/files/attach/2019/04/Electric-Utility-Investment-Truck-Bus-Charging.pdf*

[17] *https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/115086/zero-emission-bus-evaluation-results-king-county-metro-battery-electric-buses-fta-report-no-0118.pdf*

[18] *https://cdn.stateofsustainablefleets.com/state-of-sustainable-fleets-2020-report.pdf*

For additional support regarding electricity capacity, utility rate structure, or other technical transportation topics, consider utilizing Clean Cities' Technical Response Service (TRS). TRS is a trusted resource that can be used when technical questions arise concerning alternative fuels, fuel economy improvements, idle-reduction measure, advanced vehicles, and Clean Cities and related resources.[19]

Phase 2 of the guide, Develop Project Scope, dives further into charging infrastructure.

Table 1 - Factors

Factors that Can Add Costs to Charging	Factors that Can Save Costs from Charging
Charging during peak use periods: Periods of higher rates set by utilities based on time of day, week, and season.	**Charging during off-peak use periods:** Fleets that can do most of their charging at the lowest cost times, especially at nighttime, can minimize the cost of charging.
Demand spikes in charging: Utilities may assess monthly "demand charges" based on the peak power demand of the customer, even for brief periods.	**Charging below demand thresholds:** Fleets that understand and manage demand spikes will reduce charging costs.
Facility located in a utility service area without an EV rate: Overall costs are typically higher in utility service areas without a dedicated rate. Many utilities do not yet offer EV-specific rate options.	**Facility located in a utility service area with an EV rate:** Charging rates are on average lower for fleets using an EV rate in utility service areas where they are offered.
Facility served by a utility without an EV rate specific to fleets: Where utilities do offer EV specific rates, they may be designed primarily for residential customers and lack features that would better serve fleet customers.	**Facility served by a utility with an EV rate specific to fleets:** Facilities located in a utility service area who offer a rate designed for fleet needs can often capture savings compared to other types of rates.
	Negotiation with energy providers: Fleets that negotiate for favorable energy supply prices, often as part of an electricity offtake or agreement to install infrastructure, may secure favorable rates.

[19] *https://cleancities.energy.gov/technical-assistance/*

Project Scope Best Practices

- Reach out to nearby municipalities, universities, or school districts who have electrified buses in their fleets for local advice and guidance.
- Reach out to your Clean Cities coalition for technical resources, funding opportunities, and to connect with organizations outside your area that have completed electrification projects.
- Inquire with bus manufacturers if they provide incentives or grant funding, training support with lease or purchase agreements.
- Ensure there is adequate service and maintenance support within the deployment marketplace.
- When conducting outreach for possible project partners and vendors, evaluate your pool of contacts and communication channels to ensure diversity, equity, and inclusion.

Phase 2: Develop Project Scope

Step 1: Evaluate potential funding opportunities.

It can be overwhelming to navigate various funding opportunities and determine what is the best fit for your project. One resource is your local Clean Cities coalition. In addition to connecting you with their network of fleets and industry experts, your coalition can help secure project funding from multiple sources including grants, rebates, and other financial incentives.

The Alternative Fuels Data Center (AFDC) also provides a plethora of resources including, but not limited to, a list of federal and state laws and incentives for alternative fuels and vehicles, air quality, fuel efficiency, and other transportation-related topics.[20]

There are also steps you can take to prepare to apply for funding, including getting staff and decision makers on board right away so there are no delays in submitting applications. These include understanding your vehicle and infrastructure needs, developing a clear project timeline, and engaging the airport legal team on legal and contractual issues.[21,22] Overall, ensuring all stakeholders have a clear understanding of the project goals, timeline, etc. as soon as possible will streamline the entire deployment process.

Step 2: Evaluate potential public and private partnerships.

The deployment of EVs impacts many aspects of airport and city planning; therefore, successful project planning involves a wide variety of stakeholders. By incorporating a diversity of experience and expertise, your project will be more holistic and balanced.[23]

[20] *https://afdc.energy.gov/laws/*
[21] *Kunesh, D. O'Neill, T. (2020). Pacific Gas & Electric Company (PG&E). (E. Wolfe, Interviewer).*
[22] *https://info.burnsmcd.com/electrification/getting-the-most-from-ev-infrastructure-investments*
[23] *https://afdc.energy.gov/pev-readiness.html*

In addition to your Clean Cities coalition, other stakeholders may include local universities, businesses, building developers, and environmental and sustainability groups. For example, Charlotte Douglas International Airport (CLT), which deployed five electric buses in their shuttle fleet in 2020, worked with Duke University to determine what size chargers they would need.[24] Working with a university also provides students with the opportunity to enter the workforce with experience in new technology.

When conducting outreach for possible project partners, evaluate your pool of contacts and communication channels to ensure diversity, equity, and inclusion. Consider connecting with building and trade unions, local community colleges and universities, or national and local societies for minority and women professionals. KCI, which has nearly completed its $1.5 billion terminal project, is on track to meeting its goal to have 35% of the work go toward minority and women-owned businesses, including both the construction and design phases.[25] While EV deployment projects will likely not match the size and scope of KCI's terminal project, it is an example of how to set and achieve diversity, equity, and inclusion goals.

When conducting outreach for possible project partners, evaluate your pool of contacts and communication channels to ensure diversity, equity, and inclusion. Consider connecting with building and trade unions, local community colleges and universities, or national and local societies for minority and women professionals.

Step 3: Complete modeling to determine energy use and needs.

In this step, you will utilize modeling to determine how much energy capacity your system will need to carry to meet your fleet's needs. You can accomplish this by utilizing the AFLEET tool mentioned in Phase 1, Step 4. If your proposed fleet uses telematics software, this data may already be available. Once the modeling is completed, you can determine how many chargers are needed and where.

Medium- and heavy-duty vehicles like transit buses often require direct-current fast chargers (DCFCs), which use 200-500 direct current (DC) voltage and up to 350 Amps. DCFCs provide approximately 100-200+ miles of range per hour of charge.[26] However, this is not always the case, especially for light-duty vehicles. At airports, light-duty vehicles may include customer and employee parking, third party fleets, airline equipment, etc. Long-term and some short-term parking installations may only need AC Level 1 charging (a standard 120-volt electrical outlet offering approximately 5 miles of range per hour), while AC Level 2 chargers (a standard 240-volt electrical outlet that can deliver anywhere between 20-50 miles of range per hour) serve many other fleet needs. Fleets often overestimate the number of charging stations needed. As described in the U.S. DOE's Mobility Advanced Fueling Infrastructure Capstone Report, demand should guide charging network design, with solutions that go beyond simply adding more stations, and should include potentially maintaining some

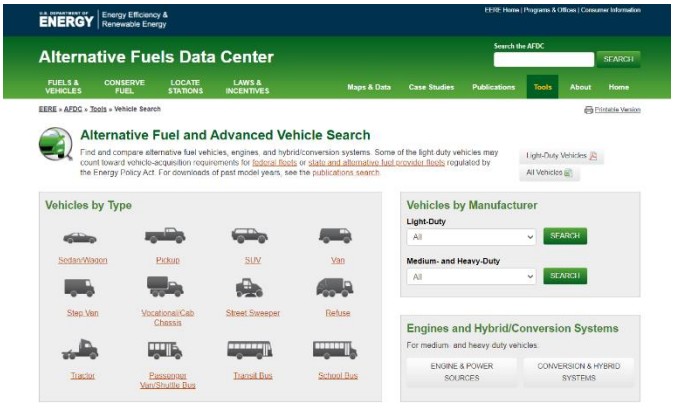
[24] *Kincaid, S. (2020). Charlotte Douglas International Airport. (E. Wolfe, Interviewer).*
[25] *https://www.kshb.com/news/local-news/kci-developer-awards-work-to-100-plus-women-minority-businesses*
[26] *https://afdc.energy.gov/fuels/electricity_infrastructure.html*

slow-charging locations in contrast to switching over all charging stations to faster rates.[27] The U.S. DOE's Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Consortium is responsible for the capstone report, as well as others, and includes a collection of procedures to help fleets create an accurate model for larger projects with the deployment of multiple EV fleets.

In Step 5 of this Phase, we will discuss infrastructure needs and charging station considerations more in-depth.

Step 4: Create a list of ideal characteristics of vendors and technologies.

As the number of EVs and support systems rapidly grows, navigating the variety of vendors and technology available can seem overwhelming. A great place to start is by developing a list of ideal characteristics of the vendors and technology you would like to use. To develop these lists, consult with the experts themselves: the airport drivers and technicians who will be utilizing the technology. In addition to collaborating with applicable airport personnel, below are resources and tips for evaluating technology options.



Vehicles: To view an entire list of vehicle options, utilize AFDC's advanced vehicle search tool to find and compare transit buses (as well as other vehicle types and duty cycles), motors, maximum seating, and estimated range.[28] AFDC also has a case studies database for examples of fleets transitioning to alternate fuels which is a valuable resource when comparing vehicles.[29] Remember to try it before you buy it. Scott Kincaid, Fleet Manager at CLT, wanted to experience firsthand riding an electric bus and the vehicle's range in action. Due to the similarities in their fleets, Kincaid traveled to nearby universities, Clemson and Florida State.[30] Connecting with a local fleet is a more cost-effective way to experience the vehicles firsthand and provides you with additional contacts to ask questions and troubleshoot future issues. For airport shuttle deployments, area transit systems or school districts are other helpful resources to explore.

When looking at different vehicle manufacturers, also consider the funding your airport plans on pursuing. The Federal Transit Administration's (FTA) Buy America Act has specific requirements for third-party procurements by FTA grant recipients.[31] For the most up-to-date information, visit the FTA's Buy America webpage and contact your Clean Cities Director for additional information and guidance. When evaluating different bus manufacturers, be sure to inquire if they have incentives or grant funding available and if they provide training support with lease or purchase agreements.

Differences also exist between different vehicle systems. Practice due diligence and investigate the various systems thoroughly, especially for any special or unique circumstances your fleet may need. The EV systems that differ from conventional, which may need special consideration depending on your operational

[27] *https://www.energy.gov/sites/prod/files/2020/08/f77/SMART-AFI%20_Capstone_7.22.20.pdf*
[28] *https://afdc.energy.gov/vehicles/search/*
[29] *https://afdc.energy.gov/case*
[30] *Kincaid, S. (2020). Charlotte Douglas International Airport. (E. Wolfe, Interviewer).*
[31] *https://www.transit.dot.gov/buyamerica*

conditions, include air cooled vs. liquid cooled battery maintenance systems (see Phase 4, Step 1 for additional information); regenerative braking; cab heating and cooling; and potentially others, depending on your fleet's unique needs and configuration.

Service and maintenance support: Airports need not only to be able to buy the equipment but also to service and maintain it on site or at nearby trusted shops. This is a key consideration with new technology that often gets overlooked by enthusiastic policy- and decision-makers (though less often by the fleet supervisors).

Include local service and maintenance support as a requirement in your procurement specifications. You may also choose to specify a window of time for getting on-site support from a remote service provider. Research for this element should also include whether on-site maintenance teams can receive direct training on target equipment.

Telematics software: Every airport fleet will need to implement some level of telematics. As previously discussed, demand charges can have an outsize impact on the cost of operating an EV fleet. Telematics can help to control electricity costs by ensuring energy usage and time of use charges are optimized for your operations.

When biometrics are part of the telematics system, security is enhanced. Telematics helps ensure driver and passenger safety through video monitoring of operating conditions and can also help to mitigate risk by adding detail to incident reporting. Efficiency and timing mean everything to travelers and operators. By having an overview of the entire fleet, managers can make better decisions.

Adding vehicle area wi-fi can upgrade the airport transit experience by promoting information that is useful for travelers arriving and departing from the airport. When exploring telematics options, be sure to consider connectivity, driver and employee education, and operations training.

Again, consider conducting meaningful outreach and solicitation to minority and women-owned businesses when exploring different vendors and technology. Federal funds may fall under the Justice40 Initiative, which requires 40% of the overall benefits of certain federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution.

Step 5: Identify charging infrastructure requirements.

New EVs will, of course, require implementing an adequate charging system that will ensure a fleet is moving efficiently and effectively. To ensure the transition is as smooth as possible, a detailed plan must be laid out identifying the infrastructure needs. Charging infrastructure consists of the *electrical system* at the point of grid connection as well as "behind the meter" on the fleet facility site, in addition to the *actual charging station equipment.* Charging infrastructure considerations include the following:

Electrical system upgrades: One key component to a fleet transition plan is evaluating the current electrical system of the facility, in this case the airport. A certified electrician, or a professional with similar qualifications, should visit the site in question and evaluate the electrical system and the proposed requirements. In Phase 1, Step 5, you evaluated the facility's current electrical system and its

capacity. At that time, you also connected with your utility account manager.

Now, it's time to compare the system capacity with energy needs as modeled in Phase 2, Step 3. This will help determine additional system upgrades that may be required to adequately charge the new vehicles. During this step, you are also evaluating the charging station equipment against your energy needs. Most new models for electric transit buses have an average range of 150 miles on a fully charged battery which may be sufficient for operating a bus through an entire workday. If this is the case, then only AC Level 2 charging stations, with one or two DC Fast charging stations, may be needed. Understanding your fleet's regular duty cycles, how they operate, and where they park will help determine your system and equipment needs. All the necessary equipment should be detailed in the energy needs model from Step 3 of this phase.

Charging station equipment: According to Burns and McDonnell's whitepaper on EV infrastructure, a charging station may look like an appliance, but proper operation depends on a number of factors, including network connectivity, firmware/software compatibility, and scheduled maintenance. Furthermore, most medium- and heavy-duty electrification initiatives should consider the benefits of integrating chargers with fleet management systems and load mitigation technologies (e.g., site controllers, dynamic load sharing and other features) to lessen demand charges. This can be challenging because information on equipment capabilities, compatibility with software protocols, constructability and interoperability with vehicles and other infrastructure is often not available or requires extensive knowledge to implement.[33]

"Transportation is a "system of systems," where many factors, such as vehicle electrification, connectivity, automation, traveler behavior, shared ridership, micro-mobility, freight, and transit, operate simultaneously, creating outcomes not attributable to any one element alone."

-Michael Berube, Deputy Assistant Secretary for Sustainable Transportation, "Understanding the Next Revolution in Transportation: DOE Publishes Results from 3 year SMART Mobility Consortium Effort"[32]

Future proof the system and equipment: To ensure your airport does not have to undergo additional infrastructure construction or purchase new equipment in a few short years, consider the airport's current and future electrification plans. This is not limited to but may include laying all electrical conduit now and phase in later the electrical service, make updates to the circuit and substation, or choosing chargers with higher outputs.[34] It may also be a good idea to discuss new technology. For example, KCI will be the first airport in U.S. with a wireless, inductive charging system. The system is part of their new terminal project and will provide incremental charging to keep their transit buses in service longer along their seven-mile loop.[35] One way to accomplish this step is by discussing the airport's future electrification plans with several of the stakeholders mentioned in Phase 1, Step 2, during the recurring project meetings, and with your local utility.

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[32] *Published August 28, 2020. Retrieved 9/19/2022. https://www.energy.gov/eere/articles/understanding-next-revolution-transportation-doe-publishes-results-3-year-smart*

[33] *https://info.burnsmcd.com/white-paper/getting-the-most-from-ev-infrastructure-investments-a-programmatic-design-build-approach*

[34] *Kunesh, D. O'Neill, T. (2020). Pacific Gas & Electric Company. (E. Wolfe, Interviewer).*

[35] *https://www.masstransitmag.com/bus/maintenance/power-converters-battery-chargers-and-inverters/article/21250916/kci-to-be-first-us-airport-with-wireless-charging-for-electric-fleet*

Utilities often have long planned runways with varying degrees of flexibility. As a reminder, your local utility likely has an account manager assigned to your airport. Engaging in a partner relationship with the local utility as soon as possible will allow planners to identify potential stumbling blocks. In addition to communication with the governing utility, construction of new infrastructure will likely require regulatory support at the federal level. Early engagement and partnering can help ensure unexpected delays are the exception rather than the norm.

Phase 3: Pre-Deployment

Pre-Deployment Best Practices:

- Implement policies for vehicle data management to ensure that fleet vehicle data is comprehensive and accurate.
- Ensure that all drivers, fleet technicians, and other staff are trained on EV safe operation and maintenance.
- Ensure fleet management has processes developed with energy or facility

Step 1: Develop and begin executing a communication plan.

As stated in previous sections of the guide, communication across each division of the airport and with external stakeholders is crucial to prevent confusioElectrn, which can lead to project delays or increased costs to fix errors. The project lead should consider working with key stakeholders outlined in Phase 1, Step 2 of the guide (marketing, fleet manager, aviation director, etc.) to create a communications plan. In addition to outlining goals for communications and outreach, the template includes sections stating project objectives, key barriers, opportunities, target audiences, outreach strategies and tactics, key metrics, key messaging, and a timeline. The plan should be an evolving document that incorporates equity, diversity, and inclusion goals, and be considered a core document created in collaboration with the project team.

Step 2: Develop infrastructure implementation schedule.

First, plan for Steps 2 and 3 in this phase to be completed in coordination, since barriers and opportunities in either step may change timelines and expenses in the other.

Once you have decided which fleet to electrify, determined your energy use and needs, and identified infrastructure requirements to ensure adequate charging, it is time to develop a schedule to procure the equipment (charging stations) and install it. There are two ways to approach this schedule. Under one approach, you can separate upgrades into affordable chunks that can be implemented when new EVs are procured. The second approach is to implement all planned upgrades at once. The second approach can make it easier to transition to EVs over time, but it will take longer to implement and may be best used when a full-scale facility upgrade or move is planned. Both approaches are sufficient to upgrade one's electrical system. The choice of the schedule approach is dependent upon how much room is in the current budget for the upgrades and future plans for EV procurement.

Once the general approach is determined for your project, then meet with your utility to ensure the substation(s) can handle the increased energy consumption. After ensuring the electric utility company has the capacity for the increased demand, the airport should meet with a trained and licensed professional to develop a procurement and implementation schedule for on-site infrastructure. The schedule should follow the general approach decided upon earlier, with special considerations as to the specific order of procuring system upgrades. The first consideration is to break down on-site upgrades into three categories – electrical panel and fuse box infrastructure, general electrical system, and charging station implementation. The second consideration is to make any necessary on-site upgrades first and focus on those implementations first. The final consideration is to create a hierarchy of upgrades based on cost and previous considerations, with a focus put on cheaper upgrades over expensive ones. This will ensure that the budget will not be stretched thin quickly and allow for more flexibility of this schedule. The total cost of all these upgrades should be provided by a professional that can visit the facility and evaluate the current system, and upgrades required.

Again, be sure to coordinate the infrastructure implementation schedule with Step 3, below, for vehicle procurement.

Step 3: Develop vehicle procurement schedule.

Developing a vehicle procurement schedule is essential to transition any fleet from typical internal combustion engine vehicles to EVs. It is best to evaluate the current remaining life span of the existing fleet based on AFLEET principles (see Phase 1, Step 4 of the guide), and/or by similar principles from outside experts such as Clean Cities coalitions, other fleets who have gone electric, etc. The remaining estimated life span of a vehicle can give a general idea of the best time to sell when considering the costs of EV procurement. This will also tell fleet owners whether it is more viable to sell a vehicle, or to scrap it and sell the parts. The funds acquired from sales can then be used to procure EVs to replace what was sold.

This procurement schedule should be heavily based on your fleet's replace and retain schedule. This schedule will cover, and provide, the vehicles' life span for the procurement plan. However, this will be a schedule to track the market value of any fleet vehicle and compare it against the projected maintenance costs. This schedule will provide the best window to sell a vehicle or to inform a fleet owner if an existing fleet vehicle will yield more profits from scrapping it for parts. A widely used rule of thumb is that the costs associated with retaining a vehicle must be at least 25% less than the costs associated with a new vehicle.[36] Completing or updating a replace and retain schedule is often glossed over, but taking the time to ensure the schedule is efficient and as strategic as possible can yield large benefits.

National Fire Protection Association
https://www.nfpa.org/product/id/evt009

Familiarity with the typical length of time between purchase order and delivery is another important piece of data to consider. This period will vary greatly between consumer-market vehicles, such as sedans and SUVs to heavily modifiable buses and work trucks, to specialty fleet vehicles. Communicating early with potential vendors and manufacturers to get the best timeline possible for long-lead vehicle equipment is crucial.

[36] *https://metroenergy.org/current-projects/green-fleets/*

The entire procurement schedule can be used to schedule electrical system upgrades that are outlined by the infrastructure implementation schedule and the energy needs modeling (Phase 2, Step 3) from earlier. Coordinating vehicle procurement with the infrastructure upgrades will ensure necessary installations are completed and tested far in advance of decommissioning existing fleet vehicles.

Step 4: Provide training to applicable stakeholders.

New technology means new skills. EV operators must be trained in how to drive, troubleshoot, and manage the vehicles while on their routes to maximize their range and meet expectations for performance. Vehicle maintenance staff will require additional training on the inspection and maintenance of EVs and the maintenance and replacement of battery systems in particular. Facility maintenance staff will also require training to assess and maintain the vehicle charging systems components and infrastructure.[37] Modifications may be needed to your maintenance facility. Be sure to discuss possible modifications with the vehicle manufactures and other fleets who have gone electric. All key workers such as drivers, technicians, maintenance staff, and first responders should receive initial and recurring EV training as it relates to their position. This is especially important for local and regional emergency services professionals in the event of a collision involving an alternative fuel vehicle.

Training hours for fleet staff are often included in contracts with vendors; however, it may be worth pursuing additional resources, so everyone feels prepared. For example, Kincaid, Fleet Manager at CLT, purchased additional training hours from their bus vendor.[38] Other resources are also available. The Federal Energy Management Program (FEMP) offers free online courses to fleet and facilities managers on converting fleets to electric. These online courses include information on EV regenerative braking systems and how to drive and charge electric vehicles.[39] The National Fire Protection Association also offers free online training to a variety of audiences. The training regarding Alternative Fuel Vehicles were funded by the U.S DOE Vehicle Technology Office.[40] In summary, providing adequate training ensures drivers, technicians, and facility maintenance feel confident deploying a new technology and can reduce the chance of future issues.

For EV operators, it is also important to train on the different behaviors that come with charging versus fueling. Typically, if on-route fueling becomes necessary for an internal combustion vehicle, it is easy to quickly locate a fueling station that meets the fleet's needs, so operators may consequently wait until the last minute to refuel. However, that same behavior cannot apply when operating an EV. While public charging stations are becoming more prevalent, it may take a lot more time to locate one. In addition, if a battery is depleted, it can take from 30 minutes (with a DC Fast Chargers) up to more than a day (with AC Level 1 charging) to recharge it. For these reasons it is important the operations crew be well-trained on the fleet's

[37] *https://www.hdrinc.com/insights/designing-tomorrows-electric-fleet-facilities*
[38] *Kincaid, S. (2020). Charlotte Douglas International Airport. (E. Wolfe, Interviewer).*
[39] *https://www.energy.gov/eere/femp/federal-energy-management-program-training*
[40] *https://catalog.nfpa.org/Alternative-Fuel-Vehicles-Safety-Training-C4105.aspx*

charging plan for the new vehicles.

Below are a few tips to help ensure your EV fleet is powered for the day and beyond.[41]

1. **Plug it in:** Be sure the vehicle is plugged in wherever it "sleeps" at night or as needed to charge within the peak efficiency range.

2. **Set it up to charge within the peak efficiency range:** Batteries charged at a level between 20% and 80% extend their life and keep them operating at peak efficiency.

3. **Do not charge to 100%:** Fully charging an EV reduces the regenerative braking and can degrade the battery.

4. **Switch up your charging methods:** Sole use of fast chargers has a negative effect on battery health.

Like any new technology, EVs have unique characteristics that take some time to get used to. Below are some important safety considerations when driving an EV versus a vehicle with an internal combustion engine:

- **Faster acceleration:** EVs accelerate more quickly from a stopped position than an internal combustion engine.

- **Noiseless motors:** Electric motors are extremely quiet, which can pose a danger to pedestrians and bicyclists who use engine noise to detect danger. Most government safety agencies are now requiring EVs to be equipped with vehicle warning sounds.

- **One pedal driving/braking:** To maximize energy utilization, EVs are equipped with a feature called regenerative braking. With practice, the accelerator pedal controls both speeding up and slowing down. Pressing this pedal makes the vehicle move as usual, but lifting the foot makes it slow down, hard, not like coasting. (There is also a brake pedal; using it does not transfer power to the battery pack.)

- **More stability:** EVs tend to have a lower center of gravity than conventional vehicles, making them more stable and less likely to roll over.

All EVs must meet the same Federal and Canada Motor Vehicle Safety Standards, and undergo the same rigorous safety testing, as vehicles with internal combustion engines. EVs must also meet the electrical and safety standards set by the Society of Automotive Engineers, the National Electric Vehicle Infrastructure Working Council, and others. Emergency response for EVs is not significantly different from that of conventional vehicles except with regard to treatment of fires. EVs are designed with cutoff switches to isolate the battery and disable the electric system, and all high-voltage power lines are clearly designated with orange coloring. Your state fire safety training schools have access to excellent safety training courses, including those generated by the National Fire Protection Agency.[42] It is a good idea to encourage your local and regional emergency services professionals to undergo training to understand fire safety in the event of a collision involving any alternative fuel vehicle. **Again, drivers, technicians, maintenance staff, and first responders need to receive initial and recurring EV training as it relates to their position.**

[41] *https://www.wheels.com/public/resource-hub/blog/educating-the-ev-operator/*
[42] *https://catalog.nfpa.org/Emergency-Field-Guide-P13872.aspx*

Step 5: Develop a resiliency plan.

Resiliency planning helps ensure EV operations remain sustainable in the event of natural or human caused hazards resulting in power outages. The installation of EV chargers may also cause energy demand on existing conductors, transformers, and substations during peak hours. Development of a resiliency plan requires a holistic, adaptive approach at all operational levels. The U.S. DOE 2021 Federal Fleet Resiliency Planning Report provides a broad overview of resiliency planning.[43] Additionally, the FEMP's Technical Resilience Navigator (TRN) provides a modular approach to the resiliency planning process.[44] However, at its basic level, the key to resiliency planning is to gather all necessary information about transportation infrastructure assets and identify which are vulnerable and which are critical. From there, policymakers, department leaders, and professional consultants can develop mitigation strategies to minimize the impact of a disaster, or potentially avoid impact altogether.[46]

In order to ensure resiliency, it is necessary to work closely with your utility and update the service agreement. Energy service agreements are a way for fleets and utilities to better manage energy supply and use through sharing of data and coordinating to ensure adequate power supply for the planned charging stations. This may include time-of-use rates for EV charging that encourage charging outside of peak demand hours, reducing strain on the grid and costs for both the utility and the fleet. By reducing demand on the grid, coordinated EV charging during off peak hours can reduce the likelihood of power outages.[47]

Five key phases in a resiliency plan according to the September 2020 issue of Roads & Bridges[46]:

- **Discover and assess.** The first step is to identify all system assets to be assessed and perform a geographic information system (GIS) analysis of existing databases to identify potential risks. Stakeholders are engaged and social, economic, and environmental goals are also incorporated during this phase.
- **Strategize, plan, and prioritize.** In this phase of the resiliency framework, identified risks are used to vet solutions, relying heavily on stakeholder engagement.
- **Reimagine, redesign, and fund.** Next, solutions, innovation, imagination, and policy are turned into reality. All funding options should be considered from traditional sources, such as tax revenue, to creative solutions like cost-sharing.
- **Respond and execute.** This phase enables the current emergency response processes to be incorporated into resiliency planning. This can also be a two-way street, where emergency responders learn from and incorporate resilient actions into their plans.
- **Control, adapt, and recover.** After an event, there are still opportunities to be proactive. Asset management, long-term logistical planning, even pre-positioned documentation/contracting that is all designed to speed and aid the recovery process.

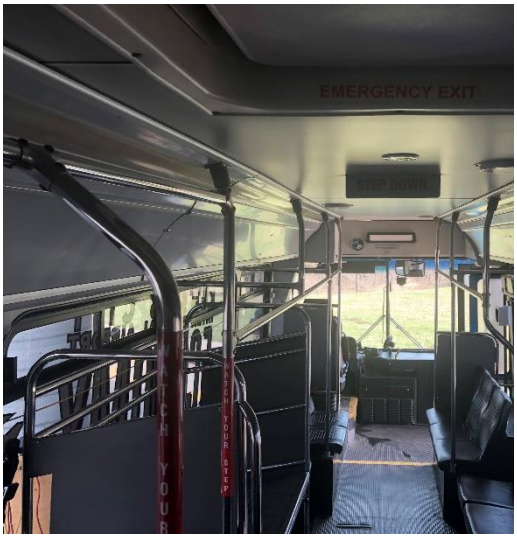
[43] *https://www.nrel.gov/docs/fy21osti/77721.pdf*
[44] *https://trn.pnnl.gov/*
[45] *https://www.roadsbridges.com/sustainable-transportation/article/10652927/how-to-develop-a-proactive-resiliency-framework-in-your-planning-programs-or-organizational-approach*
[46] *https://www.roadsbridges.com/sustainable-transportation/article/10652927/how-to-develop-a-proactive-resiliency-framework-in-your-planning-programs-or-organizational-approach*
[47] *https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=931827*

Other key considerations for EV resiliency are alternative power generation and battery storage for emergency power use. A typical EV battery can power a residential home for several days, and EVs may be crucial for future emergency management during power outages.[48] Additionally, by including off grid and renewable energy sources such as solar, fleets can ensure that they have continued access to battery charging in the case of a grid outage. The City of Kansas City, MO recently completed a feasibility study that outlines steps and challenges to bring a utility-scale solar farm to KCI. The potential farm could one day house one of the nation's largest airport solar farms, capable of powering as much as one-third of Kansas City's homes.[49] If alternative power generation does not fit into your short-term EV deployment plans, be sure long-term goals are discussed throughout the project with key stakeholders.

Because solar charging stations generate and store their own electricity, they are not only operable in natural disasters, but they are also a disaster preparedness tool. When an outage occurs due to a natural disaster, off-grid solutions can keep your fleet operating. The fleet won't be tied to the grid and your fleet won't be stopped.[50] For example, the City of Olathe, KS installed portable, solar-powered EV charging systems in 2021. The EV ARC™ chargers installed can withstand 120 mph winds and includes a power panel that first responders or businesses can connect to during emergencies.[51] This is one-way Cities can implement sustainable, reliable, environmentally friendly infrastructure for their community members.

Resiliency planning for your EV deployment can seem overwhelming, especially when you are already working with a new technology. However, this step of the guide should spur additional questions to ask your utility when developing a resiliency plan and updating your electricity service agreement.

[48] *https://cleanfuelsohio.org/what-does-electric-vehicle-adoption-mean-for-grid-resiliency/*
[49] *https://missouriindependent.com/2022/06/10/kansas-city-moves-ahead-with-study-of-massive-solar-farm-at-kci-airport/*
[50] *https://www.automotive-fleet.com/green-fleet/354017/why-solar-is-a-fleets-best-ev-charging-option*
[51] *https://www.olatheks.org/Home/Components/News/News/3076/58?npage=3&arch=1*



Deployment Best Practices:

- New technology requires thoughtful monitoring and feedback to ensure unintended costs don't sneak up on you.
- Revisit the communication plan created in Phase 1 and make sure you're engaging all stakeholders in the success of your deployment.

Phase 4: Deployment

Step 1: Engage in maintenance best practices.

As previously mentioned, when considering different vehicle manufacturers, a key consideration should be what type of maintenance support and training is provided (nearby or onsite). While EVs are less expensive to maintain and more efficient to repair, you will still need to keep up a regular preventive maintenance schedule. While it is important to consult with your vehicle manufacturer to learn more, below are some key maintenance-related differences.[52]

Vehicles:

- **Electric Motors:** Electric motors do not need the same level of maintenance as an internal combustion engine. Electric motors have fewer parts and no oil and fuel filters.

- **Powertrain:** The direct-drive or multi-speed transmission of an EV may require a periodic fluid change.

- **Brakes:** EVs still have friction brakes, and the brake fluid and individual components, such as the pads and rotors, will eventually require replacement, but much less often.

- **Cooling:** To keep key electrical components from overheating, most EVs use coolant or refrigerant to cool the charger, inverter, and battery pack. Infrequent coolant flushes or refrigerant recharges may be required.

- **Tires:** Tires on EVs wear out just like those on an ICE vehicle and will need to be rotated and replaced. This may happen faster for EVs, depending on how heavy the original vehicle was.[53]

[52] *https://www.energy.gov/eere/femp/electric-vehicle-training*
[53] *https://www.olatheks.org/Home/Components/News/News/3076/58?npage=3&arch=1*

- **Batteries:** Maintenance of batteries is often a concern for fleets going electric. Carefully review manufacturer and
vendor warranties, so you understand your responsibility and the limits of theirs. There are two commonly used types of battery management systems for EVs: air cooled and liquid cooled systems. Each type has its benefits and drawbacks but can be adversely affected depending on the climate where the system is operating. In moderate climate regions, air cooling systems have an abundance of air as an available resource making them an ideal choice. They are widely used in many industries, and with low maintenance costs are a popular choice amongst automobile manufacturers such as Toyota and Nissan. However, air cooling systems are not as effective as liquid cooling systems in climates that experience temperature extremes. Liquid cooled systems have a higher heat capacity, strengthening their overall efficiency. They are also very compact systems, saving up to 40% of power compared to fans required for air cooling. The downside to the higher efficiency is the more frequent maintenance checks, because liquid cooling has the potential to leak which can be harmful to the system. The biggest consideration when choosing between these systems is climate, as that will have a direct impact on the efficiency of the system. For areas of extreme heat and cold, liquid cooling is highly recommended. In more moderate climates either system is a viable option. The next step is to consider maintenance costs.

  Like combustion engines in conventional vehicles, the advanced batteries in EVs are designed for extended life but will wear out eventually. They have a limited number of charging cycles but are designed to last for the expected lifetime of the vehicle.[54] Nevertheless, it is a good idea to protect their lifespan by continually updating your operations plan to take advantage of lower voltage charging where possible.

- **Charging equipment:** Generally, the local utility owns and is responsible for electricity generation via transmission and distribution lines and substations, while the facility (in this case the airport) is responsible for on-site wiring, service transformers and panels, and conduits. Understanding this breakdown is important when planning for charging equipment installations, operations and maintenance, or equipment upgrades.[55] It is important to consult with your charging manufacturer to learn maintenance best practices. However, below are five key pillars to maintaining and managing operations of an EV charging station:[56]

  1. Manage on-site repairs to minimize downtime and optimize on-site repair costs. Runaway repair costs can easily ruin the ROI on an EV charger investment.

  2. Manage scheduled preventative maintenance tasks and track the fail/pass of various types of inspections. If inspections are not carried out, exception handling needs to ensure compliance with operational, electrical and potential government uptime regulations.

  3. Ensure visibility and control for tracking uptime and performance by site and by asset.

[54] *https://afdc.energy.gov/vehicles/electric_batteries.html*
[55] *https://www.energy.gov/eere/femp/electric-vehicle-training*
[56] *https://www.forbes.com/sites/forbestechcouncil/2022/07/29/the-five-pillars-of-ev-charging-station-maintenance-and-management/?sh=1e540e0d31fa*

4. Track service-level agreement performance of regional suppliers that install, maintain and repair chargers.

5. Provide business intelligence reporting. Good, clean operations data can produce accurate business insights, which drive sound business decisions.

- **Energy usage:** Commercial and industrial electric customers have high energy demands due to heavy equipment and vehicles. Fleets consume much more electricity compared to an average household, so they are subject to demand charges. A demand charge is based on the highest peak demand for electricity within the billing period, an added cost larger scale commercial systems must pay.[57] Providing large amounts of power can be taxing on the electric distribution system. Demand charges are a proactive way for the utility to ensure the system can meet peak demand.

  Monitoring energy usage is a good way to understand overall consumption and manage energy costs for the fleet. During high traffic, expect to consume higher amounts of energy and spend more on electricity. There are many tools available to monitor energy usage.[58] Most charging stations have a built-in meter that tracks electricity consumption and collects data from each transaction. If that technology is not available there are alternatives like FEMP M&V standards that help estimate energy usage. Electric utilities vary depending on the location, so check with your local provider to understand more about average costs.

As a reminder, maintenance best practices and lessons learned should be discussed with the project team on an ongoing basis and shared with the manufacturers and your local utility. By providing them with real world feedback, you may have the opportunity to influence adjustments they make to their technology or operate their programs.

Step 2: Maintain an active feedback loop.

Once the vehicles have been deployed, it is important to engage in an active feedback loop with the project stakeholders, such as those you identified during Phase 1, Step 2. They will help troubleshoot issues and make improvements. Feedback can be gathered via one-on-one meetings, by conducting surveys, and by continuing to hold recurring meetings with the project team and appropriate internal and external stakeholders. During these meetings, quantitative and qualitative data should be reviewed and discussed.

Utilizing telematics data, the project team can analyze overall fuel expenses (comparing EV and non-EV performance on the same shift), look at service disruption data, efficiency of vehicles by shift and drive cycle, and review any additional telematics provided by the vendor. It is also important to hear firsthand from the drivers, technicians, and maintenance facility staff, because their on-shift decisions and actions may have an

[57] *https://betterenergy.org/blog/demand-charges-and-dcfc/*
[58] *https://www.energy.gov/sites/default/files/2021/01/f82/measuring-and-reporting-ev-electricity-use.pdf*

impact on the data.

Next, any identified improvements need to be communicated with the appropriate parties. By sharing mitigation plans and results of those efforts (internally and externally), you may have an impact on programs and services provided by utilities, Clean Cities programs nationwide, vendors, etc. It is also important to revisit the previously created fleet profiles and scenarios to see if the projected benefits match the actual results. What data was originally missing that you now have? Are you on track to meeting ROI goals? Do you have additional telematics data you can review?

Step 3: Revisit communications plan.

As previously mentioned, the communications plan is an evolving document that should be revisited throughout the project to make certain all stakeholders stay informed and receive necessary updates in a timely manner. The plan can be reviewed by the project team during recurring meetings, and if needed, edits can be made. Throughout this process be sure to identify communications plan successes and failures, incorporate observations and lessons learned in anterative manner, connect with your marketing team to inform community members and visitors about the benefits of EVs, and have a plan to make your experiences available to others.

Phase 5: Project Sustainability

Project Sustainability Best Practices:

- Document successes and share them with peers and community stakeholders.
- Monitor technology advances and reinvest periodically to update systems and keep fleet operations running smoothly.
- Plan for long-term funding.

Step 1: Document successes and share widely.

First, airports should identify lessons learned from all aspects of the project. This should include understanding the perspectives of all those who worked on the project, such as project managers, grant administrators, fleet mechanics, drivers, etc. Key considerations for each area should be documented and incorporated into future planning. Williams, former Fleet Manager at KCI, credits his local Clean Cities coalition with being a valuable resource, through which he gained opportunities to share information about his project in technical forums and educational events and panels, both regionally and nationally.[59] By participating in regional and national events, he was not only able to share their successes, but also network with other fleets and learn from their experiences.

To ensure staff stays motivated, celebrate accomplishments and recognize those who are actively working toward success. There may also be recognition programs within the Aviation Department, your municipality, or nonprofit and for-profit organizations in your region who are focused on sustainability.

Step 2: Monitor technological advances.

As novel advanced technologies continue to proliferate, it is important to stay up to date on the most exciting and innovative industrial news. Staying involved with your regional Clean Cities coalition gives you full access to the latest in technological advancements. Due to their national framework, Clean Cities is the ultimate resource as coalitions can reach out to fleets across the country that are implementing both pilot and large-scale projects. Furthermore, Clean Cities can assist in more complex, complicated challenges. They can also provide high-touch, in-depth support with projects relating to technical problem solving for vehicle operations, infrastructure operations, and evaluation of project potential. Finally, Clean Cities has access to a team of seasoned research experts who can find answers to all your project's needs.

[59] *Williams, K. (2020). Kansas City International Airport. (E. Wolfe, Interviewer).*

While evaluating technological advances, airports should consider which fleets would be best suited for the next electrification project. Some key factors to consider include vehicle model availability, vehicle miles traveled (VMT), total cost of ownership (TCO), vehicle utilization and operational consistency, frequency of overnight parking locations, and facility suitability for EV charging.[60] Additionally, airports should consider efficiency of the built environment, such as airport facilities. It is estimated KCI's new terminal will use 20% less power than the current terminals due to a variety of factors including utilizing more efficient and smart technology for things like lighting and achieving LEED Gold certification by adhering to a variety of green prerequisites.[61] As future building construction, renovation, and expansion plans are considered, energy efficiency and EV futureproofing should be incorporated into the plans from the beginning to ensure long term savings. Finally, airports should identify pie in the sky goals, or long-term big goals for future consideration in comprehensive planning.

Step 3: Create a sustainability plan.

Airport fleet electrification is one piece of an overall comprehensive sustainable operations plan. The FAA's Airport Sustainability Planning Program provides Airport Improvement Program (AIP) grants to certain airports for Sustainability Master Plans or Airport Sustainability Plans.[62,63] A good airport sustainability plan includes greenhouse gas emissions inventories and emission reduction initiatives. By taking advantage of planning grants, airports can ensure that their future initiatives are streamlined and are strategically meeting sustainability objectives.

The sustainability plan should also include potential funding opportunities for each initiative. There are federal funding opportunities available through multiple agencies, such as the FAA's Voluntary Airport Low Emissions (VALE) and Zero Emissions Vehicle and Infrastructure Pilot (ZEV) Programs, the EPA's Diesel Emission Reduction Act programs, and U.S. DOE's Vehicle Technologies Office grant programs.[64,65,66,67] Several of these programs enable demonstration of emerging technologies, which can keep the airport current with increasingly efficient fleet electrification, as well as testing newly electrified equipment for adequate reliability in airport operations.

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[60] *https://www.government-fleet.com/326191/which-vehicles-should-i-replace-with-evs*
[61] *https://www.kshb.com/news/local-news/earth-day-2022-green-initiatives-at-kcis-new-terminal*
[62] *https://www.faa.gov/airports/environmental/sustainability*

Sustaining Fund Sources

Fund Name	Fund Source	URL
Airport Improvement Program	FAA	[63]*https://www.faa.gov/airports/aip*
Voluntary Airport Low Emissions Program (VALE)	FAA	[64]*https://www.faa.gov/airports/environmental/vale*
Airport Zero Emissions Vehicle and Infrastructure Pilot Program	FAA	[65]*https://www.faa.gov/airports/environmental/zero_emissions_vehicles*
Diesel Emissions Reduction Act (DERA) Funding	EPA	[66]*https://www.epa.gov/dera*
Open Funding Opportunities	EERE	[67]*https://www.energy.gov/eere/vehicles/funding-opportunities*