G

Airport Electrification Initiative

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FLORIDA AVIATION SYSTEM PLAN

Appendix G

Airport Electrification Initiative

Background

Airport electrification can include energy generation, transmission, storage, and use cases that are not limited to aircraft. Traditionally, the conversation regarding electrification was focused on ways to reduce electrical consumption such as the transition to more energy efficient lighting systems including LED lighting for runway and taxiway lights, navigational aids and building lighting. Now, however, the conversation around electrification is taking on a whole new meaning with regards to impacts to air and ground transportation.

Emerging technologies may transform future generations of air and ground transportation, which may have significant impacts to airports of all sizes. A global initiative to reduce environmental impacts has a focus on airports to replace air and ground transportation with electric aircraft and vehicles. This document focuses on the latest trends and technology involving electric ground transportation, electric aircraft, and information pertaining to electric capacity and demand for all modes of transportation.

Electric Vehicles (EVs)

The easiest segment of electrification to observe is ground transportation since there are already numerous use cases available today with both passenger vehicles and some airport ground support vehicles being electric vehicles or hybrids.

The effect of vehicle electrification on airport infrastructure will be dependent on the airport's uses. Airports with high passenger levels and tenants that operate large fleets of rental vehicles as well as those that see a high volume of electrically powered automobiles may need to consider the provision of electrical charging infrastructure and to what effect this provision will have on power consumption on airport. ACRP Synthesis 54[1] in 2014 explored this topic for the airport industry. In 2021, the Federal Aviation Administration (FAA) reported that it provided more than $300 million in grants to help airports reduce vehicle emissions through electrification projects.

In a Zero Emissions Vehicle Transition Council dashboard titled *Zero-Emission Vehicles Progress Dashboard*[2], Bloomberg New Energy Finance (Bloomberg NEF) reports that over 122,000 public charging stations were installed in the U.S. as of the first half of 2022. In comparison, more than 145,000 retail

[1] National Academies of Sciences, Engineering, and Medicine. 2014. ACRP Synthesis 54: *Electric Vehicle Charging Stations at Airport Parking Facilities*. Washington, DC: The National Academies Press. https://doi.org/10.17226/22390

[2] ZEV Transition Council. 2022. "Zero-Emission Vehicles Progress Dashboard." BloombergNEF, September 21, 2022. https://assets.bbhub.io/professional/sites/24/BloombergNEF-ZEV-Dashboard-Sep-2022.pdf

locations in the United States sell fuel[3]. However, the U.S. lags other countries such as Canada, the United Kingdom, and several Nordic countries when comparing the number of chargers per electric vehicle in each country. This indicates that the public charging infrastructure in the U.S. market will need to grow if EV sales increase. A 2020 study by the Southern Alliance for Clean Energy found that Florida has the second highest number of EVs and the third highest number of electric busses in the United States.

The electrification of automobiles on airports is divided into four general categories: airport service vehicles, passenger and employee vehicles, rental vehicles, and transit vehicles. The sections that follow describe the technologies and market for each vehicle class and provide considerations for Florida's airports as they look to accommodate these vehicles at their facilities.

Airport Service Vehicles

Airport service vehicles include trucks and cars used by airport operations and maintenance staff as well as ground service equipment such as baggage carts and push-back tugs. As battery technology has improved, some vehicle types previously thought off-limits for electrification are seeing hybrid and fully electric models come to the market. An example is the hybrid Oshkosh Striker Volterra aircraft rescue and firefighting vehicle. Pickup trucks used by airport operations and maintenance staff are also seeing more EV options, such as the Ford F-150 Lightning and the Chevrolet Silverado EV.

A challenge associated with airport service vehicles is that they are expected to work for extended periods of time in a wide variety of weather conditions. While internal combustion engine vehicles can be refueled in a matter of minutes, EVs can take significant amounts of time to recharge, requiring backup vehicles or a recharging plan to avoid periods where there is no coverage. Although cold weather is unlikely to affect many of Florida's airports for extended periods of time, the American Automobile Association reports in a web-based article titled "Icy Temperatures Cut Electric Vehicle Range Nearly in Half[4]" that battery-powered vehicles suffer a reduction in range as the temperature drops.

[3] American Petroleum Institute. "Service Station FAQs." https://www.api.org/oil-and-natural-gas/consumer-information/consumer-resources/service-station-faqs
[4] AAA. 2019. "Icy Temperatures Cut Electric Vehicle Range Nearly in Half." Newsroom, February 7, 2019. https://newsroom.aaa.com/2019/02/cold-weather-reduces-electric-vehicle-range/

The EV industry is making progress towards addressing these challenges, and airport service EVs continue to become more capable and reliable. Airports looking to accommodate more EVs in their fleet should consider the placement of charging infrastructure; the ability of existing maintenance shops to perform repairs to batteries, electric motors, and drivetrains; and what contingency plans may need to be in place should the airport lose power in the event of disaster or outage. Hybrid vehicles can be an alternative to fully electric vehicles for airports looking to reduce emissions and fuel expenditure without losing the reliability of gasoline as a backup.

Passenger, Employee, and Rental Vehicles

As more EVs are sold, passengers and rental car operators will expect to find charging infrastructure at airports. Airports may contemplate the revenue potential of providing this service to passengers using their parking facilities. A consideration is that vehicles can charge in the span of a few hours, while cars parked at airports can remain for days and weeks. A charger for each stall is unlikely to be necessary, and airports may need to work with the industry to develop solutions that enable charging cables to be disconnected from unattended cars when charging is complete so other customers can use them.

The charging of rental car fleets, if this activity takes place on airport property and is connected to the same power supply as the rest of the airport, requires a detailed analysis of peak demand patterns and usage. During busy periods, rental car companies clean, fuel, and return rental cars into service in a matter of hours. Customers expect a full tank, or full battery, when they pick up their car. In 2022, rental car company Hertz announced a plan to develop a network of charging stations to support the tens of thousands of EVs that the rental car company has already purchased. The demand from these chargers, especially when fleets are connected and charging at the same time, will strain the local electrical grid. This could lead to failures during peak times. A study is recommended to determine what types of upgrades – from grid capacity improvements to onsite electricity generation to on-site battery storage – are needed to avoid system failures.

EVs tend to weigh more than their internal combustion powered counterparts. This is due to the weight of the batteries powering the EV. This may have implications for the design of future passenger and rental car parking structures in terms of how much weight each level is designed to accommodate. Currently, EVs make up such a small percentage of the existing vehicle fleet that their added weight is not a concern for parking structures. But should EVs grow to become a significant portion of the vehicle fleet, their additional weight will need to be a consideration in the design of parking structures.

Transit Vehicles

Transit vehicles are another segment of the transportation system that is increasingly going electric. There are numerous grant programs designed to help transit operators electrify their fleet. In Florida, transportation agencies received $14.7 million to support local efforts between 2016 and

2020. It is likely that electric busses and other transit vehicles will charge off airport property, but there may be opportunities for airports to sell electricity to transit operators if their vehicles are sitting at airport stops between routes.

In addition to public transit, some airports use busses to move passengers and employees between terminals, parking, rental car lots, hotels, and other points of interest. Planning to accommodate the electrical needs to operate these vehicles on-airport may also be an important consideration. As with other forms of electrification, this underscores the importance for an airport to reach out to tenants when preparing comprehensive plans for electrification.

Electric Aircraft

Urban air mobility (UAM) uses automated aircraft to carry goods and people to and from place to place. UAM includes a wide range of vehicle configurations powered by electric and other sustainable fuels. Whether or not the general public realizes, they are already familiar with UAMs like drones and their use cases such as recreational use, military use, and aerial imagery. It is possible that, in the near future, electric aircraft will be as familiar to the public as drone use is in 2023.

There are several families of electric aircraft: electric conventional takeoff and landing aircraft (eCTOLs) and electric vertical takeoff and landing aircraft (eVTOLs). A third family is typically grouped with eCTOLs: electric short takeoff and landing aircraft (eSTOLs).

- **eCTOLs** use conventional aircraft designs and replace the original internal combustion engines with electric ones, allowing the aircraft to use existing runways, taxiways, flight paths, and airport infrastructure. Examples include Cessna 208 Caravans and de Havilland Canada DHC-2s that have been fitted with batteries and electric motors.

- **eVTOLs** operate similarly to a helicopter with their ability to take off and land vertically. They have various types of configurations – fixed and rotary wing models. With their ability to take off vertically, they are suitable for environments with less space to maneuver.

- **eSTOLs** differ from eCTOLs in their facility needs. eSTOLs can operate on much shorter runways than eCTOLs. This provides some of the flexibility that eVTOLs offer without the excessive energy requirements associated with vertical takeoffs and landings. Leaders in eSTOL technology include Electra.aero, Inc.

Canadian airline Harbour Air has been testing an electric float plane (**Figure 1**) that will provide passenger and cargo service between the communities in southwestern British Columbia. This aircraft performed its first all-electric, point-to-point test flight in August 2022 and is most similar to an eCTOL.

Figure 1. Harbour Air ePlane

Source: https://harbourair.com/eplane-update/

Design of eVTOL aircraft vary greatly. Some fly like multi-engine helicopters while others take off vertically before switching the orientation of the motors to fly like a conventional airplane. Most have propellers driven by independent electric motors, but some, such as Germany's Lilium, are developing aircraft with a vectored thrust engine that operates like a jet turbine. A core attribute of the eVTOL family is that their takeoff and landing characteristics mean that they can operate outside of traditional airport environments. The concept of advanced air mobility (AAM) envisions a world where eVTOLs can connect passengers and cargo from point-to-point within a city or region without requiring a stop at an airport.

In addition to purely electric aircraft, another category is hybrid electric aircraft designs with the potential to increase flight range compared to aircraft that are solely electric. Hybrid aircraft may run on conventional aircraft fuel, sustainable aviation fuel (SAF), or hydrogen fuel cells, in addition to battery power.

Design Standards and Guidance

The FAA sets the standards for engineering, design, and construction for various airport-related equipment, facilities, and structures. With eVTOLs and eCTOLs operating similarly to conventional aircraft, design standards that govern airport development are expected to be applicable for the near future. The eVTOLs and eCTOLs currently in design are on the smaller side of the aircraft size spectrum, largely due to range and power limitations with current battery systems. The largest eVTOLs and eCTOLs in development have wingspans of up to 49 feet, which puts them in FAA Aircraft Design Group II.

Siting and installing electrical charging infrastructure follows a similar process to any other type of airport construction. Form 7460-1 will still need to be submitted so that the FAA can perform an airspace review on any infrastructure of height that is installed on an airfield. Airfield design standards identified in FAA Advisory Circular (AC) 150/5300-13B, *Airport Design*[5], also need to be considered.

[5] FAA. 2022. Advisory Circular (AC) 150/5300-13B – Airport Design. March 31, 2022. Washington, D.C. https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentnumber/150_5300-13

An additional consideration is the source of the power supply. Electrical supply infrastructure may need to be improved to enable fast charging, which is critical for high volumes of electric aircraft operations. Similar to conventional aircraft turnaround times, optimizing electric aircraft turnaround times is just as critical in order to generate the most revenue. To optimize electric aircraft turnaround times, the power to fast charge electric aircraft is vital. If the power supply needs come from another part of the airport, consideration may be needed in how the cables will be located, either below ground in a trench or above ground on towers. Above ground options may be less expensive but could present obstructions to airspace surfaces if not considered during planning.

Since eVTOLs operate like helicopters in the sense that they take off and land vertically, this may allow operators to use existing heliports to support eVTOL operations. Heliports could provide convenient access to urban environments and previously underserved areas, but they must have the correct operating certificates and air rights before they support eVTOL operations. FAA Advisory Circular (AC) 105/5390-2D – *Heliport Design* contains heliport guidance that may be considered for eVTOL operations. If heliports are to be repurposed for the use of eVTOL operations, they may need to be modified with other amenities such as passenger amenities and charging facilities.

Vertiport design is described in FAA *Engineering Brief (EB) 105, Vertiport Design*[6]. The FAA states that this guidance, particularly for airspace surfaces associated with flight corridors, is subject to change as more details about eVTOL flight characteristics are learned. As of March 2023, airports planning a vertiport should consult the updated version of EB 105 and consider how the vertiport will interface with the rest of the airport environment. The updated version of EB 105 defines electric battery systems and provides guidance on the airspace approval process, vertiport design, markings, lightings, and visual aids.

Electric Vehicle and Aircraft Infrastructure

As airports prepare to plan for the increased use of electric vehicles, they will need to consider both aircraft needs as well as ground vehicles including passenger vehicles and airport vehicles. Both of these segments are discussed below to generally outline infrastructure that is expected to be required.

Electric Vehicle Infrastructure

Selection of EV charging infrastructure for vehicles at airports depends on its intended use and type of demand. Before addressing these issues, understanding the terminology used to describe the three existing levels of EV charging infrastructure for automobiles is useful:

- **Level 1 (120 Volts, 1.4 kilowatts [kW])** – Level 1 charging stations are the equivalent of a typical electrical receptacle and are the least expensive to install. Level 1 charging stations have the longest charging time.

[6] FAA. 2023. Engineering Brief No. 105, Vertiport Design. March 13, 2023. Washington, D.C. https://www.faa.gov/airports/engineering/engineering_briefs/engineering_brief_105_vertiport_design

- **Level 2 (208 or 240 Volts, 7.7 kW)** – Level 2 charging stations are approximately six times more expensive to install compared to a Level 1 charger but complete the charge much faster. These are the most common charging stations because airports are able to use existing electrical infrastructure present at most facilities.
- **Level 3 (480V, 50-350 kW)** – Level 3 charging stations such as the Tesla Supercharger typically require the installation of utility infrastructure sized to accommodate 480 Volts/3 phase/350 kW systems with a direct current converter. These charging stations offer the fastest charging option. Level 3 charging stations are the most expensive to install and are not as prominent as Level 1 or Level 2 charging stations.

For example, Level 1 charging infrastructure could be well suited for charging electrical vehicles parked in long-term parking lots or in charging motorcycles, scooters, and bicycles by those commuting to the airport. Level 3 charging infrastructure, on the other hand, could be installed as a fast-charging option for short-term airport visitors picking up or dropping off travelers. Other considerations such as the installation of solar panels to power charging stations, conduit routing to supply electricity to charging stations, and communication infrastructure to link power consumed with an airport's revenue control network could also factor into the level of charging infrastructure installed at an airport. A comprehensive energy use study is recommended to determine what level of infrastructure investment is needed to support the anticipated demand of tenants and users.

Electric Aircraft Infrastructure

Two of the primary considerations are whether any of the existing physical infrastructure needs to change to accommodate the way electric aircraft operate, and what is necessary for the recharging of electric aircraft on the airfield. Both issues are somewhat speculative since no standards have emerged for how electric aircraft function and are resupplied with energy. The following sections address both issues using the current line of thinking in this evolving market.

Electric aircraft, such as eCTOLs, have more similarities with conventional aircraft than they have differences. Aircraft in design are expected to be flown by a pilot, carry passengers and cargo, operate on runways, and move around the airport on a taxiway system. eVTOLs will operate similarly to conventional helicopters with hover and lift. All electric aircraft will need space to park, maintenance facilities, and a way to "refuel" before their next flight. While the design of some aircraft, particularly multi-rotor eVTOLs, may appear different from that of traditional aircraft, electric aircraft require minimal changes in airport infrastructure to accommodate electric aircraft facilities. The following discusses airport infrastructure considerations that may impact airports in Florida.

Charging infrastructure needed to support electric aircraft may vary widely based on the frequency and type of operations being conducted at each airport. It may be premature to assume what that charging infrastructure will be, but it is possible that a charging network with multiple levels – similar to that described above for cars – may be developed.

Some airports may consider installing chargers on the transient apron, while others may want to provide conduit and electrical lines with capacity sized appropriately to meet anticipated demand when building new hangars or vertiports. Airports in other states have placed empty conduit under new and rehabilitated aprons in anticipation of the need for electrification of the ramp. Airports with a high volume of flight training, cargo, and regional passenger traffic may see considerably more demand that could require upgrades to the electrical power infrastructure serving the airport. They also may require consideration of on-site electricity generation and storage. Alternatively, a future electric aircraft design may accommodate battery swapping technology where depleted batteries are replaced with fully charged batteries and the depleted batteries are charged off site.

A comprehensive overview of airport electrification infrastructure is included in ACRP Report 236, *Preparing Your Airport for Electric Aircraft and Hydrogen Technologies*[7]. Other considerations include constructing infrastructure to support aircraft operations powered by alternative fuels. Manufacturers are developing new engines that run on hydrogen fuel cells, are entirely electric, or are hybrid-electric aircraft. Alternative fuels that Florida airports may consider include:

- SAF.
- Hydrogen: Can be used to generate electricity to fuel or power aircraft.
- Hybrid: A hybrid configuration consists of multiple types of energy sources to optimize the efficiency of an aircraft's power.

Regardless of fuel type, understanding what type of aircraft activity is expected in a planning period is critical for infrastructure planning to meet the operational needs of the airport. Possible electrification of the Florida airports includes preparing the electric infrastructure needed to charge both aircraft and automobiles and to supply energy for buildings and navigational aids (NAVAIDs). Further consideration should be given to the electrical needs of tenants as some aeronautical and non-aeronautical businesses may have electrification plans of their own. Electrical infrastructure can take years to go from planning to implementation, so airports should work to stay ahead of demand.

Outside of charging infrastructure and the design of supporting infrastructure for aircraft hangars, electric aircraft do not necessarily need specialized facilities to operate at established airports. As stated earlier, eVTOLs and eCTOLs can use existing runways, taxiways, and parking aprons like other aircraft. Airports that expect high volumes of electric aircraft, particularly of eVTOLs, and airports with runway capacity challenges may want to consider providing dedicated landing facilities for the eVTOL fleet. This could help keep slow-moving eVTOLs out of the traffic pattern, freeing it up for more demanding business jets and airlines. This strategy could also help consolidate support

[7] National Academies of Sciences, Engineering, and Medicine. 2022. Preparing Your Airport for Electric Aircraft and Hydrogen Technologies. Washington, DC: The National Academies Press. https://doi.org/10.17226/26512

facilities, such as cargo, passenger processing, and charging, in a dedicated location instead of having these activities spread across the airport.

Siting a vertiport may affect the overall layout and infrastructure at an airport and could be more involved than siting a helicopter landing area since the FAA has only provided guidance in EB 105 and not published an AC pertaining to vertiports. Therefore, the following process is recommended in coordinating with the FAA on planning, designing, constructing, and operating a vertiport:

- Prepare a site plan in coordination with the FAA Airports District Office.
- Complete an environmental review.
- Update the Airport Layout Plan (ALP).
- Design and construct the vertiport.
- Operate the vertiport according to grant assurances and aviation regulations.

Terminals for eVTOL aircraft are another component that could be either a stand-alone facility, integrated into an existing passenger terminal, or operated as a fixed-base operator. The first full-scale, functional eVTOL terminal debuted in April 2022 in Coventry, England. The terminal, named Air One, was built by Urban-Air Port and occupies 20,000 square feet in an urban parking lot. The building features a rooftop landing deck that can be lowered to ground level for boarding and access to charging infrastructure, battery storage, and on-site command and control. The terminal has areas for check-in, waiting, concessions, security, and cargo. The landside features personal car parking, rental cars, Lyft and Uber pick up, and transit. Other concepts will develop over time, with developers like Skyports and Ferrovial bringing other options to the market.

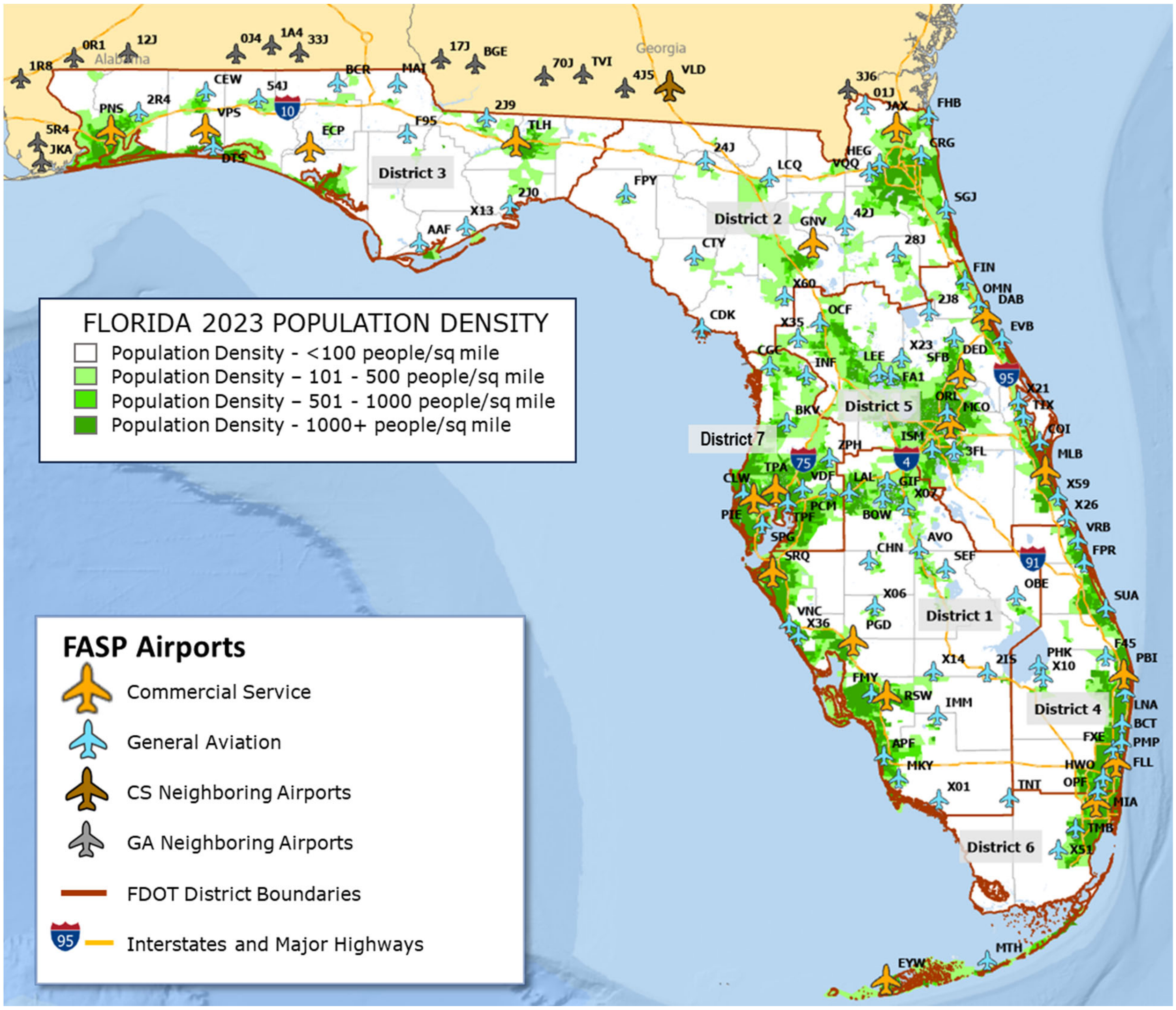
Electrification Trends at Florida Airports

The Florida Department of Transportation has seven districts which are home to 106 public use airports in Florida[8].The location of these districts and the airports are shown in **Figure 2**, along with the relative population distribution in the state.

- **District 1 (Southwest Florida):** Consists of 12 counties, and approximately 2.7 million residents.
- **District 2 (Northeast Florida):** Consists of 18 counties, and approximately 1.9 million residents.
- **District 3 (Northwest Florida):** Consists of 16 counties, and approximately 1.4 million residents.
- **District 4 (Southeast Florida):** Consists of five counties, and approximately 4.0 million residents.
- **District 5 (Central Florida):** Consists of nine counties, and approximately 4.1 million residents.
- **District 6 (South Florida):** Consists of two counties, and approximately 2.7 million residents.
- **District 7 (West Central Florida):** Consists of five counties, and approximately 2.8 million residents.

[8] Florida Department of Transportation (FDOT). 2022. Districts. Florida Department of Transportation: Tallahassee, Florida. https://www.fdot.gov/agencyresources/districts/index.shtm

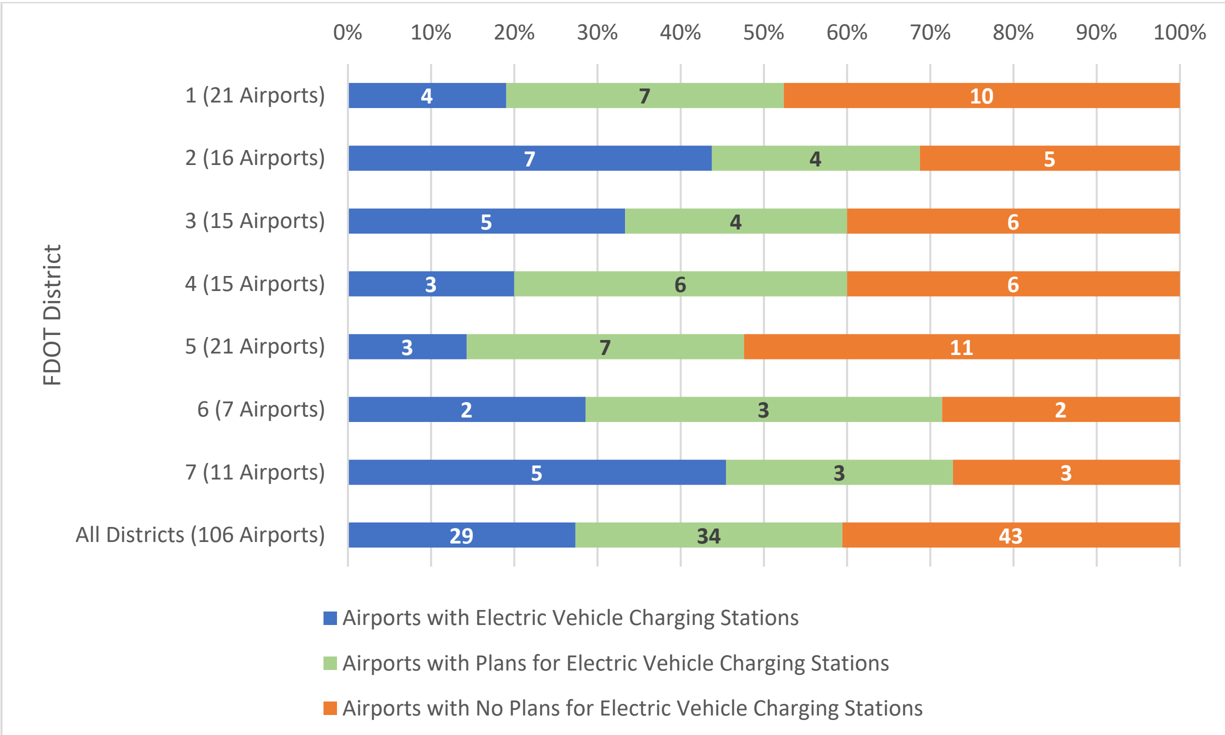
Figure 2. Florida Aviation System



Note: Areas shown in green denote significant population densities.
Source: Mead and Hunt, 2023

As part of the FASP 2043 update, an electronic survey was distributed to each of the public use airports within Florida. The survey consisted of yes or no questions asking if individual airports had existing, or future, electrification plans for automobiles (**Figure 3**) and aircraft (**Figure 4**). A free response section allowed airports to provide additional information or written comment. Only one of the 106 airports did not participate.

Figure 3. Electric Vehicle Charging Station Status at Florida Airports

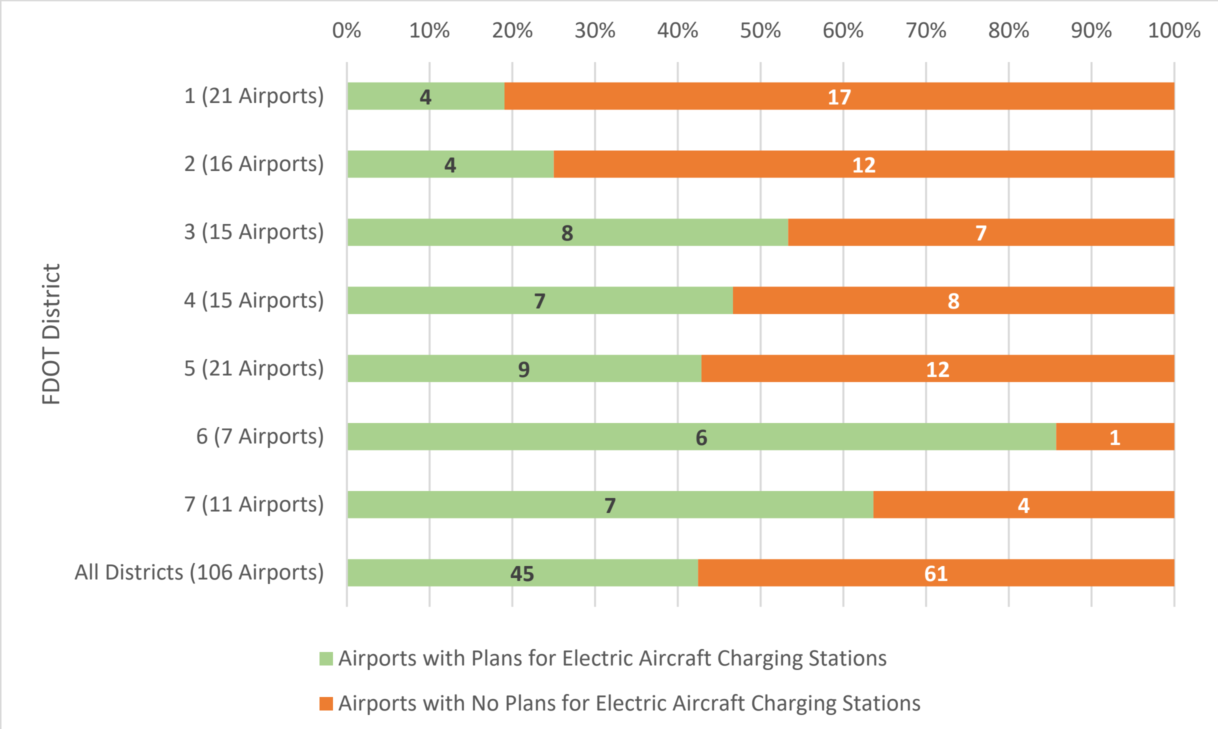


Source: Mead & Hunt, 2023

Takeaways from **Figure 3** include:

- 27 percent of airports have existing EV charging stations.
- 32 percent of airports are planning to have EV charging stations.
- 41 percent of airports do not have a plan to accommodate for EV charging stations.

Figure 4. Electric Aircraft Charging Station Status at Florida Airports

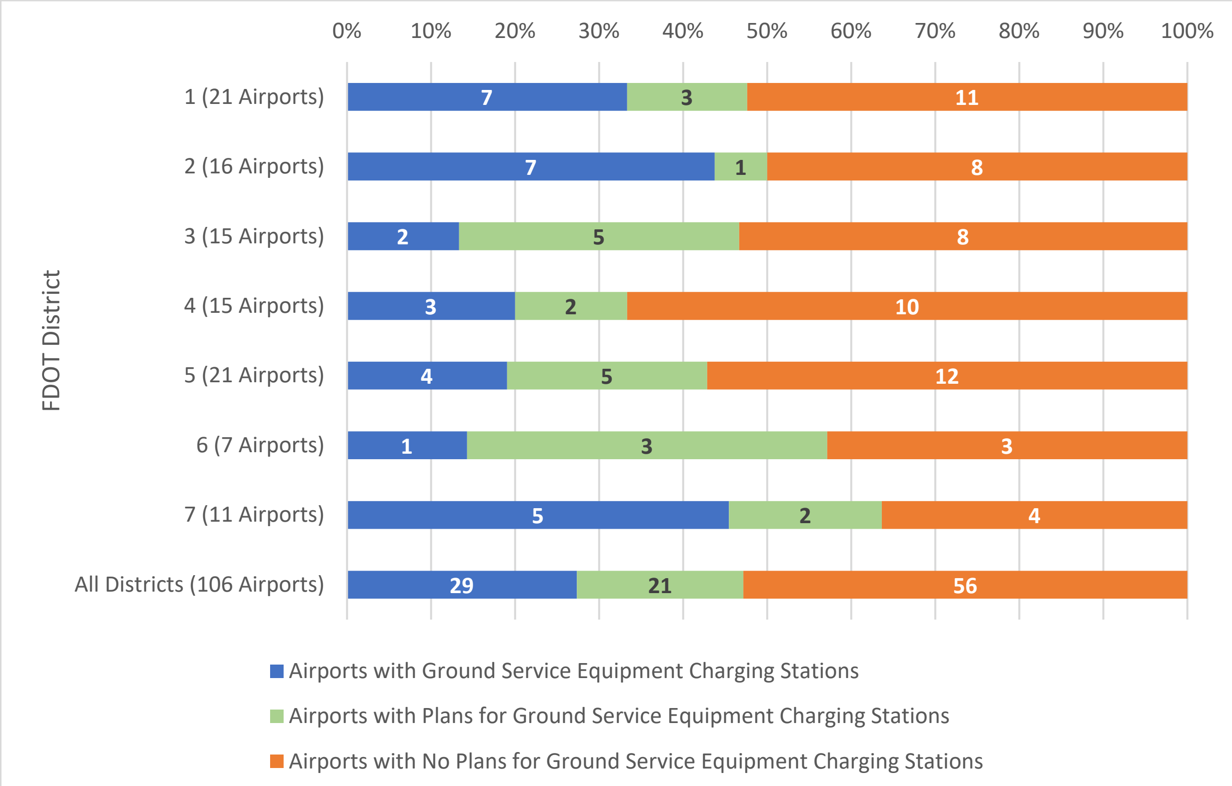


Source: Mead & Hunt, 2023

Takeaways from **Figure 4** include:

- No airports have existing electric aircraft charging stations.
- 42 percent of airports are planning to have electric aircraft charging stations.
- 58 percent of airports do not have a plan to accommodate electric aircraft charging stations.

Figure 5. Ground Service Equipment Charging Station Status at Florida Airports



Source: Mead & Hunt, 2023

Figure 5 shows the responses related to airport GSE charging stations. Takeaways from **Figure 5** include:

- 27 percent of airports have existing infrastructure for electric GSE.
- 20 percent of airports are planning to have infrastructure for electric GSE.
- 53 percent of airports do not have a plan to accommodate for electric GSE.

Figures 3, 4, and **5** indicate that electric charging stations for automobiles and GSE have established similar footholds at Florida airports, while charging stations for electric aircraft have yet to materialize. This should come as no surprise since electric aircraft development is still in its infancy compared to the more mature technology of electric vehicles and GSE. The certification requirements for electric aircraft face multiple hurdles that are expected to slow the deployment of electric aircraft for several years, at least.

These figures indicate that Florida's airports are primarily focused on serving EVs, with more than half planning to provide, or already providing, charging stations for EVs. The outlook for charging stations for GSE and electric aircraft is less rosy, with slightly more than 40 percent of Florida's airports planning to provide, or already providing (in the case of GSE), charging stations for these segments. In the case of electric aircraft, airports may be waiting for FAA certification before putting their plans into action. For GSE, other forms of propulsion, such as propane powered tugs, may be taking airport's attention away from electrification.

Sources of Funding

The electrification of airports is not limited to preparing for electric aircraft; the incentive to reduce emissions encompasses the use of vehicles for passenger transport, aircraft refueling and servicing, cargo loaders, ground service equipment (GSE), and security and emergency vehicles.

EVs have been in commercial production for decades and include hybrid internal combustion/electric motors and fully electric powertrains. Automobile electrification has been growing rapidly in the U.S. resulting from increasing consumer demand driven by government incentives and emissions reduction goals. This has encouraged automobile manufacturers to add more hybrid and fully EVs to their lineups. Market research firm IHS Markit released a report in April 2021 titled, *Pivoting to an Electrified Future: The Automotive Industry Amps Up*[9]. The report forecast up to 50 percent of U.S. passenger car sales will be electric automobiles by 2035.

Federal Funding

The FAA has committed to make aviation cleaner, quieter, and more sustainable by 2050 through a Climate Action Plan[10]. The United States Aviation Climate Action Plan was published in November 2021 and identifies electrification as a way to achieve net-zero emissions and offset carbon. Typical electric projects at commercial airports include the electrification of gates, ground support vehicles, geothermal vehicles, and solar hot water systems. Several programs provide funding to airports within the National Plan of Integrated Airport Systems (NPIAS) to incentivize them to reduce emissions. The programs authorized and funded by the FAA include the following:

Voluntary Airport Low Emissions Program (VALE): VALE was created in 2004 to encourage Airport Sponsors meet responsibilities listed in the Clean Air Act. Since then, several projects pertaining to electrification have been funded.

- **Funding Amounts:** Airport Sponsors can use Airport Improvement Program (AIP) Passenger Facility Charges (PFCs); funding varies depending on the Airport Sponsor.[11] In fiscal year 2023, the VALE program funded five projects with a total of $13.9 million. Funding levels in fiscal year 2022 were similar, with five projects funded with $14.5 million.
- **Eligible Projects:** Alternative Fuel Vehicles, Gate Electrification, Remote Ground Power, Ground Support Equipment (GSE), Geothermal Systems, Solar Thermal Technologies, and Underground Fuel Hydrant Systems.[12]

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[9] HIS Markit. 2021. “Pivoting to an Electrified Future.” April 21, 2021. https://cdn.ihsmarkit.com/www/pdf/0421/675485260-0421-CU-AUT-ZEV-Whitepaper.pdf

[10] Federal Aviation Administration (FAA). n.d. “Working to Build a Net-Zero Sustainable Aviation System by 2050.” https://www.faa.gov/sustainability#climate-action-plan-international-leadership

[11] Voluntary Airport Low Emissions Program Grant Summary Fiscal Year (F Y) 2005 - 2023, October 2023 (faa.gov)

[12] Voluntary Airport Low Emissions (VALE) Program (faa.gov)

Zero Emission Vehicle (ZEV) Program: This program incentivizes airports to use zero emission technologies.

- **Funding Amount(s):** Airport Sponsors can use AIP funding to purchase ZEVs; funding varies depending on the Airport Sponsor.[13] The ZEV program funded 20 programs in fiscal year 2023 with $19.5 million. This was a significant increase over fiscal year 2022, when only $13.2 million was awarded for seven projects.
- **Eligible Projects:** A 12-page Technical Guidance document was published by the FAA on March 8, 2022 to guide Airport Sponsors on eligibility and the application process.[14]
- **Eligible Airports:** All public use airports that are classified in the NPIAS are eligible for funding.

The following two projects are listed in the FAA's Climate Action Plan. However, eligible projects and funding are not disclosed on the website.

- **Energy Efficiency Program:** Typical projects include light-emitting diode lighting or other energy efficiency measures.

- **Sustainability Program:** This program has since been eligible for inclusion in Airport Master Plans addressing a broad array of environmental and energy activities (e.g., recycling, green construction and operations, energy efficiency, renewable energy, water quality, and climate resilience).

<u>**State Funding**</u>

Projects eligible for state funding vary state to state. There are several state funding opportunities that support the electrification of airports. One example is the Washington State Department of Transportation (WSDOT), which lists the following sustainable aviation projects online that support the electrification of eligible state airports[15]:

- Sustainable aviation fuel storage.
- Electrification of ground support equipment.
- Electric aircraft charging infrastructure.
- Airport clean power production.
- Electric vehicle (EV) charging stations or fuel cell electric vehicle (FCEV) stations (hydrogen) whose infrastructure may also support ground support equipment and/or electric aircraft charging.

In addition, WSDOT provides application guidance, evaluation criteria, and defines eligible applicants. Not all states provide electrification funding opportunities.

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[13] Zero Emission Vehicle and Infrastructure Pilot Program Grant Summary Fiscal Year (FY) 2015 - 2023 (faa.gov)
[14] Zero Emission Vehicle Pilot Program Technical Guidance, version 2, 2022 (faa.gov)
[15] Aviation grants | WSDOT (wa.gov)

Next Steps and Challenges

Several infrastructure companies and original equipment manufacturers (OEMs) are working to obtain the first Airworthiness Certification from the FAA to support the global initiative of electrification. The certification process includes[16]:

- A review of any proposed designs and the methods that will be used to show that these designs and the overall airplane comply with FAA regulations.
- Ground tests and flight tests to demonstrate that the airplane operates safely.
- An evaluation of the airplane's required maintenance and operational suitability for introduction of the airplane into service.
- Collaboration with other civil aviation authorities on their approval of the aircraft for import.

While most electric aircraft are considered experimental, many designers are aiming for certification as early as 2024 and an entry into the national airspace system soon thereafter. Financial firm Morgan Stanley released a market assessment in 2019 titled *Are Flying Cars Preparing for Takeoff?*[17] predicting that the electric aircraft market could exceed 15 trillion dollars by 2040. As of November 2023, the Advanced Air Mobility Reality Index (ARI), published quarterly, shows the top 25 primary companies designing and flight-testing electric aircraft and dozens of smaller players and suppliers. There are over 800 entrants in the AAM industry that are not listed within the ARI.[18] ARI is published to reflect the OEMs predicted to be first to market based on level of funding, established corporate leadership, technology readiness, and ability to reach full-scale manufacturing in a short timeframe. **Table 1** reflects the top ten leading OEMs as of November 2023.

[16] FAA. 2023. Airworthiness Certification. January 6, 2023. Washington, D.C., https://www.faa.gov/aircraft/air_cert/airworthiness_certification
[17] Morgan Stanley. 2019. Ideas: "Are Flying Cars Preparing for Takeoff?" January 23, 2019. https://www.morganstanley.com/ideas/autonomous-aircraft
[18] SMG Consulting, LLC. 2023. "Advanced Air Mobility Reality Index." https://aamrealityindex.com/aam-reality-index

Table 1. Top 10 Leading OEMs According to the ARI

OEM (stock ticker)	Funding ($M)	Use Case	Vehicle Type	Propulsion	Operation	Vehicle(s)	First Flight	EIS[1]	Country
Joby Aviation (NYSE: JOBY)	$2,251.30	Air Taxi	Vectored Thrust	Electric	Piloted	N/A	2018	2025	USA
Beta Technologies	$796.0*	Cargo, Regional, Air Taxi	Conventional/ Lift + Cruise	Electric	Piloted	CX300/Alia-250	2020/2022	2025	USA
Volocopter	$761.0*	Air Taxi	Multicopter/ Lift + Cruise	Electric	Piloted	VoloCity/ VoloRegion	2021/2022	2024/ 2026	Germany
Archer (NYSE: ACHR)	$1,096.30	Air Taxi	Vectored Thrust	Electric	Piloted	Midnight	2023	2025	USA
Ehang (NASDAQ: EH)	$160.40	Tourism, EMS, Firefighting	Multicopter/ Lift + Cruise	Electric	Autonomous	EH216-S/ VT-30	2018/2021	2023	China
Wisk (Boeing)	Corporate backed	Air Taxi	Vectored Thrust	Electric	Autonomous	Generation 6	N/A	N/A	USA
Elroy Air	$50.00	Cargo	Lift + Cruise	Hybrid	Autonomous	Chaparral C1	2023	2024	USA
AutoFlight	$200.00	Air Taxi	Lift + Cruise	Electric	Piloted	Prosperity I	2022	2026	China
Eve Holding (NYSE: EVEX)	$377.40	Air Taxi	Lift + Cruise	Electric	Piloted	Eve	2024	2026	Brazil
Pipistrel (Textron)	Corporate backed	Cargo	Lift + Cruise	Hybrid	Autonomous	Nuuva V300	2024	2025	USA

Notes:
1. Estimated Entry into Service (EIS)
2. Information not available (N/A)
Source: SMG Consulting, LLC, "Advanced Air Mobility Reality Index," Accessed November 1, 2023.

The FAA and the European Union Aviation Safety Agency (EASA) are tasked with certifying electric aircraft in the U.S. and European Union, respectively. While many manufacturers have entered flight-testing, they are still adjusting their aircraft for certification. These manufacturers, working with the FAA and EASA as well as the aviation regulatory authorities of other countries, are charting a path to certification. Some of the more ambitious companies are predicting an entry-into-service (EIS) date of 2024 (e.g., Volocopter and Elroy Air), while others are expecting to enter service as late as 2026 (i.e., Eve Holding and AutoFlight). Historically, OEMs have published optimistic estimated EIS dates. For example, in 1998 Bell and Boeing partnered to design the AugustaWestland (AW609), a civil tiltrotor aircraft. In 2002, the certification of the AW609 was projected for 2007[19]. Despite its first flight[20] in 2003, as of November 2023, the AW609 is still

[19] FlightGlobal. 2002. "Bell Aiming for BA609 Certification in 2007," *Flight International via FlightGlobal*, October 7, 2002.
[20] Bogaisky, J. 2020. "After 24 Years, the Civilian Version of the Marines' V-22 Osprey Tiltrotor is Finally Nearing Takeoff," *Forbes*, March 9, 2020.

not certified[21]. This is in large part due to the new nature of the aircraft and the FAA having to develop aircraft certification standards to address its unique tiltrotor capabilities. These same aircraft certification standards are expected to apply to similar types of eVTOL aircraft, so certification of these eVTOL aircraft is dependent on when the FAA finalizes these aircraft certification standards, or any changes the FAA decides to implement to the standards.

This illustrates why the certification of electric aircraft is more than likely to take longer than OEMs anticipate. A key challenge for certification is that they require a ground up design, and the FAA is still developing certification standards for electric aircraft. This is the case for both electric propulsion systems, and some of the eVTOL aircraft designs that fall under what the FAA classifies as powered lift. The AW609 example cited previously is planning to obtain certification under the forthcoming FAA powered lift rules.

As an example of these challenges, Joby has collaborated with the FAA to establish a five-stage process for certifying its aircraft. Joby has managed to work its way to the third stage, but the FAA has yet to settle on finalized rules for certification of powered lift aircraft.

How FDOT AO May Prepare for Electrification at Airports

Electrification is one of the many solutions the FDOT AO can implement to prepare Florida airports for work towards the FAA's Sustainability 2050 initiative, but there are other sustainable fuels like hydrogen and SAF. The full extent of market forces and engineering challenges are still unknown and are being discovered as technology emerges. FDOT AO may encourage plans for electric aircraft and vehicle electrification through the following recommendations:

- **Encourage and Help Airports Plan for Electrification Infrastructure** – The FDOT AO could both encourage and help airports plan for the installation of charging infrastructure for electric aircraft and vehicles. This includes helping airports decide how to determine the number and layout of charging stations placed at airports for electric aircraft and airport operations/maintenance vehicles, as well as rental car parking facilities and passenger vehicle parking lots. The FDOT AO could also assist airports in how to initiate a comprehensive energy use study to determine future power demands including evaluation of the capacity needed from transmission line infrastructure. Finally, the FDOT AO could encourage and assist airports in developing emergency contingency plans in the event a temporary loss of power is experienced from public utilities.
- **Involvement with Development of eVTOL Airways and Vertiport Siting** – With the possible growth of eVTOL use, the FDOT AO could play an important role in working with the FAA to develop dedicated flight corridors for these vehicles between vertiports so that operations do not interfere with other aeronautical activity within Florida's aviation system. This could help establish flight paths and dedicated corridors that could safely accommodate growing use without interfering with other fixed-

[21] Johnson, O. 2023. "FAA pilots fly Leonardo AW609 for first time as certification enters 'final stage'." *AvFoil News*, March 7, 2023.

and rotary-wing aircraft operations while also considering compatible and non-compatible land uses under these flight paths.

- **Encourage Airports to Electrify Vehicle Fleets** – Airports with large operations, maintenance, and emergency service vehicle fleets, such as at air carrier service airports, could be encouraged to purchase electrified models of vehicles and be encouraged to install associated charging infrastructure, where feasible. This includes encouraging the use of electrified transit vehicles to shuttle passengers between terminal buildings, parking lots, and rental car facilities. Creating financial incentives for electric vehicle purchases to assist airports with the cost of these purchases could encourage their use.
- **Support Initiatives to Improve Power Transmission to Airports** – The FDOT AO could assist airports in improving power supplies through public utility transmission by facilitating conversation with suppliers about the energy demands anticipated from electric aircraft and vehicle operations. This could include initiating a system-wide study to evaluate the potential power demands of airports across the state. Carrying out coordination with airports directly could also help to evaluate existing and anticipated power demands as a part of determining the overall electrical demand of the system's airports.
- **Continual Evaluation of Airport System in Meeting Electrical Demands** – As part of a system-wide study, an effort to develop performance metrics measuring how well electrification demands are being met at Florida's airports could be implemented. Similar to performance measures that are developed for other system goals, these metrics could be used to focus resources in areas where improvements are needed to meet demand. These performance measures could be included as part of the overall evaluation of the system of airports in the next update of the Florida Aviation System Plan.

Conclusion

The electrification of airports may have short- and long-term impacts on the economy, environment, and community. Florida airports may need to engage government agencies, the business community, educational partners, utility providers, nonprofit organizations, and residents to develop a plan that benefits all stakeholders.

Planning for electrification should follow a process similar to other types of facility planning. Airports should inventory what exists, determine future demand, prepare a gap analysis, develop improvements to address deficiencies, and prepare a capital plan that considers the expenditures and potential revenues. Electric aircraft and vehicles are already operating and may grow in popularity in the coming decades. Due to the extended lead time needed to update electrical grids, airports and their neighbors should incorporate electrical studies into their planning documents and engage with their stakeholders and utility providers during the planning and implementation processes. The FDOT AO could assist by encouraging system airports to install electrification infrastructure and help initiate planning exercises to determine the level of demand. The FDOT AO could also help identify the power demands of airports in working with public utilities to understand the improvements in transmission infrastructure that may be needed. Finally, continually evaluating trends and how airports are accommodating the electrification demands will support efforts to focus resources to improve areas of deficiency, which allows Florida's airports to be well positioned to accommodate this growing emerging trend and align with the FAA's Aviation Climate Action Plan.

Additional Resources

A list of international, federal, state, and other resources are listed below for consideration:

International:

- **European Union Aviation Safety Agency Urban Air Mobility Resource Library[22]:** A study conducted by EASA to provide a better understanding of society's acceptance of Urban Air Mobility (UAM) operations throughout the European Union.
- **EASA – *Prototype Technical Specifications for Vertiports*[23]:** The report contains suggestions and ideas regarding the design of vertiports in Europe. Factors considered include obstacles, vertical landing operations, noise abatement, and environmental impacts.

Federal:

- **ASTM F2490-20[24]:** A standard guide that analyzes the electric load and power source capacities of aircraft that meet FAA requirements. The guide does not address safety concerns associated with the use of electric propulsive power or electrical loads.
- ***Advanced Air Mobility Implementation Plan*[25]:** The FAA published a working paper to document the work required to enable the initial AAM operations in a variety of operational settings.
- ***Urban Air Mobility (UAM), Concept of Operations, Version 2.0*[26]:** The FAA published a working paper to provide a technical roadmap to enable UAM operations with a focus on urban areas.

State:

- ***FDOT Advanced Air Mobility*** (https://www.fdot.gov/aviation/advanced-air-mobility). FDOT maintains a web page that explains many aspects of advanced air mobility (AAM). It also has links to other useful AAM pages, and several documents published by FDOT, including *FDOT*

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[22] European Union Aviation Safety Agency. 2023. "Urban Air Mobility." https://www.easa.europa.eu/en/light/topics/urban-air-mobility
[23] European Union Aviation Safety Agency. 2022. "Prototype Technical Design Specifications for Vertiports." https://www.easa.europa.eu/en/document-library/general-publications/prototype-technical-design-specifications-vertiports
[24] ASTM International. 2020. ASTM F2490-20: Standard Guide for Aircraft Electrical Load and Power Source Capacity Analysis. West Conshohocken, PA, Jul 27, 2020. https://www.astm.org/f2490-20.html
[25] FAA. 2023. *Advanced Air Mobility (AAM) Implementation Plan, Version 1.0*. July 2023. Washington, D.C. https://www.faa.gov/sites/faa.gov/files/AAM-I28-Implementation-Plan.pdf
[26] FAA. 2023. *Urban Air Mobility (UAM) Concept of Operations Version 2.0*. April 26, 2023. Washington, D.C. https://www.faa.gov/sites/faa.gov/files/Urban%20Air%20Mobility%20%28UAM%29%20Concept%20of%20Operations%202.0_0.pdf

Advanced Air Mobility Working Group (August 2023), and *FDOT AAM Implementation and Public Outreach Plan* (September 2023).

- ***Electric Aircraft Working Group Report* (WSDOT)[27]:** The report explores how electric aircraft technology could be used to expand regional air mobility (RAM) markets in Washington State.
- ***Advanced Air Mobility Roadmap*[28]:** The FDOT published a paper in June 2022 to better define AAM and the relationship between AAM and the state of Florida.
- **City of Los Angeles's *Advanced Air Mobility Vertiport Considerations: A List and Overview*[29]:** The document addresses 450 considerations for various groupings pertaining to the AAM ecosystem and its stakeholders.
- ***Advanced Air Mobility, Ohio AAM Framework*[30]:** Ohio DOT provided a strategic framework to provide readers a better understanding of the AAM industry. The document summarizes the infrastructure, policies, and technologies in place as of July 2022.
- ***Report and Recommendations of the Urban Air Mobility Advisory Committee*[31]:** The document assesses current (September 2022) state law regarding UAM and provides suggestions for potential changes, as well as providing guidance on the development of UAM operations and infrastructure for the State of Texas.
- ***Advanced Air Mobility & Unmanned Aircraft Systems Legislative Report*[32]:** The report summarizes the working group's findings regarding the implementation and growth of drone package delivery, aerial taxis and electric aircraft use in Utah.

Other:

- **ACRP Report 236 – *Preparing Your Airport for Electric Aircraft and Hydrogen Technologies*[33]:** Explores the potential growth market of AAM and provides guidance to help estimate the future impacts of electric aircraft to airports.

[27] Washington Department of Transportation. 2019. https://wsdot.wa.gov/sites/default/files/2021-11/ElectricAircraftWorkingGroupReport-June2019.pdf

[28] Florida Department of Transportation. 2022. "Advanced Air Mobility Roadmap." Tallahassee, Florida. https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/aviation/fdot-aam-roadmap-report---june-28-2022-final.pdf

[29] Mendonca, N. , Murphy, J., Patterson, M., Alexander, R., Juarez, G., and Harper, C. Advanced Air Mobility Vertiport Considerations : A List and Overview. City of Los Angeles https://ntrs.nasa.gov/api/citations/20220007100/downloads/Vertiport%20Considerations%20Paper%20Final%20v2.pdf

[30] Ohio Department of Transportation. 2022. *Advanced Air Mobility: Ohio AAM Framework*. https://uas.ohio.gov/wps/wcm/connect/gov/ad6a839a-13fa-4266-b0ee-e9590d82d3e2/Aug2022_AAM+Planning+Framework_Sm.pdf?MOD=AJPERES

[31] Texas Department of Transportation. 2022. *Report and Recommendations of the Urban Air Mobility Advisory Committee*. https://ftp.txdot.gov/pub/txdot/avn/uam-report.pdf

[32] Utah Department of Transportation. 2023. https://www.udot.utah.gov/connect/employee-resources/uas/

[33] National Academies of Sciences, Engineering, and Medicine. 2022. *Preparing Your Airport for Electric Aircraft and Hydrogen Technologies*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26512

- **ACRP Project 11-02/43 – *Successful Community Inclusion of Advanced Air Mobility*[34]:** Assesses potential impacts of urban air mobility at airports, which includes a primer for the coordination of community, airport, and applicable agencies relative to AAM activity. This report also recommends steps to successfully integrate AAM activity in their communities.
- **ACRP Research Report 243 – Urban Air Mobility: An Airport Perspective[35]:** The document provides a comprehensive examination of the emerging UAM industry, with a particular focus on its impacts and opportunities for airports.

[34] Transportation Research Board Airport Cooperative Research Program. 2023. ACRP 11-02/Task 43: *Successful Community Inclusion of Advanced Air Mobility.* Washington, D.C. https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5213
[35] National Academies of Sciences, Engineering, and Medicine. 2023. *Urban Air Mobility: An Airport Perspective*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26899