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Report to Congressional Requesters

August 2023

AIRPORT INFRASTRUCTURE

Selected Airports' Efforts to Enhance Electrical Resilience

GAO-23-105203

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GAO Highlights

Highlights of GAO-23-105203, a report to congressional requesters

Why GAO Did This Study

The nation's commercial service airports require continuous, reliable electricity to power airfield operations and airport facilities. FAA and airports are responsible for ensuring the resilience of airports' electrical power systems—including the ability to withstand and recover rapidly from electrical power disruptions.

GAO was asked to review major power outages at airports and steps federal agencies and airports are taking to minimize future disruptions. This report describes (1) the extent to which selected airports reported they had experienced electrical power outages since 2015, (2) actions selected airports have taken to improve the resilience of their electrical power systems, and (3) actions FAA has taken to help airports develop and maintain resilient electrical power systems.

GAO conducted semi-structured interviews with officials from 41 selected airports of varying sizes, representing 72 percent of passenger enplanements. GAO administered a follow-up survey to these 41 airports, focusing on the extent to which they had experienced electrical outages; 30 responded to the survey, representing 53 percent of total enplanements. GAO also reviewed applicable statutes and regulations and analyzed funding data to identify examples of electrical power projects. Further, GAO interviewed FAA officials and airport, academia, state government, and energy stakeholders.

View GAO-23-105203. For more information, contact Heather Krause at (202) 512-2834 or KrauseH@gao.gov.

What GAO Found

Twenty-four of the 30 commercial service airports that responded to GAO's survey and interviews reported experiencing a total of 321 electrical power outages—i.e., an unplanned loss of power lasting 5 minutes or longer—from 2015 through 2022. Eleven of these airports reported having six or more outages over this 8 year period. Airports reported that these outages affected a range of airport operations and equipment (see table). Not all responding airports were able to provide detailed information about their outages, and some provided estimates about affected activities.

Reported Effects of a Portion of Electrical Power Outages on Selected Airport Activities and Equipment, 2015-2022 (percentage of outages)

Airport activity or equipment affected	Yes	No	Don't know
Baggage handling	34%	30%	35%
Concessions	22%	26%	50%
Other (e.g., automated people movers, escalators)	18%	9%	15%
Gate/boarding	16%	34%	49%
Check-in/ticketing	16%	33%	50%
Parking	14%	34%	52%
Communications	13%	32%	54%
Flight delays & cancellations	11%	30%	59%

Source: GAO analysis of airport survey responses. | GAO-23-105203

Note: Airports provided responses on whether outages affected specific airport activities or equipment for 114 of the 321 electrical power outages, with the exception of flight delays and cancellations, for which information was provided for 119 outages. Percentages may not add up to 100 due to rounding or missing responses. For more details, see table 1 in GAO-23-105203.

Selected airports reported taking several actions to improve the electrical power resilience of their airports, including (1) conducting electrical infrastructure assessments, (2) undertaking projects to improve electrical infrastructure, and (3) installing equipment to generate additional backup power. For example, 40 of the 41 airports GAO interviewed reported planning or completing an infrastructure project to increase electrical power resilience. Of these, four airports reported installing microgrids. Such microgrid systems are capable of independently generating, distributing, and storing power.

The Federal Aviation Administration (FAA) is administering new and expanded grant programs and issuing guidance to support airports' electrical resilience efforts. For example:

- Airport Improvement Program funding eligibility was expanded to include the Energy Supply, Redundancy, and Microgrids Program projects, which may include certain electrical power resilience projects.
- The new Airport Terminal Program provides funding for airport terminal development projects, including those that may strengthen resilience.
- FAA issued program guidance and conducted airport outreach to help increase airports' awareness of available federal funding for resilience projects.

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Abbreviations

AAM	advanced air mobility
AIP	Airport Improvement Program
DHS	Department of Homeland Security
DOE	Department of Energy
eVTOL	electric vertical take-off and landing (aircraft)
FAA	Federal Aviation Administration
FERC	Federal Energy Regulatory Commission
HVAC	heating, ventilation, and air conditioning
LED	light-emitting diode
MWAA	Metropolitan Washington Airports Authority
NAS	National Airspace System
NPIAS	National Plan of Integrated Airport Systems
PFC	passenger facility charge
QER	Quadrennial Energy Review
TSA	Transportation Security Administration
VTOL	vertical take-off and landing

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August 29, 2023

The Honorable Sam Graves
Chairman
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Garret Graves
Chairman
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

The nation's commercial service airports, which moved approximately 847 million passengers and 105 million tons of cargo in calendar year 2022, require continuous, reliable electricity to power airfield operations and airport facilities. Ensuring the resilience of airports' electrical power systems—including the ability to withstand and recover rapidly from disruptions—is a shared responsibility between the Federal Aviation Administration (FAA) and airports.[1] The FAA, which is responsible for the safe and efficient operation of airports and the National Airspace System (NAS), requires NAS facilities to have reliable and economical electrical power sources to provide safe, secure, and efficient air traffic control. In addition, both the primary and backup systems must provide sufficiently reliable and available electrical power to safely guide arriving and departing aircraft. According to FAA, airports are responsible for determining their supplemental electrical power needs and plan for contingencies in the event of an outage that would affect other airport

[1]The term "resilience," as defined by a 2013 presidential policy directive, means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, and naturally occurring threats or incidents. See White House, Office of the Press Secretary, *Presidential Policy Directive—Critical Infrastructure Security and Resilience Presidential Policy Directive*/PPD-21 (Washington, D.C.: Feb. 12, 2013). In the context of airport electrical resilience, resilience can include building redundant electrical infrastructure and maintaining backup power sources to allow for electrical service to be shifted to those sources when an outage occurs to help ensure continuous power. It may also include managing existing and future power system requirements to reduce demands on an electrical power source, such as by increasing energy efficiency.

infrastructure, such as passenger and cargo terminal buildings, baggage machines, and aircraft gates.[2]

In recent years, several electrical power outages at major U.S. airports affected airport terminal facilities and resulted in significant air travel disruptions, drawing attention to airports' electrical power resilience efforts. For example, in February 2023, an outage at New York's John F. Kennedy International Airport Terminal 1 resulted in cancelled and delayed flights and disrupted various services in the airport terminal. Likewise, in December 2017, an approximate 11-hour electrical power outage at the Hartsfield-Jackson Atlanta International Airport led to the cancellation of about 1,200 flights and cost one airline an estimated $50 million.

You asked us to review major power outages at airports and steps federal agencies and airports are currently taking to minimize future disruptions. This report describes (1) the extent to which selected airports reported they had experienced electrical power outages since 2015, (2) actions selected airports have taken to improve the resilience of their electrical power systems, and (3) actions FAA has taken to help airports develop and maintain resilient electrical power systems.

To describe selected airports' reported electrical power outages since 2015 and actions taken to improve the resilience of their electrical power systems, we analyzed information collected from selected airports through interviews, written responses, and a web-based survey. Specifically, we conducted semi-structured interviews with officials from 41 selected airports.[3] See appendix I for a list of these airports. We selected these 41 airports based on airport hub sizes and enplanements. Specifically, we selected airports with the greatest number of passenger

[2]For purposes of this report, we refer to facilities as infrastructure.

[3]Airports provided written responses or participated in interviews with GAO. Some airports provided both written responses and participated in interviews. We also interviewed officials from Boeing Field/King County International Airport and California Redwood Coast-Humbolt County Airport for exploratory purposes. These airports were not among our 41 selected airports.

enplanements and cargo traffic in 2019 within each hub size category.[4] The 41 selected airports comprised approximately 72 percent of passenger enplanements in 2019. We interviewed airport officials about their airports' electrical power infrastructure, outages, capital planning projects, future electrical power requirements, and federal agency support, among other topics. In addition, we conducted site visits to nine of the 41 selected airports to observe these airports' electrical power infrastructure and operations.[5]

Additionally, we administered a web-based survey to the 41 selected airports that allowed us to calculate descriptive statistics to quantify airport officials' collective views on topics, including airports' electrical power outages, electrical infrastructure, and future electrical power requirements. Of the surveyed airports, 30 airports (73 percent) responded. These 30 airports represented 53 percent of total enplanements in calendar year 2019. Because there is no comprehensive data on airport electrical power outages, and because many airports do not track detailed information on electrical power outages, many airports provided estimates or varying levels of information about the number, duration, causes, and effects of the electrical power outages they experienced.[6] The information provided often represented airport officials' best estimates of outages and their effects.

To characterize airports' responses to the interviews, written questions, and our online survey, we defined modifiers to quantify airport responses as follows:

- "most" if three-fourths or more of responding airports provided information on a topic,

[4]There are five hub size categories which are defined under federal statute and based on annual U.S. commercial passenger boardings (i.e., enplanements). See 49 U.S.C. § 47102. COVID-19 had a significant impact on air traffic from 2020 through 2021. Therefore, we relied on FAA enplanement and cargo traffic data for calendar year 2019 to make our selections because we determined this to be the most recent and representative data set available at the time of our selection.

[5]We conducted site visits to the following airports: Baltimore/Washington International Thurgood Marshall; Charlotte/Douglas International; Dallas-Fort Worth International; Hartsfield-Jackson Atlanta International; John Wayne/Orange County; Long Beach (Daugherty Field); Pittsburgh International; San Diego International; and San Francisco International.

[6]Our survey provided space for each airport to include detailed information for up to 20 electrical power outages.

- "many" if at least one-half but less than three-fourths of responding airports provided information on a topic,
- "some" if at least one-fourth but less than one-half of responding airports provided information on a topic, and
- "few" if fewer than one-fourth of responding airports provided information on a topic.

The perspectives of officials at these 41 selected airports are not generalizable to those at other airports. However, they allow us to provide examples of airports' electrical resilience efforts.

To determine the actions FAA has taken to help airports develop and maintain resilient electrical power systems, we reviewed applicable statutes and regulations, FAA documents describing its Airport Improvement Program (AIP), and other relevant programs, guidance, and policies. For example, we reviewed FAA's AIP Handbook, Passenger Facility Charges (PFC) guidance, and FAA Advisory Circulars, such as its guidance on airport emergency planning. In addition, we analyzed project descriptions of FAA AIP grant awards and PFC approvals from fiscal years 2015 through 2022 to identify examples of electrical power projects that were funded from these sources and may have resulted in improving airports' electric power resilience.[7] All dollar figures in this report are reported without adjustment for inflation. We also reviewed descriptions of airport awards made under FAA's Airport Terminal Program. In addition, we interviewed FAA officials to obtain information about FAA's role in supporting airports' electrical power resilience efforts. We also interviewed officials from the Department of Energy's (DOE) National Renewable Energy Lab and Department of Homeland Security's (DHS) Transportation Security Administration (TSA) to learn about how they coordinate with airports and FAA on airport resilience efforts. We selected these agencies because they provide airports with assistance for their electrical power resilience efforts through research, assessments, and inspections of airport's electrical infrastructure.

To address all objectives, we reviewed our previous reports, including our *Disaster Resilience Framework: Principles for Analyzing Federal Efforts to Facilitate and Promote Resilience to Natural Disasters*, which identifies

[7]We used key word searches of FAA's AIP award and PFC approvals in order to identify examples of expenditures on projects that may have directly or indirectly enhanced the reliability and resilience of airport electric power systems.

three broad principles that federal agencies and policy makers can consider when analyzing opportunities to mitigate the effects of natural disasters.[8] We also reviewed reports from the National Academies of Sciences, Engineering, and Medicine, Transportation Research Board, and other relevant reports on airport resilience efforts.[9] We interviewed airport stakeholders, including representatives from the Airports Council International-North America, and representatives from academia, state government, and energy consultants to obtain additional perspectives on airport power resilience efforts. We selected these stakeholders based on background research and prior GAO work. See appendix II for a list of stakeholders we interviewed.

We conducted this performance audit from May 2021 to August 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Airports and Their Electrical Power Infrastructure

The U.S. has about 19,000 airports, which vary substantially in size and the type of aviation services they support. Approximately 3,300 of these airports are included in the National Plan of Integrated Airport Systems (NPIAS). These airports are eligible for federal assistance for airport development projects.

Commercial service airports—which are public airports, have scheduled service, and board at least 2,500 or more passengers per year—are classified into one of five categories based on their annual passenger

[8]GAO, *Disaster Resilience Framework: Principles for Analyzing Federal Efforts to Facilitate and Promote Resilience to Natural Disasters,* GAO-20-100SP, (Washington D.C: Oct. 23, 2019).

[9]Examples of reports that we reviewed include National Academies of Sciences, Engineering, and Medicine, *Airport Energy Efficiency and Cost Reduction*, (Washington, D.C.: 2010); National Academies of Sciences, Engineering, and Medicine, *Airport Climate Adaptation and Resilience*, (Washington, D.C.: 2012); National Academies of Sciences, Engineering, and Medicine, *Airport Microgrid Implementation Toolkit*, (Washington, D.C.:2021); and National Academies of Sciences, Engineering, and Medicine, *Investing in Transportation Resilience: A Framework for Informed Choices*, (Washington, D.C.: 2021).

boardings or enplanements.[10] Of those, the three categories that support the highest levels of passenger boardings are large hub, medium hub, and small hub airports.[11] Regardless of size or type, the U.S. airports that are part of the NPIAS are predominantly owned by states, counties, cities, or local public authorities, which are also referred to as airport sponsors.

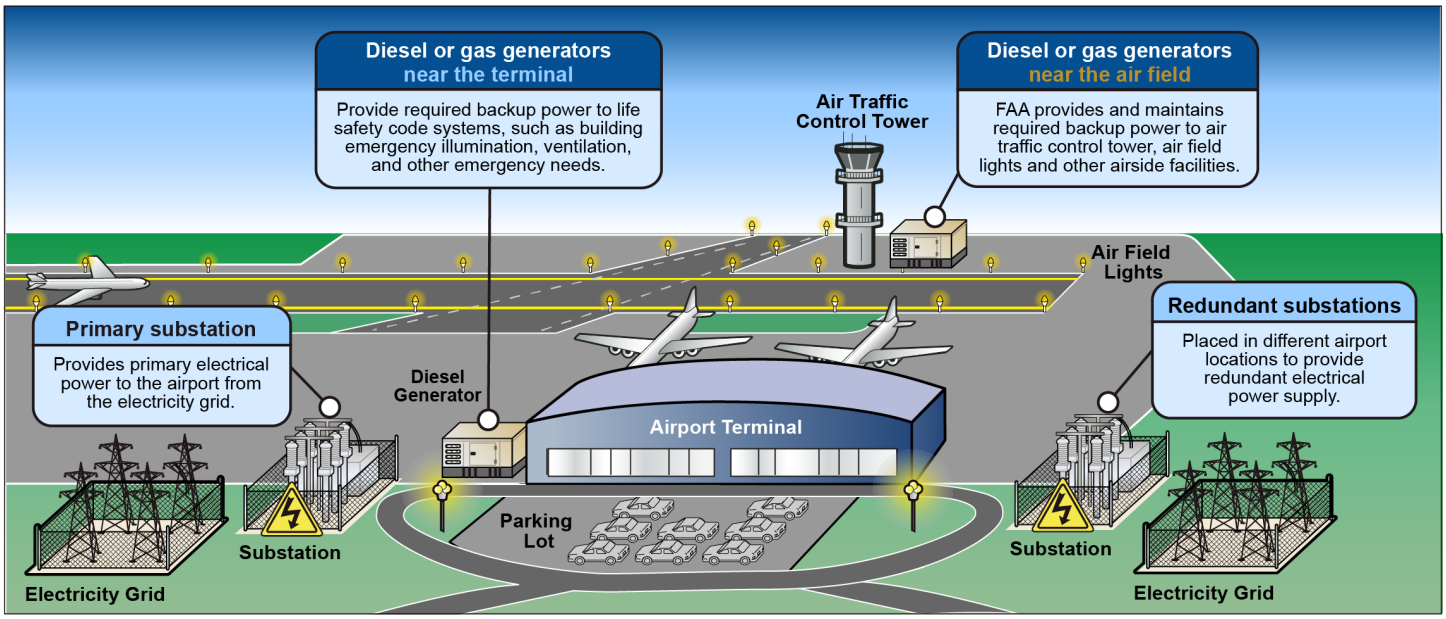
Commercial service airports depend on local electric utilities to support their operations. Electrical power is typically distributed to an airport's electrical facilities from a local utility's distribution system. This power supports FAA's air traffic control electrical infrastructure as well as electrical infrastructure throughout airport facilities and non-airfield grounds. As shown in figure 1, some airports have more than one substation that can provide redundant or backup electrical power to the airport.[12] An airport may also have several emergency power supplies, such as diesel or natural gas generators.

[10]*See* 49 U.S.C. § 47102.

[11]"Large hub" airports are those airports that enplane 1 percent or more of all passenger boardings. "Medium hubs" enplane at least 0.25 percent but less than 1 percent of all passenger boardings. "Small hubs" enplane at least 0.05 percent but less than 0.25 percent of all passenger boardings. "Nonhub airports" enplane less than 0.05 percent of all passenger boardings. "Primary nonhub" airports enplane more than 10,000 passengers but less than 0.05 percent of all passenger boardings, while "nonprimary airports" enplane at least 2,500 and no more than 10,000 passenger boardings. *See* 49 U.S.C. § 47102.

[12]Some larger airports own and operate their distribution substations, while some smaller airports may rely on service from a single distribution transformer owned and operated by the electric utility.

Figure 1: Example of Electrical Power Redundant Capability at an Airport



Source: GAO. | GAO-23-105203

The electricity grid is susceptible to disruptions from aging infrastructure, extreme weather events, cyberattacks, and other risks that can damage electrical infrastructure and communications systems, resulting in power outages that can affect airport operations.[13] According to the Quadrennial Energy Review and the U.S. Global Change Research Program's *Fourth National Climate Assessment*, extreme weather events have been the principal contributors to an increase in the frequency and duration of power outages in the U.S.[14] Our prior work on U.S. energy infrastructure

[13]In prior work, we reviewed risks to the U.S. electricity grid. GAO, *Electricity Grid Resilience*, GAO-21-105403, (Washington, D.C.: Sept. 20, 2021). For example, we examined cybersecurity risks to the grid and federal efforts to address those risks. See GAO, *Critical Infrastructure Protection: Actions Needed to Address Significant Cybersecurity Risks Facing the Electric Grid*, GAO-19-332, (Washington, D.C.: Aug. 26, 2019) and GAO, *Electricity Grid Cybersecurity: DOE Needs to Ensure Its Plans Fully Address Risks to Distribution Systems*, GAO-21-81, (Washington, D.C., Mar. 18, 2021).

[14]See Quadrennial Energy Review (QER) Task Force, *Transforming the Nation's Electricity System: The Second Installment of the QER* (January 2017); and U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, vol. II (Washington, D.C.: 2018). Extreme weather includes high winds, thunderstorms, hurricanes, heat waves, intense cold periods, intense snow events and ice storms, and extreme rainfall.

resilience found that extreme weather resulting from climate change is expected to have far-reaching effects on the electricity grid that could cost billions, including costs of power outages to utility customers and costs from storm damage, among other costs.[15]

Roles and Requirements for Electrical Power Redundancy at Airports

FAA is responsible for providing safe and efficient air navigation services to the NAS and requires that NAS "airside facilities"—which include air traffic control towers and runway lighting—have the necessary primary and standby or backup electrical power systems to maintain safe, secure, and efficient air traffic control.[16] FAA develops and implements operational contingency plans for mitigating the impacts of disruptions on safe and reliable air traffic control services. It also issues advisory circulars, one of which provides guidance to airports for developing and implementing airport emergency plans. These plans include how airports will maintain continuity of air traffic control services during power outages.[17]

FAA has set additional backup power requirements at 50 airports in the U.S., known as "continuous power airports," which are selected based on their activity and location. According to FAA, FAA standby power systems (such as generators) that support these airports' operations are legally required. The agency also recommends that the backup power system at a continuous power airport be capable of maintaining runway operations for at least 4 hours in the event of a utility power failure. Generators installed at these airports should be capable of powering a control tower, airport surveillance radar, approach-light system, instrument landing system, and runway lights on the primary runway.

[15]GAO, *Electricity Grid Resilience: Climate Change is Expected to Have Far-reaching Effects and DOE and FERC Should Take Actions*, GAO-21-346 (Washington, D. C.: Mar. 5, 2021). GAO made the following recommendations to the Department of Energy (DOE) and Federal Energy Regulatory Commission (FERC): 1) DOE should develop a department-wide strategy to enhance grid resilience to climate change, and (2) FERC should identify and assess climate change risks to the grid and plan a response. DOE and FERC agreed with GAO's recommendations and have taken steps to address them. DOE plans to update its strategy, and FERC has held a technical conference but has not yet identified actions it needs to take.

[16]Federal Aviation Administration, *Electrical Power Policy*, JO 6030.20G (Mar. 21, 2019).

[17]Federal Aviation Administration, *Airport Emergency Plan*, AC 150/5200-31C (June 19, 2009). FAA regulations require airport operators to develop and maintain these plans. 14 C.F.R. § 139.325.

FAA does not require that airports have backup power to support areas serving travelers and the general public (i.e., “landside facilities”). Rather, airports determine their electrical power requirements and plan for power outage contingencies for their landside facilities. According to FAA guidance, airports must also meet local building codes.[18] FAA stated that these codes include applicable life safety codes that require airport terminals and aircraft loading walkways to provide for occupant evacuation that meet specific requirements and have the ability to be powered by an emergency standby power system. Beyond applicable life safety code requirements, airports may choose to power other landside equipment and systems that the airports deem important to maintain operations during an outage. These systems may include passenger baggage handling systems, ticketing kiosks, and concessionaire services in passenger terminals.

There are several approaches that airports may take to increase their electrical resilience and continue to operate through electrical power disruptions, according to literature we reviewed. For example, airports may have redundant connections (i.e., more than one connection) to utility-provided electrical power. This can help to ensure continued supply of power for all or some essential airport services in case a substation is disrupted. Airports may also have on-site backup generators to supply electricity in case of an area-wide power outage from the utility. Other airports may invest in renewable energy systems, such as solar energy installations and storage technologies to capture energy for later use.

Another option for airports to continue operations through electrical power disruptions is by installing a “microgrid,” which is a system capable of generating, distributing, and storing power.[19] According to a report by the National Academies of Sciences, Engineering, and Medicine, microgrids offer the potential to reduce utility costs, improve grid reliability, and enhance the resilience of critical facilities.[20] Specifically, the report noted that depending on cost-effectiveness and other considerations, a microgrid can provide electrical power for the needs of some airports, and

[18]See FAA, Advisory Circular 150/ 5370-10H, *Standard Specifications for Construction of Airports*, (Washington, D.C.: Dec. 21, 2018).

[19]For the purposes of certain FAA grant funding, a microgrid is generally a system of interconnected loads and distributed energy resources, such as generators, that can operate in parallel with the utility grid or in another mode. *See* 49 U.S.C. § 47102(3)(P).

[20]National Academies of Sciences, Engineering, and Medicine, *Airport Microgrid Implementation Toolkit.*

can allow an airport to disconnect and operate independently from the electricity grid. Since airports draw large amounts of power from the electricity grid, independently powered airports could alleviate some strain on the electricity grid during times of high demand and reduce the risk of utility power outages. Microgrids can also enable parts of the grid to independently maintain power during a larger service disruption.

Funding Sources for Airport Electrical Resilience Projects and Other Federal Assistance

The 3,300 airports in the U.S. that are part of the NPIAS are eligible to use federal grants and revenues from passenger charges for planning and infrastructure development, which can include electrical power projects in limited circumstances. Federal agencies may also provide airports with other assistance, such as assessing airport electrical power needs and vulnerabilities.

Federal funding available to airports includes Airport Improvement Program (AIP) grants, which may be used for airport planning and development, including some electrical resilience projects.[21] FAA's AIP program provides more than $3 billion in grants each year for airport planning and infrastructure development and noise compatibility planning and programs.[22] Federal AIP grants include entitlement funds, which are available each fiscal year to airport sponsors and states for eligible projects, and discretionary funds that FAA may award for eligible projects based on a priority score.[23] The amount of entitlement funds is calculated using a statutory formula. Discretionary funds are awarded by FAA on a competitive basis using selection criteria and a priority system, which FAA uses to rank projects based on the extent to which they reflect FAA's nationally identified priorities. AIP grants must be used for "eligible and justified" projects, which are planned and prioritized by airports, included

[21]The airport development projects eligible for AIP funding include certain activities defined by statute. *See* 49 U.S.C. § 47102(3); 49 U.S.C. § 48103.

[22]For fiscal years 2020 and 2021, the annual AIP grant funding increased to over $13 billion, which includes both annual appropriations and additional financial support due to the COVID-19 pandemic. We previously reported that this additional funding allowed airports to respond to the COVID-19 pandemic, including funding their operations and meeting their ongoing debt payments. See GAO, *COVID-19 Pandemic: Observations on the Ongoing Recovery of the Aviation Industry*, GAO-22-104429, (Washington D.C.: Oct. 21, 2021).

[23]Discretionary funding includes the available funding that remains after entitlements are calculated using statutory formulas, supplemental funding made available under annual appropriations acts, and certain other funds that were deposited into the small airport fund. 49 U.S.C. §§ 47115-47116. See GAO, *Airport Infrastructure: Information on Funding and Financing for Planned Projects,* GAO-20-298, (Washington D.C.: Feb. 13, 2020).

in their capital improvement plans, and reviewed and approved by FAA staff and the Secretary of Transportation. Eligible projects include certain improvements related to enhancing airport safety, capacity, and security and addressing environmental concerns.[24] For AIP-funded projects, the airport must provide a share of matching funds. The federal share is generally from 75 to 90 percent depending on the size of the airport or type of project.[25]

Airports can also use revenues from passenger facility charges (PFCs) to support aviation-related ground infrastructure projects, including electrical power resilience projects. PFCs are federally authorized fees added to passenger ticket prices.[26] These fees were statutorily authorized to be imposed in 1990 in part to help pay for infrastructure at commercial service airports. FAA oversees the PFC program and approves applications by airports to collect PFC revenues. Airports can use their revenues to cover the costs of all or part of an FAA-approved project that meets statutory and regulatory requirements. These projects include airport development and planning, terminal development, noise capability planning, and gate construction projects.[27]

[24]Generally, most types of airfield improvements are eligible for AIP funding. In some specific situations, projects for airport areas serving travelers and the general public may be eligible for AIP funding. These may include improvements to entrance roadways, pedestrian walkways and movers, and common space within terminal buildings, such as waiting areas.

[25]In certain instances, the federal share may be increased. For example, the federal share for airports in economically distressed communities is typically 95 percent. Additionally, the CARES Act provided $500 million to pay the federal share for some AIP projects in 2020, permitting those projects to be 100 percent federally funded. The American Rescue Plan Act of 2021 provided an additional $608 million to pay the federal share of AIP infrastructure costs for grants awarded in fiscal year 2021 and certain grants awarded in fiscal year 2020.

[26]The PFC for each ticket is currently capped at $4.50 per flight segment with a maximum of two PFCs charged on a one-way trip, for a maximum of $9 total, or four PFCs on a round trip, for a maximum of $18 total. On behalf of the airports, airlines collect the PFC at the time of the ticket purchase and remit the PFC, minus an administrative fee, to the airport. 49 U.S.C. § 40117.

[27]In addition, airports can use PFC revenues for some infrastructure projects that might not be eligible for AIP funding. PFCs can also generally be used as matching funds for AIP-funded projects or to make payments for debt service related to carrying out these projects. Airport terminal development projects that address the aging infrastructure of the nation's airports may also be funded through the Airport Terminal Program, a competitive discretionary grant program that FAA is administering under the project grant authority for the AIP.

Other federal agencies also provide airports with assistance for their electrical power resilience efforts. For example, DOE's National Renewable Energy Lab (NREL) provides assessments of energy needs for both airfield and terminal operations, including facilities, ground vehicle electrification, and aerial vehicle electrification.[28] According to DOE, the lab provides these assessments for a fee when requested by an airport.

In addition, TSA conducts airport inspections, which are not solely focused on airports' electrical power systems but, according to TSA, include those systems as a component of the inspections.[29] According to TSA officials, the TSA Joint Vulnerability Assessment Unit, in coordination with the Federal Bureau of Investigation, conducts inspections triennially at selected airports. The purpose of these inspections is to reduce the risk of an attack and to mitigate the consequences of an attack on airports and the civil aviation system. As part of its inspections, the TSA Joint Vulnerability Assessment Unit interviews airport personnel about the airport's electrical system. According to officials, these interviews include questions about the extent to which the airport has identified single points of failure, incorporated redundancies to improve resiliency, established fire suppression systems, and documented key power lines at the airport.

Most Selected Airports Reported Experiencing Power Outages Since 2015

Twenty-four of the 30 airports that we interviewed and surveyed reported experiencing a total of 321 electrical power outages[30]—i.e., an unplanned loss of power lasting 5 minutes or longer—from 2015 through 2022.[31] According to responding airports, some were able to provide the precise number of outages they experienced, while other airports estimated the

[28]According to DOE, this lab works across energy carriers, evaluating fuels from petroleum, sustainable aviation fuels, natural gas, electrification, hydrogen, and other related renewable energy sources as these energy sources converge at transportation nodes such as airports.

[29]See 49 U.S.C. § 44904(b).

[30]In this report, we define "electrical power outage" as an unplanned loss of power lasting 5 minutes or longer to the entire airport, or to one or more areas of the airport, including airport terminals and electrical equipment supporting airport functions.

[31]Out of 41 selected airports, we received detailed information on the number of electrical power outages from 30 airports. This included 28 airport responses from our online survey and two airport responses that we collected from written responses. We omitted one airport's survey response from this analysis because we were unable to confirm whether the information provided corresponded to our definition of an electrical power outage.

number.[32] Thirteen of these airports reported having one to five outages, and 11 reported having six or more over this 8-year period. For those outages for which airports provided information on duration, the outages lasted from 5 minutes to more than 1 week.[33] More than half of these outages lasted 2 hours or less, while nearly a quarter lasted 4 hours or longer.

Effects of Outages

With regard to impacts, airports reported that electrical power outages affected a range of airport operations and equipment. The information airports provided often represented airport officials' best estimates of those impacts. As shown in table 1, airports reported that baggage handling and concessions were the most common activities affected during electrical power outages.[34]

[32]Because there is no comprehensive data on the number of airport electrical power outages, and because many airports do not track detailed information on electrical power outages, many airports provided estimates about the number, duration, causes, and effects of the electrical power outages they experienced. Other airports provided either varying levels of information on their electrical power outages or did not provide this information.

[33]Our survey provided space for each airport to include detailed information for up to 20 electrical power outages. Airports provided information on the duration of 88 of the 321 electrical power outages the airports reported experiencing from calendar years 2015 through 2022.

[34]Our survey provided space for each airport to include detailed information for up to 20 electrical power outages. Airports provided information on the airport activities or equipment affected for 114 of the 321 electrical power outages airports reported experiencing from calendar years 2015 through 2022, with the exception of flight delays and cancellations, for which airports provided information for 119 of the 321 electrical power outages reported.

Table 1: Reported Effects of a Portion of Electrical Power Outages on Selected Airport Activities and Equipment, 2015-2022 (percentage of outages)

Airport activity or equipment affected[a]	Yes	No	Don't know
Baggage handling	34%	30%	35%
Concessions	22%	26%	50%
Other[b]	18%	9%	15%
Gate/boarding	16%	34%	49%
Check-in/ticketing	16%	33%	50%
Parking	14%	34%	52%
Communications	13%	32%	54%
Flights delays and cancellations[c]	11%	30%	59%

Source: GAO analysis of airport survey responses. | GAO-23-105203

Notes: Thirty of the 41 selected airports responded to GAO's online survey, which provided space for each airport to include detailed information for up to 20 of the electrical power outages the airport reported experiencing from calendar years 2015 through 2022. Many airports do not track detailed information on electrical power outages, and, as a result, some airports provided estimates about the airport activities or equipment affected by each electrical power outage. Other airports provided either varying levels of information on their electrical power outages, or did not provide detailed information about their outages. Percentages may not add up to 100 due to rounding or missing responses.

[a]Airports reported 321 electrical power outages from calendar years 2015 through 2022 in total. In response to our survey questions, airports provided responses on whether outages affected specific airport activities or equipment for 114 of the 321 electrical power outages the airports reported experiencing, with the exception of flight delays and cancellations, for which information was provided for 119 outages.

[b]Several airports also reported that "other" activities or equipment were affected by electrical power outages, such as an automated people mover and escalators.

[c]Airports provided responses on whether their electrical power outages resulted in flight delays and cancellations for 119 of the 321 electrical power outages the airports reported experiencing.

The impact on airport operations from electrical power outages can persist even after power has been restored. For example, a severe storm caused an electrical power outage at one large hub airport and, although the outage only lasted a few hours, the airport said that, due to the outage, it experienced flight delays and cancellations until the next day.

Some airports also said they experienced voltage sags and surges that did not cause an electrical power outage but did affect airports' electrical equipment, such as elevators and escalators.[35] For example, one medium hub airport reported that the airport has experienced numerous voltage

[35]During our interviews or in written responses, a small number of airports (11) reported brief electrical service disruptions, including voltage sags or surges. For example, one airport characterized these service disruptions as momentary and reported that the airport experienced over 200 such service disruptions from calendar years 2015 through 2021.

fluctuations that required staff to perform manual resets of equipment, such as baggage systems.

Causes of Outages

Airports provided information on the causes of 121 of the electrical power outages they reported experiencing.[36] While causes of reported outages varied, those cited by selected airports we surveyed and interviewed generally fell into the following three broad categories and included factors both within and outside the airports' control.[37]

- **Utility electrical infrastructure failure.** For those outages for which airports provided information on causes, airports attributed nearly half of them to electrical infrastructure or equipment failure by the utility company that services the airport. For example, according to one small hub airport, an automobile accident damaged utility power lines and equipment, causing the airport's power outage. A large hub airport reported that it experienced an electrical power outage lasting approximately 50 minutes, which was caused when a local utility transmission tower was struck by construction equipment.
- **Airport electrical infrastructure failure.** For those outages for which airports provided information on causes, airports attributed about one-third of them to an electrical infrastructure or equipment failure on airport property, caused by a variety of factors including maintenance errors or aging electrical infrastructure. For example, one large hub airport identified an incorrectly installed switch as the cause of an outage at the airport rental car facility. In addition, a small hub airport reported experiencing an electrical power outage lasting 2 hours when a planned maintenance repair tripped a breaker. A few (3) airports attributed at least one of their electrical power outages to aging electrical infrastructure. For example, one large hub airport reported that a mechanical failure in an aging switchgear caused a power loss at an airport substation. An Airports Council International-North America representative told us that aging airport infrastructure, including electrical infrastructure, is a concern for some airports. The

[36]Airports provided information on the causes of 121 of the 321 electrical power outages airports reported experiencing from calendar years 2015 through 2022. However, because many airports do not track detailed information on electrical power outages, the information provided often represented airport officials' best estimates of outages and their causes.

[37]Airports may not know the direct causes of outages. For example, an airport may have reported an electrical power outage that resulted from electrical infrastructure or equipment failure by the utility company that services the airport, but not have information on the direct causes (e.g., extreme weather or aging infrastructure) of the utility's electrical infrastructure or equipment failure.

representative added that some airports have legacy terminals that have not been renovated or updated for several years, which might place airports at risks for future electrical power outages.

- **Severe weather.** For those outages for which airports provided information on causes, airports attributed a few to severe weather that damaged their airport or utility service provider's electrical equipment or infrastructure. Some of the reported impacts of these events were significant. For example, one medium hub airport stated it lost power due to a utility power outage that lasted multiple days because of Hurricane Ida. Other airports described power outages caused by lightning strikes that damaged electrical infrastructure and equipment. According to a National Academies of Sciences, Engineering, and Medicine report, a third of U.S. electrical power outages are attributed to weather-related causes and power line damage caused by falling trees.[38] Similarly, a representative from the Airports Council International-North America told us that severe weather events are a major contributor to electrical power outages at airports.

Airports' Actions to Improve Electrical Resilience Include Assessments, Infrastructure Improvements, and Additional Power Sources

Selected airports reported taking several steps to improve the electrical power resilience of their airports, including: (1) conducting airport electrical infrastructure assessments, (2) undertaking projects to improve electrical infrastructure, and (3) installing equipment to generate additional backup power.

[38]National Academies of Sciences, Engineering, and Medicine, *Microgrids and Their Application for Airports and Public Transit*, (Washington, D.C.: 2018).

Conducting Electrical Infrastructure Assessments

During our interviews or in written responses, most of the selected airports (33) reported planning or completing assessments of their respective airports' electrical power infrastructure.[39] According to airports, these assessments included the identification of potential risks to the airport power system, such as single points of failure, as well as recommending improvements to electrical power systems to address these risks and improve electrical power resilience. Airports described assessments of varying depth and breadth, from targeted assessments examining electrical infrastructure of individual capital projects to comprehensive assessments of the airport's entire electrical infrastructure. For example, one airport reported that as part of the airport's planning and design process for critical, large-scale projects, an assessment is conducted to determine the need for adding redundancy to its electrical system (e.g., additional service feeds and transformers). Another airport described its electrical system assessment as a broad review of the airport's electrical infrastructure, including the condition, age, and capacity of its electrical power infrastructure.

In addition, a number of airport officials that we interviewed mentioned having undergone third-party assessments. Four airports said that they contracted with DOE's NREL to assess their electrical infrastructure. According to NREL, its assessments support airports' long-term facility, infrastructure, and energy planning efforts through a wide range of services. This support can include assessing energy systems' resilience to identify airport electrical infrastructure risks as well as evaluating airport renewable energy options, such as solar and wind power. In addition, airport officials from four airports said TSA (in coordination with the Federal Bureau of Investigation) has conducted targeted security inspections at their airports, which includes assessing the risk of power disruptions to airport security.

Other airports stated that they conducted assessments to estimate their respective airport's future power demand and to identify recommendations for necessary electrical upgrades to increase airport electrical capacity and meet future demand. For example, in anticipation of increased demand from electric vehicles and electric aircraft, one

[39]Of the 41 selected airports, 39 airports provided information related to planning or completing electrical infrastructure assessments during our interviews or in written responses. Thirty-three airports reported planning or completing assessments of their airports' electrical power infrastructure, while six airports reported no such assessments. Two airports did not respond to questions about their airport's electrical infrastructure assessments.

airport is currently conducting an assessment to address challenges associated with electric power distribution at existing facilities that were not originally designed for this purpose.

Airport officials that we interviewed and surveyed reported that future power demand from electric vehicles, such as electric ground service vehicles, rental car fleets, and public-facing electric vehicle chargers, and aircraft will require new electrical infrastructure investments. Specifically, some airports (13) reported that over the next 10 years, increased electrical demand from electric vehicles will have a major impact on their electrical power infrastructure. About one-third of airports surveyed (11) reported expecting a moderate impact.[40] One airport official noted that the electrification of rental car fleets to meet the varied rental car agencies' stated climate change goals will have significant impacts on electrical demand at their airport. Another airport official stated that the airport's existing electrical power infrastructure is not suitable for the increased demand from electric vehicles. This official stated that upgrades to the existing infrastructure will be necessary to accommodate this additional demand. Similarly, many airports reported that new electric aircraft will have either a major (8) or moderate (7) impact on their electrical infrastructure, although a third of the airports (10) reported being unsure about the impact of electric aircraft.[41]

According to airport officials we interviewed and literature we reviewed, to accommodate increased electrical demand in the future, airports will require a range of additional electrical infrastructure. Two airports also raised concerns about the costs associated with procuring charging

[40]Overall, 30 airports provided information about the anticipated future impacts of electric vehicles. Three airports reported that electric vehicles would have a minor effect, two airports reported that they were unsure about the impact of electric vehicles, and one airport said that electric vehicles will have no effect on their electrical resilience over the next 10 years.

[41]Overall, 30 airports provided information about anticipated future impacts of electric aircraft. Two airports reported that electric aircraft would have a minor effect, and three airports reported that electric aircraft will have no effect on their electrical resilience over the next 10 years. We previously reported that electrically powered aircraft, such as electric vertical take-off and landing (eVTOL) aircraft, may soon transform the aviation market with services known as "Advanced Air Mobility" (AAM), but that a number of issues will need to be addressed by industry and the federal government before AAM operations can be widely implemented. See GAO, *Transforming Aviation: Stakeholders Identified Issues to Address for 'Advanced Air Mobility,'* GAO-22-105020 (Washington, D.C., May 9, 2022) and GAO, *Transforming Aviation: Congress Should Clarify Certain Tax Exemptions for Advanced Air Mobility*, GAO-23-105188 (Washington, D.C., Nov. 30, 2022).

stations, which include installation (equipment, labor, materials) and annual costs (information technology services, power consumption, and maintenance). One of these airports estimated the costs of installing electric vehicle chargers for approximately one-fourth of its parking spaces to be approximately $61.5 million. According to an NREL report, similar to electric vehicles, there will be a need for a range of charging stations with a variety of charging speeds to accommodate various types of electric aircraft, such as passenger or cargo.[42]

Electrical Infrastructure Improvement Projects

Almost all airports (40) reported planning or completing an electrical infrastructure project that increased or could increase their electrical power resilience.[43] These electrical infrastructure improvements included projects to upgrade existing electrical systems, add redundant electrical infrastructure, and improve airports' energy efficiency. For example:

- In response to the Atlanta Hartsfield-Jackson International Airport's power outage in 2017, one large hub airport reported undertaking electrical infrastructure improvement projects to eliminate 90 percent of its single points of failure. For example, the airport has more than one substation and has installed a device that automatically switches power to an alternate substation in the event one of the substations loses power.
- Another large hub airport reported having quarterly meetings with the airport's utility company to review past power outages and find corrective actions to mitigate the events. Airport officials reported that the utility company recently improved the resiliency of the airport's main feeder lines by removing the overhead power lines and installing the lines underground.

[42]A range of charging speeds could include slow charging that would charge aircraft within 1 to 8 hours and fast charging that would charge aircraft within as little as 15 minutes, to accommodate shorter residence times. This range of charging times corresponds to a range of electric aircraft applications. For example, it is anticipated that some electric cargo planes will fly to a location in the morning and stay all day only to return in the evening, whereas some passenger planes will land and take off as quickly as they can exchange passengers, maximizing operational efficiency of the aircraft. See Jordan Cox, Tom Harris, Kathleen Krah, James Morris, Xiangkun Li, and Scott Cary, *Impacts of Regional Air Mobility and Electrified Aircraft on Airport Electricity Infrastructure and Demand* (Washington D.C: National Renewable Energy Laboratory, Feb. 2023).

[43]Of the 41 selected airports, 40 airports responded to provide information about their planned or completed electrical infrastructure projects. In some instances, these projects were completed by the utility in consultation with the airport.

- One medium hub airport described working with its utility provider to obtain a dedicated power line that would service only the airport. The airport also reported plans to add additional power lines to provide an adequate power supply for future airport upgrades.
- Nearly all of the airports we included in our interviews (35) reported that they are currently undertaking or completing projects to improve their energy efficiency, such as installing LED lighting and improved heating ventilation and air-conditioning.[44] By becoming more energy efficient, airports lower their energy demand and reduce the amount of standby power from generators needed in the event of an electrical power outage.

Installing Backup Power Sources

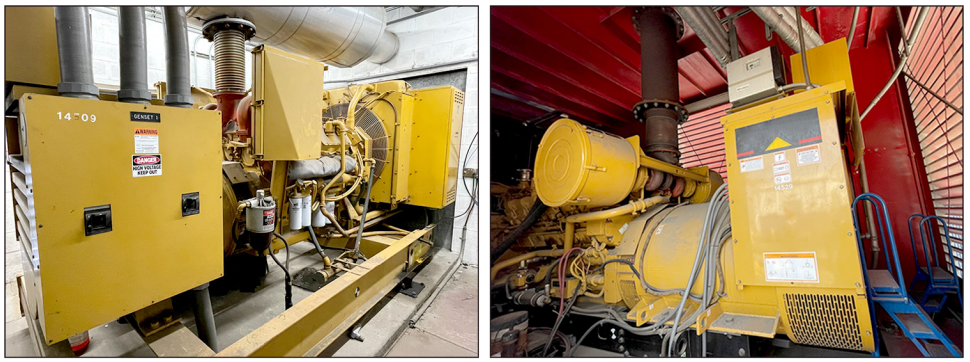
All of the selected airports we spoke with reported having backup power sources, including generators, to provide power for their airports in the event of an electrical outage. In addition, many airports reported having solar panels or microgrids to generate power on airport property to supplement utility power and, in a few instances, provide additional backup power in the event of an electrical power outage.

Generators

All selected airports reported that they use generators to provide backup power for life and safety equipment, which includes ensuring power for exit lighting and fire protection equipment in the event of a power outage. Additionally, some airports also reported having backup generators to maintain some level of airport operations in the event of an outage (see fig. 2). Specifically, many (24) airports said they are able to power other airport systems, such as operation centers and computer rooms, to maintain some level of terminal operations during an electrical power outage. For example, one medium hub airport reported that its generators can provide power to jet bridges to allow passengers to board or disembark from flights. A few airports (7) reported having enough generators to temporarily provide full power throughout a terminal in the event of an outage. For example, one large hub airport reported having 10 diesel fuel generators and enough fuel on site to power the entire airport for 3 weeks. Two airports reported investing in additional generators in response to an electrical power outage.

[44]Of the 41 selected airports, 35 airports provided information on their planned or completed energy efficiency projects during our interviews or in written responses.

Figure 2: Examples of Backup Generators at an Airport



Source: GAO. | GAO-23-105203

Solar panels

Many airports (25) reported that they had installed or plan to install solar panels on airport property, including on the roofs of airport parking garages, among other places.[45] One large hub airport reported also having batteries to store excess electricity generated by their solar panels. The airport reported charging its batteries when airport power consumption is low and discharging energy stored in the battery as the airport approaches its peak power consumption.

While many airports have installed solar panels, officials from other airports cited challenges, including the costs of battery storage and the space needed to produce solar power at an appreciable scale, as reasons they have not installed solar panels. Solar energy production can vary significantly with climate, and as a result, it may not be a viable option for all airports without also incorporating an energy storage system. Officials from one medium hub airport said that they had evaluated installing solar panels with battery storage at their airport, but the airport ultimately declined to pursue the project due, in part, to the high cost of battery storage at that time. We have previously reported that the per kilowatt-hour cost of large-scale lithium-ion batteries has declined rapidly in recent years. Decreases in the cost of battery storage technology could drive increased adoption of renewable energy sources such as solar power.[46] One medium hub airport told us that the airport did

[45]In some instances, airports stated they lease property to firms that install solar panels. A number of airports stated they lower their energy costs by pushing the solar-generated power back through the meter to the utility provider.

[46]GAO, *Utility-Scale Energy Storage: Technologies and Challenges for an Evolving Grid*, GAO-23-105583 (Washington, D.C., Mar. 30, 2023).

not own enough wide-open plots of land needed to install a sufficient number of solar panels to make solar power a viable backup power source for the airport.

Another reason airport officials stated they had not installed solar panels was the potential for reflections from solar panels to affect air traffic control. Under FAA policy, FAA relies on an airport's statement on whether its proposed solar project will not produce glint (a momentary flash of bright light) or glare (a continuous source of bright light) that could affect air traffic control operations.[47] Its policy also encourages airports to conduct an analysis of whether this might occur before submitting the required notice for the proposed project, which contains the statement. One large hub airport reported that the airport evaluated installing solar panels but could not identify a suitable place on airport property where the panels would not cause glare that could impact the airport's air traffic control operations.

[47]While solar photovoltaic or solar hot water systems (solar energy systems) are designed to absorb solar energy to maximize electrical energy production or the heating of water, in certain situations the glass surfaces of the solar energy systems can reflect sunlight and produce glint and glare. FAA has learned that glint and glare from solar energy systems could result in an ocular impact to airport traffic control tower personnel working in the tower cab, and compromise the safety of the air transportation system. FAA will rely on the sponsor to confirm that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport traffic control tower cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the airport traffic control tower cab. Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports, 86 Fed. Reg. 25801 (May 11, 2021).

Figure 3: Example of Solar Panels at Denver International Airport

Source: Denver International Airport. | GAO-23-105203

Microgrids

A few (4) airports reported installing microgrids to independently power the entire airport or provide additional backup power, and a few other airports (8) reported that they are considering installing one.[48] Of the airports that reported installing microgrids, one reported that its decision was primarily based on the cost savings it would obtain from generating its own electric power. Specifically, airport officials stated that the airport's microgrid is fueled by natural gas extracted from airport property and supplied to the airport at a discount by a third party. Another airport reported that it currently uses its microgrid only as a backup power source. One large hub airport reported that it is considering installing solar panels on the airport's unused acreage to support a future microgrid.

While there has been significant growth in demand for microgrids across energy-related sectors, some airports we spoke to cited several challenges associated with installing these systems. For example, one medium hub airport stated that it had evaluated installing a microgrid but

[48]Of the 30 airports that completed the online survey, all 30 responded to the question about whether their airport has installed a microgrid. During our interviews or in written responses, eight of our selected airports reported considering a microgrid.

ultimately did not proceed with the project due to the high cost of reconfiguring existing infrastructure. Similarly, a National Academies of Sciences, Engineering, and Medicine report identified several technical, financial, and regulatory barriers that can pose challenges to installing a microgrid.[49] For example, airports generally have large critical electrical loads that require a large, complex electrical system. In addition, airports may not have the space needed for microgrid components or the generation resources, such as solar panels, may not be in close proximity to the electrical infrastructure. In addition, large up-front costs associated with a microgrid can also pose financial challenges to some airports. According to the National Academies of Sciences, Engineering, and Medicine report, to offset financial costs, some operators participate in wholesale power markets, selling back power to the market during peak times when rates are high. However, according to FAA officials, airports cannot use AIP funding for a project that results in the airport selling electrical power to a commercial electricity grid.

FAA Primarily Supports Airports' Electrical Resilience Efforts Through Airport Grant Programs and Guidance

FAA Is Administering New and Expanded Grant Programs

The FAA Reauthorization Act of 2018 expanded AIP funding eligibility to include projects to (1) improve the reliability and efficiency of the power supply and (2) prevent power disruptions, such as by acquiring and installing electrical generators, separating the main power supply from the redundant power supply, and constructing or modifying facilities to install a microgrid.[50] Prior to that, AIP funding could only be used to fund an airport's primary and secondary electrical power supply costs and to purchase fixed generators under certain circumstances. See appendix III

[49]National Academies of Sciences, Engineering, and Medicine, *Microgrids and Their Application for Airports and Public Transit*.

[50]FAA Reauthorization Act of 2018, Pub. L. No. 115-254, § 165, 132 Stat. 3186, 3226 (2018).

for a description of the types of projects eligible for AIP funding prior to the enactment of the FAA Reauthorization Act of 2018.

To provide AIP funds for a wider range of projects, FAA established the Energy Supply, Redundancy, and Microgrids Program, which is a program that falls under its grant authority for the AIP. The FAA Reauthorization Act of 2018 did not set aside specific AIP funding amounts for these types of projects, but rather expanded eligible uses for AIP funds in general. According to FAA guidance, in order for a project to be eligible under the Energy Supply, Redundancy, and Microgrids program, the project must meet several eligibility criteria. For example, airport sponsors must demonstrate that the proposed project will improve the reliability and efficiency of the power supply and that it will help prevent disruptions to the airfield, passenger terminal, or other airport facilities.[51] See table 2 for examples of projects eligible for AIP funding under these expanded AIP eligibility criteria.

Table 2: Electrical Resilience Project Types Eligible for Airport Improvement Program (AIP) Funding as part of FAA's Energy Supply, Redundancy, and Microgrids Program

Project type	Examples of potentially eligible projects
Planning for projects that improve the reliability and efficiency of the power supply	Planning projects to: • improve the reliability and efficiency of the power supply; • assess the current energy efficiency and reliability of an airport's power supply; • identify efficiency and reliability improvements; and • determine the feasibility and requirements for implementation of a microgrid.
Electrical generators	Acquisition and installation of electrical generators to provide backup power to the airside, passenger terminal facilities, and other airport facilities are eligible.
Separation of main power supply	Installation of electrical equipment to separate airport's main power supply from its redundant power supply.
Construction or modification of facilities to install a microgrid	Projects to install a microgrid.
Other projects that prevent power disruptions	Projects that improve energy efficiency, provide backup power, or improve effectiveness of transmission, such as: • switching from halogens to LEDs; • producing power on-airport that can be used during a disruption from the main grid; and • installing infrastructure to transmit backup power during power outages.

Source: GAO summary of FAA guidance. | GAO-23-105203

Note: For the purposes of certain FAA grant funding, a microgrid is generally a system of interconnected loads and distributed energy resources, such as generators, that can operate in parallel with the utility grid or in another mode. See 49 U.S.C. § 47102(3)(P).

[51]FAA, *Airports Climate Challenge: Table of Relevant FAA Funding Programs*, December 29, 2022.

In addition, the Infrastructure Investment and Jobs Act (IIJA), enacted in 2021, established the Airport Terminal Program–a competitive discretionary grant program, which provides approximately $1 billion in funding annually for fiscal years 2022 through 2026 for airport terminal development projects that address the aging infrastructure of the nation's airports.[52] FAA is administering the Airport Terminal Program under the project grant authority for the AIP program. According to FAA, one of the goals of this program is to support airports' efforts to be more energy efficient, which includes strengthening infrastructure resilience to all hazards, including climate change. FAA officials noted that a wide array of projects could be eligible for this funding, including projects that may include an electrical resilience component.

FAA issued a notice of funding opportunity in September 2022 for the approximately $1 billion available for FAA to award for fiscal year 2023. FAA indicated in this notice of funding opportunity that it will give favorable consideration to certain airport terminal developments. For example, projects that replace aging infrastructure including those aimed at terminal modernization or upgrades to meet the changing user or community expectations, will receive favorable consideration, provided that they are otherwise eligible and justified. These projects can also include those that address changing environmental conditions and improve climate resilience.

FAA Has Approved Funding for Multiple Electrical Resilience Projects, but Total Amount is Not Known

FAA has awarded and approved airports' use of AIP grant funding and PFC revenues for electrical power resilience related projects. According to our analysis of FAA data from fiscal years 2015 through 2022, federal grant programs and PFC revenues have provided at least $93 million and $105 million, respectively, for electrical power resilience-related projects. However, FAA officials noted that the total amount of federal grant funding for these types of projects is likely higher for a variety of reasons discussed later in this section.

AIP Projects

Examples of AIP grant funding that may have been directed to electrical power resilience projects at airports include those for generators, geothermal and solar power projects, as well as airport equipment and infrastructure. We identified 66 AIP funded projects totaling about $93 million that could directly or indirectly support airport electrical

[52]Pub. L. No. 117-58, div. J, tit. VIII, 135 Stat. 429, 1418 (2021).

resilience.[53] Of the 66 projects we identified, most were for the installation, purchase, or rehabilitation of generators. The remaining awards we identified were for renewable energy projects (solar power and geothermal), energy efficiency equipment and infrastructure, and to conduct energy efficiency assessments (see table 3).

Table 3: GAO Analysis Identifying Airport Improvement Program (AIP) Grant Funds Awarded for Certain Electrical Power Projects for Fiscal Years 2015-2022

Project type	Number of projects identified	Grant funding awarded (dollars)
Generators	50	$64,147,759
Energy efficiency equipment and infrastructure	10	$13,447,404
Energy efficiency assessments	3	$472,589
Solar power	2	$5,165,795
Geothermal	1	$ 9,570,427
Total	**66**	**$92,803,974**

Source: GAO analysis of FAA AIP fiscal year 2015 – 2022 award data. | GAO-23-105203

Note: These are electrical resilience related projects that we identified after conducting word searches of project descriptions for these project types. FAA officials said that the total amount of federal grant funding awarded to airports for electrical power projects is likely higher, but that due to data limitations, the total amount awarded for these projects is unknown. All dollar figures in this table are reported without adjustment for inflation.

In addition, according to FAA officials, some airports that are experiencing very high demand for electricity are exploring options for installing microgrids for producing and storing energy. FAA officials added that while FAA's Energy Supply, Redundancy, and Microgrids Program provides AIP funding for airports to use to install a microgrid, as of January 2023, no airports have applied to use AIP funding for microgrid projects.

PFC Projects

Additionally, from fiscal years 2015 through 2022, we identified 23 projects approved by FAA and funded with PFC revenues, totaling almost

[53]In total, from fiscal years 2015 through 2022 FAA awarded approximately $31 billion in AIP funding to airports for approximately 19,000 infrastructure projects. We conducted word searches of project descriptions of the 19,000 projects. Specifically, we searched for the terms: energy efficiency equipment, energy efficiency assessments, generators, solar, and geothermal.

$105 million that could improve airport power resilience (see table 4).[54] One large hub airport accounted for the vast majority, receiving approval of about $83 million in PFC revenues as part of an airport equipment and infrastructure project to replace its central utility plant. According to airport documents, the central utility plant provides heating and air conditioning for the main terminal.

Table 4: GAO Analysis Identifying Passenger Facility Charge (PFC) Approved Amounts for Certain Types of Electrical Power Resilience Projects for Fiscal Years 2015-2022

Project type	Number of projects identified	Amount (dollars)
Generators	16	$8,925,411
Energy efficiency equipment and infrastructure	3	$94,907,509
Solar power	3	$944,950
Energy efficiency assessments	1	$25,000
Total	**23**	**$104,802,900**

Source: GAO analysis of FAA fiscal year 2015 - 2022 PFC approvals data. | GAO-23-105203

Note: These are electrical resilience related projects that we identified after conducting word searches of project descriptions for these project types. FAA officials said that the total amount of PFC revenues used by airports for electrical power projects is likely higher, but that due to data limitations, the total amount used for these projects is unknown. All dollar figures in this table are reported without adjustment for inflation.

Terminal Projects

In July 2022 and February 2023, FAA announced 195 selected airport projects that were awarded funding from FAA's Airport Terminal Program for fiscal years 2022 and 2023.[55] Specifically, $1 billion in annual funding was available for fiscal years 2022 and 2023.[56] According to FAA, 88 percent of the 195 projects that have received this funding included at least one component that is designed to increase energy efficiency.

[54]From fiscal years 2015 through 2022, FAA approved the use of approximately $24 billion in PFC revenues for approximately 2,738 infrastructure projects at airports. We conducted word searches of project descriptions of the 2,738 projects. Specifically, we searched for the terms: energy efficiency, generators, solar, and geothermal.

[55]Specifically, in fiscal year 2022, 91 projects at 85 airports were selected to receive funding from FAA's Airport Terminal Program. In fiscal year 2023, 104 projects at 99 airports were selected to receive this funding.

[56]The number of applications that FAA received for this program far exceeded the amount of available funding. Overall, FAA received approximately 658 applications for terminal projects totaling more than $14 billion for the first round of grants and applications totaling more than $10 billion for the second round of grants.

According to project descriptions we reviewed, several of the projects receiving this funding specifically identify project components that will upgrade power infrastructure and equipment. For example:

- A $21 million award to a large hub airport for terminal improvements will also include replacing electrical substations that serve critical areas of the baggage system.
- A $14 million grant for upgrades to a small hub airport's utilities, fire, and life safety systems includes the installation of a generator to ensure continuous and efficient operation of the main terminal building and maintenance building.

According to project descriptions we reviewed, at least five airports received about $28 million to be used for projects that include a climate resilience or electrical resilience component. For example:

- A $5 million award to a non-hub airport for terminal improvements will update and consolidate the electrical systems to improve the energy efficiency and resiliency of the terminal.
- A $5 million grant to a small hub airport will be used for design and construction services to replace the terminal electrical distribution system and the standby power system. This funding will also be used to install electrical infrastructure to support the recently expanded terminal, future electric vehicle charging demands, and complete the existing grounding system.

Total Federal Funding for Electrical Resilience Projects Unknown

FAA officials noted that the total amount of funding for airport power resilience projects is unknown because project descriptions contained in FAA's award data do not contain the level of detail needed to identify all relevant components of a project. FAA tracks information about airport development projects that have received AIP funding and approval for PFC revenues in its System of Airports Reporting. While this system includes fields to track the project type and description of the project, the project type and descriptions do not contain sufficient information to identify all electrical resilience projects funded with AIP and PFC revenues. FAA officials pointed to two main reasons for this:

- **Electrical resilience as part of a larger project.** Projects that can improve an airport's electrical resilience can be part of a larger AIP or PFC eligible infrastructure project. As a result, there may be components of a project that would improve airport electrical resilience but are not specifically itemized in the project description.

For example, as part of a terminal expansion project, an airport could also be making improvements to electrical equipment that would increase electrical resilience. FAA officials explained that if a single project has multiple project components, it would not be possible to isolate specific funding and revenue amounts for individual project components because FAA's System of Airports Reporting does not line-itemize individual project components.

- **Project descriptions may not include key words.** Project descriptions of AIP and PFC funded projects do not always contain sufficient detail to indicate whether a project will improve electrical resilience. For example, many AIP awards made during our selected time frame were for the purchase of "Energy Efficiency Equipment and Infrastructure." The award descriptions, however, did not contain sufficient information to indicate whether such projects had an electrical resilience component. According to FAA officials, more AIP and PFC funded projects might have an electrical resilience component but that component may not have been described in the award description. For example, one large hub airport installed a new electrical system to reduce their carbon emissions. Because the project is primarily intended to reduce emissions, the project description characterizes this project as an efficiency project rather than an electrical improvement project. However, according to FAA officials, the project will likely also result in electrical resilience improvements.

FAA Is Further Supporting Airports' Electrical Resilience Efforts Through Guidance, Outreach, and Research

AIP Project Guidance and Outreach

FAA has taken steps to increase airports' awareness about the availability of AIP funding by developing program guidance to describe AIP project eligibility changes and conducting airport outreach to communicate program changes to airports.

Issuing guidance on airport funding. In March 2022, FAA issued updated program guidance summarizing selected changes made by the FAA Reauthorization Act of 2018 to the AIP program.[57] The guidance states that if an airport would like to pursue an electrical power resilience

[57]FAA, Reauthorization Program Guidance Letter (R-PGL) 19-02: *Planning and Project Eligibility*, March 4, 2022.

project using AIP funds, such as installing a microgrid, FAA should coordinate on a project-by-project basis to determine whether the specific project is eligible and justified. FAA officials said that they also plan to update the AIP handbook to clarify provisions of the FAA Reauthorization Act of 2018. The AIP Handbook provides guidance and sets forth all policies and procedures for the AIP program. As of May 2023, FAA officials said they expected to release an updated AIP Handbook for public comment in 18 to 24 months. FAA has also published several other resources for airports related to the Airport Terminal Program.[58]

Airport outreach on funding availability. FAA officials have also conducted outreach and presentations to airports to provide more information about AIP funding availability for eligible electrical power resilience projects. For example, FAA's Office of Airports Planning and Environmental Division delivered a presentation in early April 2022 to industry participants to increase funding awareness and participation in several of the discretionary grant programs that fall under FAA's AIP grant authority. Those programs included the Energy Supply, Redundancy, and Microgrids Program. According to FAA officials, they have also met individually with members of the Airports Council International-North America, Airports Consultants Council, and American Association of Airport Executives to talk about challenges that climate change may have at airports and the types of resilience projects eligible for FAA funding.

Airport Planning Guidance

FAA's broader airport planning guidance discusses issues related to resilient electrical infrastructure. For example, FAA's guidance provides information for how airports can assess their existing and future electrical power needs and conduct resilience assessments as part of their emergency, master, sustainability, and terminal planning efforts.[59]

Airport emergency planning. FAA has a longstanding Airport Emergency Plan advisory circular that provides guidance to airports on how to plan for and mitigate a variety of risks or incidents on or adjacent

[58]For example, FAA has published and posted on its website a Frequently Asked Questions document, describing the criteria that will be used to evaluate applications.

[59]FAA officials noted that while their office produces general planning guidance for airports, they do not have the expertise to provide detailed guidance to airports about electrical power issues or the authority to oversee the use of this guidance.

to airport property.[60] This guidance states that power outages are among the wide variety of airport incidents or emergencies that can occur and are among the risks that airports should plan to address. According to the guidance, in the event of a movement area lighting power failure, airports should document their (1) primary power supplier for this lighting; (2) secondary or alternate power supplier; and (3) backup power generators (including location, airport areas served, size, fuel type and capacity, testing, and maintenance schedule). If a power loss occurs, the guidance states that airports are responsible for determining the cause and applying lessons learned to planning and training programs. This guidance also includes information on how airports can develop mitigation programs for power outages.[61]

Airport master planning. FAA issued an advisory circular that provides guidance to airports for developing airport master plans.[62] This guidance states that airport master plans should consider an airport's existing and future utility needs, including power supply and backup power, in cases of emergencies. It also provides that existing utility systems should be evaluated and their capacity verified. Moreover, the guidance recommends that airport planners both discuss their projected utility needs with local utility providers to help ensure this information is included in the utilities' long-term service plans and identify or consider sustainability practices.

Airport sustainability planning. Issued in 2010, FAA's preliminary guidance on airport sustainability planning has emphasized that an airport's sustainability planning can include reducing the airport's environmental impacts and energy consumption.[63] According to FAA's guidance, sustainability planning should include a sustainability policy or mission statement, a baseline assessment in areas that airports choose

[60]See FAA, Advisory Circular 150/5200-31C, *Airport Emergency Plan*, (Washington, D.C.: June 19, 2009). Part 139 certificated airports are required to develop an airport emergency plan. 14 C.F.R. § 139.325.

[61]Specifically, this guidance includes information on how to use hazard analyses to develop planning priorities and prepare mitigation programs for an airport's loss of power due to climate events.

[62]FAA does not require but recommends that airports develop airport master plans. According to FAA's guidance, airport master plans can be tailored to the unique conditions of an airport. As a result, master plans for individual airports will vary in what elements they include and in the level of detail they include. See FAA Advisory Circular 150/5070-6B, *Airport Master Plans*, (Washington, D.C: July 29, 2005).

[63]FAA, *Memorandum: Airport Sustainable Master Plan Pilot Program*, May 27, 2010.

to focus on—such as environmental resource usage, which can include energy usage—establishment of goals for each area, and identification of sustainability initiatives to help the airport reach the set goals. According to FAA, as of May 2023, FAA has funded the development of 48 sustainability plans with AIP grants. FAA officials noted that while energy efficiency and reducing air emissions (e.g., planning for and implementing electric bus utilization, high efficiency lighting, HVAC upgrades, etc.) has been a focal point since 2011, when FAA's Sustainability Program began, electrical resiliency was a relatively new area, and therefore airport sustainability plans may not include information about electrical resiliency.

Metropolitan Washington Airports Authority's Sustainability Plan

One example of an airport sustainability plan that did incorporate electrical resilience was developed by the Metropolitan Washington Airports Authority (MWAA), which operates Dulles International Airport and Ronald Reagan Washington National Airport. MWAA's 2020 Sustainability Plan includes a section devoted to electrical resilience. The plan notes that as the airport sponsor evaluates options to electrify its operations, it will plan for the low probability, high-risk potential of a commercial power outage. The plan also illustrates how sustainability projects can serve multiple airport goals. Dulles International Airport, for example, anticipates: (1) long-term cost-savings goals from investing in a natural gas powered combined heat and power facility, which will generate electricity, thereby reducing power purchases from the utility and (2) potential resilience benefits when the grid is down. The airport also plans to evaluate the installation of a 100-megawatt solar power farm and the feasibility of adding battery energy storage for resilience purposes to compliment the project's primary goal of renewable energy generation.

Source: Metropolitan Washington Airports Authority. | GAO-23-105203

Airport terminal facility planning. FAA developed an advisory circular that provides guidance on the planning process for airport passenger terminal facilities.[64] This guidance includes information about airport terminal power sources and provides guidance on airport sustainability considerations when initiating a passenger terminal-related project. Several of the sustainability practices described in the guidance can also intersect with an airport's resilience goals. For example, the guidance recommends that airports carefully evaluate the capacity of their energy sources to determine whether a terminal project will affect the sustainability of regional power supplies. This practice can help an airport meet both its sustainability goals and assess its electrical power resilience. The guidance also notes that airports could ensure a sustainable energy supply that remains independent of fluctuations in the power grid by connecting to renewable power sources through a smart grid or microgrid. It also discusses how resilience assessments can help airports identify improvement projects that will help airports ensure that terminals can remain in operation or quickly recover from a climate-related event.

Resilience Research

FAA has funded studies conducted under the Airport Cooperative Research Program as well as, according to FAA, studies conducted by the Volpe Center and NREL, which airports can use to evaluate and improve their energy sustainability and electrical power resilience.

[64]FAA, Advisory Circular 150/5360-13A, *Airport Terminal Planning*, (Washington D.C., July 13, 2018).

Airport Cooperative Research Program. FAA sponsors the Airport Cooperative Research Program—a program managed by the Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine. Under the Airport Cooperative Research Program, the National Academies has published several reports for airport sponsors on how to incorporate energy sustainability, climate resilience, and other measures related to electrical resilience into airport planning and infrastructure development projects. For example, the National Academy of Sciences, Engineering, and Medicine published a 2021 Airport Microgrid Implementation Toolkit, which provides airports with a comprehensive set of microgrid resources and guidance on how to conduct a feasibility study for a microgrid project.[65] In addition, in April 2022, the National Academy of Sciences, Engineering, and Medicine announced it was undertaking research to develop an airport primer on energy resilience and a guidebook on how to develop an energy resiliency roadmap, expected in October 2023.[66]

Volpe Center. In September 2021, the FAA and DOT's Volpe Center initiated a project to research how to incorporate resilience analysis and prioritization into airports' project planning and funding.[67] According to FAA officials, through this research, FAA plans to identify best practices and gaps in current resilience and infrastructure planning processes and develop a resilience analysis framework to assist airports to conduct repeatable and effective resilience assessments during the master planning process. According to FAA documents, the research will be conducted over the next 5 years.

National Renewable Energy Laboratory. FAA is also coordinating with DOE's NREL on a variety of research projects to inform FAA's electrical resilience guidance. Specifically, in April 2021, FAA and DOE entered into

[65]National Academies of Sciences, Engineering, and Medicine, *Airport Microgrid Implementation Toolkit*.

[66]According to the National Academies of Sciences, Engineering, and Medicine, an energy resilience plan can prepare airports to respond to incidents that may cause power disruptions and address current and future power needs. An energy resilience plan can also help airports identify the capacity and reliability of their local power grid and the type of regional or geographic stressors (e.g., frequent power outages, natural disasters) in the area where the airport is located.

[67]The Volpe Center conducts multidisciplinary and multimodal transportation research activities on behalf of DOT's modal administrations, the Office of the Secretary of Transportation, and external organizations.

an interagency agreement for NREL to provide technical services to FAA on a range of research areas, according to DOE. For example:

- NREL is conducting research to assess selected U.S. airports' electrical needs in order to identify solutions for implementing aircraft electrical charging infrastructure at scale. According to FAA, this research is intended to inform FAA's efforts to develop guidance that airports can use to prepare for future electrical needs.
- NREL's research team is performing a hazard analysis to help FAA set standards for energy resilience and security. The analysis is intended to assist sites with estimating the likelihood and effects of a range of possible disruptions, such as a power surge or weather events, and the mitigation measures that can limit the risk and impact of such disruptions. According to NREL, while the hazard analysis focuses on new technology adoption at airports, the results of this analysis could also be utilized as part of an airport's broader energy resilience efforts.[68] According to NREL, the hazard analysis report is currently under FAA review and will be published in summer 2023.
- FAA and NREL are also collaborating on ongoing research related to electric vertical takeoff and landing (eVTOL) aircraft, and ground-based infrastructure for eVTOL aircraft—known as vertiports.[69] According to FAA officials, this research will help inform FAA's vertiport design guidance and will help FAA better understand the impact of eVTOL aircraft on the energy demand of a vertiport. Understanding the energy needs of vertiport and eVTOL aircraft could help airports better anticipate their future energy demands and prepare for electrical power outages by increasing their airport's electrical power resilience.

[68]According to NREL, this analysis provides methodologies and relevant code requirements to develop site-specific infrastructure approaches with a base assumption that existing systems are providing sufficient airport-wide resilience.

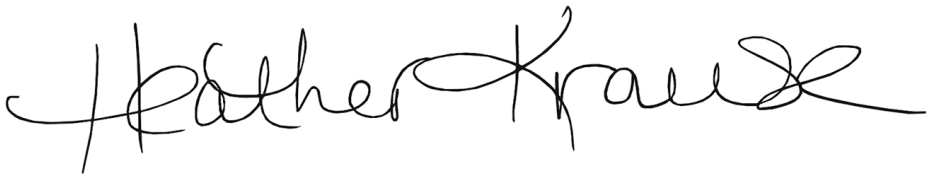
[69]According to DOE, NREL has two ongoing studies in this area examining vertiport electrical infrastructure and AAM hydrogen infrastructure. A vertiport is an area of land (including associated buildings and facilities) or a structure used or intended to be used, for vertical takeoff and landing aircraft. AAM is an emerging form of air transportation that may use aircraft with novel propulsion systems, increased levels of automation, and vertical take-off and landing capabilities to transport people and cargo. These aircraft are often referred to as air taxis or eVTOL aircraft.

Agency Comments

We provided a draft of this report to DOT, DOE, and DHS for review and comment. DOT, DOE, and DHS provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, and Secretaries of Transportation, Energy, and Homeland Security. In addition, the report is available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or KrauseH@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.



Heather Krause
Director, Physical Infrastructure

Appendix I: List of Airports Selected for GAO Interviews

Table 5: List of Airports Selected for GAO Interviews

Airport size	Airport name
Large hub	Baltimore/Washington International Thurgood Marshall
	Charlotte/Douglas International
	Chicago Midway International
	Chicago O'Hare International
	Dallas-Fort Worth International
	Daniel K. Inouye International
	Denver International
	Detroit Metropolitan Wayne County
	General Edward Lawrence Logan International
	George Bush Intercontinental/Houston
	Hartsfield-Jackson Atlanta International
	John F. Kennedy International
	Los Angeles International
	Miami International
	Minneapolis-St Paul International/Wold-Chamberlain
	Newark Liberty International
	Orlando International
	Philadelphia International
	Phoenix Sky Harbor International
	Ronald Reagan Washington National
	San Diego International
	San Francisco International
	Seattle-Tacoma International
	Tampa International
	Washington Dulles International
Medium hub	Austin-Bergstrom International
	Cleveland-Hopkins International
	Dallas Love Field
	John Wayne/Orange County
	Louis Armstrong New Orleans International
	Metropolitan Oakland International
	Norman Y. Mineta San Jose International
	Pittsburgh International
	Sacramento International
	San Antonio International

Airport size	Airport name
Medium hub	Southwest Florida International
	St Louis Lambert International
	William P. Hobby
Small hub	Long Beach (Daugherty Field)
	Louisville Muhammad Ali International
	Memphis International

Source: GAO. | GAO-23-105203

Note: “Large hub” airports are those airports that enplane 1 percent or more of all passenger boardings. “Medium hubs” enplane at least 0.25 percent but less than 1 percent of all passenger boardings. “Small hubs” enplane at least 0.05 percent but less than 0.25 percent of all passenger boardings. See 49 U.S.C. § 47102.

Appendix II: List of Academic, Airport, and Energy Stakeholders GAO Interviewed

Table 6: List of Academic, Airport, and Energy Stakeholders GAO Interviewed

Category	Organization name
Academia	University Of Denver
Airport stakeholders	Airports Council International–North America (ACI-NA)
	Boeing Field/King County International Airport
	California Redwood Coast-Humbolt County Airport
Energy consulting groups	Arup
	Barrett Energy Resources Group (BERG) LLC
	Burns
	Converge Strategies LLC
	Jacobs
	Woolpert
	WSP Consulting
Energy stakeholders	California Energy Commission
	Edison Electric Institute (EEI)
	National Association of State Energy Officials (NASEO)
	National Rural Electric Cooperative Association (NRECA)
	North American Electric Reliability Corporation (NERC)

Source: GAO. | GAO-23-105203

Note: GAO interviewed officials from Boeing Field/King County International Airport and California Redwood Coast-Humbolt County Airport for exploratory purposes.

Appendix III: Selected Funding Eligibility for Electrical Power Resilience Projects, Prior to the FAA Reauthorization Act of 2018

Prior to the enactment of the FAA Reauthorization Act of 2018, the eligibility of electrical power resilience projects for Airport Improvement Program (AIP) funding was more limited.[1] These types of projects included projects to install, improve, or reconstruct an airport's primary electrical power supply, and projects for purchasing fixed generators under limited circumstances. Table 7 describes the types of electrical power resilience projects eligible for AIP funding prior to the act's expansion of this eligibility. The eligibility requirements are currently described in FAA's AIP Handbook, which was last updated in February 2019. According to FAA officials, they plan to release an updated version of the AIP Handbook that includes changes to the AIP eligibility requirements, in 18 to 24 months.

Table 7: Types of Electrical Power Resilience Projects Eligible for Airport Improvement Program (AIP) Funding, as of September 30, 2018

Project type	Selected eligibility requirements	Examples of eligible projects
Primary electrical power supply costs	• Costs of the installation, improvement, reconstruction, or repair of an airport's primary electric power supply. • The project must serve eligible areas and facilities. If the utility installation will serve both eligible and ineligible areas or facilities, the allowable cost is limited to a prorated share for the eligible portion.	Installation of a primary electric power supply to an airport terminal building or aircraft storage hanger.
Secondary or redundant electrical power supply costs	• Costs of obtaining a secondary or redundant electric power supply from a power company. • The primary power supply must be considered extremely unreliable, such as an extensive documented, history of cable cuts, extraordinary meteorological conditions, or extensive, documented record of commercial utility interruptions.	Installation of a secondary power feed from a second substation and electricity grid.

Fixed emergency generators for airside operations	• Costs to acquire, install, or rehabilitate a fixed emergency engine generators to power airside operations if:
	  • the generator is necessary to provide runway lighting on a category 2 or 3 runway, or
	  • the airport is a designated continuous power airport[a] and the generator is needed to provide continuous operations in the event of an area-wide utility failure.
		Installation of a fixed generator to be used to provide backup electric power to airside facilities and a surveillance radar.

[1]FAA Reauthorization Act of 2018, Pub. L. No. 115-254, 132 Stat. 3186 (2018).

Project type	Selected eligibility requirements	Examples of eligible projects
Fixed emergency generators for airport terminal use	• Costs to acquire, install, or rehabilitate a fixed emergency generator to meet life safety code requirements for building evacuation of an airport terminal's public use areas. • May not be used to allow the terminal to continue operations.	Installation of a fixed generator to be used to provide backup electric power in the terminal for life safety purposes, such as: • exit sign lighting, • emergency voice and alarm communication systems, or • fire alarms and exhaust ventilation in terminal facilities.

Source: GAO summary of AIP Handbook project eligibility requirements. | GAO-23-105203

Note: These projects were eligible for AIP funding prior to the date that the FAA Reauthorization Act of 2018 was enacted, which was October 5, 2018. See Pub. L. No. 115-254, 132 Stat. 3186 (2018).

[a]According to FAA, continuous power airports are legally required to have FAA standby power systems (such as generators) that support airport operations in the event of a utility power failure. There are 50 continuous power airports in the U.S. which were selected based on their activity and location. *See* Federal Aviation Administration, *Electrical Power Policy*, JO 6030.20G (Mar. 21, 2019).

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, Jean Cook (Assistant Director), Maria Mercado (Analyst-in-Charge), Paul Aussendorf, George Depaoli, Philip Farah, Jim Geibel, Parker Hallof, Delwen Jones, Edward Laughlin, Nick Nadarski, Mary-Catherine P. Overcash, Madhav Panwar, Joshua Parr, Malika Rice, Elizabeth Wood, and John Yee made key contributions to this report.

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