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Hourly Load Profile Dataset for Electric Airport Ground Support Equipment in the United States

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NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated under Contract No. DE-AC36-08GO28308

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Technical Report
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Suggested Citation
Liu, Bo, Kevin Robby, Jayaraj Rane, Adway Das, Kara Podkaminer, and Brennan Borlaug. 2025. *Hourly Load Profile Dataset for Electric Airport Ground Support Equipment in the United States*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-92139. https://www.nrel.gov/docs/fy25osti/92139.

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NOTICE

This work was authored in part by the National Renewable Energy Laboratory for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Vehicle Technologies Office. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

Cover photos (clockwise from left): Josh Bauer, NREL 61725; Visualization from the NREL Insight Center; Getty-181828180; Agata Bogucka, NREL 91683; Dennis Schroeder, NREL 51331; Werner Slocum, NREL 67842.

Acknowledgments

The authors gratefully acknowledge Yi He (National Renewable Energy Laboratory [NREL]) and Marcus Alexander (Electric Power Research Institute [EPRI]) for their insightful reviews and valuable recommendations. Special thanks are extended to Jamie Dunkley, Britta Gross, and Jennifer Kwong from EPRI for their guidance, and Mike Weismiller (U.S. Department of Energy) for his continued support. Additionally, Michael Deneen (NREL) provided copyediting assistance.

List of Acronyms

eGSE	electric ground support equipment
GSE	ground support equipment
LAX	Los Angeles International Airport
MOVES	MOtor Vehicle Emission Simulator

Table of Contents

List of Figures

List of Tables

1 Introduction

The aviation sector plays a critical role in the U.S. transportation system, supporting economic growth, domestic and global connectivity, and national security. In 2019, aviation accounted for 11% of U.S. transportation-related energy consumption (U.S. Department of Energy et al. 2023). As demand for air travel and e-commerce continues to grow, the aviation industry faces increasing pressure to enhance efficiency, reduce operational costs, and ensure long-term industry resilience. Addressing this challenge will require advancements in fuel efficiency, operational optimization, and the development and deployment of next-generation propulsion technologies, such as battery-electric and hydrogen-powered aircraft (U.S. Department of Energy et al. 2023; Bardon and Massol 2025).

While advancements in aircraft efficiency and alternative propulsion technologies are in development, airports themselves present immediate opportunities for cost savings, reliability improvements, and health benefits. Modernizing airport infrastructure, including space and water heating systems, ground support equipment (GSE), and surface transportation fleets, can yield substantial operational and financial benefits. Electrifying GSE, for example, can reduce fuel and maintenance costs**,** minimize downtime**,** and improve air quality for workers and passengers. These advancements not only position airports for future growth but also strengthen their resilience against fluctuating energy costs and supply chain disruptions.

GSE plays an important role in airport operations, servicing aircraft between flights. This equipment is responsible for tasks such as refueling, towing, passenger transport, cargo handling, deicing, and firefighting. As of 2024, more than 80% of U.S. GSE fleets remain primarily powered by fossil fuels, with 25% exclusively reliant on them. Despite this, 65% of airports have adopted at least one piece of electric ground support equipment (eGSE), and nearly 70% plan to increase investment in eGSE in the future (Smith 2024). Electrifying GSE represents a near-term opportunity for reducing the environmental impact of airport operations (Greer, Rakas, and Horvath 2020). However, achieving this will require strategic investments in electric infrastructure to accommodate the increased electricity demand, emphasizing the need for proactive planning.

Currently, there are limited data on the magnitude and timing of electricity demand from eGSE across U.S. airports. To address this gap, this study presents a modeling approach for an initial estimation of hourly annual electricity demand from eGSE at the 50 largest U.S. commercial airports (by total enplanements). These datasets, accessible at data.nrel.gov/submissions/279, provide critical insights into the potential grid impacts and electricity demand associated with eGSE adoption.

2 Methods

The modeling of airport-level hourly electricity loads relies on projected annual GSE energy consumption at each airport, user-defined electrification targets, and hourly flight schedules (Figure 1). This approach integrates multiple existing models and datasets, including:

- **U.S. Environmental Protection Agency's MOtor Vehicle Emission Simulator (MOVES) model:** The MOVES non-road module is run at the county level to estimate annual GSE fuel consumption by county and fuel type for the years 2023 through 2035 (Environmental Protection Agency 2023).
- **Bureau of Transportation Statistics' TranStats database:** Geographic coordinates for all U.S. commercial airports are sourced from the TranStats database and used to map each airport to its corresponding county (Bureau of Transportation Statistics 2024).
- **Federal Aviation Administration's Calendar Year 2022 Passenger Boarding Data:** Total annual enplanements at the airport level are used to disaggregate county-level GSE fuel consumption (from MOVES) to individual airports within each county (Federal Aviation Administration 2023b).
- **Federal Aviation Administration's Aviation System Performance Metrics database:** Hourly flight schedule data for major U.S. commercial airports are obtained from this database. The total number of airport arrivals and departures, recorded hourly for each day in 2023, is used to distribute electricity demand on an hourly basis (Federal Aviation Administration 2023a).

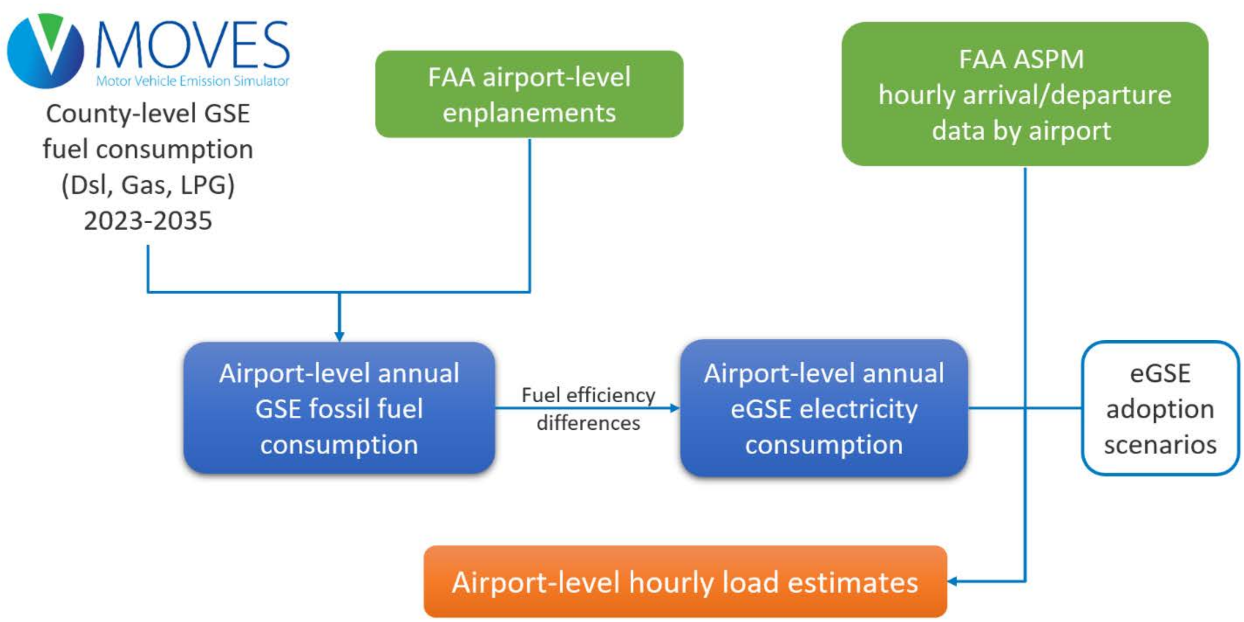

Figure 1. eGSE modeling framework

2.1 Estimating Airport-Level Total Annual Electricity Demand

County-level annual GSE energy consumption is estimated using projected fuel consumption data from MOVES for 2023–2035, combined with fuel-specific energy conversion efficiency factors. Where applicable, airport-level total enplanements are used to distribute county-level annual energy consumption among individual airports within the same county.

Given that passenger electric vehicles are currently 2–4 times more efficient than conventional internal combustion engine vehicles at highway speeds and 5–7 times more efficient at lower speeds (California Air Resources Board 2018; Singer et al. 2023), an energy efficiency ratio of 5:1 for eGSE compared to conventional GSE is applied when estimating electricity demand. Additionally, it is assumed that eGSE is charged with 88% efficiency, with the remaining 12% consumed by battery conditioning or lost due to transmission inefficiencies (Voelker 2021).

To account for varying airport electrification goals and timelines, scenarios with eGSE adoption rates ranging from 10% to 100% are considered.

2.2 Estimating Airport-Level Hourly Annual Load Profiles

Airport-level hourly load profiles are estimated using projected annual electricity demand and hourly flight schedules, which represent the number of aircraft arriving and departing each hour of the year. Annual electricity demand is distributed across the 365 days of the year in proportion to daily flight activity, with busier travel days resulting in greater eGSE activity and higher electricity demand. Energy consumption and charging demand for each day are assumed to be in equilibrium, accounting for charging losses, with all energy consumed being recharged on the same day.

Hourly load shapes vary depending on charging strategies and charger power ratings. For these estimates, it is assumed that charging can occur up to 23 hours per day, with no charging scheduled during the busiest hour of the day to minimize disruptions during peak flight activity. Charging power limits are not explicitly enforced, and the daily charging demand is distributed across hours inversely proportional to hourly aircraft arrivals and departures, reflecting reduced charging activity during periods of increased flight activity.

3 Airport eGSE Electricity Demand Dataset

The modeled eGSE hourly load dataset is organized by airport, year, and eGSE penetration level for 2023–2035 (Table 1). Figure 2 presents an example annual hourly eGSE load profile for 2030 (50% eGSE) at Los Angeles International Airport (LAX).

Table 1. Airport eGSE Electricity Demand Dataset Description

Feature	Details
Vehicle segment(s)	eGSE
Years	2023, 2025, 2030, and 2035
Spatial resolution	Airport-level, top 50 commercial U.S. airports
Temporal resolution	Hourly annual (8,760)
Other features	eGSE penetration levels ranging from 10% to 100%

During a typical week, peak eGSE charging loads at LAX generally occur between late evening and early morning hours (10 p.m. to 4 a.m.), with higher demand on weekdays compared to weekends. Throughout the year, peak demands coincide with the busiest travel periods, summer in the case of LAX, reflecting established air traffic trends and airport operational schedules.

Figure 3. Annual hourly eGSE load profile for LAX in 2030, assuming 50% eGSE adoption

4 Dataset Guidelines and Limitations

The development of this dataset relies on several assumptions and constraints, introducing important caveats and limitations.

First, the annual energy demand and projected growth are derived from MOVES projections, a widely used tool for transportation emissions and energy modeling. The future growth of GSE population is based on state-level projections of commercial aviation operations from the Federal Aviation Administration's Terminal Area Forecast (EPA, 2018). However, these projections do not explicitly account for potential changes in the demand for air travel at the airport level or improvements in GSE efficiency over time.

Second, there is a lack of publicly available data on eGSE fuel efficiency. Unlike on-road electric vehicles, where fuel efficiency metrics are widely available, standardized data for eGSE remain limited. As a result, the assumed energy efficiency ratio for eGSE (5:1) is extrapolated from on-road electric vehicle efficiency data. In practice, actual efficiency ratios for eGSE may vary depending on vehicle type, operational patterns, and environmental conditions.

Third, the disaggregation of annual electricity demand across all modeled years relies on hourly flight schedules from 2023. At the time of development, this dataset represented the most recent and comprehensive yearlong flight schedule available. However, flight schedules are inherently dynamic, influenced by seasonal fluctuations, economic conditions, airline strategies, and global events. Future deviations from these 2023 patterns could affect the accuracy of the load projections.

Additionally, hourly load estimates are based on a single set of assumptions regarding charging strategies and behavior. Charging demand is modeled as inversely proportional to flight activity, with minimal charging assumed during peak operational hours. The analysis does not account for variations driven by infrastructure constraints, time-varying electricity prices, or adaptive charging strategies.

Despite these limitations, this dataset, available at data.nrel.gov/submissions/279, serves as a valuable foundation for analyzing hourly electricity demand from eGSE across various U.S. airports and electrification scenarios. Users should consider these caveats when interpreting results or integrating these data into broader planning frameworks. Future iterations could address these limitations through more granular data inputs, dynamic modeling of diverse GSE types and operations, and refined assumptions informed by real-world performance data from eGSE deployments.

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