ALIGHT
SUSTAINABLE AVIATION

GUIDELINE FOR SMART CHARGING AND VEHICLE-TO-GRID IN AIRPORTS

ACKNOWLEDGEMENT

The H2020 funded project (ALIGHT) – is a Lighthouse project for the introduction of sustainable aviation solutions for the future. More info can be found on www.alight-aviation.eu.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957824.

Title:	Guideline for smart charging and vehicle-to-grid in airports
Version number:	1.0
Work package:	WP4 – Smart Energy Supply to Airport
Date:	30.06.2025
Tool ID:	1.18
Front photo:	Courtesy of Danish Technological Institute
Lead beneficiary:	Danish Technological Institute (DTI)
Author(s):	DTI: Lea Kornbeck Askholm & Zenia Lagoni
Contact person	Lea Kornbeck Askholm, lkoa@dti.dk

RELATED GUIDELINES

Guideline for battery energy storage systems in airports

Guideline for charging infrastructure in airports

Guideline for smart energy management systems in airports

Guideline for solar power plants in airports

INTRODUCTION TO ALIGHT

Alight is an EU 2020 Horizon project: A Lighthouse for the Introduction of Sustainable Aviation Solutions for the Future (ALIGHT). The consortium consists of 17 partners who have jointly committed to addressing the challenges of creating a transition in the aviation industry. Spread across 10 different European countries, the ALIGHT partners range from European airports to technology providers and knowledge institutions. The project is divided into two main focus areas: the supply, implementation, integration and smart use of Sustainable Aviation Fuel (SAF) and the development, integration and implementation of a Smart Energy system.

The smart energy section of the project addresses the full chain of system mapping, energy consumers, energy supply, including renewable energy and energy storage and energy management. In example, a Battery Energy Storage System (BESS) has been installed to gain valuable experience in, for example, the practical implementation of such a system in an airport, as well as how storage can aid in an increase in the use of renewable energy.

INTRODUCTION TO THE GUIDELINE

This guideline provides best practices based on lessons learned in the ALIGHT project, related to implementing smart charging and vehicle to grid (V2G) in airports. The aim is to provide insights and help to overcome possible barriers related to mapping, planning, designing, and executing smart charging and V2G projects in airport environments. The guideline is divided into three main pillars: mapping, planning, and implementation.

The aim of the mapping phase is to create a solid base for the later decision making through initial analyses. The aim of the planning phase is to choose the relevant technologies and to ensure a thorough foundation of data and information for the implementation and commissioning phases. The aim of the implementation phase is to ensure smooth installation of smart charging and V2G technologies.

As part of the ALIGHT project, four airports—Copenhagen, Rome, Warsaw, and Vilnius—serve as case studies for implementing smart energy solutions. These four airports are different in size, location and stage of development in the area of smart energy, offering diverse insights and learnings. Opportunities, challenges and lessons learned related to smart charging and V2G from the airports are described in this guideline.

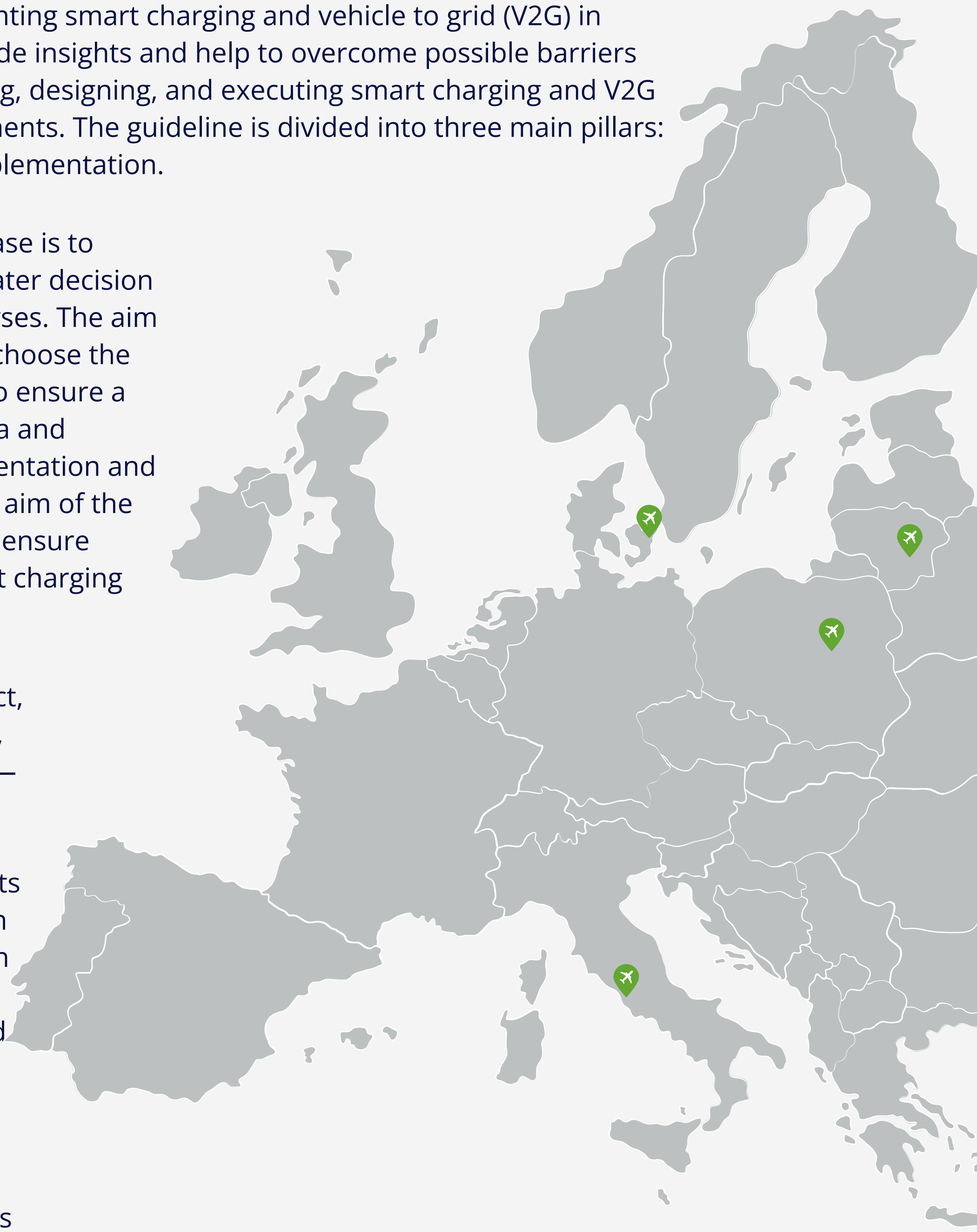


Figure 1 – Location of ALIGHT airports: Copenhagen Airports in Denmark, Aeroporti Di Roma in Italy, Lithuanian Airports in Lithuania, and Centralny Port Komunikacyjny in Poland.

INTRODUCTION TO THE GUIDELINE

ALIGHT Airports

Copenhagen Airport

Copenhagen Airport is the lighthouse airport in the ALIGHT project, meaning that it is the primary airport. Copenhagen Airport is located 8 km from the city centre of Copenhagen. In 2023, CPH served over 26 million passengers.

Rome Fiumicino “Leonardo da Vinci” Airport

Rome Fiumicino “Leonardo da Vinci” Airport (FCO) is managed by Aeroporti di Roma (ADR), and it is located 30 km from the city centre of Rome. The airport received more than 44.4 million passengers in 2023.

Centralny Port Komunikacyjny

Centralny Port Komunikacyjny (CPK) is a part of a large infrastructure project in Poland. CPK airport will be a new international airport, located around 40 km from Warsaw. It is planned to be in operation from 2028. The airport is expected to accommodate around 34 million passengers, and with the ability to expand in the future.

Vilnius International Airport

Vilnius International Airport (VNO) is part of Lithuanian Airports (LTOU) and is located 5.9 km from Vilnius. It is the largest of the three commercial airports in Lithuania including Kaunas Airport and Palanga Airport. In 2023 the Vilnius airport served around 4.4 million passengers.

INTRODUCTION TO THE GUIDELINE

Motivation

Airports are energy-intensive infrastructures, requiring innovative solutions to meet the growing need for sustainable transition. As the aviation industry transitions toward carbon neutrality, integration of smart energy technologies has become essential to continue airport operations without compromising on their environmental responsibility.

This handbook serves as a practical guide offering actionable insights of planning and implementing of smart charging infrastructures in an airport environment. Through practical guidelines, case studies, and lessons learned, this handbook provides the readers with technical insights and strategic considerations for addressing the complexities of modernising energy infrastructure in airports.

Smart charging is an intelligent approach of charging EVs, where the charging is optimised considering different factors such as CO_2-intensity of available electricity, grid utilisation, electricity prices, mobility needs, etc., instead of only seeking to charge the battery as fast as possible and as soon as it has been connected to a charger. This requires applications which communicate with both the electricity grid and the consumer i.e., EV, the charger and a management system. The Vehicle-to-Grid (V2G) technology enables EVs to deliver electricity to the electrical grid by discharging the battery of the EV. The schedule for V2G can be optimised by considering the same factors as for smart charging.

SMART ENERGY SYSTEM AS A CONCEPT

The energy system is smart when it can decouple the need for simultaneity between supply and consumption, while also prioritising delivering the cheapest and/or cleanest energy to consumers. A smart energy management system is needed to monitor the energy system, make decisions and control assets. Smart energy thus encompasses how the interaction between the various energy assets and energy sectors (electricity, heating/thermal, gas, transportation, and industry) can lead to a 100% renewable energy-based system in the cheapest and most efficient way.

Therefore, cross-sectoral synergies such as flexible production, different conversion technologies, demand side-management, and a wide range of storage technologies, are necessary in smart energy systems. The concept of a smart energy system presented in Figure 2 is focusing on the electrical aspect of smart energy, including both physical assets such as PV and batteries and control assets like energy management system (EMS). Airports have multiple reasons to invest in renewable energy sources (RES). Transitioning from fossil fuels to renewables reduces greenhouse gas emissions and supports sustainability goals, while also improving local air quality.

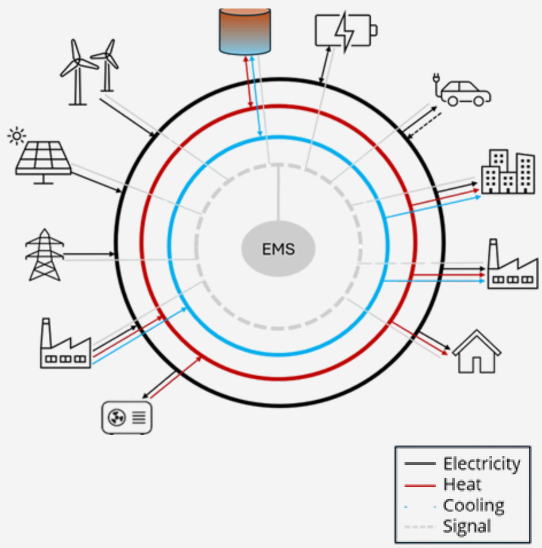


Figure 2 – Example of subsystems in a smart energy system.

Producing energy locally enhances security of supply and reduces reliance on the external grid, benefiting both the airport and the collective grid operator by limiting the need for grid reinforcements. Economic advantages include more predictable energy prices and potential cost savings. Airports may also benefit from regional or national incentives and can generate revenue by selling surplus energy, leasing land for renewables, or providing grid-support services.

The storage technologies among others can facilitate coupling between the energy sectors in an efficient and viable manner. The storage technologies cover all types of storages including electric, thermal, gas, liquid, etc. Thermal storages are often significantly cheaper than electrical storages and can advantageously be integrated into heat supply systems and thereby making the electricity demand for heat production (in e.g., a heat pump) more flexible. However, electrical storages play a pivotal role in enabling a more flexible, resilient, and renewable-based energy system, by balancing electrical generation and consumption, especially in systems with renewable energy sources (RES) like solar and wind, which are intermittent. [1]

Energy Management Systems (EMS) and be used to enable flexibility in the airport energy system. It can be used to optimise energy usage, increase efficiency, and manage bottlenecks, potentially reducing costs and emissions. EMS integrates software and hardware to monitor and control energy production, storage, and consumption in real time, ensuring flexibility and maximizing value. EMS can also plan the delivery of grid services and help defer costly grid upgrades by rescheduling power flows and shifting loads, relying on controllable assets and storage.

SMART ENERGY SYSTEM AS A CONCEPT

Energy Flexibility

Flexibility is becoming more and more important with the increase of non-programmable renewable energy production, such as PV and wind turbines, necessary for energy system decarbonisation. Flexibility in energy systems can be achieved and utilised in various ways, offering numerous benefits. The adoption of smart energy technologies and the effective use of flexibility within an energy system can lead to reductions in greenhouse gas emissions, lower energy costs, and decreased reliance on expanded energy infrastructure.

Implementation of smart charging of electric vehicles is demand-side-management and can be used for multiple purposes, such as load-shifting, peak shaving, CO_2- and cost reductions and delivery of ancillary services. By introducing vehicle-to-grid (V2G), where the car battery can be discharged to the electricity grid, the EVs can be used as additional storage capacity. In airports both smart charging and V2G can be considered for airport vehicles, employee cars as well as passenger cars and public transport. The charging infrastructure plays a significant role in enabling smart charging and V2G, as this places requirements on both charger types, power capacity, bidirectional energy flow, communication protocols, system integration etc.

ENERGY FLEXIBILITY

Flexibility use cases

Load shifting
Energy consumption can be scheduled to avoid short-term congestion at both local installations behind the meter and at the local distribution grid.

Peak shaving
Power peaks from high demand can be reduced by either reducing the power consumption, turning off some loads (load shedding) or by utilising additional power generation facilities or storage systems to feed the demand. Load-shifting can also be used as a measure to implement peak-shaving.

Energy arbitrage based on CO_2 emissions
By importing electricity during the hours with the highest share of renewable generation in the grid it is possible to reduce the CO_2 emission of electricity used.

Energy arbitrage based on costs
Purchasing electricity when prices are low and selling when the prices are high generates a profit from the price difference.

Delivery of ancillary services
Ancillary services refer to services that help maintain grid stability and reliability often at TSO level.

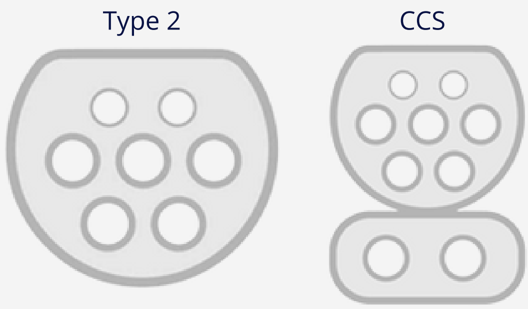
Optimising self-consumption from RES
By storing energy when RES produce more energy than needed to cover the demand, or by shifting the load to meet the RES production, thud the RES will be better utilised, and a higher share of the consumption will be covered by local RES.

TABLE 1

Impacts from different smart energy actions and technologies.

Aim/Goal	Smart energy actions	Method/technology
Reduce GHG-emissions of energy	Convert energy production plants from fossil fuel energy to renewable energy	Replace fossil fuel vehicles with electric, hydrogen or biogas driven vehicles
	Optimise self-consumption from local RES	Smart charging Energy storage (e.g., as V2G)
	Energy arbitrage based on CO_2-emissions of electricity from the grid	
	Optimise self-sufficiency from local RES	Smart charging Energy storage (e.g., as V2G)
Reduce energy costs	Energy arbitrage based on costs	Smart charging Energy storage (e.g., as V2G)
	Optimise self-consumption from local RES	
Reduce the need for reimbursement of energy infrastructure	Peak shaving	Energy storage to absorb and deliver power as needed
	Load-shifting	Smart charging Electrical energy storage
Reduce the reliance of external energy providers	Optimise self-consumption from local RES	Smart charging Electrical energy storage
	Optimise self-sufficiency from local RES	Load-shift of EV-charging. Electrical energy storage

GUIDELINE FOR SMART CHARGING AND VEHICLE-TO-GRID (V2G)



In Europe, there are two types of charging connectors/plugs: Type 2 and CCS. The Type 2 connector is the standard AC charging plug in Europe. This connector supports AC charging up to 22 kW. The CCS (Combined Charging System) connector is primarily used for DC fast charging. It builds upon the Type 2 design by adding two additional pins for high-power DC charging, making it a "combo" connector. This connector supports significantly higher power level than Type 2, as the typical power levels are 50 kW for fast charging and above 150 kW for ultra-fast charging.

Charge points categories:

- **Charging Destination:** These are charge points that are dedicated locations for charging of vehicles and appliances. Hence these locations need to have high power chargers installed.

- **Destination Charging:** This is where the user of an electric vehicle would go regardless of the charger such as parking lots at airports, shopping centres etc. Destination charging generally consist of AC chargers rated to 11 kW or 22 kW.

At landside, airports primarily have a need for destination chargers, because users travel to the airport regardless of the chargers. Fast chargers can be used in spaces of short period parking and for taxis and drop-off areas, where slow chargers can be used in the long-term parking spaces. At airside, chargers in the charging destination category with fast chargers to reduce the charging time for equipment.

This chapter presents guidelines related to charging infrastructure in airports considering both airside and landside. The illustration contains examples of analyses and assessments which can be conducted and the possible outcomes for each phase (see table 2).

TABLE 2

Overview of examples of relevant analyses

Phase	Mapping	Planning	Implementation and operation
Analyses and assessments	Impact on operation Initial business case Sustainability assessment Fleet analysis Analysis of charging facilities Use case scenarios	Stakeholder analysis Implementation plan Financial considerations Owners Tendering and procurement	Installation of chargers SW Platform Integration into EMS Test and commissioning Scale up/roll-out Monitoring
Outcomes	Defined use case for smart charging Identification of investment costs Identification of environmental impact	Stakeholder engagement Detailed plan for implementation Ownership Procurement of equipment	Installation of compatible chargers Establishment of SW platform to handle smart charging and V2G Monitoring usage Integration into EMS

GUIDELINE FOR SMART CHARGING AND VEHICLE-TO-GRID IN AIRPORTS

Mapping

In the mapping phase the purpose is to assess the potential barriers for and benefits of smart charging and V2G. This phase also aims at providing a baseline of the airport's current electric vehicle fleet and charging infrastructure to assess the V2G potential and identifying gaps.

RISK ASSESSMENT AND IMPACT ON AIRPORT OPERATION AND AVIATION

The main concern and risk when implementing smart charging and V2G in airports may be regarding IT and cyber security of the airport data and systems. This may include fulfilling national law under the Directive (EU) 2022/2555, known as NIS2, specific requirements for information security in aviation made by EASA (EU Regulation 2019/1583) among others. Proper design of software integration into the airport is necessary together with proper handling of sensitive data about critical infrastructure, the electric vehicle, the user considering also the General Data Protection Regulation (GDPR). Any mishandling of personal or operational data can result in legal penalties.

When applying smart charging and/or implementing V2G to use the EV-battery for other purposes than driving it may affect and require some behavioural changes. In the transition from fossil fuels to electric equipment users are already required to learn the charging needs of the equipment and the charging procedures. This first step is expected to be the primary behavioural challenge. When introducing smart charging or V2G the benefits can be even higher if the user is plugging in the vehicle as soon as not in operation, and not only when needed, to enhance the time periods where the vehicle is available in the energy system. The ideal patterns for charging are dependent on the type of equipment, operational pattern of the equipment and availability of charging points.

If the airport would like to include the passenger cars to provide V2G, they should consider how to ensure fairness, proper functionality and smooth implementation:

1. The airport should consider who will benefit financially from the service, as multiple actors are included in the action;
   1) the airport owning the charging infrastructure,
   2) car owners,
   3) third parties such as V2G platform operators, or electricity providers.

2. The airport needs a system to recognize vehicles capable of V2G functions, and where the car owner can provide consent to participate with V2G.

3. The airport must consider how to balance V2G usage with ensuring that car owners have their vehicles charged as needed. Many chargers do not inherently know the State-of-charge (SOC) of the connected vehicle. This requires integration with vehicle data or the use of smart chargers capable of advanced communication

INITIAL SUSTAINABILITY ASSESSMENT AND BUSINESS CASE

The sustainability assessment for smart charging and V2G may focus on the environmental impact, considering GHG-reductions from the electricity used for charging the electric vehicles and equipment.

CASE: OBSERVING V2G DEVELOPMENT

Currently ADR does not have any equipment for V2G, but they are following the development of V2G regarding technology maturity, regulation and interaction between actors as they see a potential.

THE INITIAL BUSINESS CASE MAY INCLUDE ESTIMATES OF:

- Initial and operating costs related to smart charging software solutions (this may in some limited forms be part of the EV charging operators software already or part of other energy management systems implemented in the airport).
- Initial costs for replacing or upgrading conventional charging facilities to V2G
- Potential reduced costs for EV charging sessions
- Potential reduced costs for electricity infrastructure upgrades (like cables, transformers etc.)
- Potential revenue from delivering grid services, like participation in market for ancillary services
- Potential reduced electricity costs due to better utilisation of local renewable energy production

The business case could also include planning costs related to e.g., involving internal IT and Cyber security departments to ensure sufficient IT security levels and for personnel to select chargers to be included, compile data to do a mapping of the technical potential.

The knowledge of the possible gain/benefits of smart charging and V2G can be used in decision-making processes, to have awareness of derivatives prioritising EVs and GSEs and potentially V2G compatible vehicles and charging infrastructure.

The airport should consider how smart charging and V2G in the airport contributes to the sustainability goals for the airport. Depending on the use cases chosen for smart charging and V2G as presented in Section on Energy flexibility (p. 7), the sustainability impact can be different. The airport should establish relevant measurable objectives to evaluate the impact and define a baseline to compare and monitor the impact of smart charging in the future to the baseline.

FLEET ANALYSIS TO ASSESS THE POTENTIAL AND AVAILABILITY OF VEHICLES FOR SMART CHARGING AND/OR V2G

CASE: V2G POTENTIAL IN CPH

A case study has been conducted to determine the V2G potential at CPH. The scope for this case study is the CPH-owned fleet of GSE. The case study investigated a conceptual fleet of eGSEs, where electric equivalents of the actual fleet were investigated.

The case study aims to determine the following two intermediate results:

1. The total battery capacity in the CPH-owned fleet of battery-electric ground support equipment.

2. V2G availability during charging.

The study found a significant disparity in the contribution of the different GSE categories to the overall V2G potential: Specifically, five categories - cars, large vehicles, GPUs, buses, and snow removal trucks - emerge as the primary contributors to the total battery capacity. Despite comprising only 65% of the total GSE units, these five categories account for an overwhelming 96% of the total battery capacity in the CPH context (see Figure 3). The total potential battery capacity is therefore found to be around 54 MWh, if the five largest categories are considered.

Distribution of GSE Categories [count] Distribution of Battery Capacity [MWh]

Figure 3 - CPH case study: GSE categories and battery capacity.

Besides identifying the potential battery capacity, the availability of the battery capacity due to usage if the equipment should be addressed.

In addition, qualitative information of the usage patterns is compiled through interviews with the operating personnel at CPH. This added great value to the analysis. Using the number of GSE units available for V2G and the assumed charging/discharging power, both the power capacity and energy capacity available for V2G were calculated on an hourly basis.

The combined V2G potential for the entire fleet is determined through multiple scenarios that explore the extremes in the usage patterns of the categories. Two of the finding are presented in this case, the complete analysis can be found in the report

Assessment of vehicle-to-grid potential in airport fleets available at the ALIGHT website[1].

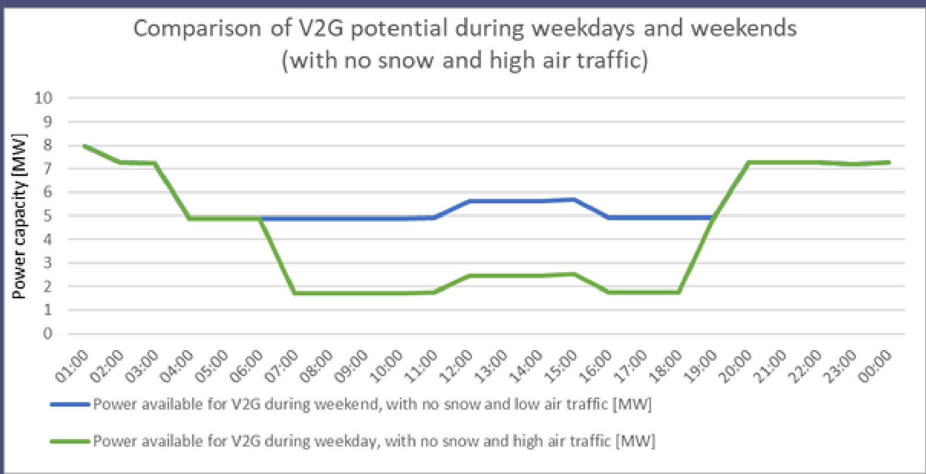


Figure 4 – Illustration of the impact of usage patterns in the weekdays compared to weekends.

The study concluded that the fleet of cars and their availability for V2G makes a significant difference in V2G availability during daytime hours, substantially increasing the number of available units and, consequently, the power. These plots demonstrate that, under the chosen assumptions, the number of vehicles is more important than the battery capacities, and that the power and energy available for V2G primarily are limited by the charging/discharging powers.

[1] Assessment of vehicle-to-grid potential in airport fleets, Nov. 2025: https://alight-aviation.eu/

As presented in Figure 5 the dimensioning of V2G chargers have a significant impact on the energy available for providing V2G. If the chargers are under dimensioned, it will lead to lower utilisation rates of the V2G potential, whereas over dimensioning will lead to higher investment costs than needed. (See the guideline on charging infrastructure for more information of the dimensioning, planning and implementation of charging infrastructure in airports).

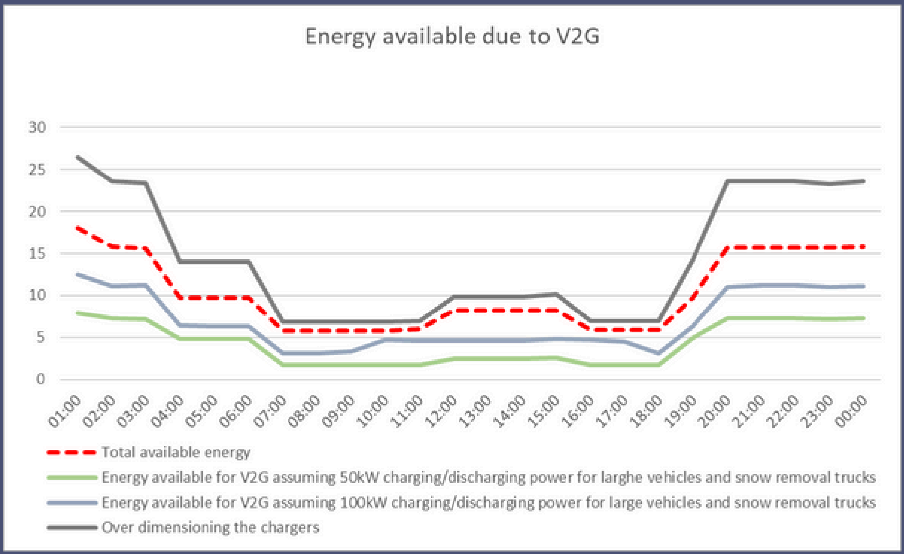


Figure 5 - Comparison of energy available in batteries and energy transferrable through V2G chargers.

To assess the potential energy and power for smart charging and V2G in an airport fleet different approached can be used. The assessment can be based on a theoretic analysis of the potential of the existing and future fleet in the airport depending on the existing fleet and the availability of data this can be done in many ways. A case study for CPH has been performed and can be seen the report Assessment of vehicle-to-grid potential in airport fleets[3].

The proposed method here is a theoretic analysis to get an estimate of the potential. After this analysis it is recommended to continue with a market analysis where focus is on the vehicles which showed to have the highest potential.

[3]Assessment of vehicle-to-grid potential in airport fleets, Nov. 2025: https://alight-aviation.eu/

The first step of the analysis is to decide which parts of the fleet that shall be included in this analysis.

STEP 1 Estimate total battery capacity of the (assumed) electric fleet.

STEP 2 Analyse the availability of the total battery capacity based on schedules for the vehicle operations (usage pattern).

To simplify the analysis of the fleet the vehicles can be divided into categories based on their battery capacity (if not already electric then an expected battery capacity can be used) and/or their usage pattern.

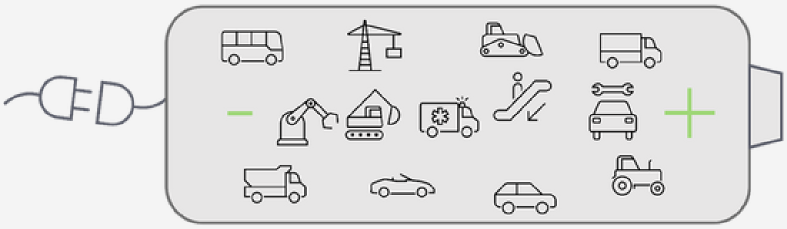


Figure 6 – Conceptual sketch of total battery capacity of fleet used for V2G in airports.

STEP 1 will give a good indication of which vehicle types that may be of highest interest, as vehicle categories with a noticeable battery capacity can have the largest impact.

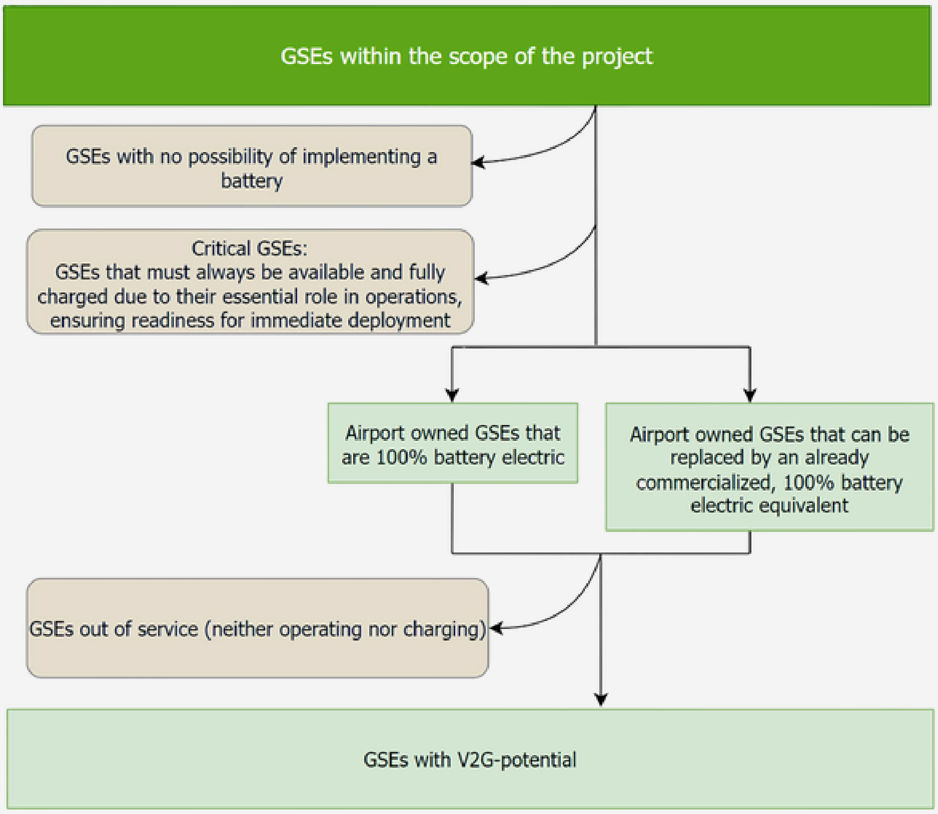


Figure 7 – Identification of GSEs/equipment interesting for further V2G-assessment.

STEP 2 is necessary to assess the availability of battery capacity and thereby what is actually possible without disturbing the airport operation. The availability will depend on the operating schedules compared with the charging time for the vehicles. This means that the sizing of chargers and number of chargers available has an impact on the potential for utilising the battery capacity in the vehicles, when they are not operating.

The V2G potential is highly dependant on the operating schedules together with sizing and availability of chargers

ANALYSIS OF CHARGING FACILITIES

CASE: CPH

Currently, V2G is not possible in CPH with the already installed and available equipment. However, in a few locations, CHP has implemented load sharing for some groups of charging stations. In some areas, the available energy for charging will be shared between the chargers if all are in use. This is implemented by a fuse limiting the delivered power in the distribution panels

Besides analysing the fleet, it is important to analyse the capabilities of the charging facilities. This includes technical assessment of chargers' hardware and communication protocols, communication and remote-control possibilities together with identification of owner and charge point operator. Assessment of existing charging facilities and their compatibility with smart charging systems and vehicle-to-grid. Furthermore, a market analysis of available technologies (especially for V2G, where both chargers and vehicles shall support V2G).

GUIDELINE FOR SMART CHARGING AND VEHICLE-TO-GRID IN AIRPORTS

Planning

The aim of the planning phase is to establish clear, technically detailed specifications for equipment and software, which then form the basis for purchasing and installing the necessary infrastructure for smart charging and V2G at airports.

STAKEHOLDERS

Mapping the usage patterns of GSEs may require either specific data on the vehicles' operations or charging sessions (if already electrified) or insights from personnel in the airport operations and knowledge about constraints (e.g., weather, air traffic and critical operating equipment).

EXAMPLES OF RELEVANT INTERNAL STAKEHOLDERS CAN BE:

- Owner of charging infrastructure (if infrastructure is not owned by the airport)
- Charge point operator (if existing charging facilities are not operated by the airport)
- EMS/software developers
- Distribution and/ or transmission system operator (DSO or TSO)
- Airport IT department
- Airport cybersecurity department
- Airport master planning department
- Airport operation department (representing vehicle operators)
- Airport parking department (if passenger cars are considered to be used)
- Balance responsible party (relevant only if ancillary services are considered)
- Aggregator
- EV owners (if passenger cars are considered)
- Electricity supplier

Descriptions of the roles and responsibilities of actors especially relevant when considering ancillary services can be found in Potential of smart charging and V2G[2].

REQUIREMENT SPECIFICATION AND PROCUREMENT

The outcome of the above-mentioned analysis can be specific requirements for new electric equipment procured in the airport, for new charging facilities procured and installed or requirements for energy management systems or similar software to manage the charging sessions.

For vehicles and charging facilities especially requirements on plugs, bi-directional capability and charging protocols are of high importance.

Important specifications for software solutions includes requirements for IT and cyber security together with requirements for communication interfaces and protocols to integrate with new or existing facilities.

These requirements can then be used for the procurement and tendering of the chargers and software.

IMPLEMENTATION PLAN

The planning department should establish a detailed implementation plan to ensure a structured implementation phase and to minimise costs (e.g., if only some chargers are installed with smart charging capabilities). The scope of the implementation plan shall be in line with the project size and can vary from being a simple project plan to an extensive project management plan including detailed budgets, identification and agreements with subcontractors, time schedule, ensuring safe integration into the IT network etc.

GUIDELINE FOR SMART CHARGING AND VEHICLE-TO-GRID IN AIRPORTS

Implementation and operation

The implementation and construction phase of charging infrastructure in airports is a critical stage where the project transitions from planning to physical execution.

INSTALLATION OF CHARGERS

The implementation can be divided into two phases:

1) PILOT

2) FULL-SCALE

1) PILOT PROGRAMS AND TESTING:

Start with a pilot project to test the smart charging or V2G concept at a smaller scale, learn from the experiences, and refine the approach.

- Install equipment (a limited number of chargers) including connecting to the public grid, integrating robust cybersecurity measures to protect the system and airport from potential threats, and install communication systems to facilitate smart charging.

- Establish clear metrics to evaluate the performance and success of smart charging and V2G systems during the pilot phase.

- Design dynamic charging and discharging schemes/protocols that do not disrupt airport operations

CASE: SMART ENERGY MANAGEMENT IN CPH

In CPH an EMS is implemented and demonstrated within the ALIGHT project. The EMS is provided by Hybrid Greentech.

THE ACTIVITIES IN CPH (SITE IN MAGLEBYLILLE) AIM TO DEMONSTRATE THE FOLLOWING USE CASES:

1.Optimising CO_2 footprint of EV charging, uncontrollable consumption and BESS.
2.Provision of ancillary services while optimising for reducing CO_2 footprint.

Moreover, in these two use cases, tests for peak load shaving, load shifting using the EVs, and PV time-shift will be conducted.

The main logic of the EMS is that it reads forecasts and based on these, it decides on an operational plan for controllable assets e.g., the operator can decide to do CO_2 optimisation, and then the EMS should determine what is the best operation, e.g., by limiting the charging capability (power) of the chargers when the CO_2 intensity in the grid is high and allow full charging to the grid when the CO_2 intensity is low. The same could be applied if optimising against costs, where electricity prices will be used as parameter.

The peak shaving through limitation on the chargers will be tested on a demonstration site at CPH. This area supports several of the internal operations regarding service, maintenance, and storage of airport equipment. Moreover, several charging points are established throughout the site to support the electric vehicles and electric ground support equipment.

2) FULL-SCALE AND FUTURE SCALABILITY:

After a successful pilot program, it is time to scale up and include more charging points and vehicles to be included in smart charging and/or V2G setup.

a. Design the management system to be scalable, allowing for future expansion as technology evolves and demand increases.

b. Ensure the system can integrate new technologies and advancements in charging facilities and vehicles.

SOFTWARE PLATFORM

Besides of installation of physical chargers, a software platform should also be implemented. The platform must ensure compatibility with different EV manufacturers and charging station standards. The software must ensure protection of sensitive data and ensure secure communication between charging stations and vehicles.

INTEGRATION INTO EMS

In order to ensure safe communication of data from the chargers and the EMS, secure protocols must be used to prevent unauthorised access or cyber-attacks on the EMS.

MONITORING

To monitor the use of EV chargers effectively for smart charging and V2G applications, several key parameters can be considered.

These parameters help in assessing the performance, efficiency, and impact of the charging infrastructure:

1. Charging session data	**a. Energy delivered:** Measures the total energy transferred during a charging session (kWh)
	b. Charging power: Monitors the power level during the session (kW). Both peak and average power.
	c. Session duration: Tracks how long the EV was connected and charging (hours)
	d. State-of-Charge (SoC): Used for monitoring the state of the battery to ensure that the battery is charged when the user needs the car while performing V2G when plugged in.
2. Grid interaction parameters	**a. Bidirectional Energy Flow (kWh):** Monitors the amount of energy sent back to the grid in V2G scenarios.

3. Other parameters	**a. Time-of-Use (ToU):** Logs when charging occurs (e.g., peak vs. off-peak hours) to optimize energy costs and grid load balancing.
	b. Idle time/plug occupancy: Measures the time the EV remains connected to the charger after charging is complete, which can inform user behaviour and charger availability.
	c. Carbon Intensity of the Energy Mix: Tracks the source of electricity (e.g., renewable vs. fossil fuels) to evaluate environmental benefits.

OUTLOOK

The transition to more sustainable energy systems in airports presents a transformative opportunity to reduce environmental impact, enhance operational efficiency, and align with global sustainability goals. By integrating renewable energy sources, energy storage, and smart energy management systems, airports can significantly reduce their carbon footprint, enhance energy efficiency, and improve operational resilience. These solutions enable airports to better align with evolving sustainability goals and regulatory requirements, such as the EU's Renewable Energy Directive (RED III). Operationally, smart energy solutions offer flexibility, allowing airports to fit energy consumption to fluctuating renewable energy production (e.g., solar and wind) and reduce dependency on fossil fuels.

The integration of energy solutions into airport operations offers a range of benefits considering environmental, economic, operational, and social dimensions.

- **Environmental:** Energy solutions enable reductions in greenhouse gas emissions through larger shares of renewable energy. Additionally, replacing local fossil fuel-based energy production improves air quality, benefiting both airport users and surrounding communities.

- **Economic:** Airports can realize long-term cost savings through enhanced energy efficiency and reduced reliance on fossil fuel. Price stability can be achieved through power purchase agreements (PPAs) or local renewable energy sources owned by the airport, and by creating revenue from grid services.

- **Operational:** Benefits include enhanced reliability of energy systems, ensuring uninterrupted power supply for critical airport functions. These solutions also improve an airport's resilience to disruptions, such as power outages or extreme weather events, thereby strengthening overall operational stability.

- **Social:** Adopting sustainable energy practices aligns airports with broader regional and national climate strategies. This also demonstrates the airport's commitment to addressing climate change and sustainability goals.

While challenges such as financial constraints, technical integration, and regulatory complexity remain, airports that proactively plan, engage stakeholders, and leverage available support mechanisms can overcome these barriers. Managing a diverse portfolio of energy assets, including photovoltaic (PV) systems, battery storage, and electric vehicle (EV) chargers, requires advanced expertise and planning. Airports will need to invest in workforce training, adopt advanced energy management platforms, and collaborate with energy experts to effectively operate and maintain these systems. By implementing future-proof energy systems and scalable infrastructure, airports can adapt to increasing passenger demands, technological advancements, and evolving regulations.

NEXT STEPS

Airports are highly energy-intensive and are under increasing pressure to become sustainable. Smart charging and Vehicle-to-Grid (V2G) are presented as practical solutions for reducing energy costs, greenhouse gas emissions, and grid dependency. Smart charging optimizes EV charging by considering electricity prices, CO_2 intensity, and operational needs.

The needed charging of EVs or other equipment can provide flexibility in the energy system by implementing smart charging and/or V2G. V2G enables EVs to supply electricity back to the grid, adding further flexibility and value.

KEY USE CASES:

- Load shifting
- Peak shaving
- CO_2 and cost arbitrage
- Ancillary services, like frequency services
- Maximizing self-consumption from renewable energy production

IF YOU ARE CONSIDERING SMART CHARGING, YOU CAN START YOUR WORK WITH THE FOLLOWING STEPS:

1. Engage stakeholders and address IT and cyber security at an early stage
2. Initiate a detailed mapping and feasibility study
3. Define requirement specifications of new vehicles, chargers, and software
4. Plan and execute pilot projects

Mapping: Key questions

- What is the current composition of the airport's vehicle fleet (airside, landside, and special equipment)?
- Is the current airport vehicle fleet suitable and available for smart charging and V2G?
- Are existing charging facilities compatible with smart charging and V2G, or are upgrades needed?
- How will smart charging and V2G change user and operational behaviours?
- How will financial benefits from V2G be shared among stakeholders?

Planning: Key questions

- Are all relevant stakeholders included in the phase and have inputs been obtained?
- How will IT and cybersecurity requirements be addressed for new charging infrastructure?
- How will the roll-out of chargers be done?

Implementation: Key questions

- What are the criteria and metrics for evaluating the success of the pilot program for smart charging and V2G systems during the implementation phase?
- How will the software platform be integrated to ensure compatibility with various EV manufacturers and charging station standards while protecting sensitive data?
- How will the performance of the chargers be measured?

ABBREVIATIONS

Abbreviation	Explanation
ADR	Aeroporti Di Roma (fellow airport in ALIGHT located in Italy)
CPH	Copenhagen Airports
CPK	Centralny Port Komunikacyjny (fellow airport in ALIGHT located in Poland)
DSO	Distribution system operator
EMS	Energy management system
EV	Electric vehicles
GHG	Greenhouse gas
GSE	Ground support equipment
LTOU	Lithuanian Airports (fellow airport in ALIGHT located in Lithuania)
PV	Photovoltaic
RES	Renewable energy sources
SoC	State-of-charge
ToU	Time-of-use
TSO	Transmission system operator
V2G	Vehicle to grid
WP	Work package

REFERENCES

[1] T. B. K. Christensen, H. Lund and P. Sorknæs, "The role of thermal energy storages in future smart energy systems," 30 12 2024. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0360544224037265. [Accessed 13 02 2025].

[2] A. B. Thingvad, A. F. Noureddine, M. H. Monin, A. Varnith, L. S. Ingvardsen, K. Nørregaard and L. K. Askholm, "Potential of Smart Charging and V2G," 30 October 2023. [Online]. Available: https://alight-aviation.eu/onewebmedia/ALIGHT-WP4_3_white_paper_about_smart_charging_and_V2G.pdf. [Accessed 23 April 2025].