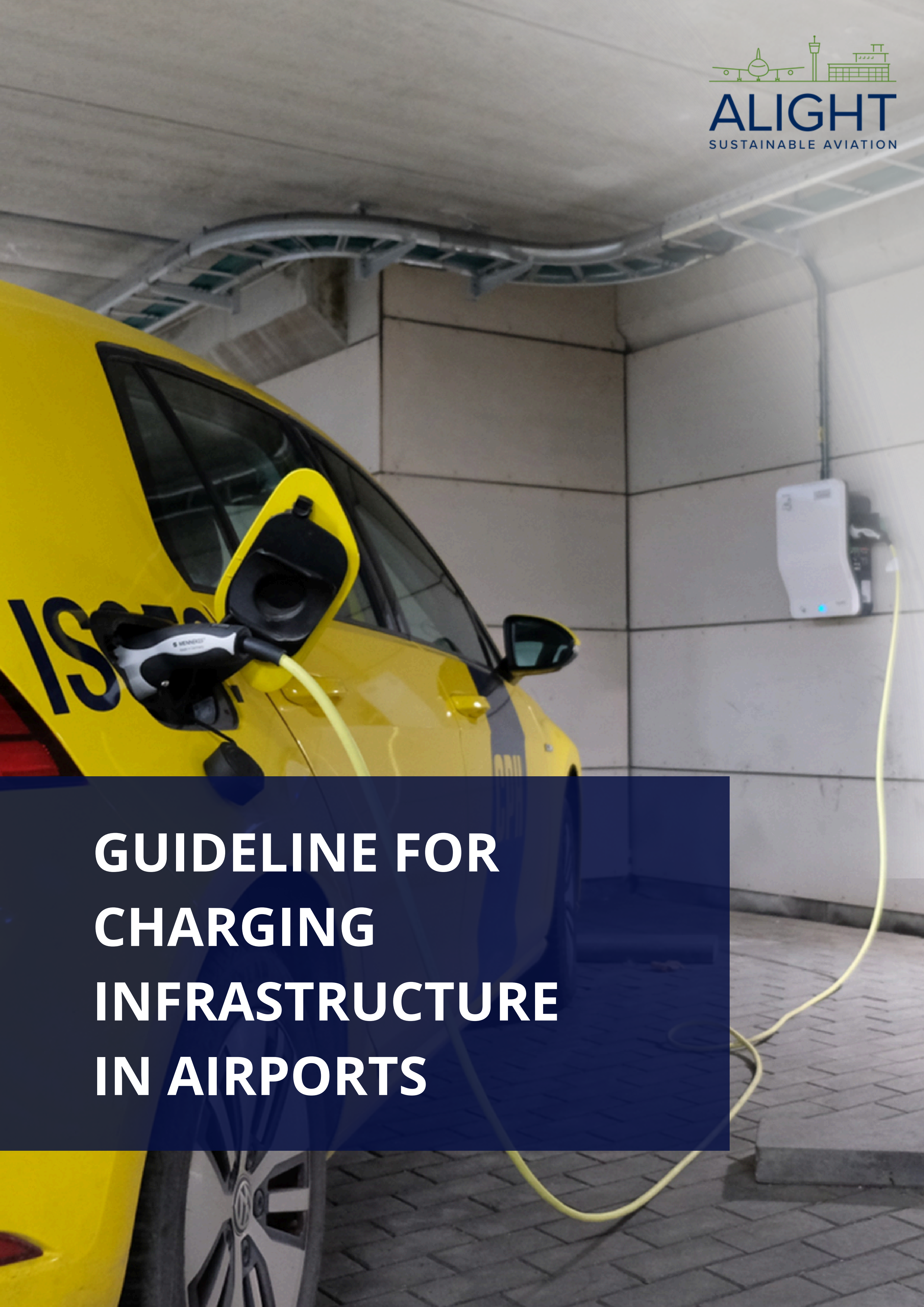
ALIGHT
SUSTAINABLE AVIATION



GUIDELINE FOR CHARGING INFRASTRUCTURE IN AIRPORTS

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RELATED GUIDELINES

Guideline for battery energy storage systems in airports

Guideline for smart energy management systems in airports

Guideline for smart charging and vehicle-to-grid 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 ALIGHT

INTRODUCTION TO THE GUIDELINE

This guideline provides best practices based on lessons learned in the ALIGHT project, related to implementing EV charging infrastructure in airports. The aim is to provide insights and help to overcome possible barriers related to mapping, planning, designing, and executing charging infrastructure 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 chargers.

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 EV charging infrastructure 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 for technical project managers, offering actionable insights of planning and implementing of EV charging infrastructures in an airport environment. Through practical guidelines, case studies, and lessons learned, this report provides the readers with technical insights and strategic considerations for addressing the complexities of modernising energy infrastructure in airports.

As a part of the green transition, a significant amount of energy consumption is transitioning from fossil fuels to electricity, thereby making charging capabilities a necessity. To address this growing need, the airport must carefully evaluate various factors to develop a strategic and scalable approach to installing an effective and future-proof charging infrastructure.

The term “charging infrastructure” covers charging of all types of electric vehicles and appliances such as electric cars (EV), electric Ground Support Equipment (eGSE), electric buses, electric aeroplanes, electric Ground Power Units (eGPU) etc.

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.

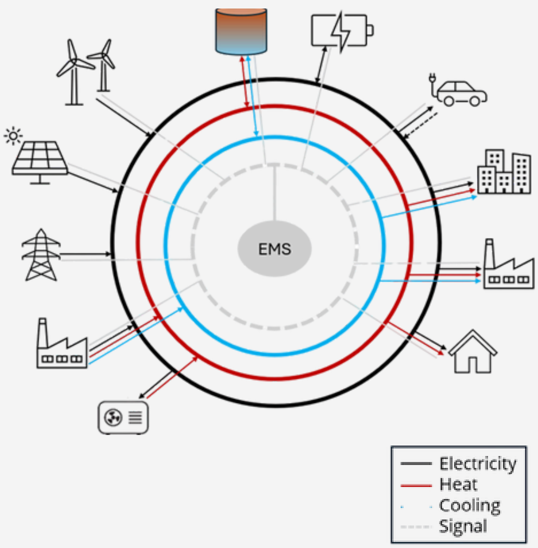


Figure 2 – Example of subsystems in a smart energy system.

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) can 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.

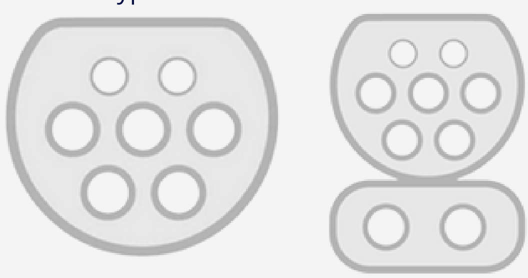
Optimising self-consumption from RES
By storing energy when RES produce more energy than needed to cover the demand, or by shifting the load to meet the RES production, thud the RES will be better utilised, and a higher share of the consumption will be covered by local RES.

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 arbitrage based on CO_2-emissions of electricity from the grid	
	Optimise self-sufficiency from local RES	Smart charging
Reduce energy costs	Energy arbitrage based on costs	Smart charging
	Optimise self-consumption from local RES	
Reduce the need for reimbursement of energy infrastructure	Load-shifting	Smart charging
Reduce the reliance of external energy providers	Optimise self-consumption from local RES	Smart charging
	Optimise self-sufficiency from local RES	Load-shift of EV-charging, heat pump operation, HVAC etc.

GUIDELINE FOR CHARGING INFRASTRUCTURE IN AIRPORTS



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. Table 2 contains examples of analyses and assessments which can be conducted and the possible outcomes for each phase. The necessary analyses and assessment are site and country specific.

TABLE 2

Overview of examples of relevant analyses

Phase	Mapping	Planning	Implementation and operation
Analyses and assessments	Mapping of current charging infrastructure and electric fleet Predictions for future demand Estimation of needed charges Initial business case Relation to overall sustainability	Infrastructure analysis (e.g., load flow calculations) Stakeholder analysis Ownership considerations Detailed implementation plan Scale up/roll out plan Tendering and procurement	Obtain relevant permits and approvals Site preparation Installation of charges Integration into EMS Test and commissioning Monitoring and maintenance
Outcomes	Stop/go of the project Estimation of charges and power	Stakeholder engagement Ownership Detailed plan for implementation Electric infrastructure layout Procurement of equipment	Approvals obtained Installation of charges Monitoring usage

GUIDELINE FOR CHARGING INFRASTRUCTURE IN AIRPORTS

Mapping

The purpose of the mapping is to provide a clear baseline of the airport's current electric vehicle fleet and charging infrastructure, identify gaps or needs for future expansion, and set the stage for informed planning and decision-making for further development of EV charging at the airport.

MAPPING OF THE CURRENT INFRASTRUCTURE AND ELECTRIC FLEET

To understand the future needs and requirements for the charging infrastructure of the airport, it is essential to establish an overview of the current fleet composition and infrastructure. This includes both landside and airside vehicles, covering everything from passenger cars and buses to specialised GSEs. At this stage, it is important to map the number of electric vehicles and their areas of use.

The planning department should ensure that the airports replacement plans for the existing fleet is aligned with the electrification strategy and thus charging infrastructure plan.

A thorough review of the current charging infrastructure is necessary to assess its ability to support an increased electrification of the fleet, when estimating the need of chargers in the airport.

ELEMENTS TO CONSIDER WHEN MAPPING:

- The number of charging stations
- Locations
- Capacities (kW)
- Usage patterns, including utilisation rates and peak load periods.

This analysis will help identify potential bottlenecks and future needs for infrastructure expansion. The airport should also consider the connector type to facilitate future electrical use-patterns including charging of buses, eGSE, planes etc. Considerations about charging infrastructure for electric planes and eGSE's dedicated to aircraft stands are further elaborated on in D5.3, infrastructure studies and push-back study.

PROJECTIONS OF FUTURE DEMAND

Besides airport related vehicles, the charging infrastructure for public charging should also be mapped and estimated. It is relevant to consider national projections for the share of EVs in the overall fleet. According to forecasts from Danish authorities and the EU, a significant increase in the number of electric and hybrid vehicles is expected by 2030 and 2050 [2].

This development must be considered to ensure that the airport's strategy aligns with national forecasts for the green transition.

ESTIMATION OF NEEDED CHARGING INFRASTRUCTURE

In the mapping phase the airport should identify the needed charging capacity considering the needed charging type (slow or fast) and charging level (maximum power of the charger).

If the airport would like to provide smart charging and/or V2G they should consider this in the mapping phase, as it requires special chargers.

Moreover, the airport should consider which types of electric vehicles are most suited for their needs and assess the battery capacity of the available vehicles, as this will affect how much energy can be utilised for V2G operation. Moreover, it should be assessed if the vehicles used within the airport (e.g., shuttle buses, service vehicles) are V2G-compatible and whether the smart charging infrastructure can manage bidirectional energy flows.

CASE: ESTIMATION OF CHARGING CAPACITY IN CPK

CPK has started the planning for integration of EVs and eGSEs in the future airport. CPK has conducted initial assessments to estimate the demand for charging infrastructure which resulted in a charging power span of 20–40 MW for eGSEs at airside and 30–70 MW for chargers in parking areas landside, which will be available to passengers and airport employees.

CPK plans to prioritise chargers with a minimum capacity of 22 kW for charging EVs and fast chargers with capacities above 100 kW for eGSEs to meet operational needs.

INITIAL BUSINESS CASE

To assess the feasibility of installation of charging infrastructure an initial business case can be conducted.

THE BUSINESS CASE CAN INCLUDE:

- Capital expenditures: Cost of chargers, installation, site preparation, and infrastructure upgrades.
- Operation expenditures: Ongoing costs such as electricity, maintenance, software licensing, and customer support.
- Potential revenue: such as pay-per-use charging fees, partnerships with EV service providers, etc.

SUSTAINABILITY ASSESSMENT

A sustainability assessment of the project could be done to assess the impact of the project according to the airport's sustainability strategy. The sustainability assessment should have a similar weight in the decision of continuing the project planning as the economical business case. Moreover, the sustainability assessment should include initial analysis of nature and environmental conditions. The assessment should cover if the installation of EV chargers supports the overall sustainability goals.

It should also be considered whether the electricity supplied to chargers is sourced from renewable energy and the implications for the business's sustainability goals.

GUIDELINE FOR CHARGING INFRASTRUCTURE IN AIRPORTS

Planning

When the potential for chargers has been mapped in the initial phase, suitable locations must be selected. This requires thorough planning to achieve optimal placement, where considerations regarding the number of chargers, electrical infrastructure, and physical location should be included.

Relevant stakeholders should be involved early in the planning process to mitigate potential barriers.

The involvement can be structured in a stakeholder analysis.

THE STAKEHOLDERS MAY INCLUDE:

- Airport master planning department
- Airport sustainability department (e.g., ensuring project is aligned with sustainability goals)
- Airport fire department
- Airport asset management (e.g. responsible for electrical infrastructure)
- Distribution system operator (DSO) (e.g. for grid connection approval)
- Parking facility operators
- Airport tenants and businesses
- Municipality (e.g. for land zone permit, building permit, occupancy approval)
- National authority (e.g., Italian law regarding fire risks)
- Vehicle and equipment manufacturers to ensure compatibility and support.

PLANNING

Detailed analyses

The detailed planning can consist of several analyses, which assist to ensure an effective, scalable and cost-effective implementation.

SPACE ALLOCATION

The optimal zones for charging stations, such as parking lots, employee parking areas, or near terminals must be identified, considering the estimated number of chargers needed, physical space required for installation, accessibility (e.g., in case of fire in chargers or vehicle), and efficient traffic flow around the charging areas.

ELECTRICAL ANALYSES AND LAYOUT

The power needed for charging depends on the type and number of charging stations as well as the specific needs of the users, e.g., long-term parking might require slow charging, whereas charging of eGSEs might require ultra-fast charging due to operational schedules where predictable power requirements are essential.

CASE: LOAD SHARING IN CPH

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. Additionally, a pilot project has investigated the possibility of adjusting charging levels between vehicles depending on the energy produced by the PV panels and the state-of-charge (SoC) of the vehicle.

Airport users, such as passengers and staff, often have varying charging time windows, ranging from brief stays in pick-up/drop-off zones to extended periods in parking lots. The allowable time and power level for charging are thus key parameters to consider.

To ensure that the electric infrastructure in the airport can accommodate the expected power demand without causing grid congestion and disruptions, both internal grid analysis and coordination with the DSO must be conducted. For the internal analysis the peak demand taking into account simultaneous charging at multiple stations during busy periods. If the internal grid cannot accommodate the charging infrastructure a need for grid reinforcement (cables, transformers, etc.).

CASE

For buses at airside, the planned charging stations will consist of ultra-fast charging stations with a rated power of 240 kW to 360 kW DC, where one station can provide power to two charging points. The charging connection will be identified by analysing the market for electrical buses and considering the stakeholders planned solutions. Depending on the network load, a buffer battery with a capacity of 100 kW/100 kWh may be installed.

The cooperation with the DSO should clarify the impact the additional loading will have on the external power grid. This detailed load analysis is necessary to determine whether the existing grid can handle the increased demand or if upgrades to substations and transformers are required. If the roll-out of the charging infrastructure is divided into several phases, the design and layout of the initial infrastructure must ensure that future expansions can be integrated seamlessly.

The peak demand can however be lowered by the airport by load management measures such as smart charging, peak shaving, limiting the allowed charging power, etc., or by installing a battery supplying energy during peak demand and thereby reducing the load on the grid. If the airport will facilitate V2G, it must be evaluated whether the electrical grid (incl. components like transformers, protection equipment etc.) can handle bidirectional flows.

Moreover, cooperation with the utility company regarding V2G should be initiated to avoid possible grid congestions and it should be considered if it is possible to integrate RES such as PV or wind turbines. The optimal locations for V2G-compatible charging stations to maximise convenience and efficiency, should also be identified.

SMART CHARGING & V2G AND ENERGY STORAGES ARE ELABORATED IN THE RESPECTIVE GUIDELINES.

Guideline for battery energy storage systems in airports

Guideline for smart energy management systems in airports

Guideline for smart charging and vehicle-to-grid in airports

Guideline for solar power plants in airports

OWNERSHIP - INTERNAL VS. EXTERNAL

When it comes to ownership of the charging infrastructure, a decision must be made on whether the airport should own and operate the facilities itself or collaborate with external stakeholders.

Considerations to make for the two ownership categories could be:

Internal ownership	External ownership
• **Advantage:** Full control over operations and maintenance, tailored solutions, and potential revenue from charging and implementation of smart charging solutions.	• **Advantage:** Lower initial investments and the ability to leverage the experience and technology of external partners.
• **Disadvantage:** Higher initial investment costs and requirements for technical expertise.	• **Disadvantage:** Less control over operations and dependency on third parties. Procedures or regulations of payment structure and responsibility between parties are not fully developed, which complicates implementation of V2G.

The airport can consider which ownership structure that makes sense for each area, and thereby not having the same ownership for all chargers.

CASE: LOAD SHARING IN LTOU

The landside EV chargers will be operated by private companies, and chargers at airside will be owned and operated by LTOU.

REQUIREMENT SPECIFICATIONS, TENDERING AND PROCUREMENT

Requirements for the chargers and infrastructure can be formulated in both functional and non-functional requirements.

The requirements can include specifications for:

- Type of chargers and number of chargers
- Power requirements
- Compliance with standards

IMPLEMENTATION PLAN

The planning department should establish a detailed implementation plan to ensure a structured implementation phase and to minimise costs (e.g., if cables must be installed in roads which must be reconstructed afterwards).

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, logistics for construction especially important on airside and near runways.

SCALE-UP/ROLL OUT PLAN

If the implementation of chargers and charging infrastructure is performed in several phases a detailed plan for the scale-up and roll out should be established to minimise costs and delay in roll out. All relevant steps described in the detailed analyses sections should be conducted for each of the later implementation steps.

The plan can be reevaluated based on monitoring of performance and usage of the chargers implemented in the previous phases.

CASE: IMPLEMENTATION PLAN LTOU

For high level implementation planning of chargers on airside, a 12-year project program was prepared. The plan includes three phases containing the following objectives:

Phase 1 (5-year timeframe):	Installation of 3 charging stations for buses, 5 charging stations for cars and 4 charging stations for GPUs, resulting in a total of 24 chargers. In this phase, all cabling work will be completed while considering the planned future expansions in the next two phases. The installation if chargers in this phase is funded by Connecting Europe Facility
Phase 2 (8-year timeframe):	Installation of 2 charging stations for buses, 3 stations for cars and 3 stations for GPUs, resulting in additional 16 chargers.
Phase 3 (12-year timeframe):	Installation of additional 4 charging stations for buses, 2 stations for cars and 2 charging stations for GPUs, resulting in additional 16 chargers.

GUIDELINE FOR CHARGING INFRASTRUCTURE 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

Before construction begins, it is essential that the airport in collaboration with the local DSO ensure availability of sufficient power from the DSO grid. Moreover, the designated site must be cleared while minimising disruption to other airport operation, hence the continuous stakeholder engagement. Hereafter the installation of the chargers can be accomplished along with grid reinforcing activities if required e.g., electrical cabling, upgrade of transformers, etc. Additionally, communication lines and protocols should be installed as well, in order to monitor the usage and eventually control the chargers. The control is however dependent on the ownership of the chargers.

Before construction begins, it is essential that all necessary permits and approvals are obtained.

CASE: FIREHANDLING IN CPH AND ADR

CPH has implemented a range of fire safety measures in the parking facilities to ensure efficient handling of fire in EVs and BESS:

- Sprinkler systems installed in the parking facilities adhere to the standard requirements outlined in CEA 4001. These systems are not specifically designed for EV-related fires but provide general fire suppression capabilities to enhance safety in the event of a fire.
- The Rescue and Firefighting team are equipped with specialised tools including cooling systems (see Figure 5) and fire blankets to contain and avoid spreading of fire from one EV to another.
- To further enhance safety, CPH has planned an investment in a FirstMover device (see Figure 6). This equipment will allow the safe removal of a burning EV from the parking facility, minimizing risks to nearby structures and other vehicles.
- For incidents occurring on the apron or taxiways, CPH's firefighting protocol includes using tow trucks to remove burning vehicles from building facades. This ensures that fires are isolated and prevents the spread of flames to critical airport infrastructure.

Figure 3 – Specialised sprinkler rack to cool burning EV and avoid spreading.

Figure 4 – FirstMover-tool used to move EVs in case of fire.

To increase the opportunities for firefighting of an EV fire and minimise the consequences ADR has chosen to locate all EV chargers at ground level in parking areas.

TESTING, COMMISSIONING AND MONITORING

Once all equipment is installed, thorough testing and commissioning are critical to ensure the system functions correctly. The tests should encompass testing of performance, safety inspections such as compliance with relevant standards and policies, and functioning software integration i.e., payment systems, user interfaces, receiving data for monitoring the usage of chargers.

MONITORING KPI'S:

Charging time	Tracks how long the EV was connected and charging (hours)
Charged energy (kWh) and power (kW)	Monitors the power level during the sessions. Both peak and average power should be tracked.
Idle time/plug occupancy	Measures the time the EV remains connected to the charger after charging is complete.

If the airport facilitates V2G and smart charging the EMS should monitor and optimise the V2G operations and performance through smart charging based on operational data. Finally, the airport should develop a maintenance schedule for periodic inspections.

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. Offering charging facilities for electric equipment, both airport-owned equipment, employee cars and passenger transport vehicles, are essential to succeed with the transition from fossil fuelled vehicles to electric vehicles.

The needed charging of EVs or other equipment can provide flexibility in the energy system by implementing smart charging and/or V2G. By having these options in mind at an early stage, the benefits of charging infrastructure can be increased.

IF YOU ARE CONSIDERING INSTALLING EV CHARGERS, YOU CAN START YOUR WORK WITH THE FOLLOWING STEPS:

1. Initiate a detailed mapping of expected fleet/users and estimate needed amount and types
2. Engage with stakeholders and consider owner structure and usage
3. Define requirement specifications of new chargers and related infrastructure
4. Plan and execute pilot projects

Mapping: Key questions

- What is the current composition of the airport's vehicle fleet (airside, landside, and specialised GSEs), and how many of these are electric?
- Are the existing charging connectors and infrastructure compatible with the anticipated future needs, including for buses, eGSE, and potentially electric planes?
- What is the current state of the charging infrastructure (number, locations, capacities, and utilisation patterns)?
- What total charging capacity (including type – slow or fast, and power level) will be needed to meet future demands from both airport-related and public vehicles?

Planning: Key questions

- What are the main purposes and goals for implementing new smart energy and charging solutions at the airport?
- Which stakeholders (e.g., airport departments, DSO, regulatory authorities) need to be involved in the planning and implementation process?
- Is the existing infrastructure (electrical, physical space) sufficient to support the planned charging installations, or are upgrades and reinforcements needed?
- What are the safety, technical, and regulatory requirements that must be met for the charging infrastructure, and which approvals need to be secured?

Implementation: Key questions

- Have all necessary permits and approvals been obtained, and is there a clear plan to ensure sufficient power supply from the local DSO for the charging infrastructure?
- How will the installation and construction of charging stations be coordinated to minimise disruption to airport operations, including grid reinforcement and communication systems?
- What key performance indicators (KPIs) will be used to evaluate the performance of the implemented solutions, and what data is required to monitor them?
- What maintenance schedules and operational protocols are established to ensure ongoing reliability, including periodic inspections and integration with smart charging or V2G systems?

ABBREVIATIONS

Abbreviation	Explanation
ADR	Aeroporti Di Roma (fellow airport in ALIGHT located in Italy)
BESS	Battery energy storage system
CCS	Combined Charging System
CPH	Copenhagen Airports
CPK	Centralny Port Komunikacyjny
Dx.x	(ALIGHT) Deliverable
DSO	Distribution system operator
eGPU	electric Ground Power Units
eGSE	electric Ground Support Equipment
EMS	Energy management system
EV	Electric Vehicle
GHG	Greenhouse gas
GPU	Ground Power Units
GSE	Ground Support Equipment
KPI	Key Performance Indicator
LTOU	Lithuanian Airports
PV	Photovoltaics
RES	renewable energy sources
TSO	Transmission system operator
V2G	Vehicle-to-grid
VNO	Vilnius International Airport

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