ALIGHT
SUSTAINABLE AVIATION

GUIDELINE FOR SMART ENERGY MANAGEMENT SYSTEMS IN AIRPORTS

ACKNOWLEDGEMENT

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RELATED GUIDELINES

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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. For instance, a Battery Energy Storage System (BESS) has been installed to gain valuable experience with the practical implementation of such a system in an airport setting, as well as to explore how energy storage can facilitate increased 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 energy management systems (EMS) 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 EMS.

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 EMS 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 implementation of smart energy management systems 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.

Energy management systems (EMS) can be tuned to minimise GHG emissions from the energy system, maximise energy efficiency or utilisation of Renewable energy sources RES, minimise congestion and/or optimise energy costs by managing the sources of energy and energy-flow, including consumption, production, storage, and interchange with the electricity grid.

The EMS consists of both software and hardware components to optimise energy production, storage, and consumption of energy connected in the electrical distribution grid in the airport, by collecting, analysing, and controlling the energy flow in real time. The EMS is therefore an important element to ensure that flexibility potentials are fully exploited, and that the airport obtains the highest value of their energy system and infrastructure.

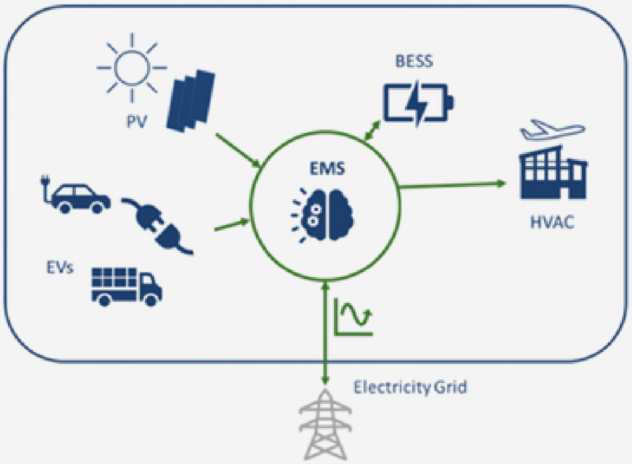

Figure 2 – The concept of an airport smart energy management system (EMS) with assets included in ALIGHT.

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 3 is focusing on the electrical aspect of smart energy. Airports have multiple reasons to invest in RES. Transitioning from fossil fuels to renewables reduces greenhouse gas emissions and supports sustainability goals, while also improving local air quality.

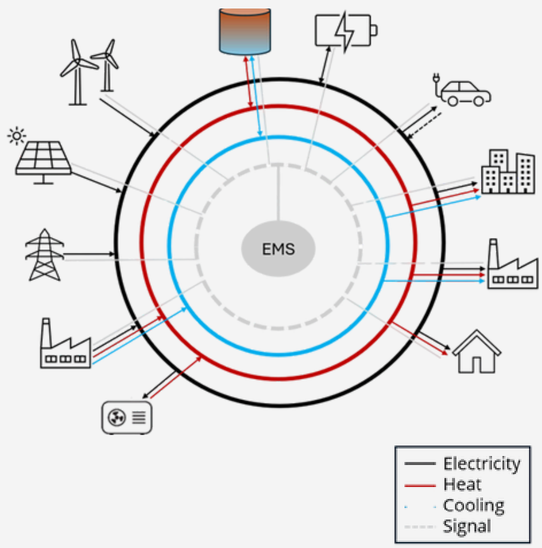

Figure 3 – Example of subsystems in a smart energy system.

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 intermittent RES like solar and wind. [1]

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.

When introducing energy storage in an energy system the role of the energy management becomes even more dynamic. Where an energy system without storage is usually managed/planned by looking at the current and expected operation (consumption and production), the introduction of energy storage allows for flexibility in absorption of produced energy, due to the buffer capacity.

The schedules of operations will become more complex in nature, especially in a diverse energy system like a modern airport, where the energy system might consist of several assets e.g.:

- Battery Energy Storage System (BESS)
- Electric Vehicles (EV)
- Heat Pumps and HVAC centrals, with thermal energy storage
- Ground services workshop, equipment
- Local renewable energy plants

As many of these assets might have synergies, and if utilised, the operator can optimise the schedules of each asset, which can result in substantial economic saving and or CO_2 reductions. To be able to facilitate these opportunities, an EMS is introduced. The main objective of the EMS is to devise operational plans that allow an optimal use of resources, assets, as well as manage bottlenecks in the system, which helps postponing some investments and increase the energy system efficiency.

An overview of impacts from different smart energy actions and technologies can be found in Table 1.

TABLE 1

Impacts from different smart energy actions and technologies.

Aim/Goal	Smart energy actions	Method/technology
Reduce GHG-emissions of energy	Optimise self-consumption from local RES Energy arbitrage based on CO_2-emissions of electricity from the grid	Smart charging Load-shift of heat pump operation and HVAC etc. Energy storage
	Optimise self-sufficiency from local RES	Smart charging Load-shift of heat pump operation and HVAC etc. Energy storage

Reduce energy costs	Energy arbitrage based on costs	Smart charging Load-shift of heat pump operation and HVAC etc. Energy storage
	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 Load-shift of heat pump operation and HVAC etc. Electrical energy storage
Reduce the reliance of external energy providers	Optimise self-consumption from local RES	Smart charging Load-shift of heat pump operation and HVAC etc. Electrical energy storage
	Optimise self-sufficiency from local RES	Load-shift of EV-charging, heat pump operation, HVAC etc. Electrical energy storage

GUIDELINE FOR SMART ENERGY MANAGEMENT SYSTEMS IN AIRPORTS

An EMS is a technology or software that helps monitor, control, and optimise how energy is distributed. A smart energy management system can ensure utilisation of energy assets, it can optimise the energy prices, the CO_2-emissions related to energy production and use, and it can improve utilisation of the local energy infrastructure. Further use scenarios are described in the following sections.

The logic of the EMS can be based on a range of sophisticated algorithms defining rules and restrictions for the units in the energy system, e.g., to maximise self-consumption from RES in the airport, charge the BESS to maximise economic utility, or reduce the electrical load to minimise congestion in the grid etc. In order to have a well-functioning energy system, the EMS often includes forecasting on both energy demand, energy production, weather, prices, CO_2 equivalents etc. The EMS can also contain an interface platform, where users can access information, live and historical data, manage energy flows, etc. The optimisation will typically run in parallel with the operation, meaning the controller is updated with the actual state of the system and starting from this information forecasts the future operating conditions. The controller advances to the next step in the schedule and re-runs the optimisation process [2]. With these advanced control devices, the airport can also coordinate its management with the network operators (e.g., electrical energy and natural gas DSOs, district heating and cooling operators) [3] by providing them services (e.g., frequency regulation) or with other actors (e.g., by exchanging energy in an energy community[1]).

[1] A group of actors collaboratively producing, consuming, and sharing energyv within a local area.

TABLE 2

Overview of examples of relevant analyses

Phase	Mapping	Planning	Implementation and operation
Analyses and assessments	Energy system overview Use scenarios Data sources Communication	Design criteria Stakeholder analysis Implementation plan IT and cyber security Ownership Tendering and procurement	Demo-test Integration with other systems Test and commissioning Monitoring Maintenance
Outcomes	Overview of the components in energy system Defined use case for EMS Overview of data availability and needed actions	Stakeholder engagement Detailed functionality of EMS Ownership is clarified Procurement of equipment	EMS is tested on small scale EMS is integrated into energy system in the airport Monitoring production and performance

GUIDELINE FOR BATTERY ENERGY STORAGE SYSTEMS IN AIRPORTS

Mapping

STAKEHOLDER ANALYSIS

To determine if and to which extent an EMS can bring value it is necessary to establish a good overview of the existing and future energy system of the airport and its energy assets.

When mapping the existing energy system, it is relevant to obtain specification of energy assets and conditions like:

- Local electricity production
- Local heat production
- Energy infrastructure capacity and its limitations
- Energy storage systems (both electrical, chemical, mechanical and thermal)
- Energy meters and data availability
- Main energy consumers (like EV charging stations, buildings, electric aircrafts, heat pumps etc.)
- Critical energy consumption/consumers
- Energy supply contracts (e.g. grid connection agreement)

For all assets it must be investigated if they are flexible and controllable and how they can be managed. The conclusion of the mapping shall give a clear overview of:

- What can be improved in the existing energy system?
- What kind of data is needed for doing smart energy management?
- Which components are interesting
    - Are there any flexible assets?
    - Are they controllable? Fully, partly? Under which conditions and constraints?

CASE: CPH - Energy management system

In CPH an EMS is implemented and demonstrated within the ALIGHT project. The EMS is provided by Hybrid Greentech, a Danish expert and software company with focus on energy storage systems.

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 have been conducted.

SYSTEM DESCRIPTION

The EMS is implemented as a cloud-based solution with interfaces to several providers of data for several assets at the airport. Moreover, the EMS can integrate public and subscription-based data sources (such as electricity prices, forecasts, usage data for assets) and generate schedules for the controllable assets i.e. BESS, EV chargers at the Maglebylille site based on several algorithms. An overview of the interfaces and examples of information is illustrated in Figure 4.
The main logic of the EMS is that it reads forecasts and based on these, it decides on an operational plan, for example the operator can decide to do CO_2 optimisation, and then the EMS should determine what is the best operation, e.g., by charging the BESS when the CO_2 intensity in the grid is low and discharge to the grid when the CO_2 intensity is high.

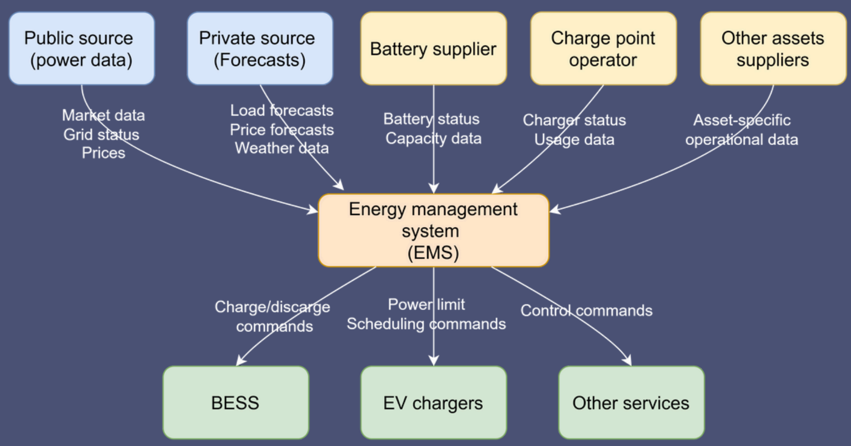

Figure 4 – Overview of interfaces with EMS at CPH.

USE SCENARIOS

An EMS can be designed to optimise on various aspects and to consider multiple factors in the optimisation process. The EMS can ensure that advantages of controllable energy producers, consumers and storage systems are utilised. The following use cases described requires physical assets that can uptake or deliver the energy as the EMS' optimised schedule prescribes.

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.

GUIDELINE FOR SMART ENERGY MANAGEMENT SYSTEMS IN AIRPORTS

Planning

STAKEHOLDER ANALYSIS

When planning to implement an energy management system, different stakeholders are important to identify and engage with at an early stage.

Some relevant internal and external stakeholders can be:

- EMS/software developers
- Owner of charging infrastructure (if existing charging facilities are not owned by the airport)
- Charge point operator (if existing charging facilities are not operated by the airport)
- Energy asset suppliers and operators of e.g., BESS and heat pumps
- Airport IT department
- Airport cyber security department
- Balance responsible party (relevant only if ancillary services are considered)
- Aggregator
- EV owners (passengers, if passenger cars are considered and field operators for GSEs)
- Airport Operation and Maintenance department
- Airport Energy department

IT AND CYBER SECURITY

It is important to be aware of IT and cyber security requirements for an EMS to be implemented in the airport. It may be the airports own security procedures defining the requirements for the system provider.

To allow external technology providers to communicate with assets inside the airport different solutions can be used. One example is to use network tunnelling, like virtual private network (VPN). If the technology provider does not comply to the IT security requirements, but need access to airport data, like live data for electricity consumption and/or production, it is an opportunity to let the airport push data to a cloud-based storage, like Azure Blob (binary large object) storage [4], and let the technology provider access the data through this platform.

CASE: TESTING AND DEMONSTRATION OF EMS IN CPH

The demonstration of the EMS relied on data from inside the airport systems. The data was made available by setting up scripts inside CPH systems to export a copy of the relevant data to a cloud infrastructure outside the protected airport systems. That way, the cloud services could be performed by an actor not fulfilling the strict requirements to cyber security otherwise necessary to protect the integrity of the airport operations. The data was planned to be exported as an automated batch operation every 5 minutes, thus creating a latency of 5 minutes. The EMS provider accepted this solution of receiving data in 5 min batches.

DATA SOURCES AND COMMUNICATION

Data and communication regulations for airports vary from one country to another, but in all cases vendors that are expected to deliver data-related services whether in operation or monitoring should have the necessary security systems in place. Therefore, the communication and data setup should be decided based on associate risks and the general trust in the different components.

Different examples of communication configurations that can be adopted are presented. These examples are provided for clarity purposes, but there can be other cases.

EXAMPLE 1 An airport might decide to let their suppliers access assets inside of the airport firewall when they have guarantees that all their communication and data is safe and will not be shared with third parties and that the different suppliers have implemented all the necessary security methods to protect their data.

EXAMPLE 2 The EMS supplier does not fulfil all the requirements set by the airport; therefore, the airport can only share read-only data with the EMS supplier and allow it to control assets through the battery supplier. This is the current case at CPH.

EXAMPLE 3 The airport deems that sharing data outside of its premised is too risky, so it can decide to operate the assets locally including EMS and battery monitoring system, with encrypted access to outside suppliers for maintenance/updates.

In Table 3 the suppliers' satisfaction of security requirements for communication and data handling for each example are illustrated.

	Satisfaction of safety requirements		
	Example 1	**Example 2**	**Example 3**
EMS supplier	✓	✗	✓
Battery supplier	✓	✓	✓
Internet/cloud	✓	✓	✗

Table 3 – Examples of suppliers' satisfaction of security requirements for communication and data handling.

This kind of configuration/design decision should be made at an early stage as it will necessitate some procurement decisions in buying equipment, setting up secure communication channels and as well the need for third party help and review of the design. Moreover, it should be considered which type of communication the data collection will use, and how the EMS will obtain the data, e.g., how to read relevant data from specific meters and how often.

Configuration and design of the EMS should be considered as early as possible in regards to procurement.

Similarly to communication, it is recommended that at an early stage the following is considered, in case an airport decides to publish data outside their premises:

- The data lifetime in any kind of third-party storage solution.
- The data sharing mechanism: should the supplier fetch data or does the airport push data?
- Checking mechanism that assures that only the relevant data is shared, and no leaks happen.

As systems evolve and as the necessity for data increases, the database design becomes as important as the EMS design itself. The EMS can only advise correctly if the data are of a good quality, not stale and not corrupted. Therefore, the data flow should be stable, consistently working and replicable for quality checks. To be able to satisfy the latter, a proper data model should be in place, and it should take into consideration the various systems that will be integrated e.g., EVs, BESS, etc. The data model is key to the success of the EMS system and therefore it is recommended that the design starts at the mapping phase.

CASE: THE DATA AND COMMUNICATION SOLUTION AT CPH

At the time of making the communication and data design it was deemed that the fastest and safest solution to be able to operate the BESS and the EMS was to let the BESS and EV supplier communicate with their assets, rather than letting the EMS supplier do this. A solution where the EMS have access to read-only data from the airport was chosen (corresponding to example 2 introduced in Section 6.1), since it might have resulted in delays in the project if the EMS supplier had to implement the necessary security requirements. Moreover, this solution provides only one entry point per asset, which allows better control from the airport side. A similar approach is going to be adopted for the control of EV chargers.

On the data sharing side, and due to the security requirements of the airport, only data coming from third party assets are shared directly with suppliers whereas any other data is pushed by the airport periodically and the airport possesses full control on what is to be shared and when.
For EV chargers the EMS supplier, Hybrid Greentech, is working with the charge point operators on a solution that allows the EMS to control chargers without passing information on the location of the chargers and/or their physical IDs. This approach means it is not necessary to handle sensitive information in the EMS and GDPR is handled by the charge point operator.
An overview of the data and communication streams for the EMS and relevant assets in CPH is illustrated in Figure 5.

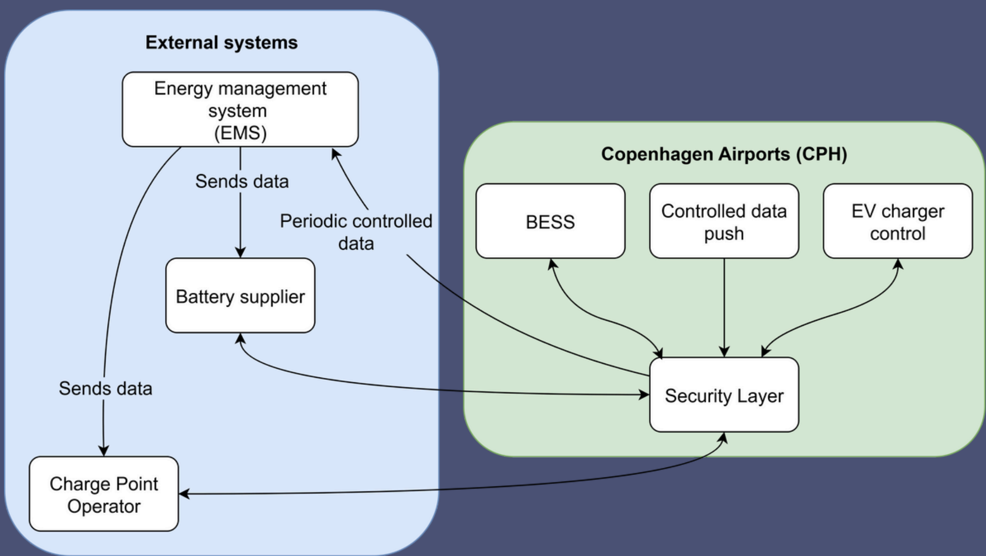

Figure 5 – Data and communication streams between external asset suppliers and CPH.

DESIGN CRITERIA AND INTEGRATION WITH OTHER SYSTEMS

The EMS design should meet both operational and regulatory needs of the airport. As described previously, the EMS should monitor and control, when possible, the various assets in the airport energy system to optimise the energy system and increase the efficiency. Therefore, the airport should consider which assets that should be incorporated into the EMS, including considering if and how they can be controlled. Since the energy system of the airport may evolve, expand and change over time, it should be possible to adapt the EMS to include new assets and changes to accommodate future airport expansions. Additionally, the EMS must be designed to withstand operational disruptions or cyberattacks.

If the airport has existing management systems (e.g., building management systems etc.) it should be considered if existing management systems should be merged into an overall EMS, exchanging data with an overall system but keep operating separately or if it should be kept entirely separated. There are advantages and disadvantages of both. Advantages of a combined EMS could be that the potential for utilising energy flexibility across different energy sectors will be increased and easier. The increasing electrification of vehicles, equipment, aircraft, and heat generation necessitates integrating and optimising these new loads with the existing electricity and heating/cooling systems in buildings. This can be achieved through a comprehensive energy management system. A disadvantage of combining existing management systems into one comprehensive system is that it is a large task and there is a risk that the combined management system will be either too complex or missing details that were else handled in the specific management system. It is also possible to keep the individual management systems and integrate inputs/outputs from them into an overall energy management system.

When designing the EMS the airport should consider having a user-friendly interface with real-time data visualisation and reporting tools.

CASE: EMS SYSTEMS IN ADR

ADR has several management systems related to different energy sectors: one for heating and cooling, one for the electrical plant, one for monitoring energy-dense assets, and so on. ADR currently monitors the consumption of various assets, which provides valuable information for the planning and execution of future projects.

There is a standalone EMS for the BESS, which can operate to minimise costs and/or CO_2 emissions. ADR plans to integrate an overall EMS that will connect PV, BESS, EVs, and consumption with the existing building management system.

CASE: EMS IN CPK

The entire energy system of the airport will be connected into one common management system. For electricity this includes networks at both high, medium, and low voltage, as well as energy storages, PV plants, and chargers for EVs and eGSEs. The EMS will be designed to offer full remote access from the Energy Centre, which are facilities housing heat pumps and other equipment for heating and cooling generation.

TENDERING AND PROCUREMENT

When requirements to the EMS are defined the airport can initiate a tendering process to find an appropriate collaboration partner and/or software company to design and implement the energy management system.

IMPLEMENTATION PLAN

An implementation plan shall ensure that the EMS can smoothly be integrated into the airport's existing infrastructure and other management systems, dashboards etc.

- Define which data to be exchanged between systems
- Define communication interface

Consider implementing stepwise and plan the order of integrating the different assets into the EMS.

GUIDELINE FOR BATTERY ENERGY STORAGE SYSTEMS IN AIRPORTS

Implementation and operation

TESTING/DEMONSTRATION IN LABORATORY ENVIRONMENT

When developing a new energy management system, it is an advantage if the system can be tested in a laboratory environment, to ensure safe and robust operation when implemented in the airport. This can e.g. be with a setup of hardware-in-the-loop[2], to validate the functionalities of the system both in terms of communication setup, response times, and optimisation algorithms to check if the system acts as expected.

CASE: TESTING OF USE CASES IN CPH

The testing conducted during the ALIGHT project was done in two phases in coordination between DTI, HGT and CPH. Phase 1 for testing BESS and phase 2 for testing characteristics of EV chargers.

In the first phase the following was tested:

- Basic logic as described in the previous section.
- Test data pipelines resiliency.
- Test BESS response time and validity of forecasts and related operational plans.

The tests of the first phase were performed between 17 January 2023 and 17 February 2023. During this period, there were only a few instances of downtime, with one notable interruption occurring on 21 January 2023. Otherwise, few problems were observed, mainly because the laboratory setup at DTI is quite resilient. As a result, testing could largely be performed without interruptions.

The first series of tests proved that the BESS could be charged when the CO2 intensity is low (see Figure 6) and discharged when the CO2 intensity is high (see Figure 7).

[2]A testing method where real hardware components are connected to a simulated environment to evaluate system performance and interactions.

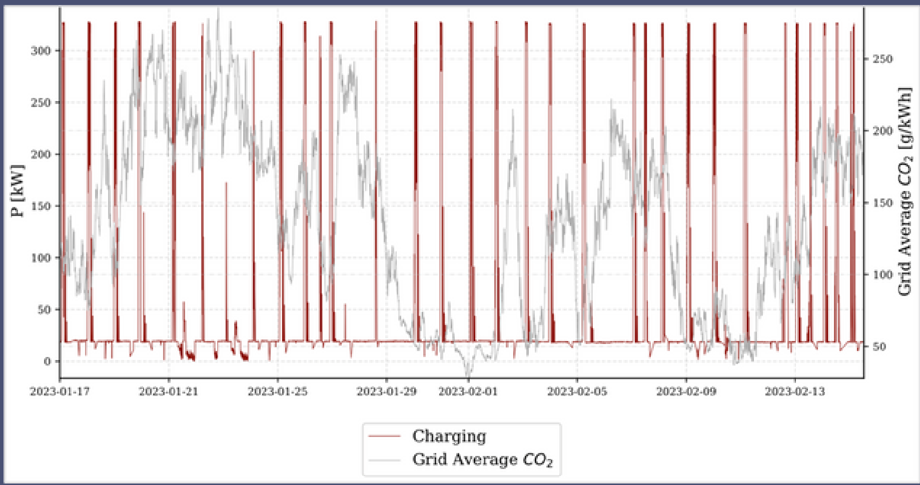

Figure 6 – Charging of BESS depending on the CO_2 intensity in the electricity grid.

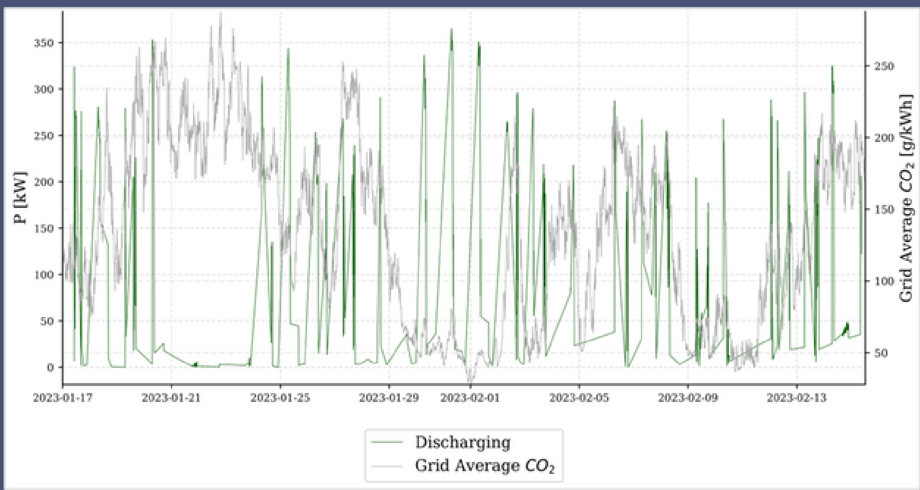

Figure 7 – Discharging of BESS depending on the CO_2 intensity in the electricity grid.

TEST AND COMMISSIONING

Before the EMS can be commissioned, the functionality must be tested to ensure:

- Reliability of the data pipelines from the data providers.
- Performance of the EMS in combination with controllable assets compared to simulated baseline.
- Reaction and capability to adjust operation based on feedback from assets.
- Capability of the EMS to operate according to the specific use case (cost reduction or CO_2 reduction or other).

Testing is carried out to anticipate control issues and system behaviours that may arise during commissioning. This includes:

- Testing of EMS logic, response times and operational schemes (e.g., in test environment or for a pilot area etc.)
- Testing of communication with physical assets (e.g., EV chargers) and controllability of these.

As an initial step in testing, these functionalities will be verified with the actual assets intended for the demonstration activities on an individual basis to isolate any potential asset-specific issues. The energy system often consists of multiple assets, each having its own data entry, physical behaviour, and control architecture, enabling individual testing. By testing each of the assets individually, it allows for highly flexible test planning, and if some asset is not ready for testing, it can either be replaced with another source, a synthetic model, or excluded from testing altogether if no suitable method is available at the time. In the subsequent step, the system will be tested as a whole to apply the previously specified use cases.

PERFORMANCE MONITORING

To monitor performance of the EMS and its impact it is necessary to be sure about the use cases and the optimisation parameters. Often the optimisation parameters will be either CO_2, costs, congestion management or a combination of those.

GHG emission reduction can be achieved by time shift of operation of electric demand (load shift). Flexible loads that can be used for this purpose may include HVAC-systems, heat pumps, and EV charging. For thermal purposes it is also worth considering the opportunity of reducing the thermal setpoints for periods, as the response time for thermal energy in a building is long and studies shows that people will not recognise temperature deviations around +-0.5°C. With large terminal buildings even small temperature deviations can result in changes in energy amounts. [5]

To maximise awareness of the impact of a smart energy management system it is recommended to prepare dashboards or other systems to visualise data to enrich the value of the data.

MAINTENANCE

Maintenance of an EMS is needed to ensure that communication equipment, data storage hardware and software solutions are working properly.

The optimisation algorithms may need periodic refinement to adapt to new energy assets, operational changes, or updated goals. Regular updates to the EMS software are required to address bugs, improve performance, and ensure compatibility with IT and cyber security protocols. Moreover, when new energy assets are added, there is a need for updating the software and integrate new communication devices.

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. As part of the transition of the energy system, including electrification and new types of technologies, like battery energy storage systems and vehicle-to-grid, it is highly recommended to consider smart energy management systems to optimise the energy system operation.

This can utilise flexibility in the energy system, optimise operational schemes, reduce the need for reimbursement of the electricity grid and reduce CO_2 and energy costs.

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 of existing energy system including assets and management systems
3. Define requirement specifications of new software and its functionalities
4. Plan and execute pilot projects where some assets are included in the EMS

Mapping: Key questions

- What can be improved in the existing energy system through an EMS?
- Are there any flexible and/or controllable assets?
- Which use cases should the EMS be designed to handle?

Planning: Key questions

- Have the relevant stakeholders been identified and engaged in the planning of the EMS?
- What are the specific IT and cyber security requirements for the EMS, and how will data sources and communication be managed to ensure compliance and operational security?
- Should the EMS be integrated with the existing management systems and assets in the airport?

Implementation: Key questions

- Have the reliability and performance of the EMS, including its communication with controllable assets, been thoroughly tested and validated through commissioning procedures?
- Have all required data pipelines, feedback mechanisms, and optimisation parameters (use cases) been tested and are functioning as intended?
- Have the possibility of integrating new assets into the EMS been considered and ensured?

ABBREVIATIONS

Abbreviation	Explanation
ADR	Aeroporti Di Roma (fellow airport in ALIGHT located in Italy)
BESS	Battery energy storage system
BMS	Battery management systems
CPH	Copenhagen Airports
CPK	Centralny Port Komunikacyjny (fellow airport in ALIGHT located in Poland)
DSO	Distribution System Operator
DTI	Danish Technological Institute
EMS	Energy management system
EV	Electric vehicle
Fellow airports	Referring to airport partners in ALIGHT: ADR, CPK and LTOU
HGT	Hybrid Greentech
HVAC	Heating, Ventilation, Airconditioning

GSE	Ground Support Equipment
Lighthouse airport	Referring to main demonstration airport in ALIGHT: Copenhagen Airports
LTOU	Lithuanian Airports (fellow airport in ALIGHT located in Lithuania)
PV	Photovoltaic
RE	Renewable energy
RES	Renewable energy sources
TSO	Transmission System Operator

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