ALIGHT
SUSTAINABLE AVIATION

D8.7 Replication toolbox for smart energy

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Content

1 Executive summary

This deliverable presents The Replication Toolbox developed within the ALIGHT project. The replication toolbox is designed to facilitate knowledge transfer and practical application of solutions, lessons learned, findings etc. done in ALIGHT to other airports. Its primary audience includes airports, and related stakeholders transitioning towards sustainable operations, but many tools and guidelines are broadly applicable to other sectors, especially those interested in smart energy solutions.

The Toolbox is structured to ensure easy navigation of tools within the focus areas and tailored guidance for different user groups. All tools are organized into two focus areas (SAF and Smart Energy), each with clear boundaries and focus areas.

The Smart Energy Toolbox covers technologies such as renewable energy (PV), battery energy storage, energy management systems, vehicle-to-grid integration, and electrification of airport infrastructure.

Each tool is accompanied by descriptions outlining its purpose, target users, and guidelines for application. The tools range from handbooks, diagrams, excel sheets, and checklists.

A key component of the ALIGHT Toolbox is its online platform, currently under development, which aims to make these resources accessible to a wide audience.

In summary, the ALIGHT Replication Toolbox combines practical tools, methodologies, and insights to guide airports and stakeholders in implementing sustainable, smart energy solutions, promoting the broader adoption of best practices across the aviation sector.

2 Reading guide for toolbox

The Replication Toolbox of ALIGHT is designed to facilitate a comprehensive understanding and application of replication strategies across two distinct workstreams:

A. Sustainable Aviation Fuels
B. Smart Energy Supply and Use

The replication toolbox for each of the workstreams are described in D8.6 (SAF) and D8.7 (Smart energy). To ensure consistency between the two workstreams, all or parts of the more generic sections are identical in the two deliverables, as developed through close cooperation between authors from Copenhagen Airports and authors from Danish Technological Institute.

The Toolbox is structured to ensure ease of navigation, enabling users to access the relevant tools and information tailored to their specific needs. It provides users with a streamlined experience by offering a clear overview of key findings, theoretical foundations, and the target audience, along with a breakdown of how stakeholders along the value chains can benefit from its solutions.

The opening sections offer a high-level overview, starting with the *Executive Summary*, which presents the report's key findings, objectives, and recommendations, providing a snapshot of the Toolbox's overall content. Following this, the *Background and Concept* outlines the foundational theories and rationale behind the replication strategies, explaining why replication is critical for both workstreams. Next, the *Target Group* section identifies the primary audience, highlighting those who will benefit most from the replication strategies and offering tailored advice for different user groups. Finally, the *Value Chains and Stakeholders* section illustrates how the Toolbox supports airports and stakeholders, offering customized tools and guidelines for various stages of the value chain.

As the Toolbox delves deeper into practical applications, it divides into two distinct workstreams, each addressing specific challenges and strategies:

Boundaries and value chain for smart energy

This section defines the scope and limitations of replication efforts for both workstreams. It clearly defines what is included and excluded in each focus area, ensuring users have a precise understanding of the focus areas. Furthermore, *Why is it relevant to replicate?* addresses the importance of replication for both workstreams, offering detailed reasonings and outlining potential benefits for users and stakeholders.

Toolbox Inventory

In this detailed section, users will find a comprehensive list of all the replication activities and tools available within the Toolbox. Each tool or activity is accompanied by a clear description that explains its purpose, relevance, and practical application. This inventory serves as a roadmap for users to navigate the Toolbox and select tools that align with their specific replication needs, ensuring that every resource is both accessible and functional.

Appendix

The Appendix houses *the tools*, including methodologies and resources necessary for effective replication. These tools range from Excel templates and video tutorials to guidelines and checklists, all designed to offer hands-on support. Each tool is aimed at providing users with actionable steps, ensuring they have practical guidance throughout the replication process. The appendices serve as an in-depth *Toolbox*, where users can explore the tools most suited to their individual replication goals.

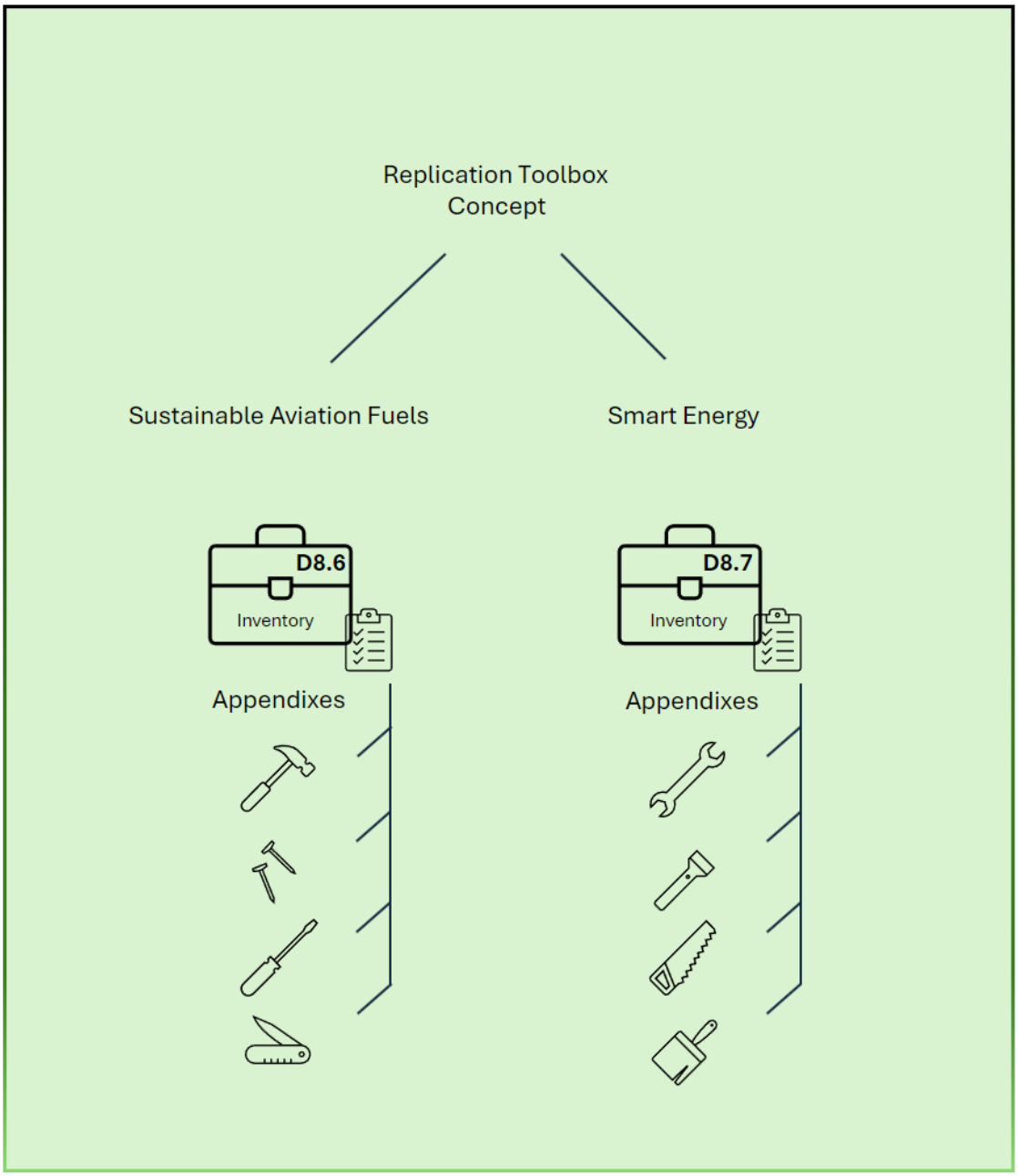

Figure 1 – Illustration of the toolbox concept where tools from the two workstreams make up the toolbox.

3 Introducing 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. With the addition of AIRBUS, who joined the consortium in 2023, adding valuable perspective of an aircraft manufacturer. The composition of partners and the expertise each partner brings to the consortium is a prerequisite for creating impactful change in the aviation sector. 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.

3.1 SAF focus area

This workstream centres around sustainable aviation fuels, and addresses challenges such as planning the future infrastructure of airports, procurement and ensuring the sustainability of SAF, as it can be made up of many feedstocks with various potential impacts on the environment, are addressed to aid airports in the project itself, as well as other airports that will learn from the project's findings.

3.2 Smart energy focus area

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

4 Background and concept of replication toolbox

The overall purpose of this report is to collect and distribute knowledge, experiences, methods, guidelines and tools developed through the Horizon funded project ALIGHT (2020-2025), which will provide value for fellow airports working towards a more sustainable operation. The tools provided within this report are meant to support and facilitate knowledge transfer and the decision making at other airports within the areas of activities covered by ALIGHT. The report will illustrate the complex outputs of the project to enable the replicability of the practical experience gained within the consortium and at Copenhagen Airports. Furthermore, the insights and feedback gained from the fellow airports of Aeroporti di Roma and Lithuanian airports, as well as the Centralny Port Komunikacyjny, will add to the understanding of the tools developed as well as how to best replicate and implement the various tools within an airport, which may vary in size, infrastructure etc.

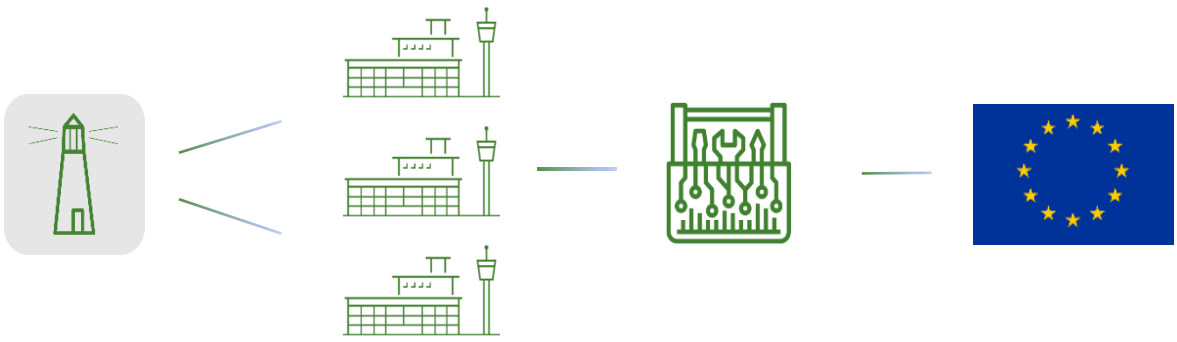

Figure 2 – ALIGHT concept illustrated.

Within the tools provided in this report it is crucial to consider the local context and local regulation as well as the local energy, environmental and climate commitments in addition to the context of the EU commitments. Thus, the tools and guidance are developed primarily in the context of Copenhagen Airport, why a Danish context may differ for an airport situated elsewhere in Europe or beyond.

Two toolboxes have been developed to reflect the two different focus areas of ALIGHT, the area of Sustainable Aviation Fuels (SAF) and the area of smart energy supply and use. The concept and the background of the toolboxes will be applicable for both toolboxes, as well as the consideration for sustainability holistically, however the content will vary depending on the focus area. Regarding sustainability it is defined as follows for the entire project:

Sustainability in ALIGHT encompasses the combination of social, economic and environmental aspects, with emphasis on environment to account for the aviation industry's climate impact. Thus, contributing to a long-term and inspiring decarbonization of the aviation sector.

For a more in-depth description of the concept and understanding of sustainability, as well as how it may differ from focus area to focus area, see deliverable 6.4 *the sustainability report.*

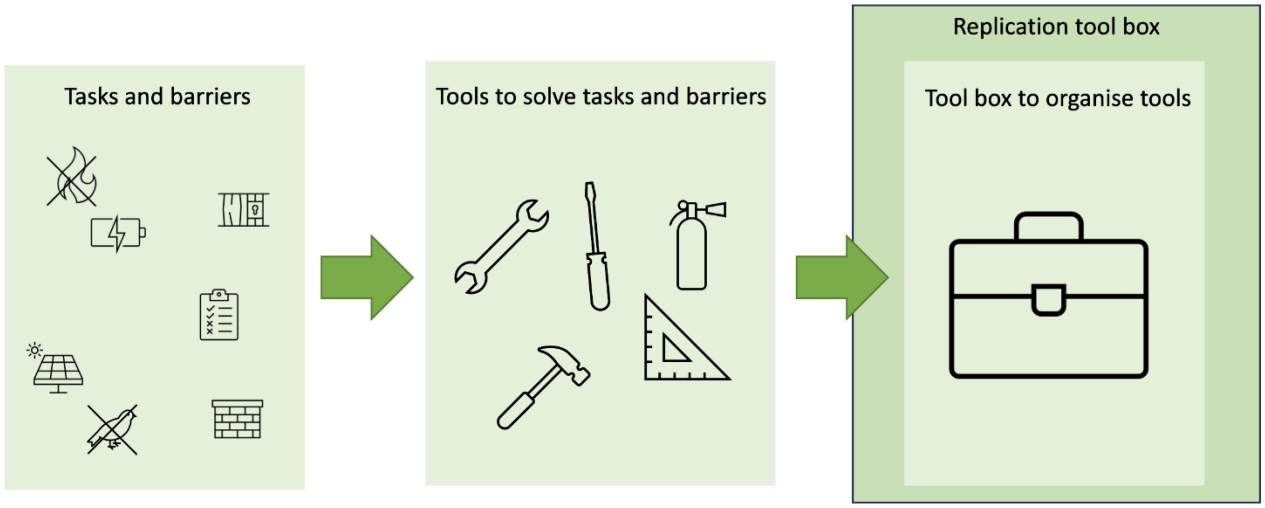

Figure 3 – Illustration of toolbox concept.

4.1 Understanding of a replication toolbox

A common understanding of the toolbox is essential to ensure their effective use. Therefore, all partners in ALIGHT were asked the same question "*What is your understanding of a replication toolbox".* The intention of the exercise is to provide the reader with a shared understanding of both the purpose and content of the toolboxes. Thus, a toolbox is meant to support knowledge transfer and provide solutions to replicate, as well as practical recommendations and sharing of best practices. Survey answers can be found in Appendix 10.1.

5 Target group

This replication toolbox is primarily targeting airports and related stakeholders, which are considering or already working with a transition towards higher degree of sustainability.

Guidelines and tools included in the replication toolbox may be applicable to or useful for other industries either closely connected to airports or, especially for parts related to smart energy, by disregarding specific aspects regarding airports.

The guidelines and tools are based on experiences from the European funded project ALIGHT and from European airports, why some cases may differ in other regions of the world. Some of the guidelines and tools are though in general terms and may therefore be applicable for airports outside Europe.

The target readers of this report are sustainability managers, technical project managers and other strategy makers in airports. Some of the tools are more technical and therefor targeting technical project managers and their teams of specialist or consultants working with topics inside the area of SAF and fuelling or smart energy in airports.

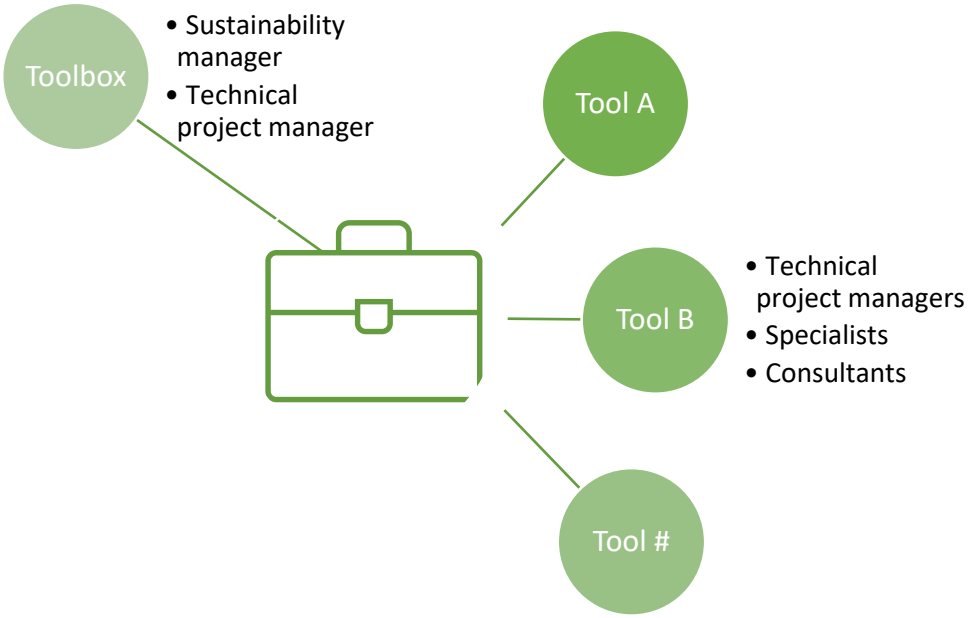

Figure 4 – Illustration of different users of the toolbox and the included tools.

6 Boundaries and value chain for smart energy toolbox

This replication toolbox for smart energy covers a wide range of topics and technologies, focusing on practical application within airport environments, and does not cover all potential smart energy topics in general. The content of the toolbox is limited to the technologies and methodologies analysed and demonstrated in the ALIGHT-project, where the smart energy tools are mainly considering topics and technologies for energy supply, energy consumption and energy storage.

For energy supply and storage, the tools are focusing on the electrical aspect of smart energy such as photovoltaics, electrical infrastructure, battery energy storage systems (BESS), energy management systems, smart charging and Vehicle-to-grid (V2G).

For energy consumption the tools focus on future electric demand from electrification of ground support equipment and airplanes, smart building management and thermal capacity of buildings together with GHG monitoring and incentives for sustainable passenger transport.

The toolbox does not cover unrelated energy technologies, non-electric mobility solutions, or other smart energy topics with no direct relevance to airport operations and infrastructure.

The toolbox contains tools, presented in section 8, for smart energy considering the following topics:

Energy supply:

- Photovoltaics in airports: Focus is on mapping and planning
- Considerations related to PPAs,
- Electrical grid

Electric energy storage

- Battery energy storage system
- V2G

Electric mobility

- Smart charging and charging infrastructure including both passenger transport and airport owned vehicles on land side and airside
- V2G

Energy management

- Energy management system integration in airports existing IT-infrastructure
- Smart energy management of BESS, PV, load, grid and EV charging

Energy consumption

- Energy consumption mapping and monitoring
- Building energy efficiency
- Flexibility in buildings by using heat capacity
- Electrification of ground support equipment
- Infrastructure for future aircraft stands – electric, hybrid and hydrogen-based aircrafts

Passenger transport to/from airports

- Incentives for transition
- Accounting for passenger transport in GHG-monitoring

Sustainability strategy making and organisational aspects

- Examples from CPH and LTOU about organising work with sustainability and how to put it on the agenda for an airport
- Stakeholders

Figure 5 Boundaries for smart energy toolbox.

The value chain for smart energy in an airport context can involve a diverse range of stakeholders and technologies as depicted in Figure 6. The airport can be supplied with energy from the public energy system (consisting of public energy generation and distribution) and/or by locally produced energy (e.g., PV in the airport). The airport infrastructure consists of the internal distribution of energy across the different energy sectors, ensuring a well-functioning energy system for the energy consumers in the airport. All the different actors in the value chain are shaped, affected, and regulated by regulation and legislation.

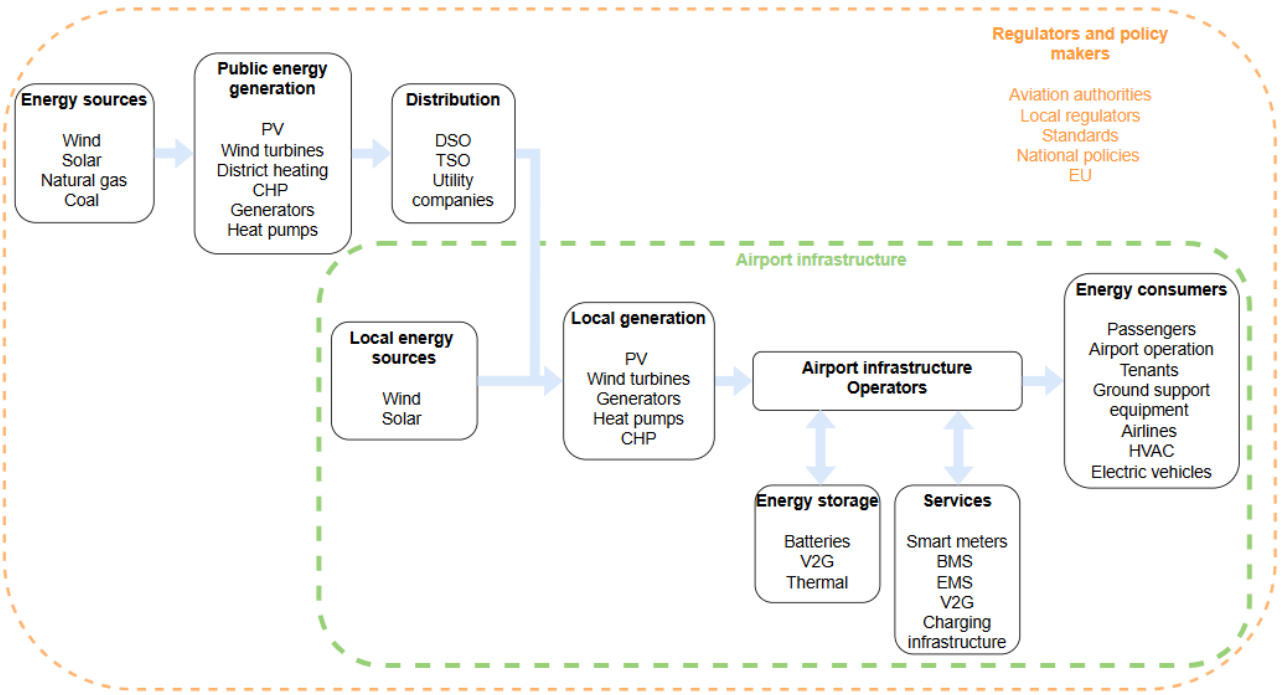

Figure 6 – Value chain for smart energy systems in airports.

7 Value assessment before replicating

Before replicating solutions, it is important to assess the potential value of technology to be replicated, as this should be the main driver for doing so.

The following diagrams illustrate examples of value creation from different smart energy assets. The cases are based on the concepts dealt with in the ALIGHT project. The primary metrics describing final value from the area of smart energy supply and use are economic values, CO_2-reductions, increased grid stability and higher independence from the public grid, improved local air quality, and decreased noise level.

The concept for the diagrams is shown in Figure 7, where the asset, which can create a value, is on the left side and the value is on the right. The process in the middle is the enabler to the value and describes in short terms how to come from an asset to a value.

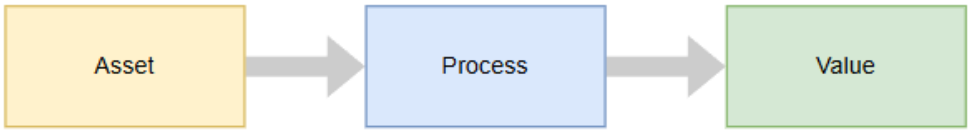

Figure 7 – Concept for diagrams of business cases.

Examples of cases for electrical energy storage, including controllable EV-chargers, controllable eGSE-chargers and vehicle to grid chargers are shown together with PV below in Figure 8.

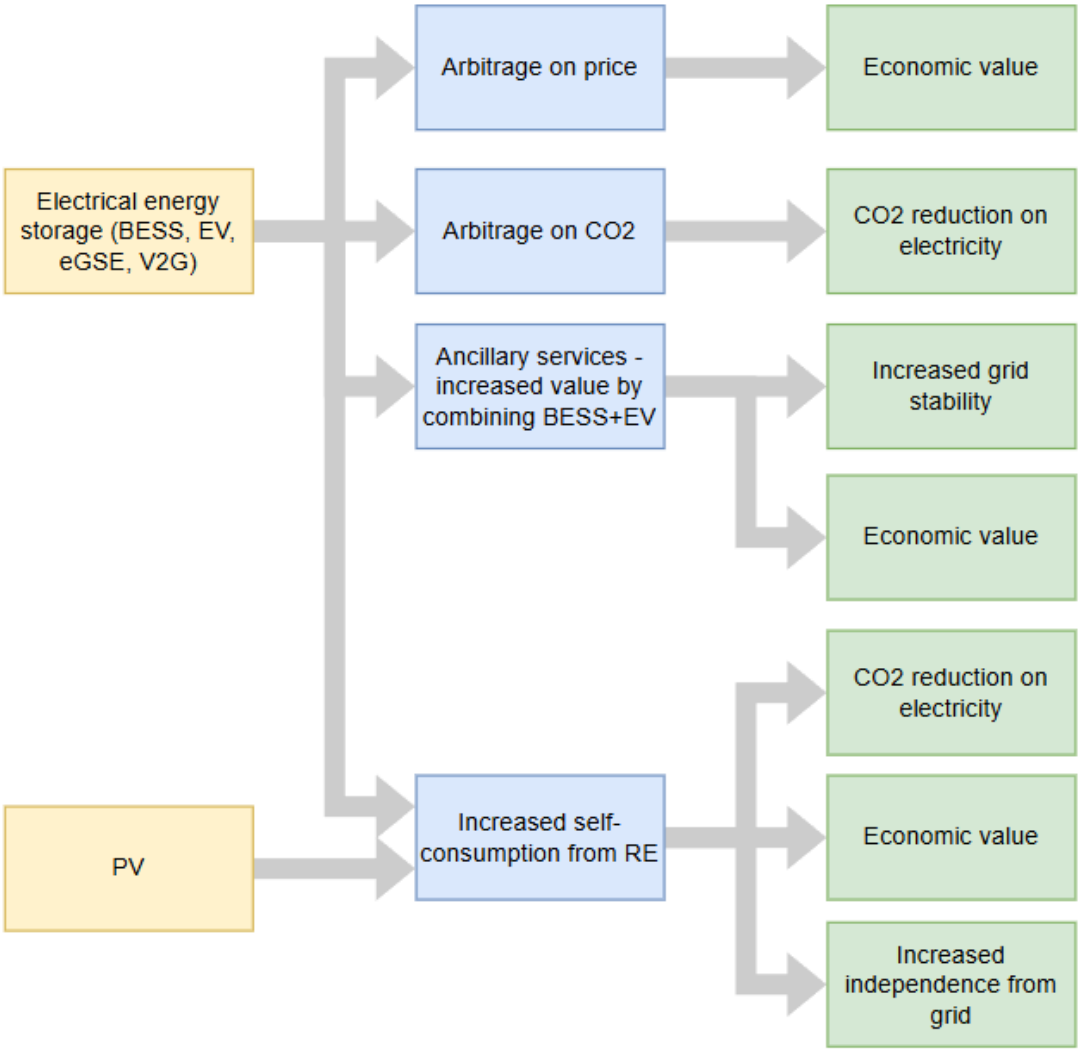

Figure 8 – Business cases for electrical energy storage and local renewable energy supply.

Business cases for GSE's are shown in Figure 9.

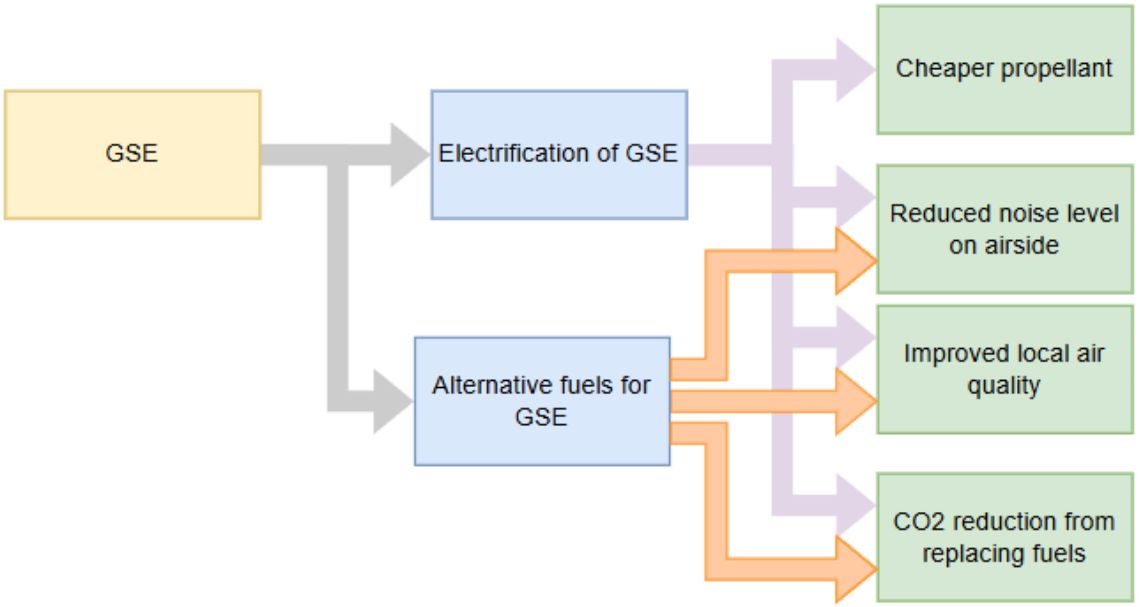

Figure 9 – Business cases for ground support equipment.

Some examples of business cases for passenger transport to and from the airport, including public transport such as buses, metros, trains and taxis, private cars among others are shown below in Figure 10.

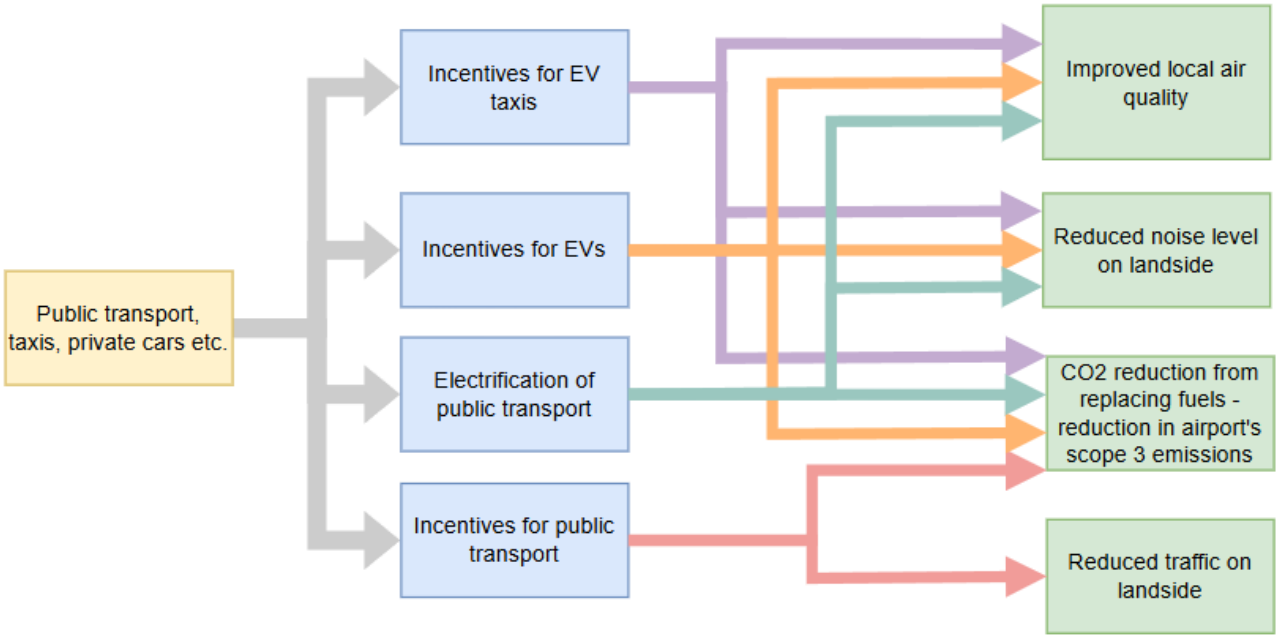

Figure 10 – Business cases for technologies used for passenger transport to/from airports.

Some business cases for publicly available EV chargers are shown in Figure 11.

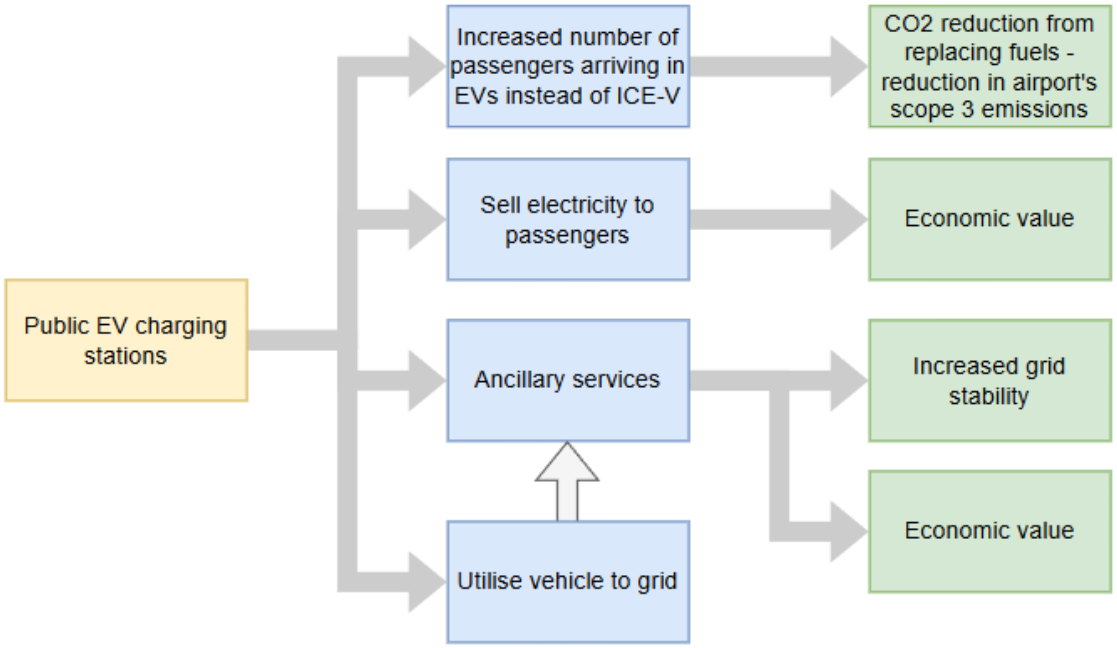

Figure 11 – Business cases for public EV charging stations.

To evaluate and quantify the potential value of each technology, deeper analysis and case studies must be made for the specific airport.

8 Toolbox inventory

This section provides an overview of the tools developed in ALIGHT related to the field "Smart energy" as described in section 6. All tools are attached to the report as separate documents named with identification numbers accordingly to the following descriptions. A "Tool description" is made together with each tool which presents the purpose, target user, attention points and guideline on usage etc. These tool descriptions can be found in attachment with identification numbers matching the tools. An example is shown below:

- **Tool description:** 1.1a - Tool description for tool 1.1
- **Tool:** 1.1b - Tool name

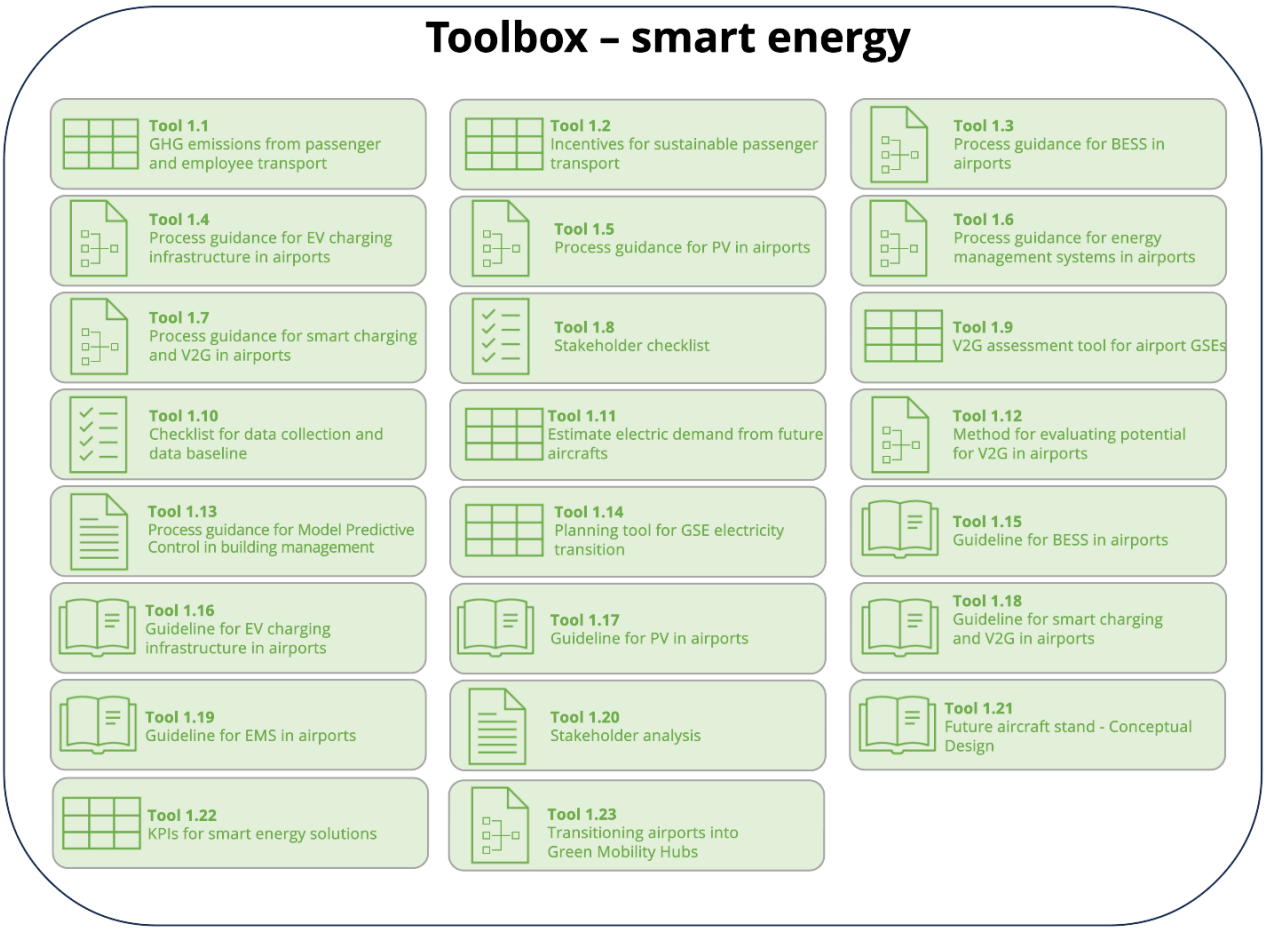

Figure 12 – Overview of tools related to smart energy developed in ALIGHT.

The following is a brief description of the purpose of the tools and the primary users of the tool. The full tool description can be found in the attachment to this deliverable.

Tool 1.1 GHG emissions from passenger and employee transport

The purpose of this tool is to guide airports in the monitoring and accounting of GHG emissions stemming from transportation to and from, primarily focusing on passenger and employee transport. The tool is an excel file which includes multiple "mini-tools" and best practices for airports to be inspired by or copy directly. Each airport must consider their own options and capabilities as it may be necessary to adjust the templates and tools to suit their needs specifically.

Tool 1.2 Incentives for sustainable passenger transport

This tool is intended to help in the process of brainstorming and evaluating incentives for passengers to choose a more sustainable transportation form to/from the airport. The tool provides a structured methodology for assessing the potential of different incentives.

The primary target group of this tool are sustainability departments working for implementation of initiatives to promote the transition of passenger transport.

Tool 1.3-1.7 Process guidance for BESS (1.3), EV charging (1.4), PV (1.5), energy management system (1.6), and smart charging and V2G (1.7) in airports

These tools are intended to help project managers to plan smart energy projects in airports. Each process guidance diagram is related to each of the topics. The purpose of using these is get is to minimise the risk of overseeing important steps by using the process guides. The tools can be used in initial phases of projects to present the scope of a project of these types.

The primary users of the tools are technical project managers at airports, consultants, and management/decision makers.

Tool 1.8 Stakeholder checklist for smart energy projects

This tool can help project managers in the planning process of smart energy projects to ensure engagement of all relevant stakeholders at an early stage to minimise the risk of overseeing specific requirements, needs for approvals or other aspects that can affect the project plan.

The primary users are project managers and technical managers.

Tool 1.9 V2G assessment tool for airport GSEs

The tool provides a structured framework for analysing Vehicle-to-Grid (V2G) potential in airport Ground Support Equipment (GSE) fleets. It enables airports to estimate total battery capacity and V2G availability in a conceptual fully-electrified GSE fleet through a two-phase analyses approach.

The primary users are airport sustainability managers, GSE fleet managers, infrastructure planners, energy consultants, and technology providers.

Tool 1.10 Checklist for data collection and data baseline

This data collection checklist is intended to help project managers in the planning process of smart energy projects to ensure knowledge and gathering of all relevant data and data sources at an early stage.

Collecting data is the foundation of a successful smart energy project. It enables making evidence-based decisions, maximizing savings, minimizing risks, and demonstrating actual impact. Skipping this step often leads to wasted resources and missed opportunities.

Data collection is essential for several reasons. Some of the reasons are:

- Understanding baseline performance and thereby quantifying improvements
- Informed decision making e.g., by informing which technologies, strategies, or interventions are likely to be most effective.
- Setting goals and KPIs require accurate initial data.
- System design and sizing prevents over-investment or underperformance due to incorrect assumptions.
- Monitoring and verification through ongoing tracking of project impact against baseline
- Risk reduction through early identification of technical or operational risks.

Primary target users are technical project managers in airports and at consultancy companies working projects in airports.

Tool 1.11 Estimate electric demand from future aircrafts

The purpose of this tool is to estimate electric demand for future airplanes. The tool is an excel based calculator, where the user can enter data on relevant routes including fuel consumption and traffic data from their specific case to estimate the electric demand if conventional airplanes on specific routes are replaced by electric planes. The purpose is to get an indication of the electric demand to have a more solid ground for planning and investing in electric infrastructure upgrades and charging facilities. The results can be used toward decision makers and master planners to ensure that the airport is preparing for future needs.

The target users of this tool are specialists within the field of electric infrastructure and master planners or similar functions with a technical understanding.

Tool 1.12 Method for evaluating potential for V2G in airports

The tool presents a method for identification of equipment/eGSEs at the airport which could be interesting to include in the assessment of Vehicle-to-Grid (V2G) potential at the airport. The tool assists the user in assessing whether a type of vehicle/equipment is suitable for V2G.

The primary users are technical specialists with fleet operations and technical project managers.

Tool 1.13 Process guidance for Model Predictive Control in building management

This tool is intended to help project managers to plan building management projects in airports. The purpose of using these is get is to minimise the risk of overseeing important steps by using the process guides. The tools can be used in initial phases of projects to present the scope of intelligent HVAC control systems.

The primary users of the tool are technical project managers at airports, consultants, and management/decision makers.

Tool 1.14 GSE planning tool

This tool is intended to help airport personnel plan the transition of GSE fleet toward sustainable alternatives. You can minimize the risk of overlooking important steps by using this structured mapping of the fleet.

The tool presents an overview of the analyses and assessments needed to support decision-making regarding the GSE fleet. It includes a wide range of data parameters that enable optimal strategic planning for fleet conversion at the right time.

The primary users of this tool are asset management, fleet managers, sustainability officers, financial and procurement staff.

Tool 1.15-1.19 Guideline for BESS (1.15), EV charging (1.16), PV (1.17), smart charging and V2G (1.18), and EMS (1.19) in airports

These tools are handbooks containing all learnings from ALIGHT when considering implementation of smart energy projects in airports. The purpose of the guidelines is to assist technical

project managers in planning, designing, and executing energy transition strategies, while addressing the specific barriers related to safety, regulatory, and operational aspects that may arise when smart energy projects are done in the airport environment, and to provide solutions for overcoming these barriers.

Tool 1.20 Stakeholder analysis

This tool can be used for conducting a stakeholder analysis. The tool includes tables and figures to help identify the stakeholders in the project and how to priorities the engagement of them.

Tool 1.21 Future aircraft stand - Conceptual Design

This guideline aims to serve as a practical tool to help replicate sustainable aircraft stand solutions across European airports. It presents generic designs for these stands that can be adapted to specific airports, addressing the electrification and automation of ground support equipment (GSE), recommendation on stakeholders to include implementation guidelines, value drives and risk mitigation.

The primary users are regulators related to standards for green aviation, designers of airports, airport planning department and other relevant departments working with infrastructure, alternative fuels and ground operation, and finally manufactures of innovative aircrafts and GSEs.

Tool 1.22 KPIs for smart energy solutions

The purpose of this tool is to help airport sustainability managers to be aware of relevant parameters to track the performance and impact of smart energy solutions. The tool consists of a list of key performance indicators (KPIs) that may be relevant to track and monitor to evaluate if specific solutions have had the intended impact and options to fill in baseline values and targets where relevant. The list is for inspiration and is not an exhaustive list.

The target user of this tool is sustainability managers or other functions working with sustainability strategies or energy data and performance tracking of energy solutions.

Tool 1.23 Transitioning airports into Green Mobility Hubs

This tool describes the framework needed when transitioning airports into green hubs. The tool presents different phases combined with case examples from fellow airports.

The primary target group includes airport decision-makers, operation managers, sustainability departments, and other stakeholders involved in airport planning and management.

9 Online facilitation of replication toolbox

A part of the replication toolbox is an online platform that clearly communicates the various tools, extracted from the deliverables of ALIGHT to a variety of stakeholders and users in the aviation industry and beyond. The online replication toolbox will communicate all findings to a diverse audience primarily within or adjacent to the aviation industry, as well as decision makers and policy makers.

The online replication toolbox is primarily aiming at inspiring and facilitating the replication and scale-up of the solutions and results developed, found, and tested throughout ALIGHT. To effectively achieve this, the online toolbox provides practical guidance on how to use the learnings and findings of ALIGHT to implement in other airports, or other, similar contexts even when these may differ from those of the lighthouse and fellow airports. This online toolbox ensures that valuable results of ALIGHT have a broad and significant impact that extends well beyond the airports directly involved in the ALIGHT consortium.

The online toolbox provides easy access to the wealth of knowledge gathered throughout the duration of ALIGHT, to stakeholders all over the EU and beyond, including airports not directly involved in the project, airlines companies, fuel suppliers and handlers, technology providers, local, regional, and national authorities, city planners, policymakers, standardisation bodies as well as the wider aviation sector and smart city stakeholders.

The architecture of the online replication toolbox is based on a landing page where the user can easily understand and navigate between relevant topics rather than workstreams and work packages making the tools accessible to users outside the ALIGHT project. A mockup of the landing page is presented in Figure 13.

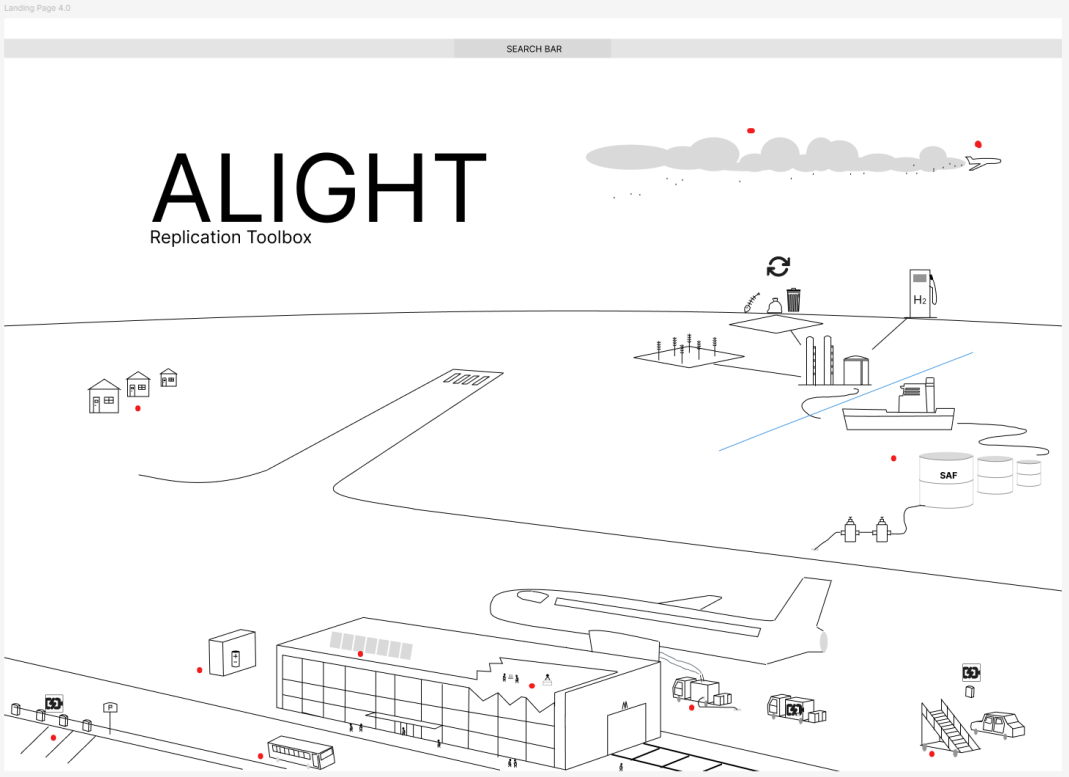

Figure 13 – A mockup of the landing page design of the replication toolbox.

The landing page is the entry point from where the user can dive into specific topics. When entering a topic, all relevant tools within this topic will be presented. This concept is illustrated in Figure 14.

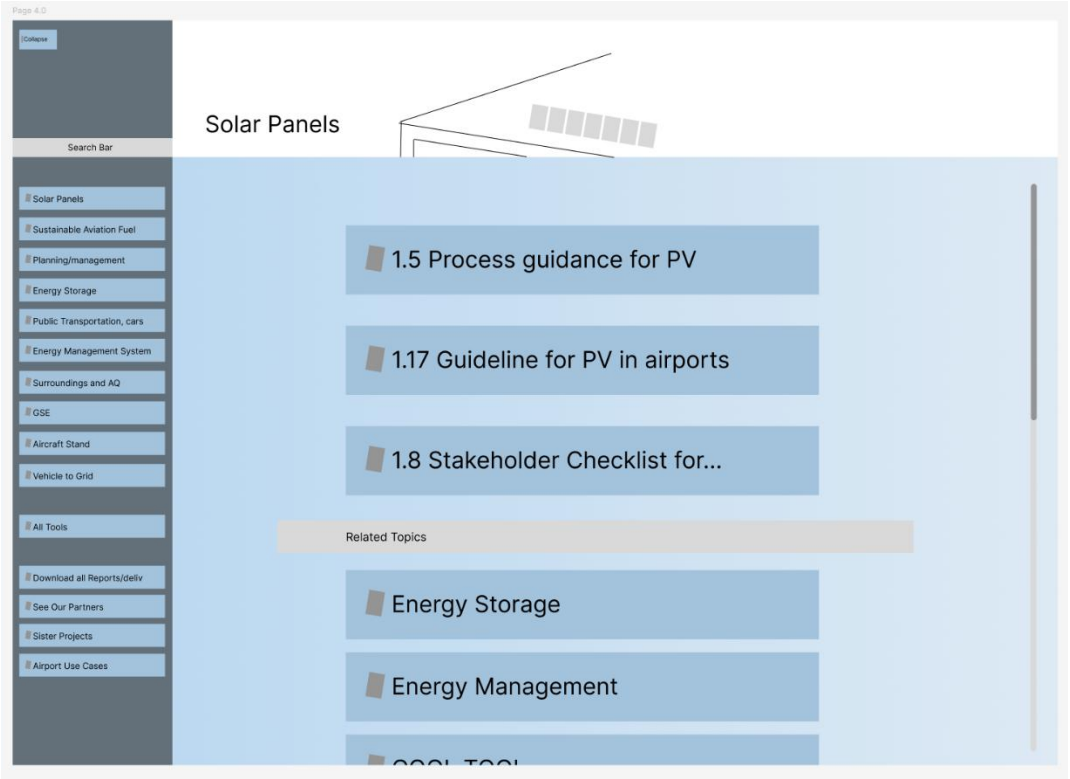

Figure 14 – This mockup of the webpage shows the topics and tools of the toolbox *and different actions.*

Moreover, each tool will be presented and available directly or for download in the online replication toolbox.

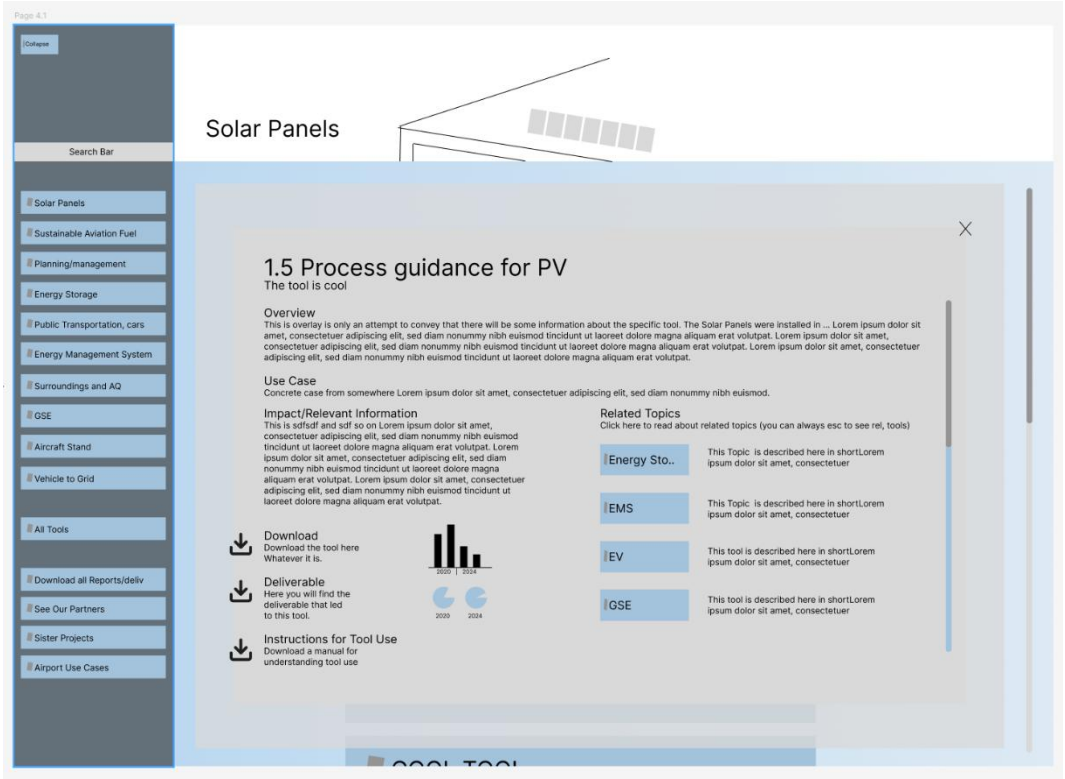

Figure 15 – This mockup of the webpage shows an overlay which *provides information about the tools as well as downloads and other actions. There are no dead ends in the toolbox, and users are continuously invited to consider other relevant tools.*

10 Annex

10.1 Survey answers

Figure 16 – collections of answers on the understanding of a replication toolbox.