ALIGHT
SUSTAINABLE AVIATION

Definition of parameters and metrics for field performance monitoring

D 3.4

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Content

1 Introduction

1.1 Background

The overall mission of the ALIGHT project is to integrate environmentally sustainably solutions for commercial aviation. With Copenhagen (CPH) as the lighthouse airport, the project will bring forward the knowledge, guidelines and best practices to support the transition towards zero-emission aviation and airport operations. Over the course of ALIGHT, three European fellow airports in Italy, Latvia and Poland will replicate the solutions deployed in Copenhagen. Through effective communication, the mission is to ensure maximum impact and benefits to the European air transport sector beyond the duration of the project.

1.2 Objective

The purpose of Work Package 3, deliverable D3.4 "Definition of parameters and metrics for field performance monitoring" is to compile the performance indicators that the project partners deem important for the field performance monitoring of the Sustainable Aviation Fuel (SAF) deployment and utilization strategies in ALIGHT.

The definition of appropriate performance indicators includes economic variables (e.g. price, market availability, supply security, supply resilience etc.), technical aspects (e.g. impact on maintenance and efficiency – considering that effects may be difficult to observe at low SAF blend rates), operational considerations (such as deployment and logistics) as well as environmental impacts including GHG emission reduction and local air quality.

These indicators will be used to monitor overall performance resulting from the implementation and usage of SAF during ALIGHT. Moreover, the proposed indicators are envisioned to support the goals and targets of other work packages and tasks, as depicted in Figure 1.

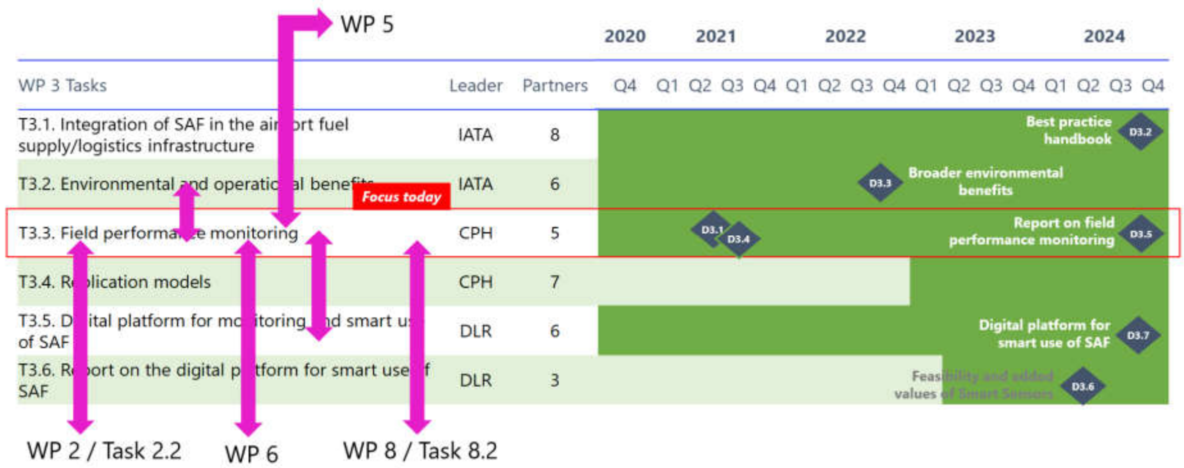

Figure 1: Interfaces and dependencies with other tasks and Work Packages

Therefore, this deliverable proposes a list of potential performance parameters which is in a first step as comprehensive as possible. In project deliverable 3.1 the "Detailed plan of field performance monitoring", these parameters will be described in depth together with a down-selection based on measurability and relevance within the ALIGHT project. Deliverable 3.1 will thus specify the parameters and performance indicators to be actually monitored in ALIGHT.

1.3 Literature review

A literature review was performed to provide an overview of previous approaches to define performance metrics for SAF usage at airports. As the topic is quite new, the EASA report "Sustainable Aviation Fuel 'Monitoring System'" [EASA 2019] is the only source providing tangible context and results for the KPI definition for SAF usage at airport level. In addition, a list of related publications of a more general nature can be found in the references section of this deliverable (see section 5).

EASA's scoping study from2019 containins a review of three sources of possible indicators for SAF use:

1. European Union / EEA official indicators

The study identified a minimum set of three indicators that are currently used in the existing European Energy transport and environment reporting to Eurostat:

- SAF consumption (supply), EU-28 (Mtoe)[1]
- Share of SAF in gross final consumption (supply) of aviation fuels use (%)
- Greenhouse gases emissions savings from SAF supply (tCO_2eq)[2]

2. Indicators used by other international agencies or stakeholders

In this section some supporting initiatives are depicted but no specific SAF use indicators were identified.

3. Indicators used in scientific and technical literature

This section of the study compiled a list of 16 references (see table 1) that propose potential performance indicators for SAF usage.

[1] Million tonnes of oil equivalent
[2] Tonnes of carbon dioxide equivalents

Table 1: literature revision list from [EASA 2019]

Index	Date	Authors	Title
1	12/2/16	Miao Guoa Goetz M., Richterb Robert A., Holland Felix, et al.	Implementing land-use and ecosystem service effects into an integrated bioenergy value chain optimisation framework
2	16/10/12	Virginia H. DaleacRebecca A. EfroymsonaKeith, et al.	Indicators for assessing socioeconomic sustainability of bioenergy systems: A short list of practical measures
3	3/3/09	Francesco Cherubinia,*, Neil D. Birda, Annette Cowieb, Gerfried Jungmeiera, Bernhard Schlamadingerc,1, Susanne Woess-Gallascha	Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems:Key issues, ranges and recommendations
4	21/6/15	Laszlo Torjaia, Judit Nagyb,*, Attila Bai	Decision hierarchy, competitive priorities and indicators in large-scale'herbaceous biomass to energy'supply chains
5	24/1/11	Allen C. McBridea, Virginia H. Dalea,*, Latha M. Baskarana, et al.	Indicators to support environmental sustainability of bioenergy systems
6	24/10/14	Uwe R. Fritsche 1,* and Leire Iriarte 2	Sustainability Criteria and Indicators for the Bio-Based Economy in Europe: State of Discussion and Way Forward
7	11/11/10	Sylvestre Njakou Djomo Ouafik El Kasmioui, et al.	Energy and greenhouse gas balance of bioenergy production from poplar and willow: a review
8	7/7/16	Devin Diran	An Economic, Environmental and Sustainability Assessment of a large scale biofuel industry in Suriname
9	1/1/18	Ayla Uslu	Monitoring framework and the KPIs for advanced renewable liquid fuels (RESfuels)
10	21/8/17	K. Yankovska	Economic efficiency of the technologies of agricultural biomass use for energy purposes
11	1/1/13	Azad Rahman*, M.G. Rasul, M.M.K. Khan, S. Sharma	Impact of alternative fuels on the cement manufacturing plant performance: an overview
12	1/4/03	Annik Magerholm Fet	Eco-efficiency reporting exemplified by case studies
13	8/9/13	Stephanie Searle and Chris Malins	A reassessment of global bioenergy potential in 2050
14	4/1/15	Helen T. MurphyaDeborah A.O'ConnellbR. et al.	Biomass production for sustainable aviation fuels: A regional case study in Queensland
15	14/9/08	James I. Hileman, Jeremy B. Katz. José G. Mantilla and Gregg Fleming	Payload Fuel Energy Efficiency as A Metric for Aviation Environmental Performance
16	28/11/12	Virginia H. Dale, Matthew H. Langholtz, Beau M. Wesh, and Laurence M. Eaton	Environmental and Socioeconomic Indicators for Bioenergy Sustainability as Applied to Eucalyptus

A list of 37 renewable energy indicators were identified from the above list of references. These were shortlisted and compiled (see Table 2) as possible indicators for SAF performance, and they were categorized into Performance Indicators (PI) and Complementary Performance Indicators (CPI). Whereas not all indicators are suitable to the scope of the ALIGHT project, they offer a comprehensive overview of current indicators used in literature.

Table 2: initial performance indicators from [EASA 2019]

Type	Indicator	Unit
PI	**SAF consumption, EU-28**	**Million tonnes of oil equivalent (Mtoe)**
PI	**Share of SAF in gross final consumption of aviation fuels use**	**%**
PI	**Greenhouse gases emissions savings from SAF use**	**Tonnes of carbon dioxide equivalents (tCO_2eq)**
CPI	Types of feedstock used	List of feedstocks and %
CPI	Types of conversion technologies used	List of conversion technologies and %
CPI	Life cycle GHG emissions of biofuels	gCO_2-eq./MJ
CPI	Biofuel production	liter/year
CPI	Biofuel export	liter/year
CPI	Biofuel import	liter/year
CPI	Percentage of SAFs used per type	%
CPI	Cost of SAF type	€
CPI	Employment	Number of full time equivalent jobs
CPI	Trade volume	€
CPI	Return on investement	% (net investment/initial investment)
CPI	Public opinion	% favorable opinion
CPI	Investment expenditures (fields, storage, equipment, etc)	€
CPI	Total Biofuel profits	€/year
CPI	Total investments on SAFs	M€ or k€/MW installed
CPI	Bioenergy potential (Mass or Energy that could potentially be obtained per year)	J/year
CPI	Production surface land for SAF used within the EU in a certain year	Sq Km/year

Most of the indicators are out of the scope from an airport perspective and they address more general aspects of SAF usage in Europe. Therefore, the literature review shows that KPIs that are relevant to support the introduction and upscaling of SAF at airports still need to be identified.

2 Approach

The performance indicators contained in this document were developed collaboratively by the ALIGHT partners with the aim of including as many aspects as possible concerning the implementation and use of SAF at European airports. Several workshops were organized throughout 2021 in order to identify, discuss and define the most appropriate indicators for the field performance monitoring.

2.1 Stakeholders

In order to acknowledge the different perspectives and to encompass all relevant requirements for SAF implementation and performance monitoring, the ALIGHT partners identified the following key stakeholders:

- Airlines
- Fuel manufacturers
- Fuel suppliers
- Fuel depot operators
- Airport operators
- Policy makers / regulators
- Passengers / communication (involved in WP 10)
- Investors
- NGOs / society
- Aircraft / engine OEMs
- Certification bodies

These stakeholders each have a different perspective on SAF implementation and pursue different interests. Therefore, the performance indicators also need to consider the perspectives of the various stakeholders and to support their individual evaluation of the performance of SAF implementation. As the ALIGHT consortium already consists of small, large and new airports, airlines, oil companies, technology suppliers, consultancy firms, interest groups and research institutions, it already encompasses a wide range of the stakeholders identified above.

2.2 Focus areas and key targets

Based on the project plan and the list of stakeholders the development of performance indicators in ALIGHT is structured in two tiers. The top tier consists of 5 focus areas that are based on the concept of key performance areas (KPA) used by ICAO and Eurocontrol in the Single European Sky ATM Research Programme (SESAR). The use of focus areas facilitates the analysis of transversal and multidimensional aspects of SAF implementation under thematic groups or categories.

The focus areas in ALIGHT are:

- Operational
- Environmental
- Economic
- Technical
- Communication

Below this high-level categorization another tier of categorization is applied to structure the KPI development. Within one focus area (e.g. environmental) key targets provide a detailed structure of the different targets which are relevant for the performance measurement in ALIGHT and also for the stakeholders' evaluations. The key targets thus provide an indication of the aspects to be monitored by the performance indicators. However, in some cases the key targets do not literally represent a specific target but can also be seen a bit more general, as a topic.

This two-tier approach in ALIGHT is illustrated in Figure 2.

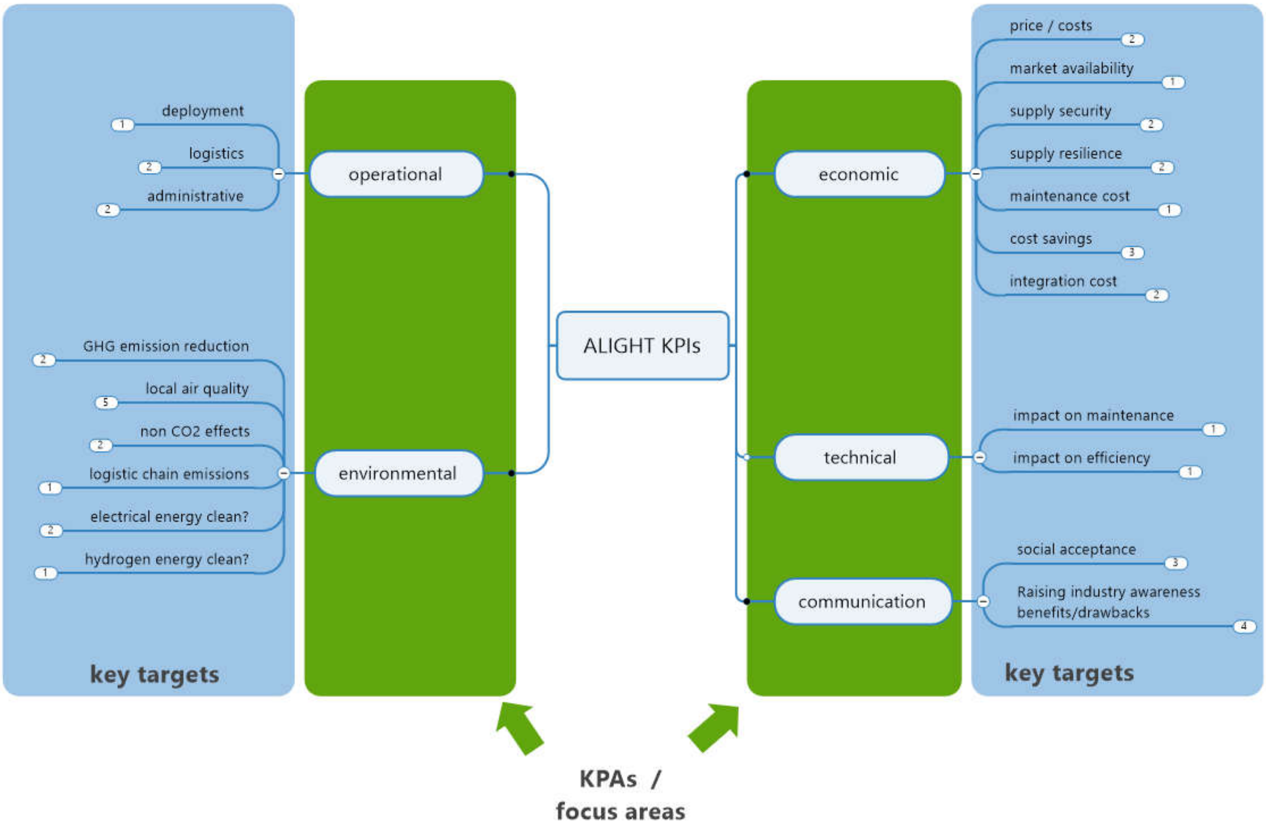

Figure 2: KPAs / focus areas and key targets in ALIGHT

The following key targets were identified for the environmental focus area:

- GHG emission reduction
- Local air quality
- Non-CO_2 effects
- Emissions from the logistic chain
- Environmental footprint of electrical energy
- Environmental footprint of hydrogen

The following key targets were identified for the operational focus area:

- Deployment
- Logistics
- Administrative

The following key targets where identified for the economic focus area:

- Price / cost
- Market
- Availability
- Supply security
- Supply resilience
- Maintenance cost
- Cost savings
- Integration cost

The following key targets were identified for the technical focus area:

- Impact on maintenance
- Impact on efficiency

The following key targets were identified for the communication focus area:

- Social acceptance
- Raising industry awareness of benefits/drawbacks

3 Table of performance indicators

Corresponding to the approach elucidated above the performance indicators are grouped according to the respective key targets detailed in the following subchapters. Each subchapter represents a focus area.

Depending on the different nature and responsibility of the performance indicators, there are different key stakeholders with access, knowledge or technical expertise to provide or measure data that is relevant for the calculation of the discussed KPIs. The following tables therefore also provide a rough overview of such potential data owners for the respective KPIs. A more detailed approach is elaborated in deliverable 3.1.

3.1 Environmental performance indicators

A major objective of ALIGHT is to highlight and quantify the environmental benefits of SAF beyond reductions of carbon dioxide emissions. Therefore, environmental performance indicators are essential to this project for the purpose of documenting the results of implementation at CPH, and for the opportunities of identifying best practices and transferring knowledge to other European airports.

Table 3: performance indicators in focus area "environmental"

Key target	Performance indicator	comment	Data source / provider
GHG emission reduction	Calculated emission reduction per SAF type multiplied by quantity of SAF used (per type)	Calculated emission reduction with regard to lifecycle	Emission model based on SAF life cycle emissions
GHG emission reduction	Reduction potential subject to blending rate of SAF	Replacement rate of fossil fuels multiplied by calculated emission reduction (see other GHG-KPI above)	Emission model based on SAF life cycle emissions
Local air quality	Total particle number concentration (5nm < d < 3µm)		Airport measurements
Local air quality	Non-volatile particle number concentration (5nm < d < 3µm)		Airport measurements
Local air quality	PM2.5 particle mass concentration	PM2.5 as measure for fine particulates	Airport measurements
Local air quality	Nitrogen Oxides (NO_x) concentration		Airport measurements
Local air quality	Lung-Deposited Surface Area (LDSA)	Derived parameter (from particle number concentration and particle size); sum indicator for exposure	Airport measurements
Non-CO_2 effects	Total particle number concentration (5nm < d < 3µm)		Airport measurements

Key target	Performance indicator	Comment	Data source / provider
Non-CO_2 effects	Non-volatile particle number concentration (5nm < d < 3µm)		Airport measurements
Non-CO_2 effects	PM2.5 particle mass concentration		Airport measurements
Non-CO_2 effects	Nitrogen oxides (NO_x) concentration		Airport measurements
Non-CO_2 effects	Lung-Deposited Surface Area (LDSA)		Airport measurements
Non-CO_2 effects	Changes in radiative forcing (e.g. from water vapor due to different contrail formation, soot, ice crystal formation)		Emission model based on SAF properties and flight missions
Logistic chain emissions	Distance of supplier multiplied by transport mode standard-emission		Fuel retailer statistics
Environmental footprint of electrical energy	CO_2 emission per kWh	Relevant to (potential) future aircraft with electric propulsion	Electrical energy provider
Environmental footprint of electrical energy	Share of renewable energy	Relevant to (potential) future aircraft with electric propulsion	Electrical energy provider
Environmental footprint of hydrogen	CO_2 emission per kWh	Relevant to (potential) future aircraft with hydrogen as main fuel	Hydrogen provider

3.2 Operational performance indicators

The following performance indicators address operational aspects and implications concerning the implementation of SAF:

Table 4: performance indicators in focus area "operational"

Key target	**Performance indicator**	**Comment**	**Data source / provider**
Deployment	SAF usage at airport [%]	Average blend delivered	Airport, fuel supplier
Deployment	Fuel characteristics influencing aircraft operation, like density, energy content and H/C ratio		fuel manufacturer, airline
Logistics	Need for segregated infrastructure at airport	Quantifiable properties: number of independent fuel systems, cost for installation and/or operation of additional systems	Airport
Logistics	Extra time for additional processes	e.g., increased turnaround time; annual person-hours for additional processes	Airport
Administrative	Extra time for additional processes	e.g., annual person-hours spent on administrating additional processes	Airport
Administrative	Segregated accounting		Airport

3.3 Economic performance indicators

Economic implications of SAF deployment are of great concern for several stakeholders as they have a direct influence on their economic sustainability. Table 5 provides an overview of the performance indicators within this focus area:

Table 5: performance indicators in focus area "economic"

Key target	Performance indicator	Comment	Data source / provider
Price / cost	Cost kerosene versus SAF per liter		Fuel supplier
Price / cost	Cost kerosene versus SAF per MJ	Specific energy content	Fuel supplier
Price / cost	Cost per kWh (electric propulsion)		Electrical energy provider
Price / cost	Cost per kWh (hydrogen propulsion)		Hydrogen provider
Market availability	SAF availability [tons per year]		Fuel manufacturers
Supply security	Mandatory usage of SAF [%]	Assuming that a SAF-quota will incentivize potential producers.	Policy makers
Supply security	Number of independent suppliers	Consider only suppliers that can deliver to a given airport	Fuel manufacturers
Supply resilience	Number of independent suppliers	(see above)	Fuel manufacturers

Key target	Performance indicator	Comment	Data source / provider
Supply resilience	Number of supply chains	Including supply chains that are unused but could be activated if required.	Fuel manufacturers
Maintenance cost	Difference in maintenance cost SAF versus kerosene	e.g., per aircraft or per airline (relevant for pure SAF or high blending ratios)	Airline, maintenance provider
Cost savings	Carbon tax avoidance	Compared to 100% conventional fuel baseline	Airline
Cost savings	ETS / CORSIA cost savings		Airline
Cost savings	Cost saving due to higher energy content		Airline
Integration cost	Cost for segregated infrastructure at airport	e.g., installation, operation, maintenance	Airport
Integration cost	Cost for additional processes	e.g., maintenance, personnel	Airport

3.4 Technical performance indicators

The following technical performance indicators were identified:

Table 6: performance indicators in focus area "technical"

Key target	Performance indicator	Comment	Data source / provider
Impact on maintenance	Intensity of maintenance [time units per flight hour]	Comparison SAF / kerosene	Airline, maintenance provider
Impact on efficiency	Energy content per ton of SAF versus kerosene	Relevant to SAF with chemical composition different from conventional fuels. Influence both fuel logistics (ground) and fuel load (aircraft).	Fuel manufacturer, airline
Impact on efficiency	Energetic process efficiency	Utilization ratio of SAF production	Fuel manufacturer

3.5 Communication performance indicators

Communication KPIs were defined as follows:

Table 7: performance indicators in focus area "communication"

Key target	Performance indicator	Comment	Data source / provider
Social acceptance	Passenger awareness of SAF benefits [share of passengers]	Could be measured via e.g., passenger surveys.	Airport, airline
Social acceptance	Passenger awareness of SAF benefits [change during project]	Could be measured via e.g., passenger surveys.	Airport, airline
Social acceptance	Communication strategies used	Measures taken to increase awareness of SAF (e.g., number of campaigns, type of media used, audience)	Airport
Raising industry awareness of benefits/drawbacks	Share of airlines using SAF of those operating at airport	Spread of SAF via (voluntary) airline action	Airport
Raising industry awareness of benefits/drawbacks	Number of airports supplying SAF [change during project]	Spread of SAF via (voluntary) airport action	Airport, fuel supplier
Raising industry awareness of benefits/drawbacks	Number of policies in place on SAF usage	within EU; focus on qualitative spread of SAF via policies and regulations	Policy maker
Raising industry awareness of benefits/drawbacks	Mandatory SAF usage by country [%]	Focus on quantitative spread of SAF via policies and regulations	Policy maker

4 Conclusion

To support the introduction and upscaling of SAF at airports, a comprehensive list of KPIs is required to monitor and evaluate progress of SAF deployments and to identify cost and benefits of SAF introduction. The literature review showed the need for robust KPIs to support the use of SAF at airports and revealed the advantages of collaborative work among the ALIGHT partners for defining new performance indicators for SAF implementation at airports not present in the literature. This also highlights the importance of this work package's task to pave the way for a meaningful and relevant performance monitoring within the ALIGHT project.

To identify relevant KPIs, key stakeholders within ALIGHT participated in a series of workshops. The main outcomes are reflected in the tables within section 3 that compiled a total of 47 performance indicators within five key performance areas:

- 17 environmental performance indicators
- 5 operational performance indicators
- 15 economic performance indicators
- 3 technical performance indicators
- 7 communication performance indicators

As indicated throughout this document, not all the KPIs identified herein will be used in the project's monitoring. Those used for the purpose of ALIGHT will be selected based on measurability, data availability and relevance, and they will be defined in deliverable 3.1 titled "Detailed plan of field performance monitoring".

5 References

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