ALIGHT
SUSTAINABLE AVIATION

D7.1 REPORT ON "STATE-OF-THE-ART" WORKSHOP

Grant Agreement:	957824
Project title:	A Lighthouse for the Introduction of Sustainable Aviation Solutions for the Future ("ALIGHT")
Project start date:	1 November 2020
Project end date:	31 October 2024
Project duration:	48 months
Deliverable number & title:	D7.1
Deliverable lead beneficiary:	DTI
Deliverable partner beneficiaries:	DLR
Work Package:	WP7
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Deadline according to DoA:	31.10.2022
Submission date:	22.12.2022
Dissemination level:	PU (public)

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

NB: All deliverable partner beneficiaries listed above should approve in below table.

Version	Date	Author	Request for review (internal/external)	Approval
1.0	20.12.2022	DTI	Internal: Bernard Gindroz	OK

CONTENT

1 Executive Summary

Three workshops will be held throughout the ALIGHT – Sustainable Aviation project, progressing from "State of the Art" to "Bold Vision" and concluding with a "Policy Maker" workshop. This report contains findings from the first workshop, held on June 1st and 2nd, 2022 in Copenhagen. The topics of this workshop on the state of the art were short-term challenges, short-term goals, and emerging solutions within Sustainable Aviation Fuels (SAF) and Smart Energy. In total 44 participants, including 20 speakers, took part in the workshop; representing a total of 10 European countries and a wide range of stakeholder groups such as airlines, airports, interest organisations, public organisations and administrations, equipment suppliers for the aviation industry, as well as universities and knowledge organisations.

Workshop conclusions for Sustainable Aviation Fuels

Conclusion of the first day was that we are heading into the right direction but implementing effective climate mitigation solutions and ensuring the strong upscaling is challenging. First, it is very important to address both CO_2 and non-CO_2 climate effects, with non-CO_2 effects making up to two thirds of climate impact of the aviation sector. Additionally, methods for the Life Cycle Assessment have to be carefully chosen to ensure that cause-effect relationships are captured (e.g., by consequential LCA). On SAF deployment, the workshop clearly showed that despite high ambitions (e.g., SAF mandates), SAF shares are currently below 0.1%. Main barriers identified were a discordance of a diverse set of goals, proposals, and regulations. Furthermore, the importance of using fuel hydrant systems and the costs that would come with changing fuel supply at an airport were pointed out in detail.

Different ideas on how to facilitate SAF deployment (e.g., SAF pool at airport) were presented and need to be further investigated. The results of the ALIGHT airport survey underlined that implementation of SAF varies widely. Only a minority (11 of 54) airports had practical SAF handling experiences. While the handling itself is not seen critical (drop-in fuel), major concerns are related to accounting and reporting.

Aeroporto di Roma shared experiences of their pioneering SAF usage in Italy. As SAF delivery routes can be more diverse and SAF is often handled in a segregated manner, efforts have been spent in creating the supply infrastructure as well. Recommendations from the Norwegian airport operator Avinor are 1) Installation of an aviation fund to incentivize SAF uptake, 2) clear and harmonized regulations for accounting and reporting practices and 3) the implementation of a collective effort to coordinate activities across the value chain.

Moving forward, collaboration was found to be key. To foster deep level of collaboration it is important to clearly identify areas of collaboration vs areas of competition for the different stakeholders and consequently focus on resolving today challenges while focusing on achieving the long term goal of truly sustainable aviation.

Workshop conclusions for Smart Energy

Energy flexibility and -efficiency are main drivers for the development as well as sales and purchases of new equipment. Hardware is only part of the solution, however: Use and management of electricity has a major influence. Smart charging strategies for electrical vehicles and ground support equipment, as well as the integration of battery energy storage systems are examples. Model-based thermal controls in buildings can lower energy consumption, avoiding both CO_2 and costs. Implementing these technologies at an airport will require specific modifications. Energy- and IT-infrastructure must be upgraded and modified to fit the solutions.

Airports cannot be seen apart from their surroundings and the supporting cities. Therefore, airports are also a major participant in the creation of a greener and more sustainable local environment. Three presentations about energy communities, passenger transportation, and how an airport can serve as an anchor to urban development, were shared and discussed with the participants.

New aircrafts with higher fuel efficiency or alternative fuels (hydrogen, electricity) are under development, and airports need to be ready to service these new types. In addition, air traffic and passenger numbers are constantly changing – both in volume (number of passengers and flights) and in structure (e.g., share of short-haul, regional, and intercontinental flights). This forces airports to constantly re-think and adapt their facilities. At the same time, airport infrastructure is meant to last, and being able to re-use existing facilities for new aircraft may give a competitive advantage. This underlines how designing aircraft and aircraft stands is mutually connected.

About the workshop and this report

In general, there was a great spirit at the state-of-the-art workshop, where all participants actively took part in the discussions. Clearly it was highly appreciated that ALIGHT now facilitates such knowledge transfer and discussions across different aviation related field of interests. The participation of important stakeholders such as Airbus clearly indicates the support to the ALIGHT project. Apart from the upcoming “Bold Vision” and “Policy Maker” workshops, ALIGHT also aims to support the coordination between the four large European lighthouse projects in the aviation sector, ALIGHT, OLGA, STARGATE and TULIPS.

Data and findings from the workshop have been gathered from notes, Slido, Miro (for speakers), presentations, photos, and videos. This public report describes the event and the main findings, while e.g., posts on the ALIGHT LinkedIn channel will supply a more popular storytelling from the state-of-the-art workshop.

2 Introduction

Airports are embedded into a dynamic network of relationships:

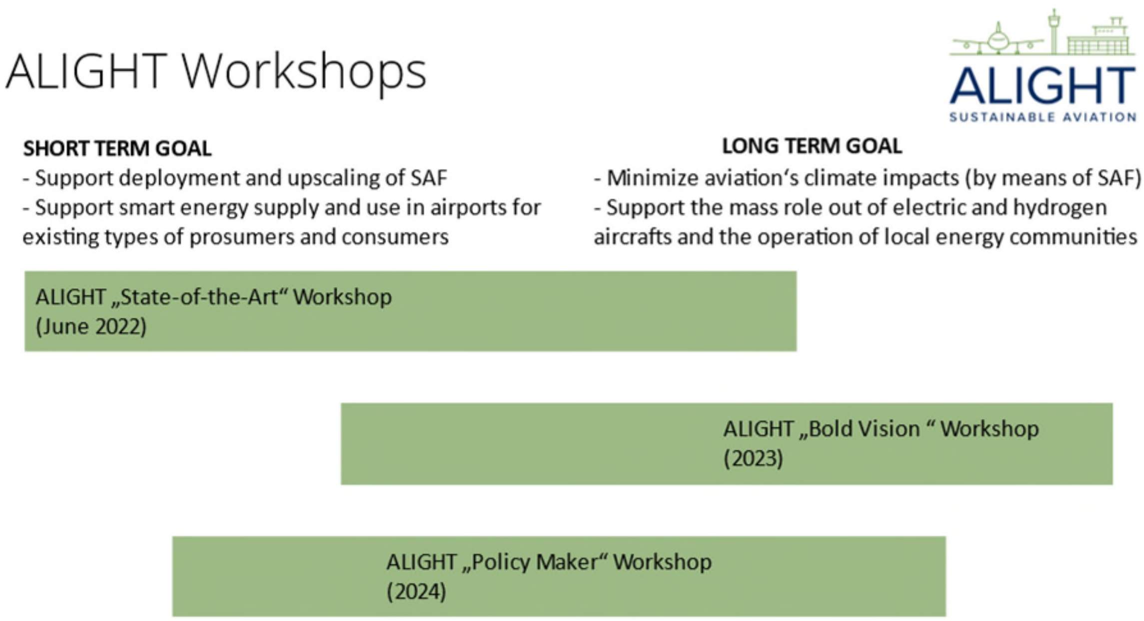
- Each (smart) airport is part of a (smart) city,
- The sustainable aviation fuel (SAF) industry and research is rapidly evolving,
- Airports are developing,
- Airlines are buying new aircraft, and
- Policy as well as public has an increasing awareness of climate change.
- A few countries, including Denmark, have or are developing policies to introduce SAF mandates.

By a series of three workshops with external and internal participants, cooperating with activities and projects on those sectors ensure that the results of this project are in line with the rapid developments in the interconnected areas and activities.

Starting in the last decade, the whole aviation sector started the endeavour to transition to climate neutrality. This enormous challenge cannot be tackled all at once. Across the sector, the pattern emerges that it needs two perspectives, one focusing on the near term, the other one on the long term. In the near term, the goal is to support the adoption and scaling of climate-friendly solutions. In the long-term, the aim is do the very best to minimize or neutralize climate impact from aviation.

These two perspectives are reflected in the organization of ALIGHT workshops:

- The ALIGHT “State of the Art" Workshop focuses on the short-term goals and aims to capture short-term challenges and emerging solutions.
- The ALIGHT “Bold Vision” Workshop focuses on the long-term goal and aims to identify the most effective solution to enable climate neutral aviation.
- The ALIGHT “Policy Maker” Workshop combines the two perspectives, identifying ways to build a bridge between them, and identify important measures to move forward effectively.



3 Organization of the State-of-the-art workshop

To have a productive and in-depth workshop, it was decided to organize the workshop at the first point in time where in-person meetings could take place again. Furthermore, for the first workshop to be very interactive, it was decided to keep participant numbers below 50.

The ALIGHT “State of the Art" Workshops took place as an in-person event at Copenhagen Airport on June 1st and 2nd, 2022.

FIGURE 1: WORKSHOP VENUE COPENHAGEN AIRPORT

The workshop was split into Day 1 workshop with focus on ALIGHT workstream A – SAF and Day 2 workshop with focus on ALIGHT workstream B – Smart Energy Supply & Use. Each workshop day had three sessions per workstream, three or four presentations per sessions, Q&A after presentations and a panel discussion at the end of each session. Slido was used for capturing questions during presentation and launching polls after each session.

In total 44 participants, including 20 speakers, participated in the workshop representing a total of 10 European countries and a wide range of stakeholder groups such as academia, airlines, airports, interest organisations, public organisations, suppliers, and knowledge organisations. The ALIGHT consortium will also use this and future workshops to reach out to representatives from aviation-related, EU-funded lighthouse projects (TULIPS, OLGA, STARGATE.)

3.1 Code of conduct summary

Participants at the workshop agreed on a code of conduct, which is summarized below:

#Safe space “Nothing will be released to public without our consent.”

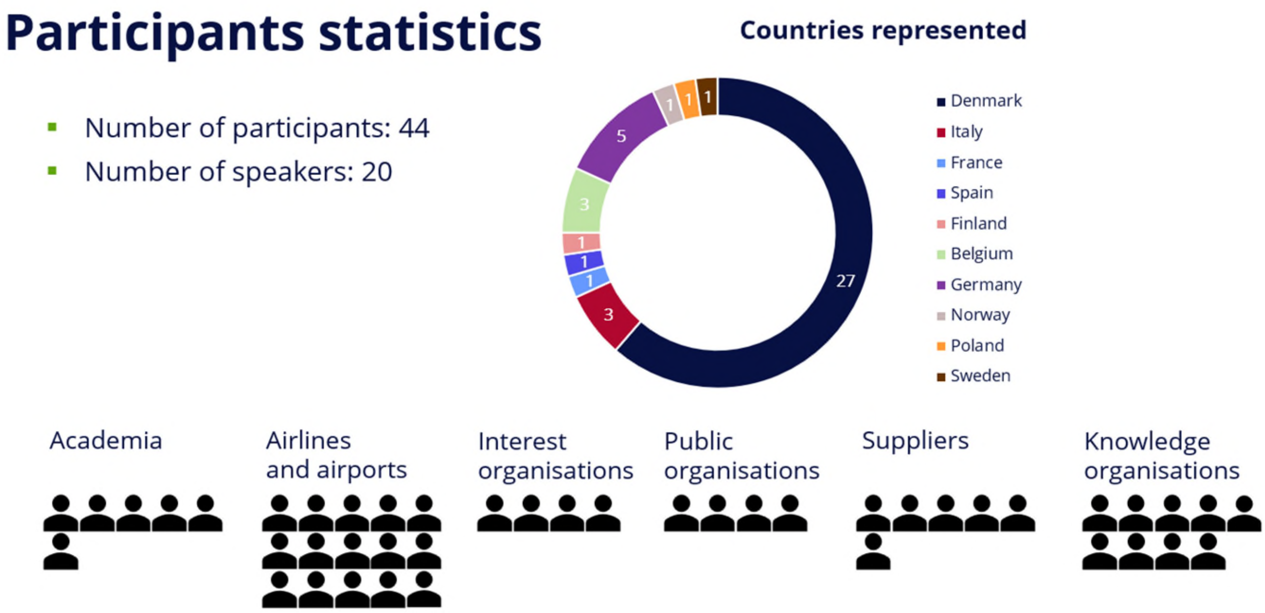
#Challenge with respect “We agree on challenging each other to create truly new insights, while showing highest levels of respect.”

#Be curious “Asking good questions is more important than having the right answer.”

#Have fun “We finally meet in person. Let’s enjoy it!”

3.2 Participants

The ALIGHT “State of the Art" Workshops took place as an in-person event at Copenhagen Airport on June 1st and 2nd. The participants joined the workshop from ten different countries. 34% of these represented airlines or airports. Knowledge organizations counted for 20%, suppliers were 14%, academia were 14%, interest organizations and public organizations represented 18% of the participants.



3.3 Workshop program

The workshop was split into two days the first day focusing on SAF, the second day on smart energy.

3.3.1 Program for day 1 – 1st of June 2022

Time	Program	Speaker
	Opening session	
10.00-10.10	Welcome	Copenhagen Airport
10.10-10.30	Policy / Fit for 55	Michael Kyriakopoulos, European Commission
10.30-10.50	ALIGHT – overview, purpose and cooperation	Jesper Jacobsen, Copenhagen Airport
10.50-11.00	Introduction to workshops and moderators	Jesper Jacobsen, Copenhagen Airport
11.00-11.10	Introduction to ALIGHT Workstream A	Bastian Rauch, DLR
	SAF in context: Climate Impacts, SAF Sustainability and Deployment	
11.10-11.30	Climate impact on aviation incl. non-CO_2	Katrin Dahlmann, DLR
11.30-11.50	SAF sustainability issues	Jannick Schmidt, Aalborg University
11.50-12.10	SAF deployment from 0 to 50 and beyond	Martin Porsgaard, NISA
12.10-12.15	Input from the audience	
12.10-12.35	Panel discussion & questions	Session speakers
12.35-13.30	**Lunch**	
	Situation at airports: How can airports facilitate the use of SAF?	
13.30-13.50	ADR experiences: Intro on SAF supply	Angela Di Lullo, Aeroporti di Roma
13.50-14.10	Inspiration from a SAF experienced, green airport	Arvid Løken, Avinor
14.10-14.30	SAF perspectives from Vilnius airport	Monica Soria Baledon, IATA
14.30-14.35	Input from the audience	
14.35-14.55	Panel discussion	Session speakers
14.55-15.20	**Coffee Break**	
	SAF Provision & Usage	
15.20-15.40	Airline perspective on buying and using SAF	Lars W. Andersen, SAS
15.40-16.00	How are SAF supplied and how might SAF be supplied in the future?	Sven Rieve, airBP
16.00-16.20	Fuel supply to the aircraft	Peter Laybourn, BKL
16.20-16.35	Input from the audience	
16.35-16.55	Panel discussion	Session speakers
16.55-18.30	**Networking on the airport terrace with a light meal**	

FIGURE 2: WORKSHOP PARTICIPANTS

3.3.2 Program for day 2 – 2nd of June 2022

Time	Program	Speaker
09.00-09.10	Welcome and short intro to ALIGHT	Jesper Jacobsen, Copenhagen Airport
09.10-09.20	Welcome to Day 2 & Introduction to ALIGHT Workstream B	Lars Overgaard, Danish Technological Institute
Future energy supply and use		
09.20-09.40	Energy control and management	Prof. Mirko Morini, University of Parma
09.40-10.00	Intelligent charging	Peter Bach Andersen, Technical University of Denmark
10.00-10.20	Utilization of energy storage	Kjeld Nørregaard, Danish Technological Institute
10.20-10.40	Greening of GSE	François Peeters, TCR Italia
10.40-10.45	Input from the audience	
10.45-11.05	Panel discussion	Session speakers
11.05-11.25	Coffee Break	
City/Airport continuity/integration		
11.25-11.55	The integration of CPH in the smart city of Copenhagen	Caroline Schousboe, Region Hovedstaden
11.55-12.15	The relevance of energy communities	Sergi Alegre, Airport Regional Council
12.15-12.35	Challenges faced by (new) airports	Arja Lukin, City of Vantaa
12.35-12.40	Input from the audience	
12.40-13.00	Panel discussion	Session speakers
13.00-13.50	Lunch	
Aircraft stand of the future		
13.50-14.10	State of the art and the development effort behind	Morten Elsmark, Copenhagen Airports
14.10-14.30	ePlane charging systems	John Nilsson, Swedavia
14.30-14.50	Hydrogen fuelling infrastructure and safety	Nicolas Landrin, Airbus
14.50-14.55	Exercise	
14.55-15.15	Panel discussion	Session speakers
Closing Session		
15.15-16.00	Workshop closing session and networking	Moderation: DLR and DTI

FIGURE 3: A SCENE FROM THE WORKSHOP

4 Workshop findings day 1 – SAF

4.1 Motivation / framing of day 1

Bastian Rauch, DLR, member of ALIGHT

On the first day of the workshop, presentations and discussions were centred around Sustainable Aviation Fuels. Topics in this part of the workshop started with a more high-level perspective, focusing then on the situation at airports and on SAF provision. Overall, the intention was to facilitate a dialogue between relevant experts and other stakeholders on how to support short term goals of supporting the effective upscaling and deployment of SAF and long-term goals to minimize all of aviation climate impacts by using SAF. The day 1 workshop "*workstream A - SAF*" consisted of three different sessions:

- SAF in context: Climate Impacts, SAF Sustainability and Deployment, 3 speakers
- Situation at airports: How can airports facilitate the use of SAF?, 3 speakers
- SAF Provision & Usage, 3 speakers

4.2 Session 1: SAF in context - Climate Impacts, SAF Sustainability and Deployment

The first session of the SAF workshop day consisted of 3 presentations by

1. Dr. Katrin Dahlmann, German Aerospace Center gave a speech on "Climate impact on aviation including non-CO_2 effects"
2. Prof. Jannick Schmidt, Aalborg University, gave a speech on "SAF sustainability issues"
3. Martin Porsgaard, NISA, gave a speech on "SAF deployment from 0 to 50 and beyond"

Climate impact on aviation including non-CO_2 effects (Dr. Katrin Dahlmann)

Katrin Dahlmann provided a comprehensive overview about aviation emissions and the full set of climate impacts. She explained the physics of how different aviation emissions interact with atmosphere and consequently are impacting the climate. She pointed out that more than 50% of aviation's climate impact stem from non-CO_2 effects. In contrast to CO_2 emissions which scale with amount of emissions, non-CO_2 effects depend on a variety of additional factors, like the location of the emissions, weather conditions and the specific characteristic of the emission (and many more.) Different emissions have different lifetimes, ranking from few hours, over weeks to several hundreds of years. Currently, ETS and CORSIA focus only on carbon emissions and would need to be extended to cope with all of aviation climate impacts. At the end of her talk Katrin Dahlmann pointed out three potential mitigation options to minimized aviation climate impact: a) technological measures (optimized aircraft, engine design), b) use of alternative energy carriers (SAF, hydrogen, electric) and c) operational measures like efficient flight guidance or climate optimized flights.

In the Q&A session Katrin Dahlmann answered and discussed the following questions with the audience:

- Where do the uncertainties in aviation climate effects come from?
- How can non-CO_2 impacts be implemented in a marked based measure?
- Are climatological measures good enough to calculate/predict non-CO_2 emissions with low uncertainty?
- Do you have data on decay functions for the individual contributors to Climate change?
- Are there saturation effects for the non-CO_2 effects, e.g., on high traffic routes?
- What about considering carbon emissions along the complete value chain? From extraction to transformation to SAF to consumption and direct emissions?
- How can we operationalize this to calculating airlines actual emissions?
- How confident are we on the contrails impact? How many studies - worldwide - confirm the figures presented?

SAF sustainability issues (Jannick Schmidt, Aalborg University)

Prof. Jannick Schmidt began his presentation that the core idea of renewable feedstock is it uptakes the same amount of CO_2 as emitted during its use. However, growing biomass requires land, direct land use changes (dLUC), Indirect land use changes (iLUC) heavily influence sustainability. Furthermore, biodiversity loss, and the fact that for waste product (like used cooking oil) markets already exists and waste products would probably be replaced with fossil alternative. In consequence, some feedstocks do not rate better on sustainability or CO_2 emissions than fossil fuels. In the following, Jannick Schmidt explained and confronted the consequential Life Cycle Assessment (LCA) method and the Attributional LCA method. He showed that the attributional approach does not capture cause and effects and thus the consequential LCA is the preferred method. Jannick Schmidt concluded his talk pointing to an initiative "Getting the data right", which is developing a global LCA databased with detailed LCA data on energy and fuels in all countries. Furthermore, he pointed to a recent analysis by Maersk and AAU showing that there are processes with negative CO_2 emissions (removing CO_2).

In the Q&A session Jannick Schmidt answered and discussed the following questions with the audience:

- How big is the share of the promising (CO_2 negative) pathways?
- Who are the current users of used cooking oils?
- What is another approach to map SAF/ renewable hydrocarbon production?

SAF deployment from 0 to 50 and beyond (Martin Porsgaard, NISA)

Martin Porsgaard, head of NISA, focused his talk on the challenges the aviation industry is facing. He started pointing out the ambitious goals that have been set by various countries, with the final goal of 100% SAF use in 2055. However, with a <0.1% share in 2022 and maybe 0.2% in 2023, there is a long way to go. In ALIGHT, WP2 (led by NISA) is focusing on four areas to support airports in their introduction and scale up of SAF: 1) security of supply, 2) regulations and compliance, 3) sustainability and 4) price. Mr. Porsgaard presented the results of study on potential fuels producers on global level. He pointed out that for most of the production capacities are being build and as of today only Neste and World Energy are supplying fuel on a commercial scale. To understand the GHG performance of potential SAF supply routes to airport, a study has been started for the use case of Copenhagen Airport. Mr. Porsgaard concluded his talk on presenting a SAF pooling idea aiming at the facilitation of SAF acquisition and supply at airports.

In the Q&A session Martin Porsgaard answered and discussed the following questions with the audience:

- What is your opinion on blending SAF on the airport premises vs blending off-site?
- Do you see sustainability only related to decarbonization? Shouldn't we include non-CO_2, economic sustainability, and social acceptance? I.e., Sustainability = economic, ecologic, social sustainable?
- What are the main challenges to quickly increase the share of SAF? Complicated production process? Supply of ingredients/components? Price?
- Is it feasible to produce the power required for Power-to-liquids (PtL)?
- In your opinion, is the goal for 2050 realistic taking into account how early in the process we are now and all obstacles?

FIGURE 4: PRESENTATION BY MARTIN PORSGAARD

Panel discussion

During the panel discussion, the following questions were discussed

- What will be the best way to support upscaling of SAF production?
- How to compensate between the two different LCA calculations?
- Is there a holistic insight / vision of SAF vs electrification vs hydrogen etc.?

The panel concluded with the comment that it is important to move away from narrow focus on decarbonization and to include full set of aviation's climate impacts (CO_2 & non-CO_2). Furthermore, it is important to choose processes and climate metrics that measure the true climate impacts (see discussion of attributional and consequential LCA).

FIGURE 5: PANEL DEBATE WORKSHOP DAY 1

4.3 Session 2: Situation at airports – How can airports facilitate the use of SAF?

The second session of the SAF workshop day consisted of 3 presentations by

1. Angela Di Lullo, Aeroporto di Roma, gave a speech on “ADR experiences: Intro on SAF supply”
2. Arvid Løken, Avinor, gave a speech on “How can airports facilitate SAF”
3. Mónica Soria Baledón, IATA, presented the results of the “ALIGHT Airport Survey”

ADR experiences: Intro on SAF supply (Angela Di Lullo, Aeroporti di Roma)

Angela Di Lullo started with presenting some figures describing the scale of Aeroporti di Roma (ADR). Starting from 2000 ADR focused on achieving high sustainability standards and in March 2021 accomplished Airport Carbon Accreditation Level 4+. In 2021 ADR became the first airport in Italy, that implements SAF into their operation. In the following Angela Di Lullo described the efforts that have been taken to get 3,000 tons of co-processed SAF/Jet A-1 which was delivered by ship to the airport. She provided the details of the fuel supply line and the different measures that had been taken for a first of a kind large scale delivery of SAF to ADR. She concluded her talk with showcasing other initiative connected to sustainable fuels.

In the Q&A session Angela Di Lullo answered and discussed the following questions with the audience:

- What is the biggest concern by using SAF?
- Has SAF to be handled totally separately from the existing jet fuel lines and tanks, or can a mix happen?
- What is the share of SAF in total fuel at FCO? What are your goals for the future?
- Can you repeat what was the most difficult point in the SAF supply line?
- Is it possible to supply SAF using same pipelines as for traditional fuels? If not, why?
- Did you also mix with traditional fuel?

FIGURE 6: ANGELA DI LULLO PRESENTED EXPERIENCES FROM ADR

How can airports facilitate SAF (Arvid Løken, Avinor)

Arvid Løken started his presentation by pointing out that due to its geography Norway is totally dependent on aviation. Avinor, Norways Air navigation service provider owns 43 airports across Norway. In 2012 Avinor started a large biojet-study and since January 2016 SAF is offer to all airlines on a commercial basis. SAF is dropped into the main fuel farm and distributed in the hydrant and dispenser system. The premium cost is shared between the project partners. Arvid Løken pointed out that with this activity it was and still is demonstrated that everything is working very well. To cope with the related challenges Arvid Løken presented three recommendations based on the experience of Norwegian aviation 1) Installation of an aviation fund to incentivize uptake, 2) clear and harmonized regulations for accounting and reporting practices and 3) the implementation of a collective effort to coordinate activities across the value chain (Aviation 21). Arvid Løken then focused on the different TRL of SAF production pathways and the technologies that have a high implementation potential in Norway. Arvid Løken is part of the ALIGHT sister project TULIPS and leading the Task 5.5 aiming at assessing different models to incentivize SAF usage and demonstrate the effect of a SAF passenger awareness program. He concluded that collaboration is key to achieve climate neutral aviation.

In the Q&A session Arvid Løken answered and discussed the following questions with the audience:

- Do you think there is a mismatch between public perception and actual environmental impact of aviation?

- Uniform rules and regulations are lacking. Could EU wide rules help? How can airlines be supported?
- What happens when different/conflicting accounting systems clash?
- What are the logistical barriers?
- What was the blending ratio of SAF used in Oslo? What was the highest blending ratio?

ALIGHT Airport Survey (Mónica Soria Baledón, IATA)

Mónica Soria Baledón presented the results of the ALIGHT Airport survey that was performed and analysed by IATA in collaboration with TUHH. Scope of the survey was to assess fuel suppliers needs and concerns about SAF integration. The survey comprised 32 questions covering the following themes: handling, safety and quality, accounting and reporting, and general aspects. 54 responses were collected in total, mainly from European airports. Monica Soria Baledón highlighted that airports see their role in the SAF ramp-up as the "enablers", "facilitators", "coordinators" as well as "infrastructure providers" for SAF. She pointed out that despite the drop-in capabilities of SAF, most airports with commingled infrastructure use segregated delivery of SAF due to low demand and to maintain traceability. Airports identified advantages for onsite blending prior to direct uplift. Only few, but still some respondents expressed concerns about the safety of using SAF as replacement for conventional jet fuel. Only 11/54 respondents had handling experience. Accounting and reporting were major concerns for the respondents. As indicated in the survey results, uptake of SAF by airports could be limited by lack of/insecurities in regulations, e.g., "who gets to claim Scope 3 emissions?" is a typical question/barrier. Mónica Soria Baledón concluded her talk by announcing that a similar ALIGHT survey focusing on airlines has be started.

In the Q&A session Mónica Soria Baledón answered and discussed the following questions with the audience:

- Can you comment on why there were little answers from outside Europe, although having experience with SAF, e.g., California?
- Can the results of the survey be shared?
- Is on-site blending at airports allowed by ASTM/DefStan/JIG?
- Can book and claim be a lever?
- How can collaborations between the different stakeholders be facilitated?
- Can the high number of announcements on the first of SAF create the impression that SAF usage is complicated and risky?

FIGURE 7: MÓNICA SORIA BALEDÓN PRESENTED THE ALIGHT AIRPORT SURVEY

Panel discussion

During the panel discussion, the following questions were discussed:

- What should airports focus on (1) in the near term, (2) in the long term to facilitate use of SAF?
- How do see the role of different alternative feedstocks, e.g., algae, what is the most promising?
- How can we foster collaboration?
- How can we overcome challenges that come with accounting and reporting?

The panel and audience concluded that to foster collaboration it is important to clearly identify areas of collaboration vs areas of competition for the different stakeholders. A common conference or approach to share information regarding SAF between the four large projects European projects (ALIGHT, TULIPS, STARGATE and OLGA) would be of high benefit.

4.4 Session 3: SAF Provision & Usage

The third session of the SAF workshop day consisted of 3 presentations by

1. Lars Andersen, SAS gave a speech on "Airline Perspective on Buying and Using SAF"
2. Sven Rieve, air bp, gave a speech on "Sustainable aviation fuel (SAF) supply, today and tomorrow"
3. Peter Laybourn, Brændstoflageret Københavns Lufthavn (BKL), gave a speech on "SAF Supply to the aircraft"

Airline Perspective on Buying and Using SAF (Lars Andersen, SAS)

Lars Andersen started his presentation by highlighting SAS environmental goals and the 2025 roadmap SAS has identified to achieve these goals. CO_2 reduction will be achieved by fleet renewal, use of sustainable aviation fuels and carbon capture technology as well as improved rail connectivity. To secure sufficient volumes and a cost-efficient scaling of SAF a mix of SAF production technologies is required. Lars pointed out that SAS beliefs the Power to Liquid fuels will be key to meet 2030 goals. He showed the SAS partnerships in the field and highlighted the Ørsted project that is being set up to supply Copenhagen Airport with considerable amount of PtL based on the Methanol to Jet process. Alongside the plans and partnership, Lars Andersen expanded on the challenges airlines are facing nowadays negatively impacting SAF demand mainly due to a discordance of a diverse set of goals, proposals and regulations. He concluded the talk by suggesting a SAF Aviation / climate fund instead of individual passenger taxes.

- In the Q&A session Lars Andersen answered and discussed the following questions with the audience:
- Can you explain how public opinion on aviation is starkly different between Denmark, Sweden, and Norway and how this impacts airline business?
- As Scandinavian countries take a lead role in SAF, could standardization bodies in these countries take the initiative and drive the development (e.g., in Europe)?
- What is the status of Methanol-to-Jet approval?

Sustainable aviation fuel (SAF) supply, today and tomorrow (Sven Rieve, AirBP)

Sven Rieve started his presentation by pointing out that the aviation sector is a hard-to-decarbonize sector. The required high energy densities make liquid hydrocarbons an optimal fuel. Sven pointed out the different advantages of SAF, like carbon emissions saving and that when blended with traditional jet fuel it is a drop-in fuel, meaning it is fully compatible with existing infrastructure and aircrafts. SAF is managed according to the same procedures and practices as conventional jet fuel. While a management of change (MOC) process is recommended for the introduction of SAF to any operation, there are no compatibility considerations. Comparing several SAF technology pathways, Sven pointed out that HEFA can be seen as a near term option that uses fungible feedstock, MSW (municipal solid waste) is probably the next step and has near to mid-term potential, first generation ATJ is capital lite and produces SAF from existing ethanol markets and second-generation biomass technologies have long-term, low-cost potential. eSAF potential is increasing due to the pace of renewables and green H_2. Sven Rieve furthermore compared advantages and disadvantages of the three distinct supply methodologies: segregation (physical separation to other jet fuel), mass balance (delivery of product to customer airport, using co-mingled storage at airport or pre-airport pipelines) and book & claim (Most efficient supply chain used. Product does not get delivered to customer location). Sven pointed out that to achieve the SAF goals the virtuous cycle of “Demand certainty” – “Supply Expansion” – “Lower Costs” has to be broken. Sven concluded his talk by bp’s 5As advocacy position for decarbonizing aviation:

- Availability: Multiple SAF pathways are required, and all should be allowed to compete on their own merits within societal preference
- Accessibility: Promote a global market with global logistics movements of SAF to ensure access and affordability
- Accountability: Support feedstocks that avoid the creation of additional demand for food and feed crops and excludes feedstocks with high risk of ILUC
- Affordability: Support economy-wide carbon pricing but recognizes that aviation needs disproportionate price support because cost per ton of carbon abated is higher than other sectors
- Acceleration: Pace of policy and collective action must be prompt in order to deliver the industry ambitions

In the Q&A session Sven Rieve answered and discussed the following questions and comments with the audience:

- Currently fuels supply methods aim at minimizing GHG emissions. Is there an impact of fuel supply methods on the potential to reduce non-CO_2 emissions, where physical qualities of the fuels used matter?
- Comment from the audience: Additionality should be an important principle to avoid displacement effects (one user’s SAF purchase should not increase another’s fossil share because the amount of SAF remains constant)
- Will the European SAF sector develop similar to the North American SAF sector?

FIGURE 8: PRESENTATION BY SVEN RIEVE

SAF Supply to the aircraft (Peter Laybourn, BKL)

Peter Laybourn started his talk by pointing out where SAF currently stands by comparing the global SAF production in 2020 of 190,000 tons, with the fuel consumption at CPH in 2019 of 880.00 tons. At CPH there are 350-450 fuelling operations daily, mainly using the 12 km hydrant system with its 190 fuelling points. Peter Laybourn also explained that as aircraft stands were designed for smaller aircrafts, handling space is limited, and larger aircrafts have to be serviced by mobile pumps from the pipeline network. Peter Laybourn detailed the stringent quality checks that are happening at the airport and that fuel blending is not allowed on site. Concluding his talk, Peter Laybourn shared the BKL perspective on fuel supply methods with mass-balance model dominating in near/mid-term future, by 2050 book & claim may prevail as it saves distribution network. Peter Laybourn sees a segregated infrastructure extremely unlikely as it takes too long to build, would not be meaningful for under 100% SAF scenarios.

In the Q&A session Peter Laybourn answered and discussed the following questions with the audience:

- what about part-segregated infrastructure, e.g., only in some areas?
- What is the difference in supply for a smaller scale airport respect to a large-scale airport?
- Are cost of infrastructure part included in SAF buying schemes?
- What could be some innovative ideas to speed up the SAF supply? It could be administration, digitalization etc.

Panel discussion

As there were intense discussions after each of the talks, there was no time for an extended panel discussion. A discussion between panellists already happened after each presentation.

4.5 Overall conclusion / sum-up day 1

The perspectives presented and discussed on day 1 of the workshop were all a presentation of state-of-the-art (SoA) as seen from the presenters' viewpoint. The first session had a high-level focus on issues around environmental/climate sustainability and deployment of SAF. Session 2 put airports into the center of discussion and compared experiences from first kind use and long-time usage. The third session captured the perspective of an airline, fuel supplier to the airport and at the airport. Due to the wide set of different perspectives, it was not possible to identify one single conclusion. Instead, session-wise conclusions and sum-up will be presented in this section.

Conclusion of the first session was that we are heading into the right direction but implementing climate mitigation effective solutions is challenging. One the one hand it is very important to address the full set of aviation's climate impacts, CO_2 and non-CO_2 climate impacts, with non-CO_2 climate impacts making up to two thirds. On the other hand, methods for the Life Cycle Assessment have to be carefully chosen to ensure that cause-effect relationships are captured (e.g., by consequential LCA) and the resulting knowledge will be used consequently. Both points are essential for ensuring climate mitigation effectiveness, on the other hand it comes with higher implementation costs, potentially adding barriers on initial SAF deployment. On SAF deployment the session clearly showed that beside high ambitions (e.g., SAF mandates), the situation is tricky, SAF shares are below 0.1% and there is a long way to go. Different ideas on how to facilitate SAF deployment (e.g., SAF pool at airport) have been presented and need to be further investigated.

The second session focused on airports and how airports can facilitate the use of SAF. Aeroporti di Roma shared their experiences of a first time of SAF usage at the airport and in Italy in general. As SAF delivery routes can be more diverse and is often handled in a segregated manner, efforts have been spent in creating the supply infrastructure as well as answering request stemming from a not “business as usual” fuel supply. After handling and supplying SAF since 2016 Avinor focus mainly on how to overcome challenges in fuel upscaling and deployment. To cope with the related challenges Avinor recommendations are 1) Installation of an aviation fund to incentivize SAF uptake, 2) clear and harmonized regulations for accounting and reporting practices and 3) the implementation of a collective effort to coordinate activities across the value chain. The results of the ALIGHT airport survey underlined that the situation is perceived very differently, only a minority (11 of 54) airports had practical SAF handling experiences. While the handling itself is not seen critical (drop-in fuel), major concerns are related to accounting and reporting. The panel and audience concluded that to foster collaboration it is important to clearly identify areas of collaboration vs areas of competition for the different stakeholders.

The third session put stakeholders into focus that are directly dealing with SAF: airlines, fuel supplier to the airport and at the airport. Beside SAF availability, the challenges airlines are facing nowadays are mainly due to a discordance of a diverse set of goals, proposals and regulations, that finally impact SAF demand. From the fuel supply perspective three methodologies can be used: segregation, mass balance and book& claim, with pro and cons for each. Discussion at the end of the presentations showed also the link of fuel supply methodology and the possibilities to utilize SAF for improving local air quality and minimizing non-CO_2 impacts. In this regard important insight of the practicalities of SAF supply at the airport have been shared. The importance of using fuel hydrant systems and the costs that would come with changing fuel supply at an airport were pointed out in detail.

5 Workshop findings day 2 – Smart Energy Supply & Use

5.1 Motivation / framing of day 2

Lars Overgaard, DTI, member of ALIGHT

On the second day of the workshop, presentations and discussions were centred around the supply and use of energy in airports. Topics in this part of the workshop were intentionally broad, with the idea of transferring knowledge from related fields to airport operations. Overall, the intention was to facilitate a dialogue between relevant experts and other stakeholders on how to support short term goals of e.g., supporting smart energy supply and use in airports for existing prosumers and consumers and long-term goals to e.g., support electric- and hydrogen aircraft and take benefit from local energy communities. The day 2 workshop "*workstream B - Smart Energy Supply & Use*" consisted of three different sessions:

- Future energy supply and use, 4 speakers
- City/Airport continuity/integration, 3 speakers
- Aircraft stand of the future, 3 speakers

5.2 Session 1: Future energy supply and use

The first session "Future energy supply and use", dealt mainly with specific technologies, which are also highly relevant for the work in ALIGHT focused on smart energy supply and use. Presentations were given on energy control and management, with a focus on buildings, heating, and local heat-/electricity networks and their coupling; smart charging of battery electric vehicles with three case studies from Denmark; energy storage with a focus on battery energy storage systems (BESS), their integration into local grids, and how BESS can be used to use renewable energy more efficiently; and a final presentation on the conversion of diesel-powered ground support equipment to other energy sources, mainly electric. This first session consisted of 4 presentations by:

1. **Prof. Mirko Morini,** University of Parma, speech on "Energy control and management"
2. **Peter Bach Andersen**, Technical University of Denmark, speech on "Intelligent charging"
3. **Kjeld Nørregaard**, Danish Technological Institute, speech on "Utilization of energy storage"
4. **François Peeters**, TCR Italia, speech on "Greening of GSE"

Energy control and management (Prof. Mirko Morini, University of Parma)

Main topics of the presentation were the growing interdependence of electricity and heating networks, how both can be controlled at different scales, i.e., from single building to cities, and how model predictive controls can be employed to increase energy efficiency. Three case studies were presented.

Heat makes up 50% of energy use, compared to 30% for transport and 20% electricity, but the relevance of heat in energy systems is often underestimated. In buildings, electricity and heat demands have usually been fulfilled separately with a linear supply chain. An exception is co-generation, but here the system is normally either led by electricity or warming demands – and therefore 'belongs' to that domain. We are now facing a transition to electricity as a primary energy input for buildings. This sector integration increases complexity and traditional management systems may fail.

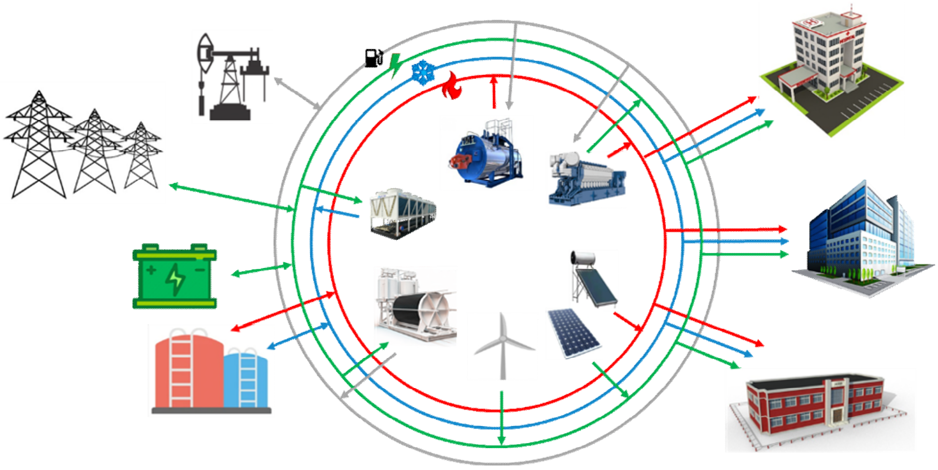


FIGURE 9: INTEGRATION OF CONSUMERS AND PRODUCERS AT DIFFERENT SCALES (SOURCE: M. MORINI, UNIPR)

Heating (and cooling) distribution systems work at different scales – from cities to districts (e.g., an airport) to individual buildings (Figure 9). It is common to control energy systems with operator experience and day-ahead scheduling. But with increasingly extreme weather conditions, predictive control strategies are necessary.

A model predictive control (MPC) uses a model to predict the future behaviour of the system and calculates the control sequence through an optimization algorithm (Figure 10). The model takes the current state and a forecasted disturbance as input, suggests a control strategy, and is constantly re-run with an updated current state. The success of this strategy relies on the quality of the forecast of the disturbances on one side and of the model on the other side. The model must be as light as possible, so it can be called many times by the optimization algorithm. A building can be represented with a simple thermal balance considering heating, dispersion through walls, and natural and forced ventilation.

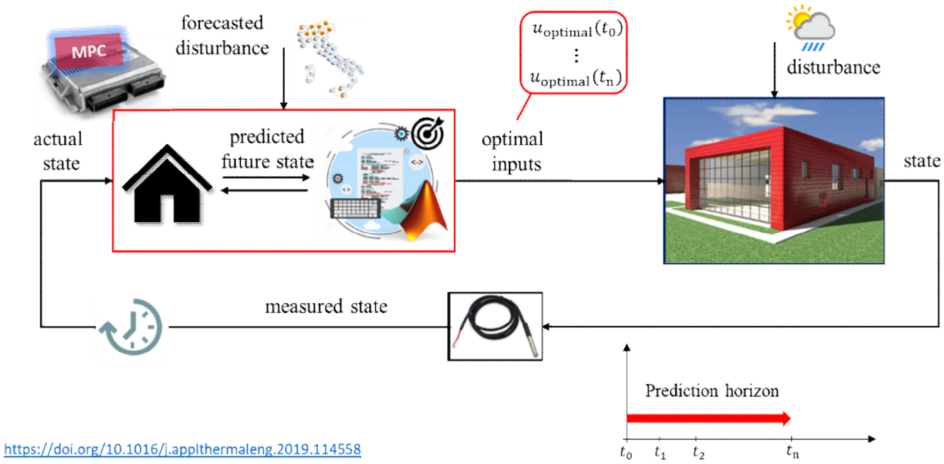


FIGURE 10: CONCEPT OF A MODEL PREDICTIVE CONTROL (SOURCE: M. MORINI, UNIPR)

Some case studies were highlighted:

- At a school complex in Podenzano, Italy, application of a MPC to the heat distribution system led to an average reduction of 13% in energy consumption (Figure 11).
- At part of the University of Parma complex, application of the system led to 34% energy consumption reduction. This system was later turned into a commercial product.

- At the hospital in Cona, Italy, a hierarchical structure is employed: distribution-MPCs manage individual branches, while a supervisory-MPC operates on a double timescale and defines the optimal management of the production plant.

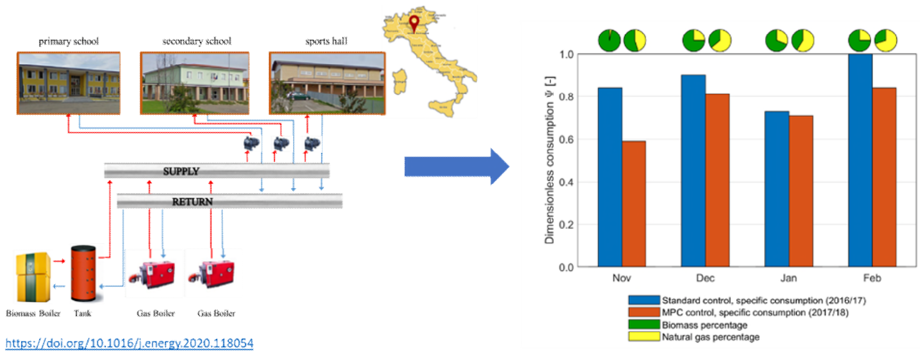


FIGURE 11: OPTIMIZATION BASED ON MPC IN PODENZANO (SOURCE: M. MORINI, UNIPR)

This kind of control allows energy savings, but also enables the use of the buildings as energy storages for peak shaving and load shifting. This gives demand flexibility for managing recovered heat, for example that wasted by data centers or electrofuel production. Smart management allows the achievement of energy goals even without significant changes in the hardware. It can help with:

- Energy saving
- Flexibility
- Integration of renewables
- Waste heat recovery
- Sustainable cities, districts, and buildings

Intelligent charging (Peter Bach Andersen, Technical University of Denmark)

The presentation dealt with aspects of optimized charging strategies for electric vehicles, as well as the potential of vehicle-to-grid-charging technologies. This was illustrated by three case studies carried out in Denmark.

Electrifying all private cars in Denmark would lead to a 25% electricity consumption (assuming 2.7 million vehicles driving 45 km per day on average). The power demand if all these electric vehicles (EVs) were to charge at the same time will even increase by 600% (=30 GW) from the grid. If electrifying large vehicle fleets is to be technically and economically feasible, intelligent management of charging is necessary. Furthermore, by integrating vehicle and grid, the EV battery can serve additional purposes.

Vehicle–grid integration has potential benefits for the owner:

- Practical: New possibilities and features
- Economic: saving or even earning money
- Convictions: sustainability and independence

On the grid side, benefits can arise at different scales:

- Buildings: EVs may support energy optimized buildings with local production

- Neighbourhoods/districts: EVs can be buffers and storages for local distribution grids and new urban energy infrastructures and communities.
- Regions: EVs may contribute to balanced and economical power systems based on renewable energy.

For this approach to work, smart chargers are needed: standardized, secure, and open communication protocols; dynamic charging limits that are fast and accurate; as well as good data – stored locally and with a high resolution (Figure 12).

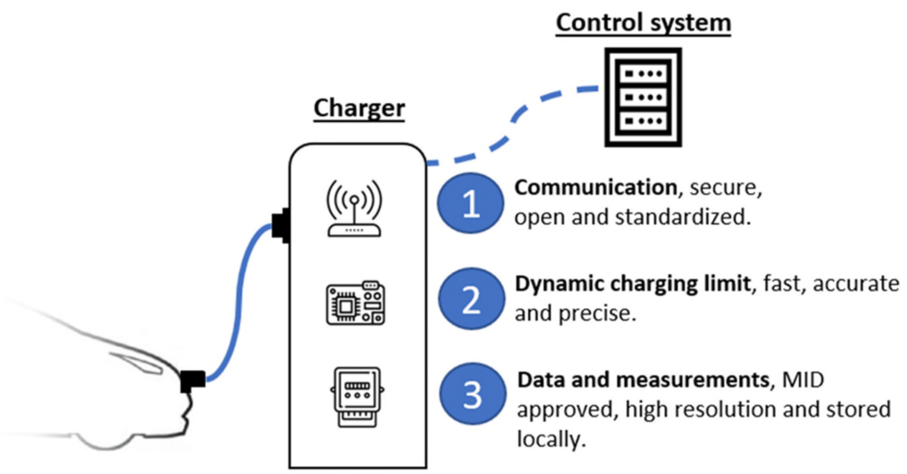


FIGURE 12: OPTIMIZING EV-CHARGING (SOURCE: P.B. ANDERSEN, DTU)

Three case studies were presented:

- Case 1 (Frederiksberg Forsyning): ten Nissan electric vans were used for frequency regulation when parked outside working hours (Figure 13). Ten bi-directional chargers with 10 kW were used, based on the CHAdeMO-standard. Charging and discharging could alternate several times within a 10-minute-timeframe. FRC-N revenue (2016–2018) was calculated to an average 1860 EUR per car and year. Battery degradation was modest, with 5% of State-of-health (SOH) loss over the 5-year test period attributed to vehicle to grid (V2G) services (the rest is normal ageing).

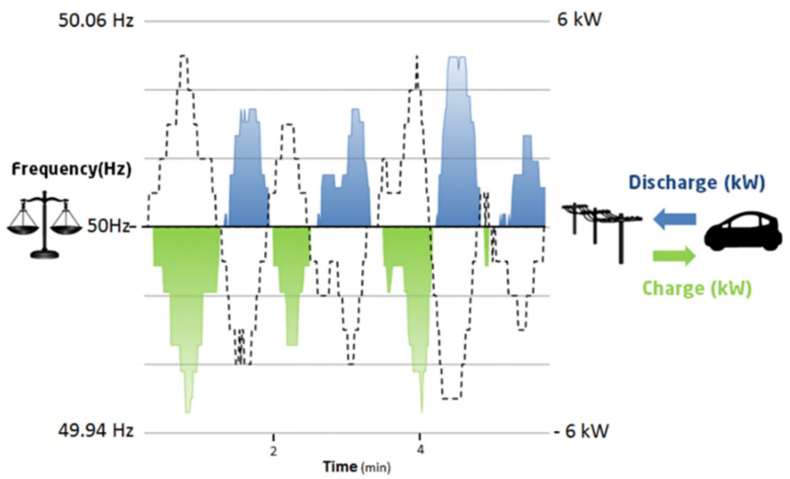


FIGURE 13: FREQUENCY REGULATION WITH EV-BATTERIES (SOURCE: P.B. ANDERSEN, DTU)

- Case 2 (DTU Lyngby): dynamic load sharing was tested with ten 22-kW-outlets. The objective was to test balancing charging under limited grid connections for large charging stations. Methods used included load scheduling and load modulating. The premise is that parking, i.e., the time the vehicles are idle and connected to a charger, is predictable.
- Case 3 (Frederiksberg): An ongoing project investigates the needs for public chargers in densely populated urban spaces. Chargers are to be placed and dimensioned to be cost efficient, while maximizing utilization and user convenience (Figure 14).

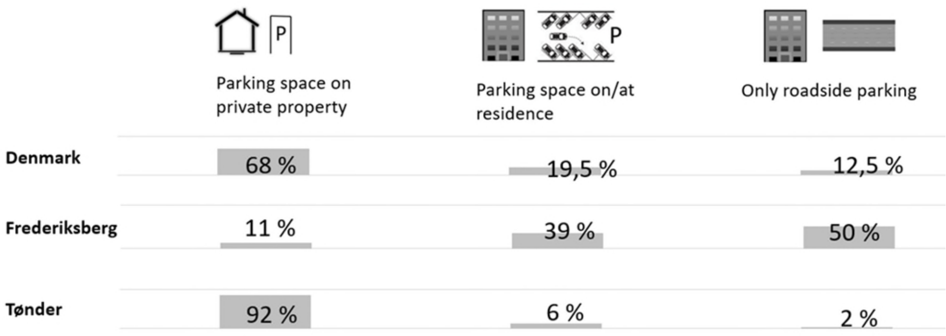


FIGURE 14: PARKING SPACE AND LOCATIONS FOR EV-CHARGERS (SOURCE: P.B. ANDERSEN, DTU)

The following discussion revolved around the question of warranty in case of battery degradation. While degradation was low in the case study, this creates a lot of legal and formal issues. As it is unclear who will carry the responsibility for premature degradation and/or damage of the battery, EV-manufacturers do not “push” V2G technology. It was commented that battery swapping may solve some of these issues. As the battery is not owned by the user, the OEM does not need to give extended warranty. This could allow for a better use and availability of batteries for grid services, etc.

Utilization of energy storage (Kjeld Nørregaard, Danish Technological Institute)

The presentation gave a brief introduction to battery energy storage systems (BESS), explained how BESS fit in with the ALIGHT project, and outlined possible additional uses of BESS at airports.

The purpose of a Battery Energy Storage System (BESS) in integration with the electrical installation of e.g., an airport, is to act as an energy buffer that can support self-consumption from renewable energy sources (Figure 15). As an example from the Horizon 2020 project “SMILE”, self-consumption at Ballen Marina, Denmark, was raised around 20 to 30 percent-point. BESS can also act as energy-reserves and power-buffers for the grid that can react within seconds. These purposes of BESS can optimize the economy of investment, use of renewable energy, and optimize the share of carbon neutral electricity used in point-of-connection.

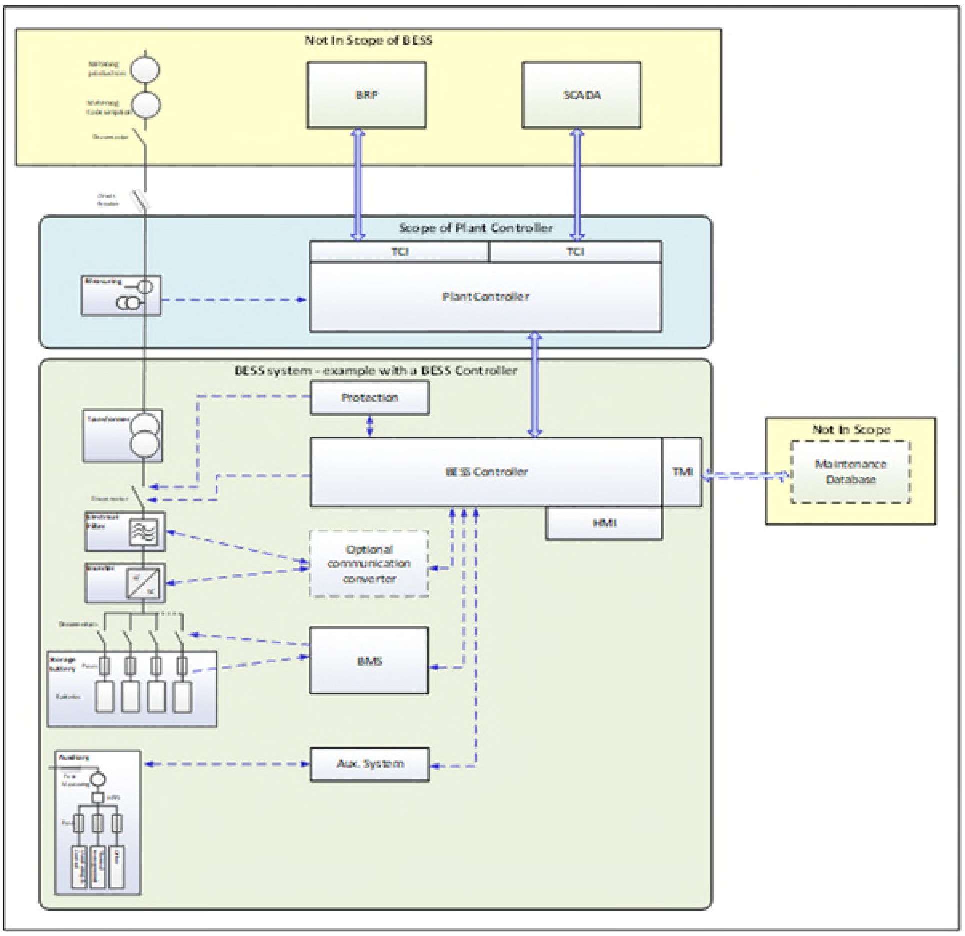


FIGURE 15: SYSTEM BOUNDARIES FOR BESS AND GRID INTEGRATION (SOURCE: K. NØRREGAARD, DTI)

For energy management, it will always be highly relevant to know how much power and capacity is available at a certain time from the energy storage system as the key parameters. Other parameters include: temperature within BESS, peak power, BESS degradation, round trip efficiency, charge/discharge from grid, forecast from multiple sources (e.g., weather, electricity consumption, price, CO_2-intensity of electricity).

In the ALIGHT project, the Smart Energy Management System for the pilot site developed by Hybrid Greentech is tested and optimized in the EnergyFlexLab facility at the Danish Technological Institute, where real energy components can be connected to emulate relevant grid scenarios in a safe, 'sandbox' testing environment. The purpose is to test and optimize the energy management system to provide simultaneous and/or prioritized smart control of frequency services, CO_2-arbitrage, EV-charge and heat pumps using as much renewable energy as possible.

A tender-process was ongoing at the time of speaking for a 1MW/1MWh BESS system for the ALIGHT pilot site in CPH. It will act as an energy- and power buffer for renewable energy and new EV-fast chargers in the area. It is not intended for emergency backup in this project, but BESS with added uninterruptable power supply (UPS) priority could be of future interest for airports, e.g., in replacement of runway signal genset UPS systems. It is assumed that a target price for BESS in the MW class is 667€/kWh with an expected lifetime cycled energy of 6.65GWh at end-of-life (EOL) criteria of 70%. That gives a target cost per cycled kWh of circa 0.147€/kWh including efficiency. Bloomberg observations on battery prices states an 18% learning rate – 18% drop in price when production is doubled. Therefore, it is foreseen that BESS capacity will grow rapidly within the next years.

The following discussion was about how to benefit from both low prices and low CO_2-intensity when charging from grid. There is not a direct coupling between the two parameters, and although airports would like to react on the CO_2-intensity to ensure the lowest carbon footprint they admit that prices still is of huge importance today.

Greening of GSE (François Peeters, TCR)

The presentation outlined how ground support equipment (GSE) can support environmental goals, both through improvements in fleet management and use, as well as through upgraded vehicle technology. Potentials and challenges of electric GSE were especially highlighted.

Ground support equipment (GSE) covers a wide range of vehicles and devices (Figure 16). TCR operates 1400 different types of GSE from 250 brands (corresponding to more than 35,000 units). To optimize GSE operation and reduce the carbon footprint, TCR advocates a three-tiered approach:

1. Optimizing the use of existing GSE
2. Optimizing the fleet size
3. Exchanging GSE with more innovative, environmentally friendly technology (mainly electric)

The electric GSE operating on airports today are mainly small units, such as baggage tactors and belt loaders, which use lead-acid batteries. Charging is based on simple protocols, and there is practically no standardization. The challenge for greening GSE is to implement "smart charging" at scale, as well as to convert the heavy-duty machinery to net-zero or electric units.

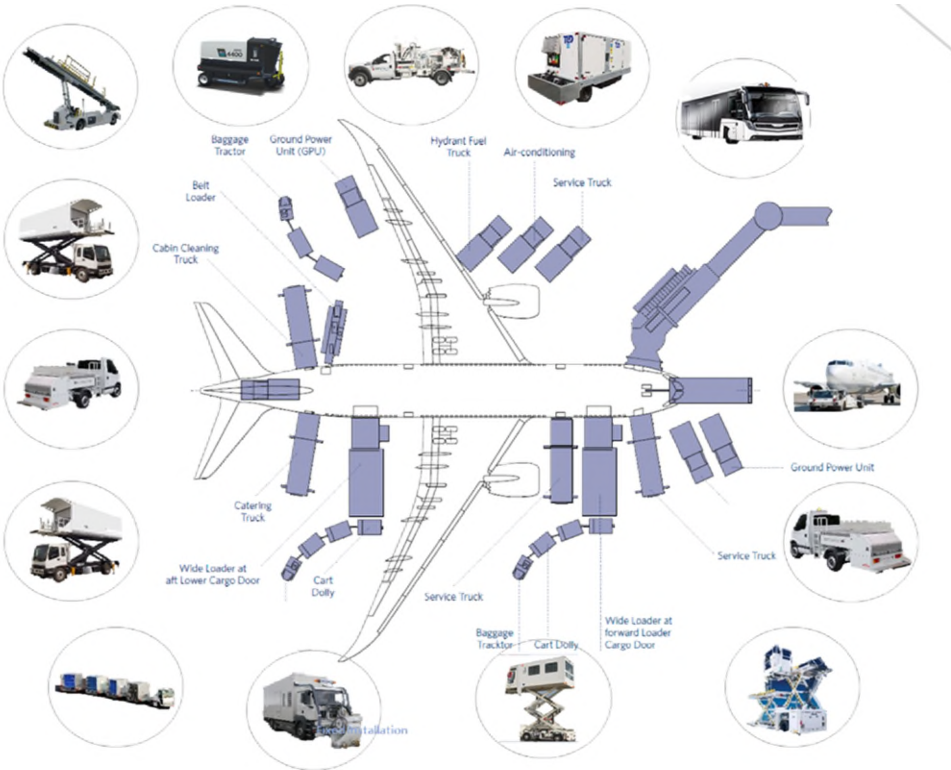


FIGURE 16: GROUND SUPPORT EQUIPMENT (GSE) SUPPLIED BY TCR (SOURCE: F. PEETERS, TCR)

Designing of net-zero and electric GSE requires to make assumptions on the future airport layout and operation. Currently, net-zero and electric GSE (other than the above-mentioned small tractors and belt loaders) are only available as prototypes. At the same time, GSE has little or no margin of error, and GSE operation must not cause any delay to air traffic (with the imperative "The airplane must start on time").

Today, electric GSE is significantly more expensive, with a 50–100% premium on the price of a conventional, diesel-powered unit. Prices for diesel and electric GSE will likely first align within 5–10 years. Moreover, electrification requires reliable and scalable energy supply and charging infrastructure. It will also change energy flows within the airport, which in turn requires new energy management strategies. Charging of electric vehicles at an airport cannot be on-demand but will require coordination. Constraints are both internal, e.g., availability management, as well as external, e.g., grid prices. Energy management for GSE will be highly data-driven, so telematics and digitalization are seen as key.

Knowledge about use patterns of GSE is important in optimization – another argument for a more data-driven approach to GSE-management. The CO_2-footprint of GSE-types varies from airport to airport, depending on the airport layout as well as the local procedures and guidelines of the handler. Most equipment is idle 50–90% of the time – again, this varies from airport to airport.

5.3 Session 2: City/Airport continuity/integration

The second session "Airport/city integration" was concerned with how airports integrate into and interact with the municipality they are located in. One presentation from the City of Copenhagen described the catchment traffic an airport generates, and how this integrates with the rest of the city. From the perspective of both environment and congestion management, the use of public transportation combined with 'muscle power' (especially biking) is attractive. A presentation from Airport Regions Council elaborated how cooperation can be formalized through energy communities. Finally, a presentation from Vantaa, Finland, showed how an airport can be an anchor point for new municipal development in the shape of a new city quarter 'Aviapolis'. This second session consisted of 3 presentations by

1. **Caroline Schousboe,** Region Hovedstaden, speech on "The integration of CPH in the smart city of Copenhagen"
2. **Sergi Alegre**, Airport Regions Council, speech on "The relevance of energy communities"
3. **Arja Lukin**, City of Vantaa, speech on "Challenges faced by (new) airports"

The integration of CPH in the smart city of Copenhagen (Caroline Schousboe, Region Hovedstaden)

One of the activities of the Capital Region of Denmark (Region Hovedstaden) is to plan and develop traffic in the region. It also part-owns the public traffic authority Movia, which is responsible for local trains and busses in the region. The Capital Region's forecasts predict a rise in daily trips of 20% from 2015 to 2035 over all transportation modes. Forecasters also expect that Copenhagen Airport (CPH) will be one of the largest transportation hubs in the region by 2036.

Car traffic in the region is one of the most intensive in Denmark, and pressure on the road network is expected to increase. The Capital Region is therefore exploring actions that will encourage people to shift from private cars to public transport. This alone will however not solve all traffic problems. Given the layout of the present road and (especially) rail network, central Copenhagen is a bottleneck for transport in the area (Figure 17). An example is that long-distance trains from other parts of the country to CPH Airport are directed through Copenhagen Central Station. A new transport hub outside of the center with a direct railway to the airport and onwards to Sweden could reduce travel time. It would also free capacity at Copenhagen Central Station by reducing the number of transit passengers. Establishment of park-and-ride opportunities in the region could also provide benefits, and the region reaches out to other actors on how to promote the use of park-and-ride in the Øresund area of eastern Denmark and southern Sweden.

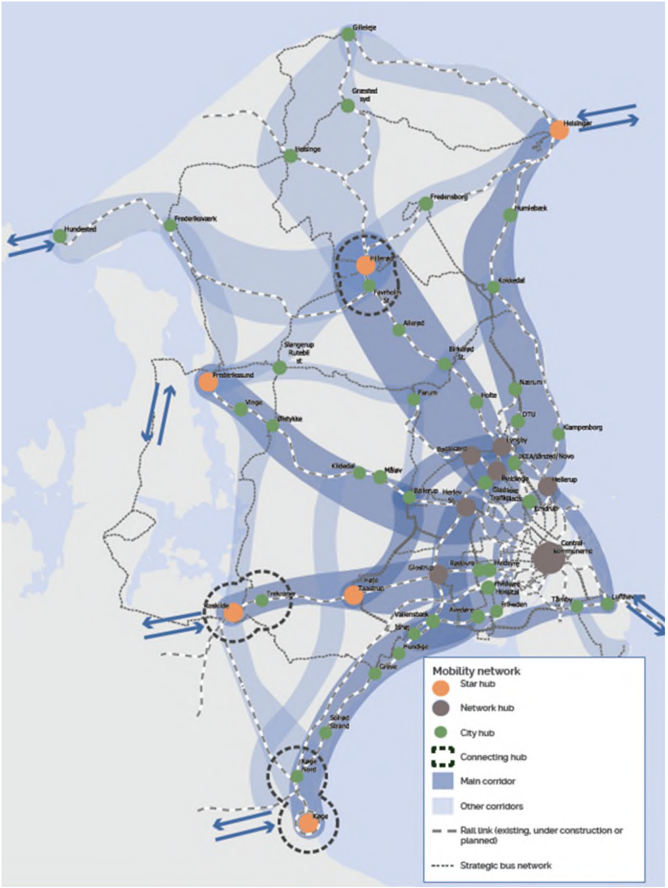


FIGURE 17: TRANSPORT CORRIDORS AND HUBS IN THE COPENHAGEN AREA (SOURCE: C. SCHOUSBOE, REGION H)

Given that many trips within the city are short, cycling also has the potential to reduce traffic congestion. So-called cycle superhighways (under the name of "Cykelsuperstier") have been highly successful in the greater Copenhagen area (Figure 18). Used for an average single trip length of 11 km, the network has seen a 23% increase in cyclists, where 14% of new cyclists are former car drivers. The capital region encourages CPH airport to work more with facilities and nudging strategies for both employees and customers in the transition to either public transport or bicycles.

FIGURE 18: "CYCLE SUPERHIGHWAYS" IN THE COPENHAGEN AREA (SOURCE: C. SCHOUSBOE, REGION H)

In summary, examples of efficient use of the transport system are:

- Increased use of public transport
- Increased use of bicycles – alone and in combination with public transport
- Intelligent traffic systems and mobility as a service (MaaS)
- Less car use in peak hours
- Ridesharing

Discussion followed on the currently poor coupling between bike and public transport in the capital area with missing bike parking at stations. The region would like to make bike parking more accessible. Another input from audience was a discussion about the taxi-strategy at CPH, where spots are reserved for green taxis. Taxi companies expect 100% EV taxis in 2025 due to nudging strategies.

The relevance of energy communities (Sergi Alegre, Airport Regions Council)

Airport Regions Council (ARC) is an organization for inter-regional cooperation, EU representation, knowledge exchange and a partner for European projects. The presentation was focused on energy communities as an essential part of the transition towards a carbon neutral energy system in and around airports with the quote in mind; "If you want to go fast, go alone – if you want to go far, go together".

Renewable Energy Communities (REC) are legal entities based on open and voluntary participation from different stakeholders (persons, SMEs or local authorities) whose primary purpose is to provide environmental, economic, or social benefits to its partners and members.

Regional and local authorities are large players that can promote and establish energy communities. Regions are also direct or indirect operators of public transport, and often are part of the airport board or owners. In a renewable energy scenario (almost) everyone can be an energy producer. Not all actors are aware of this.

Present EU legislation in the field:

- Directive (UE) 2018/2001 – Regarding the promotion of the use of EERR
- Directive (UE) 2019/944 – Concerning the common rules for the internal electricity markets

Future legislation should shield a stable and favourable regulatory framework for the creation of RECs, where the REC has the right to produce, consume, store, and sell energy with access to distribution networks under fair conditions. There should be a possibility of sharing energy within the community and establish internal energy markets on an open and voluntary participation.

Airports are areas with a huge energy consumption 24/7/365 within buildings and different transport modes at airside and landside. There are different energy demands within different areas; Today petrol, kerosene, electricity and in the future electricity, SAF, hydrogen, geothermic and others. An example of REC in relation to airport is seen at Gran Canarias airport.

FIGURE 19: PRESENTATION BY SERGI ALEGRE, ARC

Challenges faced by (new) airports (Arja Lukin, City of Vantaa)

The City of Vantaa is the most international and fastest-growing city in Finland. In 2021, it was awarded the title of “European Rising Innovative City” by the European Innovation Council. Vantaa is also the location of Helsinki’s main airport (ICAO code: HEL). The layout of the airport’s runways results in a noise-free pocket close to the terminal building. This neighbourhood is currently a logistics-focused industrial area but will be transformed into a high-density urban area under the name of Aviapolis (Figure 20). Together with the airport, Aviapolis will serve as a transportation hub between Europe, Asia, and Russia. The aim is to build a diverse hotspot for people, services and enterprises surrounded closely with nature and colourful residential areas next to Helsinki-Vantaa Airport. Easy access by car, train, and plane to Aviapolis is key feature with only 30 minutes by ring rail to Helsinki center, 15 minutes by car to the harbour and 3 hours and 40 minutes by train to St. Petersburg, Russia. Aviapolis today already accounts for 4% of Finland’s GDP from around 2000 businesses located in the area.

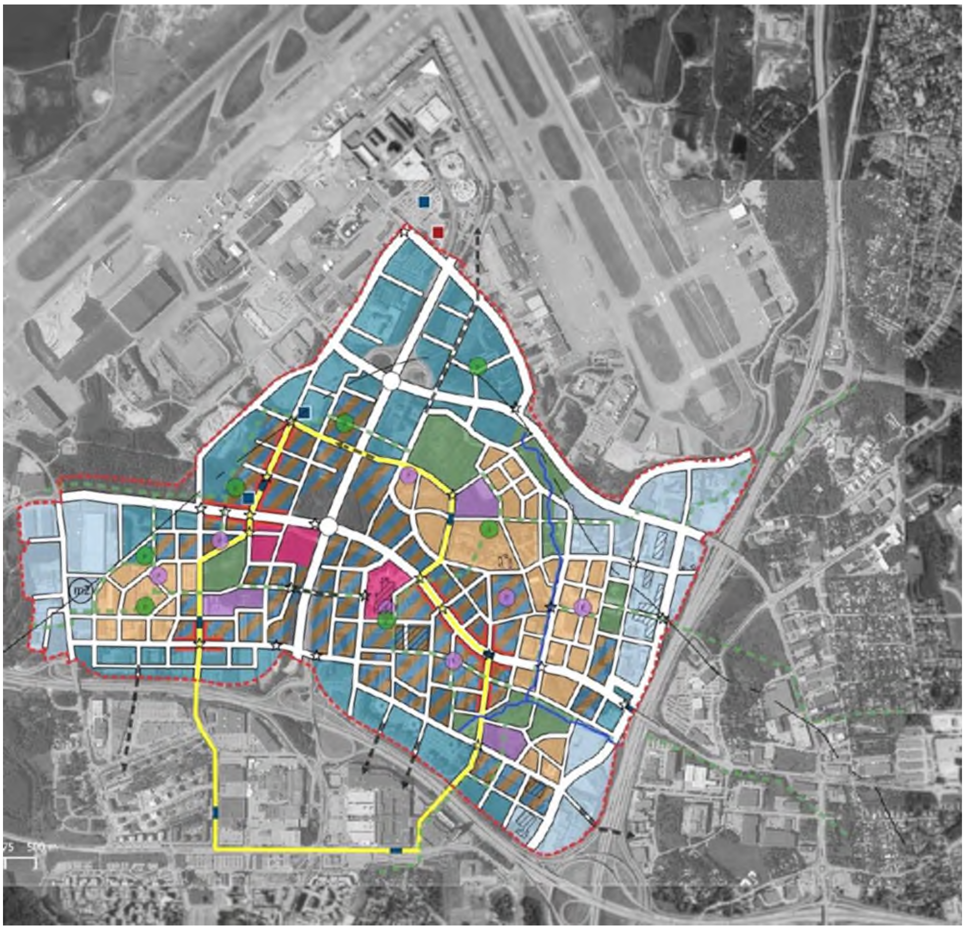


FIGURE 20: LAYOUT OF THE AVIAPOLIS AREA AROUND HELSINKI AIRPORT (SOURCE: A. LUKIN, CITY OF VANTAA)

Mega-trends and key-elements of Aviapolis by 2022-2050:

- Climate change
    - Carbon neutral Vantaa city 2030
    - Carbon neutral Avia Network 2030
    - Finavia carbon neutral at Helsinki-Vantaa 2017 and net zero carbon emissions at all its airports in 2030 at the latest.
    - Finnair to cut half of its net emissions 2025 and to be carbon neutral 2045 at the latest
    - Vantaa Road Map to Resource Wisdom: no emissions, no waste, no overconsumption
    - Stormwater management
- Increasing biodiversity
    - Max 300 meters to nearest green area
    - Experience center in the area of Backas with cultural-historical and nature values with possibilities of events and concerts.
- Globalization
    - 30 million flight passengers 2030
    - Aviapolis would develop as one of the most important train stations in Finland with new Airport Rail 2030's.
- Urbanization
    - 50,000 residents in 2050
    - 70,000 workplaces in 2050

  - Diverse, compact and walkable city of urban blocks with art, street lighting, attractive and functional public areas and rooftops.
  - Parks, greenways, bike lanes and recreation trails.
- Diversification of population:
  - Only 28% of Vantaa's residents are born in Vantaa. People of all ages and backgrounds, mainly from other parts of Finland and abroad, move to Vantaa.
  - Housing options from top-end apartments to affordable housing.
- Technology embedded in everything

To facilitate Aviapolis plans, a cooperation forum was established with more than 30 actors interested in the development of Helsinki-Vantaa airport area. Coordination between different stakeholders is handled by making small detail plans with each company and stakeholder, but within the overall infrastructure made from Aviapolis. The focus points are:
1. Experience – more than just an airport,
2. Sustainable growth – carbon-free and ecological,
3. Accessibility with clever transport solutions.

A green deal manifest from 2021 commits to attain carbon neutrality.

5.4 Session 3: Aircraft stand of the future

The third and final session of day two was more aeronautics-focused again, binding ALIGHT workstreams A (SAF) and B (Smart energy supply & use) together. In this session, titled "Aircraft stand of the future", it was discussed how advances in aircraft technology would affect ground operations as well as energy supply to the airport. Safety, flexibility, and short turnaround times of aircraft were recurring themes in this session. A presentation from Copenhagen Airport dealt with a plan to upgrade its aircraft stands, while at the same time increasing the airport's capacity within its present boundaries. Swedavia related some of their plans to introduce electric aviation to the airports they manage. It became clear that introducing a second propulsion type (electricity) alongside conventional jet fuel has the potential to fundamentally alter the layout of an airport and also how an airport is used by different passengers. Airbus presented its concept study of the ZEROe hydrogen aircraft family and shared some insights on future refuelling systems. All three presentations emphasized that aircraft and the aircraft stand (and the entire airport) cannot be developed separately from each other: Aircraft need to fit in with existing infrastructure to have a chance on the market, while any development in airport infrastructure needs to anticipate technology trends in aircraft. This third session consisted of 3 presentations by

1. **Morten Holstein Elsmark**, Copenhagen Airports, speech on "State of the art and the development effort behind"
2. **John Nilsson**, Swedavia, speech on "ePlane charging systems"
3. **Nicolas Landrin**, Airbus, speech on "Hydrogen fuelling infrastructure and safety"

State of the art and the development effort behind (Morten Holstein Elsmark, Copenhagen Airports)

The presentation gave an overview of planned and ongoing developments for future aircraft stands at Copenhagen Airport against a backdrop of developing the airport as a whole.

The development of Copenhagen Airport follows seven guiding principles:

1. Development occurs in phases and in line with increasing demand
2. Development takes place within the airport's existing area
3. Terminal areas are cohesive and connected to public transport
4. The airport is efficient and competitive
5. Increasing demand is handled within the airport's existing noise limits
6. The airport is emission-free by 2030 and air traffic is emission-free by 2050
7. The development process involves passengers, airlines, neighbours, and other stakeholders.

Development is necessary to accommodate increasing passenger numbers as well as longer and wider new aircraft. In addition, minimizing turnaround time is central to cost-efficient airport operation. More space for future aircraft stands can provide the flexibility for larger aircraft and more efficient airport operations. Currently, plans consider larger aircraft and new types of aviation fuels, while it is expected that future aircraft will have conventional fuselage-wing designs. In addition, ground support equipment (GSE) is also expected to change within the coming years. One of the drivers here is an anticipated switch from diesel-powered to electric GSE. Space for e.g., charging infrastructure will also need to be found on the apron area (Figure 21).

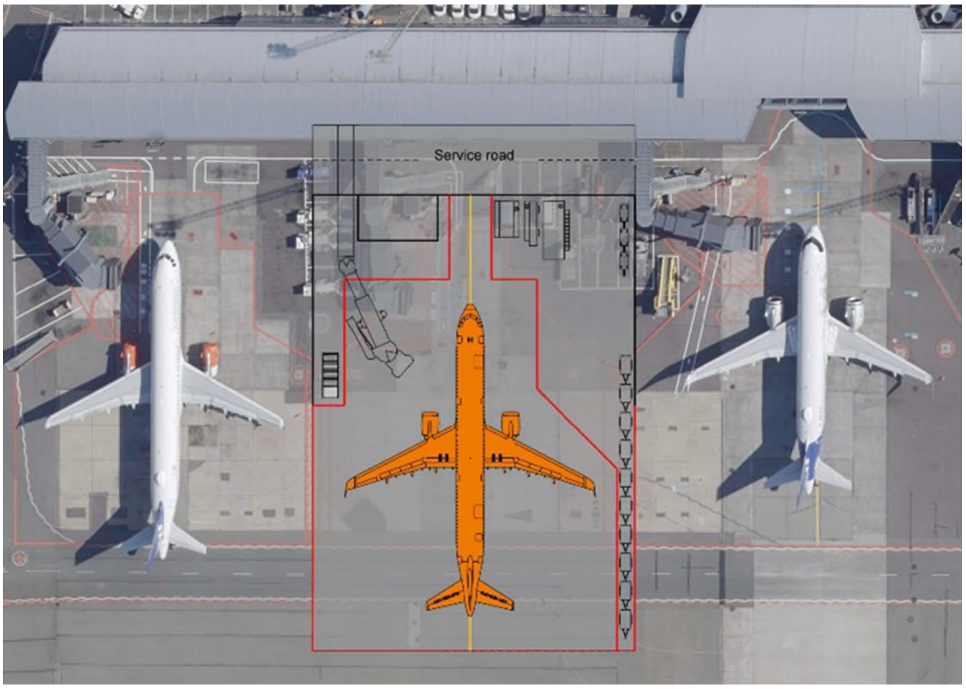


FIGURE 21: AIRCRAFT STAND LAYOUT (SOURCE: M.H. ELSMARK, CPH)

Designing the future aircraft stand is made particularly challenging by the area constraints of the airport as a whole. Historically, the airport has been developed from the Terminal 2 building. Piers A, B, and C as well as the terminal itself are originally from the 1960s. There have been several modernizations and additions between 1986 and 2020. Future development in line with the guiding principles will require to move some of the existing hangars and to enlarge the passenger traffic apron. Most importantly, it will require to shorten and move the existing crosswind runway, for which political support is necessary (Figure 22).

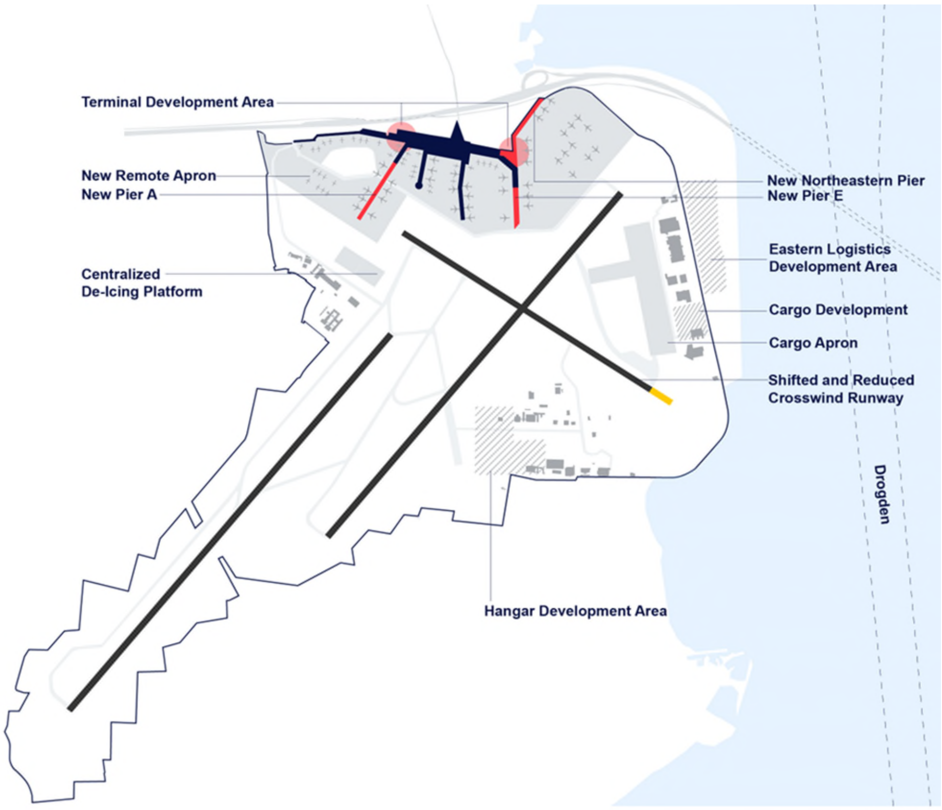


FIGURE 22: CURRENT LAYOUT AND DEVELOPMENT PLANS FOR CPH (SOURCE: M.H. ELSMARK, CPH)

According to the current master plan at CPH, 60% of the aircraft stands will have the newer, larger, and more flexible configuration. Different technologies for aircraft propulsion are currently under development, e.g., hydrogen fueled turbines and electric aircraft. Infrastructure for refueling and recharging will be installed gradually as demand from the airline's increases. Concepts for the future aircraft stand will include safety and infrastructure requirements for these fuels, as well as solutions for automized and autonomous ground operations.

ePlane charging systems (John Nilsson, Swedavia)

The focus of this presentation was how upcoming electric aircraft and their supporting infrastructure could be integrated into airports.

The future demand for aircraft stands for electric aircraft is based on many different factors. Predicting the traffic structure, and thus the peak demand for charging, is based on observing trends in four connected fields (Figure 23):

1. Business models for electric aircraft (also in relation to other transport modes)
2. Production of aircraft, establishment of routes and infrastructure, and the role of intermodal connections
3. The regulatory framework: both current and upcoming regulations
4. Technological advancements, e.g., increasing battery energy density and lower production costs

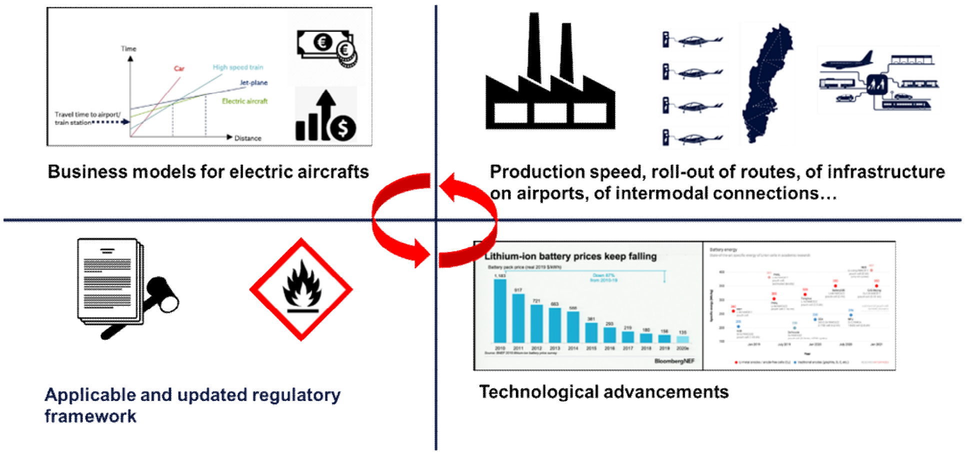


FIGURE 23: CONSIDERATIONS FOR INTEGRATING EPLANES (SOURCE: J. NILSSON, SWEDAVIA)

Planning of the actual aircraft stand also requires taking several considerations into account. The electric infrastructure, both inside the airport and the connection to the grid, must be able to handle peak demand. Long turnaround times are costly, therefore charging electric aircraft should occur as fast as possible. Based on current estimates, between 1.4 and 3 MW could be necessary to charge a smaller passenger aircraft. A future 50-seat aircraft could easily have 5 MWh battery capacity, where 8 MW charging appears as a more realistic power demand. Airport-based energy storage (batteries) can reduce pressure on the grid resulting from several aircraft charging simultaneously. Battery capacity onboard the aircraft may also offer some flexibility. The state of charge could be adapted to the length of the flight, shifting charging time and location to ensure a better load balance. Passenger preferences may also play a role. In Sweden, small domestic flights have opened for “ultra” fast lanes, where passengers can save time for security checks. Long charging times would cancel this advantage in a travel form where electric aircraft otherwise could gain a competitive edge.

Safety considerations present another range of questions to be answered, among them:

- Can battery charging and fuelling planes coexist side by side?
- Can passengers and crew remain onboard while charging?
- What kind of maximum EMI will be tolerated?
- How will power cables be handled, can they lie on the ground?
- Overheating at loading:
  - Monitor heating levels within new equipment?
  - Ground handling, need for new routines for handling overheating?
- New updated changes in knowledge and equipment within the fire force
- What kind of specific training must the fire force undertake?

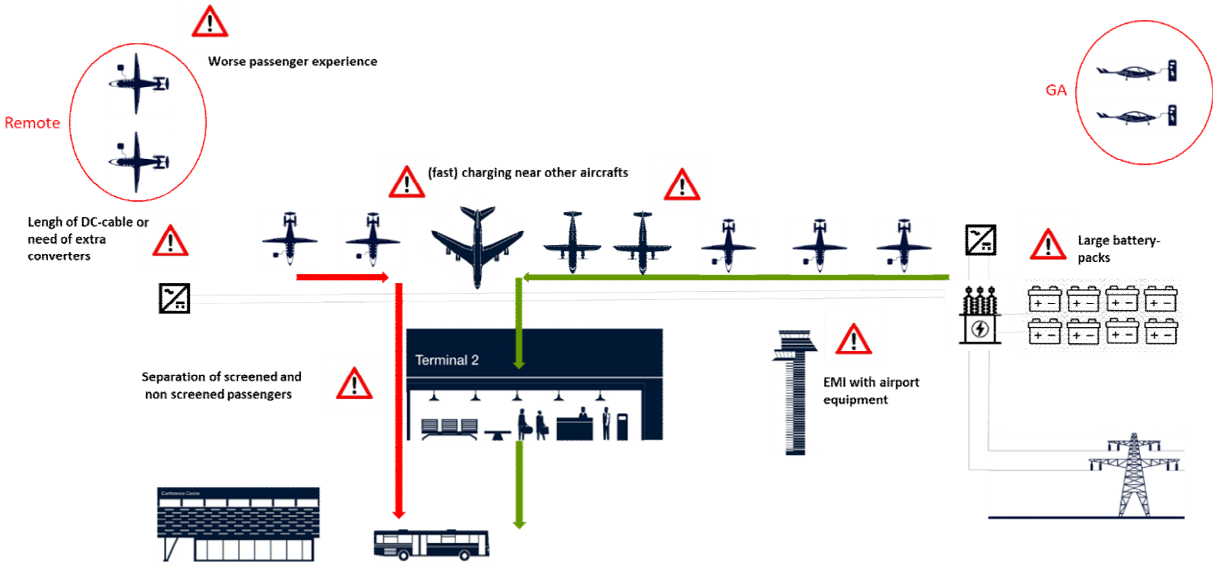


FIGURE 24: INTEGRATING EPLANES INTO EXISTING AIRPORTS (SOURCE: J. NILSSON, SWEDAVIA)

An example layout of a future airport with both conventional and electric aircraft was also discussed, and the pros and cons of different alternatives highlighted (Figure 24). Among them were trade-offs between passenger experience and fire safety from physically separating electric and conventional aircraft, length of DC cables or need for additional converters for different placement of batteries, as well as the total separation of short-range domestic flights from other (regional, continental, and transcontinental) flights.

Hydrogen fuelling infrastructure and safety (Nicolas Landrin, Airbus)

The presentation briefly outlined Airbus' "ZEROe" family of proposed hydrogen-powered aircraft (Figure 25). The series includes a medium-range turboprop airliner for up to 100 passengers and a range of 1000 nautical miles (NM), as well as a conventional wing-and-fuselage airliner and a blended-wing aircraft, each designed for up to 200 passengers and a range of 2000 NM. In all designs, the engines are a hybrid of a hydrogen-fueled gas turbine and an electric motor (driven with electricity produced from a fuel cell using hydrogen). Liquid hydrogen has a much lower volumetric energy density than conventional jet fuel. Therefore, additional space for fuel tanks is required compared to the aircraft in service today. Several placements were considered, among them podded tanks under the wings, dorsal tanks on top of the fuselage, and tanks towards the rear of the fuselage. All options have specific disadvantages – podded tanks are prone to collision errors on the ground, dorsal tanks are difficult to access for maintenance and their elongated form is structurally challenging, and caudal tanks have an unfavorable center of gravity. Ultimately, positioning the tanks in the fuselage behind the rear pressure bulkhead is the preferred option considering security and aircraft structure.

FIGURE 25: AIRBUS ZEROE CONCEPT AIRCRAFT (SOURCE: N. LANDRIN, AIRBUS)

Airport compatibility and ease of ground operations are considered as entry requirements for any new aircraft design. The turboprop design concept therefore has dimensions comparable to today's aircraft, as well as having a standard layout of access ports and panels. Refueling is to take place from the rear of the aircraft, as not to interfere with passenger access, cargo loading, water supply, catering, and other services. It also leaves evacuation pathways clear in case of an emergency.

For refueling, two concepts are presented. In a scenario with few hydrogen-fueled aircraft and/or little traffic, hydrogen production is off site. Tank trucks serve both as fuel transportation and fuel storage, i.e., no local storage facilities are needed. Liquid hydrogen trucks return to a filling station once empty. This solution is simple and requires little investment in infrastructure but has a limited capacity. As traffic and demand for hydrogen increase, a local liquefaction facility can be set up, which is supplied with gaseous hydrogen via a pipeline. Trucks are then used for transporting the fuel from the liquefaction facility to the aircraft.

5.5 Overall conclusion / sum-up day 2

On the second day of the workshop the state-of-the-art for smart energy in an airport context was presented from many viewpoints. The first session had a strong focus on the technical solutions and state-of-the-art within specific energy-technologies, while the following session had a more holistic approach to the airport as a minor – but essential – part in the surrounding community. The third session again presented specific technology fields of the future solutions for aircraft fuelling and the conceptual design of the aircraft stand of the future. Due to the various topics, it is not possible to draw one overall conclusion of this workshop day. Instead, session-wise conclusions and sum-up will be presented in this section.

The first session underlined that energy flexibility and efficiency are main drivers for the development as well as sales and purchases of new equipment. Hardware is only part of the solution, however: Use and management of electricity has a major influence. Smart charging strategies for electrical vehicles and ground support equipment, as well as the integration of battery energy storage systems are examples. Model-based thermal controls in buildings can lower energy consumption, avoiding both CO_2 and costs. Technologies presented in the first session have been tested in real environments; either as research and demonstration projects or already in commercial utilisation. Implementing these technologies at an airport will require specific modifications. Energy- and IT-infrastructure must be upgraded and modified to fit the solutions, whether it is about electrifying ground support equipment, finetuning control strategies of thermal- and electrical energy storage systems or optimizing heat use in buildings. Though the technologies are not yet available "off-the-shelf", energy efficiency and reduction of greenhouse gas emissions are high on the agenda of airports. Electrification and energy flexibility are the main pathways to achieve these goals. Two essential dependencies are common for all solutions presented in this session: 1) Digitalization is key to allow more data-driven control and optimization, and 2) the role of staff and airport personnel as stakeholders in the green transition cannot be underestimated.

The second session highlighted that airports cannot be seen apart from their surroundings and the supporting cities. Especially two areas were in focus: airports are substantial consumers of energy (electricity, heating), and they create and attract traffic (on land side). Therefore, airports need to be a major participant in the creation of a greener and more sustainable local environment. The three presentations dealt with energy communities, passenger transportation, and how an airport can serve as an anchor to urban development. These topics presented state-of-the-art actions that both were under development (legislation of energy communities) and thoughts on current and future integration of passenger transportation and behaviour around an airport. An important conclusion was that communication between several stakeholders is the key to a smooth transition and integration of new technical and practical ways of redefining the airport contribution to its surrounding and vice versa.

The presentations in the third session showcased how the development of aircraft and airports is highly interconnected. New aircraft with higher fuel efficiency or alternative fuels (hydrogen, electricity) are under development, and airports need to be ready to service these new types. In addition, air traffic and passenger numbers are constantly changing – both in volume (number of passengers and flights) and in structure (e.g., share of short-haul, regional, and intercontinental flights). This forces airports to constantly re-think and adapt their facilities. At the same time, airport infrastructure is meant to last, and being able to re-use existing facilities for new aircraft may give a competitive advantage. This underlines how designing aircraft and aircraft stands is mutually connected. Safety and legislation have to be taken into consideration when rearranging and scaling new aircraft stands and aircraft types. The infrastructure for new propellants has to be prepared now to allow for a roll-out of electricity, SAF or hydrogen. The sooner and more thorough these considerations, the more easily airports and aircraft manufacturers can support the development.

6 Summary

The ALIGHT State of the Art workshop was held at CPH in Copenhagen on June 1st and 2nd, 2022. It was the first ALIGHT event with in-person participation. To have a productive and in-depth workshop, it was decided to organize the workshop at the first point in time where in-person meetings could take place again. Furthermore, for the first workshop to be very interactive, it was decided to keep participant numbers below 50. Workshop was split into Day 1 workshop with focus on ALIGHT workstream A - *SAF* and Day 2 workshop with focus on ALIGHT workstream B - *Smart Energy Supply & Use*. Each workshop day had three sessions per workstream, with 3-4 presentations per sessions. Day 1 featured a Q&A session after the presentations, and a panel discussion at the end of each session. On Day 2, presentations within one session covered more diverse topics. Therefore, questions to the presenters were discussed directly with the audience after each presentation. Slido was used for capturing questions during presentation and launching polls after each session. To honor the agreed-upon code of conduct, not all discussions are shared in full. Only high-level summaries of those presentations and the following Q&A sessions are presented in this report.

In total 44 participants, including 20 speakers, participated in the workshop representing a total of 10 European countries and a wide range of stakeholder groups such as airlines, airports, and other companies from the aviation sector; government agencies, public organisations, and interest organisations; as well as universities and research and technology institutions.

In general, there was a great spirit on the state-of-the-art workshop where all participants took active part in the discussions. Slido was used as a tool to warm up, make simple polls and to collect questions. Clearly it was highly appreciated that ALIGHT now facilitates such knowledge transfer and discussions across different aviation related field of interests. On the other side, the participation of important stakeholders such as Airbus clearly indicates the support to the ALIGHT project in general and the cooperation activities (e.g., this workshop). It was also agreed at the state-of-the-art workshop, that apart from the upcoming “Bold Vision” and “Policy Maker” workshops, ALIGHT should also support the coordination between the four large European lighthouse projects in the aviation sector, ALIGHT, OLGA, STARGATE and TULIPS.

This report gathers the main findings from the ALIGHT “State-of-the-Art" workshop, including presentations, questions, and discussions on the two days. Apart from this report, results will also be communicated via other channels, such as the ALIGHT project website (https://alight-aviation.eu/) and ALIGHT’s LinkedIn-page (https://www.linkedin.com/company/76921354).