EUROPE
AIRPORTS COUNCIL INTERNATIONAL

GUIDANCE ON AIRPORTS' CONTRIBUTION TO NET ZERO AVIATION

REDUCING SCOPE 3 EMISSIONS AND SUPPORTING THE IMPLEMENTATION OF DESTINATION 2050

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1. **Introduction**

Context

ACI EUROPE has a long-standing history of engagement in climate action, in particular through the development and launch of the *Airport Carbon Accreditation* programme in 2009. In 2015, ACI EUROPE also adopted a first climate target, pledging to reach 50 carbon neutral airports in Europe by 2030. Two years later, this goal was upgraded to 100 carbon neutral airports by 2030. In June 2019, ACI EUROPE made another step change in its climate ambition by publishing a Climate Resolution as part of a comprehensive Sustainability Strategy for Airports.[1]

Through this Resolution, European airports have committed to reach Net Zero CO_2 emissions under their control (defined as Scope 1 and 2 emissions under the Greenhouse Gas Protocol), at the latest by 2050. This can be achieved by reducing absolute emissions to the furthest extent possible and addressing any remaining emissions through CO_2 removal and storage. This commitment is in line with recent scientific findings, as evidenced in the IPCC Special Report from October 2018[2], as well as European political objectives, in particular the objective of climate neutrality by 2050, as announced in the EU Green Deal.

Less than a year after the adoption of this Net Zero airport industry commitment, the aviation sector was hit by the COVID-19 pandemic, experiencing the worst crisis in its history. In spite of this, and fully adhering to the principle of '*Building Back Better'*, ACI EUROPE and its airport members have remained committed to ambitious climate action:

- In November 2020, two new levels – **4 'Transformation'** and **4+ 'Transition'** - have been introduced in *Airport Carbon Accreditation*, enhancing the programme's alignment with the Paris Agreement.
- Furthermore, European airports have reaffirmed their commitments to Net Zero carbon emissions. Thus, as of April 2022, **246 European airports** have individually undersigned ACI EUROPE's Net Zero pledge (up from 194 upon its launch in 2019), while **94** of them have defined 2030 or earlier years as target dates for Net Zero, thus exceeding the European climate goals. Of these, **10** airports – all operated by Swedavia - announced in March 2021 that they have already reached Net Zero carbon emissions for their operations.
- And in June 2021, the global airport community, jointly represented by ACI World and all ACI Regions also issued a **Global airport industry commitment to Net Zero CO_2 emissions**.

Globally, airport operators' Scope 1 and 2 emissions are estimated to account for 2% of aviation emissions. Aircraft emissions are not typically within the control or ownership of an airport operator, but are part of its wider eco-system and as well as a consequence of its activities - defined as Scope 3 under the Greenhouse Gas Protocol.

Recognising that airports are thus only one part of the air transport system, the ACI EUROPE Net Zero commitment came along with the call on other aviation stakeholders to define a vision and pathway towards a Net Zero carbon emissions air transport system. In line with it, in November 2020, in the context of the **European Aviation Round Table Report**, a total of 24 aviation industry associations and NGOs agreed to commit to a Net Zero CO_2 emissions goal for European aviation.[3] This was followed by the release of the **Destination 2050** report in February 2021, which provides a comprehensive roadmap to this goal, as well as recommendations for industry and policy-makers to support its implementation. Destination

[1] https://www.aci-europe.org/component/attachments/attachments.html?task=view&id=1253
[2] Download Report — Global Warming of 1.5 ºC (ipcc.ch)
[3] https://www.aci-europe.org/component/attachments/attachments.html?id=1227&task=download

2050 is the result of unprecedented collaboration between five major European aviation associations – Airports Council International Europe (ACI EUROPE), AeroSpace and Defence Industries Association of Europe (ASD Europe), Airlines for Europe (A4E), Civil Air Navigation Services Organisation (CANSO) and European Regions Airline Association (ERA) - supported by a research consortium composed of the Dutch Aerospace Centre NLR and SEO Amsterdam Economics.[4] In February 2022, a number of European airports and airport associations have endorsed the **Toulouse Declaration**[5], the first-ever public-private initiative supporting Europan aviation's goal to reach Net Zero CO_2 emissions, which complements their objective of reaching Net Zero CO_2 emissions by 2050 at the latest.

Scope and purpose of this document

This document aims to **provide airports with practical guidance to reduce Scope 3 emissions and in particular aircraft emissions, so as to support the implementation of Destination 2050 and thus contribute to the achievement of Net Zero CO_2 emissions by European aviation by 2050.**

Airport operators may also wish to use it to identify ways to respond to the requirements of *Airport Carbon Accreditation* relating to stakeholder engagement (Level 3) or partnership (Level 4). As such, **this document explains the role airport operators can take to influence, support and facilitate reductions in carbon emissions from aircraft operations which represent the main carbon footprint of aviation and are the most difficult to eliminate.** Furthermore, airports' role in reducing carbon emissions from ground handling are also explored.[6]

Other airport operator Scope 3 emissions, such as those from surface access, are not included in this document. Likewise, airport operator Scope 1 and 2 emissions are not addressed. The scope of the emissions covered by this guidance is illustrated in the figure below.

[4] www.destination2050.eu
[5] Airports Council International Europe | ACI EUROPE - Toulouse Declaration (aci-europe.org)
[6] While it is recognised that some European airport operators are directly in charge of ground handling, the present document focuses on the more widespread situation whereby ground handling is carried out by independent companies, and as such the related emissions fall into the airport operators' Scope 3.

The ultimate objective of this document is to enable all European airports to take a leading and proactive approach and develop their own, individual roadmaps on supporting a Net Zero aviation industry.

ACI EUROPE strongly recommends and encourages all its airport members to establish such roadmaps, with targets, actions and milestones – as a complement to their carbon reduction roadmaps addressing Scope 1 and 2 emissions.

The guidance document is structured into a further three sections. **Section 2** outlines the scientific, political and industry context around net zero carbon aviation, while **Section 3** introduces the role airports can play in decarbonising aircraft operations and ground handling, including an indicative, high-level effectiveness assessment of the possible key actions. **Section 4** provides more details on the various support measures airports can take.

2. **Addressing aviation's carbon emissions**

Until the outbreak of COVID-19, aviation has been one of the fastest growing sectors in the world. One of its drivers – as well as one of its benefits, arising from enhanced connectivity – is increasing welfare in many world regions. However, this positive development also means the progress made by the industry to become more efficient and emit less carbon emissions had until then been outpaced by the increase in the number of flights. Thus **between 1990 and 2016, CO_2 emissions from all flights departing the EU/UK/EFTA almost doubled**.[7] At EU level, in 2017 direct emissions from aviation represented 3.8% of total CO_2 emissions and 13.9% of the emissions from transport, making it the second biggest source of transport Greenhouse Gas (GHG) emissions after road transport.[8]

Additionally, aviation sector also entails **non-CO_2 related climate impacts**, which based on the current science are estimated to account for roughly two thirds of the total aviation climate impacts.[9] Enabling the aviation sector to continue delivering social and economic benefits to communities while reducing its climate impacts is the most important challenge faced by the sector.

International and European policy framework

In October 2018, the **Intergovernmental Panel on Climate Change (IPCC)** published a special report addressing the impacts of global warming and outlining pathways to achieve the targets of the Paris Agreement (limiting global temperature increase to 2°C and ideally 1.5°C). The report concluded that the implementation of current climate policies was unlikely to achieve these targets and could result in a global temperature increase of 3°C. Limiting global warming to 1.5°C would require *"unprecedented"* and *"deep emissions reductions in all sectors"* and a decrease in global CO_2 emissions *"well before 2030"*. Overall, **global net CO_2 emissions would need to decline by about 45% by 2030 compared to 2010, reaching Net Zero by 2050**. In addition to substantially reducing CO_2 emissions, this will require balancing any residual emissions by removing an equal amount from the atmosphere (carbon dioxide removal, CDR).

In line with these conclusions, the **European Green Deal**, announced in December 2019, defines **climate neutrality by 2050** (i.e. achieving Net Zero greenhouse gas emissions) as one of the European Union's main policy objectives. Such objective is enshrined as a binding target in the **EU Climate Law** – which also raises the European ambition for 2030, for which the goal of **reducing net GHG emissions by 55% compared to 1990** is set. All sectors of the economy will have to be part of that effort.

The **EU Sustainable and Smart Mobility Strategy**, published in December 2020, outlines how transport is expected to contribute to these goals. By 2050, the sector's emissions have to be reduced by 90%. This is to be achieved by fostering energy savings, clean and sustainable energy sources, technological disruption, more efficient traffic management systems and multimodality. The Mobility Strategy defines ***"zero-emission airports and ports"*** as one of 10 flagship policy areas. This includes, amongst others, promoting the deployment of Sustainable Aviation Fuels (SAF), avoiding kerosene burn on stationary aircraft, incentivising fleet renewal as well as more sustainable ground handling. To enable such improvements, the European Commission calls for enhanced public and private investments.

[7] European Aviation Environmental Report, https://www.easa.europa.eu/eaer/topics/overview-aviation-sector/emissions
[8] https://ec.europa.eu/clima/policies/transport/aviation_en
[9] EASA report: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2020:277:FIN

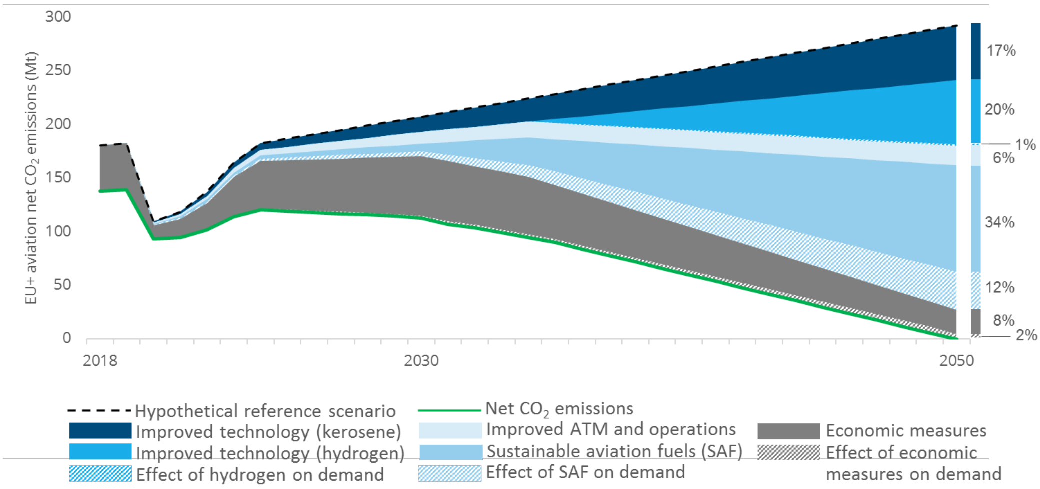
A revision of the EU Emissions Trading System (ETS) is also foreseen to incentivise emissions reductions and generate additional funds to support decarbonisation.

In July 2021, the **European Commission adopted its 'Fit for 55' legislative package,** including a set of legislative proposals aiming at reducing emissions from the aviation sector. These proposals include the introduction of an EU-wide mandate for the provision of Sustainable Aviation Fuels (SAF), the introduction of targets for the supply of electricity to stationary aircraft at airports, a tightened emissions cap under the EU Emissions Trading System (ETS), the introduction of CORSIA to extra-European flights, and a taxation on kerosene. Currently, the Fit for 55 proposals are following the legislative process. Their adoptions are expected by Q3/Q4 2022.

At the global level, the **International Civil Aviation Organization (ICAO)** has defined a four-pillar strategy - the so-called ICAO Basket of Measures - involving technological improvements, operational measures, the use of SAF and a global market-based measure (MBM). The latter is being implemented through the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), agreed upon by ICAO in October 2016 and taking effect as of 2021. At the same time, ICAO is working on a **Long-Term Aspirational Goal** for global aviation.

Airports in *Destination 2050 – A route to net zero European aviation*

Through Destination 2050, Europe's aviation has become the first regional air transport sector in the world to commit to Net Zero CO_2 emissions by 2050 and to present a concrete pathway towards achieving this goal. The flights in scope are those departing the EU/UK/EFTA:[10]



While SAF and technological innovation are the most important levers in enabling Net Zero emissions aviation, improved air traffic management (ATM) and operations, including at airports, are estimated to lead to a 6% reduction in total emissions from European aviation in 2050. Amongst others, this refers to the potential of reducing taxiing emissions as well as

[10] For simplicity, this is being referred to as "European aviation" in the rest of the document. The reduction % in 2050 are calculated based on a hypothetical reference scenario that is being called "business-as-usual" in the rest of this document.

substitution of Auxiliary Power Units (APU)[11]. Compared to the other action pillars, this contribution is rather limited. However reducing emissions on the ground and in the vicinity of airports is of particular relevance because of co-benefits in terms of local air quality and reduced noise exposure.

Furthermore, even though the deployment of SAF or technological innovation is not under the direct responsibility of airports, the latter play an important role in enabling and facilitating it. This is expected to become even more critical as new aircraft energy systems enter into service, requiring potentially significant changes in infrastructure and associated handling services.

Airport Carbon Accreditation

While its core requirements focus on the reduction of airport operator Scope 1 and 2 emissions, *Airport Carbon Accreditation* is also supporting airports in addressing emissions of their business partners and clients. As of Level 3 'Optimisation', airports have to map Scope 3 emissions associated with their main operational stakeholders and processes, as well as to establish action plans to help reduce those. This includes mainly emissions from aircraft operations and ground handling (where carried out by independent companies or airlines). At Level 4/4+, which requires airports to set long-term emissions reduction target in line with the Paris Agreement, it is also possible to include selected Scope 3 emissions sources into the airport's target scope – provided they are material and the airport can demonstrate that it has an appropriate extent of influence over them. Regardless of the target scope, all airports seeking accreditation at Level 4/4+ have to show that they lead and contribute to activities entailing quantitative emissions reductions from their operational stakeholders.

[11] Small jet engine at the rear of the aircraft that can be used to provide cabin air conditioning and power when the main engines are shut down. They are also used to supply bleed air for starting main engines.

3. An Airport Operator’s Contribution to Decarbonising Aircraft Emissions

3.1. Airport operators’ roles

Effectively addressing the collective carbon footprint of an airport requires a collaborative approach between various stakeholders. Airport operators have multiple reasons to support emissions reductions from aircraft and ground handling operations:

- Being at the interface between different stakeholders, airport operators can implement concrete actions on the ground to support the decarbonisation of aircraft and ground handling operations.
- Airport operators are perceived as accountable for the carbon footprint of aviation to the same extent as airlines. They even tend to be the most tangible aviation stakeholder on the ground and as such the most exposed to public criticism.
- Airport infrastructure is vulnerable to the impacts of the changing climate, therefore it is prudent that airport operators strive to reduce CO_2 emissions wherever possible and even beyond their operational remit.
- Airports are able to attract leading airlines and airline customers such as large corporates aiming to decrease their Scope 3 emissions by facilitating access to the required infrastructure to supply Sustainable Aviation Fuels, Hydrogen as a fuel and electric charging.

Acting to reduce emissions on an airport-wide basis is thus a pre-requisite to guarantee airport operators’ business continuity as well as their social license to operate and to keep providing connectivity.

As alluded to in the previous section, there is a variety of ways in which airport operators can influence and support decarbonisation of aircraft emissions, where these types of influence can be described as **Enable** or **Deliver**.

Enable

This type of action is encompassing four main roles of the airport operator: active operational stakeholder engagement, advocacy with policy makers and regulators and communications with airlines and with the wider public.

- A key and reoccurring theme in how airport operators support the journey to a Net Zero aviation industry is **stakeholder engagement at the operational level**. Important stakeholders are not only airlines, but also Air Navigation Service Providers (ANSPs), ground service providers, jet fuel producers, engine and aircraft manufacturers, and regulatory agencies.

  For instance, an airport operator can ‘kick start’ projects by bringing potential project partners together in a meeting or arranging a conference where a particular idea is discussed and developed. Where a project is less well defined, an initial idea to mitigate aircraft emissions may require additional research and a **feasibility study**. A feasibility study is a robust assessment of the practicality of a proposed project or system with an objective to clearly understand its application, potential difficulties and the benefits that will arise. It will include an assessment of costs and value of the initiative in terms of its ability to mitigate environmental impacts. An airport operator’s role can be to fund a feasibility study, undertake one itself or coordinate partners to work together, or a combination of these.

This type of engagement can be formalised by the implementation of **Collaborative Environmental Management (CEM)** as defined by EUROCONTROL[12] where all operational stakeholders at the airport cooperate with a view to reducing their environmental footprint. CEM has been adopted by ACI EUROPE as a Recommended Practice for the airport industry and is part of the ACI EUROPE's Sustainability Strategy for Airports[13].

Another way to engage an airport community on environmental topics would be to make use of existing Collaborative Decision Making (CDM) processes as defined by EUROCONTROL[14], which gather all key stakeholders (airport, airlines, ANSPs) to ensure the effective implementation of environmental improvement (e.g. reducing taxi time, N-1 engine, etc.).

- Many measures to reduce emissions, such as the increased use of SAFs, will be advanced by more favourable local, regional and national policy and regulatory interventions. Airports can **engage with policy-makers and regulators to advocate** for such interventions, for instance by responding to consultations in relevant policy areas. ACI EUROPE works in this domain, particularly at the EU, pan-European and wider international level. National airports associations can also play a part here.

  Sharing reliable environmental figures with airlines, describing the environmental performance of airlines at airports with a view to reward airlines operating more sustainable aircraft and engine technologies. This could be based on EASA's work on a League Table scheme tool based on Aircraft certification criteria and operational criteria individually applicable to each airport.

- A fourth area of action is **communications with the public**. It is important for the sector to publicise its efforts and successes in contributing to decarbonised aircraft operations in order to demonstrate progress and help maintain momentum among partners. Airport operators are well placed to coordinate this communication at local and regional level for their stakeholders and thus ultimately support continuous and enhanced industry action.

Deliver

This category is encompassing all those actions implemented by an airport operator that produce **effective aircraft emissions reductions** as an output.

This refers to measures providing infrastructure to support sustainable aircraft such as the installation and/or operation of fixed electrical ground power (FEGP), fixed pre-conditioned air (PCA) units, the physical delivery of Sustainable Aviation Fuel, investments in companies producing Sustainable Aviation Fuels, the purchase of electric tow tractors to reduce emissions from aircraft taxiing, a revision of an airport's taxiway configuration to reduce taxi times, or the installation of electric charging points for ground support equipment (GSE). Furthermore, there are also opportunities for airports to explore economic mechanisms to incentivise low carbon aircraft operations. For instance, some airports have developed their own SAF incentives. Heathrow introduced a SAF incentive in their landing charges from 2022.[15] In 2022, Schiphol introduced a financial incentive of € 15 million for airlines refuelling SAF. Swedavia put in place a Sustainable Aviation Fuel Incentive Programme supporting up to 50% of the premium cost for neat SAF for approved applications[16]. The exact role an airport

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[12] https://www.eurocontrol.int/initiative/collaborative-environmental-management
[13] ACI EUROPE SUSTAINABILITY STRATEGY - SECOND EDITION.pdf (aci-europe.org)
[14] Airport collaborative decision-making (A-CDM) | EUROCONTROL
[15] Sustainable Aviation Fuel | Heathrow
[16] saf-incentive-2022.pdf (swedavia.se)

operator can take in supporting decarbonisation of aircraft operations will depend on its particular circumstances. For example, an airport operator that is also the ANSP will have different and greater influence on air traffic management changes than an airport operator separate from the ANSP. In Norway, for example, AVINOR as the airport operator and ANSP ‘owns’ the Standard Instrument Departure Routes (SIDs) and Standard Arrival Routes (STARs) which gives it greater influence. And, considering external factors, for example the political, economic and regulatory context can be more favourable for implementing Sustainable Aviation Fuels in some countries than others.

3.2. Overview of support areas

Specific **‘support areas’** where airport operators can collaborate with aircraft operators and other operational stakeholders to reduce aircraft emissions can be categorised as follows, according to the phase of flight on which the measures taken are focused:

General Aircraft Issues	Flight Phase “at Gate”	Flight Phase “on Ground”	Flight Phase “in Air”
			
• Fleet renewal and retrofit of in-service aircraft • New aircraft propulsion and energy systems • SAF	• APU substitution by FEGP/PCA • Low emissions GSE and vehicles	• Operational towing • Integrated electric taxiing • Reduced engine taxi • Reduced taxi times • Optimised GSE logistics and movements of ground vehicles	• Continuous Descent Operations • Continuous Climb Operations

There are two additional areas not directly related to decarbonisation in aircraft/ground handling operations: the first regards how airport operators can involve passengers in contributing to emissions reductions and the second encompasses carbon removal and storage.

More details are provided in Section 4, where different support areas are grouped in categories. Each support area comprises a brief introduction, a list of actions airports can take, discussion of co-benefits and challenges, and identification of likely key stakeholders. In some support areas, examples of current initiatives undertaken by airport operators are provided as case studies.

3.3. Indicative assessment of support actions’ effectiveness

The effectiveness of the actions taken by airports in the different support areas will vary locally. However, to help airport operators select the most relevant actions, a **high-level and indicative assessment of their effectiveness** is provided below. **The *“effectiveness”* is measured against five dimensions:**

- **CO_2 reduction impact**
- **Technical feasibility**
- **Affordability**

- **Scalability** (i.e. potential for the action to be implemented by a wide range of airports)
- **Visibility** (for passengers and staff)

The table below aims to help airports in assessing projects that make the biggest environmental impact. This assessment is provided only for actions falling under the category “Deliver” as actions under the scope of “Enable” cannot be directly linked with CO_2 reductions.

Scoring	1	2	3	4	5
CO_2 reduction impact	Impact on emissions from aircraft on stand	Impact on emissions from ground operations	Impact on emissions on the ground and during LTO	Up to 80% reduction from full flight achievable	Above 80% emissions reductions from full flight achievable
Technical feasibility	Technical enablers are in the R&D phase.	Technical enablers are available on the market to a limited extent and can require significant changes to airport infrastructure	Technical enablers are fully commercialised but can require significant changes to airport infrastructure	Technical enablers are available on the market to a limited extent and are unlikely to require significant changes to airport infrastructure	Technical enablers are fully commercialised and are unlikely to require significant changes to airport infrastructure
Affordability	Very high cost (CAPEX) for airport operator	High cost for airport operator	Medium cost for airport operator	Low cost for airport operator	Very low cost for airport operator
Scalability	Action achievable only for major airports	Action achievable for a minimal number of airports	Action achievable for a limited number of airports	Action achievable for most airports	Action achievable for any airport
Visibility	Very low	Low	Medium	High	Very high

4. Supporting Measures for Airport Operators to Reduce Aircraft and Ground Handling Emissions

Category 1: Improvements in aircraft and engine technology

In this category, emissions reductions arise from **modifications to existing aircraft technology and design**, as well as from **future aircraft technologies** including new propulsion and energy systems, gradually brought into service through fleet renewal. **Integrated electric taxiing** is addressed as well.

Developments in aircraft technology and design have allowed to halve CO_2 emissions per seat-kilometre since 1990.[17] Between 2009 and 2019, the fuel efficiency of aircraft operations has been improving on average by over 2% annually.[18] The adoption of the first-ever CO_2 standard for aircraft, agreed by the ICAO Council in March 2017, and gradually entering into force since 2020, is expected to stimulate further progress.

New propulsion mechanisms, such as electric and hybrid-electric aircraft, as well as new energy systems, in particular those based on liquid hydrogen, are being developed. Destination 2050 projects that these will contribute to a 38% reduction in emissions from European aviation by 2050 compared to business-as-usual.

Support area 1	Fleet renewal and retrofit of in-service aircraft
Description	The generation of commercial passenger aircraft to be developed in the next 10 years has the potential to realise a step-change in energy efficiency. With an average 25 years in service for aircraft, it will however take time for its full benefits to be realised through fleet renewal. Set to be introduced from 2035 onwards, these upcoming aircraft types are forecast to reduce fuel burn by 30% or more per flight compared to their predecessors. In addition, through retrofit, engine and aircraft manufacturers can modify current technologies to achieve fuel-efficiency savings and thereby emissions reductions.
Enable	• Highlight/promote airlines with a low carbon fleet. • Assess relevance and feasibility of noise/NO_x/CO_2-based modulation of airport charges, and implement them to support use of newer aircraft by airlines. • Explore relevance and feasibility of slot allocation to airlines based on environmental criteria.
Deliver	
Co-benefits	• In general, aircraft of more recent production are quieter and produce less emissions of air pollutants, such as nitrogen dioxide (NO_2). • However, for some engine modifications a trade-off can arise where an improvement in one environmental impact, in this case CO_2 emissions, can increase another (aircraft noise, NO_x emissions).

[17] https://aviationbenefits.org/economic-growth/aviation-benefits-beyond-borders/
[18] ATAG, Aviation Benefits Beyond Boarders, page 13

Challenges	• An airport operator's ability to influence modifications to aircraft technology and design by engine and aircraft manufacturers is limited because the airport operator is not their customer. • Green airport slot allocation must be further investigated; e.g. once a green airport slot is granted, what if an airline wishes to switch to a more emitting aircraft type? How to avoid discrimination of airlines with less environmentally advanced fleets? • CO_2-based modulation of airport charges involves a number of challenges which are outlined in the ACI EUROPE Information Paper on the use of modulations of airport charges for environmental reasons.[19]
Stakeholders	Aircraft manufacturers Aircraft engine manufacturers Aircraft operators

Support area 2	New aircraft propulsion and energy systems
Description	New aircraft propulsion systems currently being developed include full electric and hybrid-electric aircraft where the electricity on-board the aircraft is provided by batteries. An example is the Pipistrel Alpha Electro full electric 2-seater aircraft. In a serial hybrid-electric configuration, a turbo generator will charge the batteries to extend the range of the aircraft. Range and capacity optimised hybrid-electric regional aircraft are anticipated to bring down CO_2 emissions by 50% per flight compared to conventionally fuelled aircraft.[20] Other new aircraft energy systems are also being developed. One is an electric aircraft where hydrogen is carried on-board aircraft and used in a fuel cell[21] as an alternative or supplement to rechargeable batteries. In another, hydrogen is carried on-board and combusted directly to power aircraft engines. This refers in particular to the Airbus ZEROe aircraft concepts.[22] As per Destination 2050, the introduction of a hydrogen-powered single-aisle aircraft on intra-European routes is expected in 2035. This would enable a 20% reduction in emissions from European aviation in 2050 compared to business-as-usual. The ACI World publications on sustainable energy sources in aviation and an airport perspective on hydrogen (jointly with Aerospace Technology Institute, ATI) provide useful insights into the airport operator's role in this area.[23]

[19] https://www.aci-europe.org/component/attachments/attachments.html?id=1072&task=download
[20] Destination2050_Report.pdf
[21] Hydrogen-oxygen fuel cells are an alternative to rechargeable cells and batteries. In a hydrogen-oxygen fuel cell, hydrogen and oxygen are used to produce a voltage. Oxygen is taken from the air, water is the only product.
[22] https://www.airbus.com/innovation/zero-emission/hydrogen/zeroe.html
[23] ACI World: White Paper Sustainable Energy Sources for Aviation: An Airport Perspective, April 2021; ACI World and ATI: Integration of Hydrogen Aircraft into the Air Transport System: an Airports Operations and Infrastructure Perspective, June 2021; both accessible on https://store.aci.aero/product-category/environment/

Enable	• Engage with aircraft operators to assess their willingness to investigate and/or operate an electrified or hydrogen-powered aircraft at the airport. • Support a feasibility study into the potential for electrified and hydrogen-powered aircraft operations at the airport.[24] • Offer airport site as testbed for new aircraft technologies and energy systems. • Explore the use of green electricity generated on-site or in the airport's vicinity to directly power aircraft or produce hydrogen. • Encourage aircraft operators to use electric or hydrogen-powered aircraft through financial incentives (e.g. temporary waiver on landing charges). • Connect aircraft operators with GSE handlers to develop joint electric charging and H2 refueling systems if applicable. • Develop safety protocols and work together to develop regulations regarding refueling, handling, etc.
Deliver	• Provide infrastructure and associated services to accommodate electrified and/or hydrogen-powered aircraft operations where relevant[25].
Co-benefits	• Electric aircraft generate no gaseous emissions during operation, therefore there are no emissions of air pollutants (such as NO_x) at the airport which contributes to better local air quality. There are also potential operational co-benefits (e.g. a shorter runway). • Hydrogen combustion is currently estimated to lead to a 50% to 80% reduction in total NO_x emissions compared to kerosene-powered aircraft.[26] • Enhanced green electrical capacity and hydrogen supply to the airport can also help decarbonise other operations at the airport, including GSEs.

Challenges	• Appropriate space and infrastructure will be needed:
	    ○ Electrified aircraft operations will likely require an overall expansion of the airports' electrical capacity, transmission infrastructure as well as facilities for battery charging and storage.
	    ○ Hydrogen-powered operations will likely require storage facilities for liquid hydrogen and liquefaction facilities for gaseous hydrogen from an external supply, as well as trucks and/or pipelines to enable aircraft refueling.
	• Safety and operational implications of handling new aircraft energy systems need to be further investigated, e.g. impacts

[24] This can include aspects such as market opportunities (e.g. shorter routes are likely to be more suitable for electrification in the medium-term), implications on airport infrastructure and services (e.g. charging infrastructure required, impacts on aircraft maintenance and ground handling, impacts on throughput), commercial impacts (e.g. define contractual agreements to provide electricity to airlines).
[25] Many airport operators already provide electrical power to aircraft in the form of fixed electrical ground power (FEGP). If these systems are to be used, modifications will be required. Alternatively, airport operators will be required to install new aircraft battery charging infrastructure or facilitate other companies to do so. Airport operators are also already exploring the use of hydrogen for ground vehicles.
[26] FCHJU and Clean Sky: Hydrogen Powered Aviation, p. 21

	on turnaround times, potentially larger or heavier aircraft, firefighting procedures, etc. • All of the above will have <u>cost</u> implications for airport operators. • An evaluation of aircraft noise is required to understand potential trade-offs or co-benefits. • To maximise benefits in terms of emissions reductions, electricity used by aircraft directly in the hydrogen production process should be sourced from renewables.
Stakeholders	Aircraft operators Aircraft manufacturers Ground service providers Suppliers of charging infrastructure Electricity and hydrogen providers ANSP

Case study

AVINOR is responsible for Norway's state-owned airports and air navigation services. Its vision is for all Norwegian domestic flights to be electrified by 2040, with the first (hybrid-) electric commercial aircraft entering service by 2025. The project is supported by the government and several other partners including SAS. The Norwegian Association of Air Sports and AVINOR have jointly purchased an electric aircraft, a Pipistrel Alpha Electro to investigate operational issues, aircraft noise and charging concepts. AVINOR will waive landing charges until 2025 for light aircraft (General Aviation traffic), and will take the responsibility for charging infrastructure to be available for electrified aircraft in the future.

In addition, AVINOR and **Swedavia** cooperate in the context of the Green Flyway project, providing a test environment for electrified aircraft operations in a meteorologically and geographically diverse region.[27]

Separately, similar waivers on landing charges for zero-emissions aircraft have been announced by **Heathrow Airport**, the **Manchester Airports Group** and **Stuttgart Airport**.[28]

Delivering infrastructure in due time is a prerequisite to enable the advent of new type of aircraft. This is notably true for liquid hydrogen, foreseen as of 2035 by Airbus in their zeroE program, and which has to be anticipated for a decade at least. **Groupe ADP**, along with **Air Liquide** and **Airbus**, has performed pre-feasibility studies of liquid hydrogen fuel farms in Paris-Charles de Gaulle and Paris-Orly airports, quantifying the electrical power requirements, footprint requirements, CAPEX impact of a full hydrogen value chain, with liquefaction, storage, distribution and refuelling being located at the airport, as well as possibly electrolysis.

[27] Green Flyway is a unique test arena for Electric aircrafts, UAS, ATS and ground support.
[28] https://your.heathrow.com/heathrow-airport-unveils-plan-for-carbon-neutral-growth/
http://www.airport-business.com/2020/11/manchester-airports-group-launches-zero-emission-flight-competition-part-long-term-commitment-green-recovery/
https://www.flughafen-stuttgart.de/newsroom/pressebereich/pressemitteilungen/2019/stuttgart-airport-first-german-airport-to-offer-free-landing-charges-to-electric-aircraft-and-to-fund-electricity-based-fuels/

Category 2: Improvements in ATM and Ground Operations

In the area of ATM and aircraft operations, measures airport operators can take to support emissions reductions from aircraft are described under the following headings: reduced engine taxi, reduced taxi times, operational towing, Continuous Descent Operations (CDO) and Continuous Climb Operations (CCO) as well as APU substitution through Fixed Electrical Ground Power (FEGP) and Pre-Conditioned Air (PCA). As regards ground handling emissions, relevant actions include Net Zero carbon GSE as well as optimisation of GSE logistics/ground vehicle movements.

In Europe, the Single European Sky and the associated Air Traffic Management Research Programme (SESAR) aim to reform the European air traffic management system to reduce environmental impacts. This includes for instance Airport-Collaborative Decision Making (A-CDM) which is improving the efficiency of aircraft operations at airports where it is has been implemented, bringing about reductions in fuel use and emissions. In 2018, 41% of European departures were operating from an A-CDM airport, with a reduced taxi time of between 1 to 3 minutes and an estimated saving of 108,072 tonnes of CO_2 emissions[29].

Support area 3	Reduced engine taxi
Description	Aircraft engines, even when idle or at minimal power settings, produce some forward thrust, which is used to taxi the aircraft whilst on the ground. Because of this, taxi-in and taxi-out can, under certain conditions, be completed with one or more engines (as appropriate) not operating. If an engine can be shut down during taxi-in or, upon departure, is not started after pushback until the aircraft is in an advanced stage of the taxi-out for take-off, then such a procedure has the potential to reduce fuel burn and CO_2 emissions. In Destination 2050, during the taxiing phase a fuel burn reduction of 30% is estimated for each arriving and 35% for each departing aircraft that moves from all-engine taxi to reduced engine taxi.[30]
Enable	• Work with airlines and the ANSP to assess the suitability of different aircraft types for reduced engine taxi having regard to the specific operational challenges at the airport (e.g. runway/taxiway configuration). • Based on the above, engage with airlines to revise and update standard operating procedures to encourage take up of reduced engine taxiing in line with manufacturer's guidance. • Establish a working group (e.g. through CEM) comprising the airport operator, ANSP and airlines to monitor performance and share good practice on reduced engine taxi, through data collection from airlines on rates of reduced engine taxi currently employed. • Contribute to revising the Aeronautical Information Publication (AIP) to support reduced engine taxiing operations.
Deliver	• Calibrate Pre-departure sequence/Departure Manager (PDS/DMAN) tool via use of Artificial Intelligence and Machine Learning so as to improve Target Take Off Time predictability

[29] EEA/EASA/EUROCONTROL (2019) European Aviation Environmental Report 2019.
[30] Destination 2050, p. 68

Co-benefits	• Reduced engine taxi will lower emissions of air pollutants and ground noise. • Fuel use is reduced so there will be fuel cost savings to airlines.
Challenges	• Aircraft manufacturers do not allow reduced engine taxiing for some aircraft types and each airline has its own policy and set of procedures. The complexity of different types of operation, aircraft types, aircraft manufacturer and airline procedures can be a challenge. • Airport operators that already have short taxi times may find it more difficult to implement because engines need to warm up before take off. • Aircraft with reduced engine taxiing can encounter challenges with some turns and gradients where further investigation is required.
Stakeholders	Aircraft manufacturers Aircraft operators ANSP

Support area 4	**Reduced taxi times**
Description	For departing aircraft delays arise from inefficient sequencing of aircraft where they may be required to wait at taxiway intersections, queue and hold before entering the runway. This leads to unnecessary fuel burn and emissions. Delays can also occur for arriving aircraft taxiing to the parking stand. Anticipation of stand availability through monitoring of turn around process is key. In A-CDM, reduced taxi times are achieved via improved real time information sharing between airport operators, aircraft operators, ground service providers and air traffic control, and the implementation of a set of operational procedures and automated processes. Availability and appropriate calibration of a PDS/DMAN tool is of paramount importance with inclusion of dynamic taxi times relevant to operational situation. Another avenue is the implementation of alternative pushback procedures, involving a longer push of the aircraft before start-up of the main engines.
Enable	
Deliver	• Implement A-CDM where not already done so, or equivalent concept adapted to all types of airports • Ensure proper calibrated PDS/DMAN tool • Set up monitoring of turn around processes making full use of AI and ML • Invest in aircraft stand automation to allow aircraft autonomy and more efficient turn around operations (Automatic Advanced Visual Docking Guidance Systems (AVGDS) and/or Passenger Boarding Bridge (PBB)) • Invest in feasible taxiway/ramp/runway alterations to reduce aircraft queuing and holding as appropriate.

	• Working with stakeholders, implement alternative pushback procedures to delay start-up of aircraft main engines.
Co-benefits	• Reduced taxi times will reduce emissions of air pollutants at the airport and reduce ground noise. • Fuel use is reduced so there will be fuel cost savings to airlines.
Challenges	A-CDM requires important changes to procedures and processes which can be a challenge. EUROCONTROL provides further information and a copy of the A-CDM Implementation Manual can be downloaded[31]. Changes to taxiway infrastructure will require an airport operator to undertake a feasibility study and make a business case for proposed changes.
Stakeholders	ANSP Aircraft operators Ground service providers

Support area 5	**Operational towing**
Description	Operational towing can be performed with a tow tractor powered by bio-fuels or electricity. This can involve a semi-robotic tractor where the pilot has greater control. Destination 2050 anticipates commercial application of electrified operational towing solutions from 2025 up to 2035. This has the potential of delivering emissions reductions of 0.8% to 1.2% for short haul and 0.3% to 0.9% for long haul flights.[32] At the moment, the only certified operational towing solution is Taxibot, whereby a hybrid-electric vehicle is towing aircraft from and to the runway. The vehicle is first controlled by a driver but as soon as it is coupled with the aircraft, it is directly operated by the aircraft pilot. The Taxibot can be used to tow the most common aircraft types: the Boeing 737 and the Airbus A320.[33]
Enable	• Support a feasibility study into the airport operational implications of aircraft towing.
Deliver	• Where ownership models allows, invest in the necessary equipment to provide operational towing, such as electrically-powered and semi-robotic tractors.
Co-benefits	• Operational towing contributes to reducing emissions of air pollutants, with fully electrically-powered towing vehicles not producing any such on-site emissions at all. • Such vehicles are also quieter in operation compared to an aircraft engine.
Challenges	Aircraft towing presents operational issues that must be overcome. The maximum emissions reduction is achieved on departure where the aircraft engines are started as late as possible (allowing for the required time for engine warm-up) and on arrival where the main engines are shut down as soon as possible (allowing for engine cool down). Both space and time is required at these locations for the switch between taxiing under engine power and towing vehicle. This is particularly challenging for arrivals, where

[31] https://www.eurocontrol.int/concept/airport-collaborative-decision-making
[32] Destination 2050, p. 69
[33] https://www.taxibot-international.com/

	for operational efficiency reasons, the aircraft has to leave the runway as soon as possible. Changes to taxiway and/or service roads (for return of tug) infrastructure will require an airport to undertake a feasibility study and make a business case for proposed changes.
Stakeholders	Aircraft operators ANSP Ground service providers

Case study

In 2020, **Amsterdam Schiphol Airport** and its partners Corendon Dutch Airlines, KLM and Transavia launched a trial of Taxibot, whereby 170 missions and 8 live flights with Boeing 737s (700 and 800) have been carried out.

The trial confirmed that 50-65% of fuel could be saved compared to standard taxi procedures, with CO_2 and NO_x emissions being reduced to the same extent.

The tests also concluded on several challenges to be addressed to enable a regular deployment of Taxibot at Schiphol Airport:

- Operational: it is necessary to make structural adjustments to checklists, communication protocols and other procedures, while associated pilot and driver training needs to be provided. The varying uncoupling points mean significant changes in airport circulation. This poses a challenge to air traffic control.
- Infrastructure: there need to be new roads at various locations and markings are required at the uncoupling points.
- Technical: the Taxibot is currently too wide for some of Schiphol's infrastructure and not compatible with all aircraft types.[34]

Taxibot is also being run in **Delhi-Indira Gandhi International Airport** (GMR Airports, subsidiary of Groupe ADP), and will be tested (proof of concept) in the configuration of **Paris-Charles de Gaulle** (Groupe ADP), as part of the H2020 Green Airport OLGA project.

Support area 6	**Integrated electric taxiing**
Description	Electric taxiing systems are being developed where an electric motor is fitted inside the wheels of an aircraft's landing gear and used for taxiing with the main engines shut down. Electric power is provided by the aircraft's APU. It is estimated to yield fuel efficiency savings, despite the system adding some weight to the aircraft. Integrated electric taxiing solutions have not been commercialised yet, but one technology, WheelTug, is currently undergoing certification.[35]
Enable	• Engage with stakeholders to assess the feasibility of integrated electric taxiing.
Deliver	
Co-benefits	• Additional environmental benefits of integrated electric taxiing are lower emissions of air pollutants and reduced ground noise.

[34] For more information, see https://www.schiphol.nl/en/innovation/page/sustainable-taxiing-taxibot-trial/
[35] https://www.wheeltug.com/

	• Operational benefits arise from no waiting for a pushback tug and eliminating the requirement to disconnect a tug after pushback. In addition, there is a reduced requirement for airside GSE parking where there are fewer tugs.
Challenges	• Aircraft operators are required to take notice of engine manufacturers specified warm up (on departure) and cool down (on arrival) times for engines. A typical engine warm up time is 4 to 5 minutes. • An important consideration is the requirement to start/shut down the aircraft's main engines as close to the runway as possible to maximise the benefit of electric taxiing.
Stakeholders	Aircraft manufacturers Aircraft operators ANSP Ground service providers

Support area 7	**APU substitution by FEGP/PCA**
Description	An APU provides cabin air conditioning and power to on-board systems when the main aircraft engines are shut down. It is estimated to account for roughly 1% of the emissions of a flight.[36] An alternative to using the APU is where the airport provides fixed electrical ground power (FEGP) and pre-conditioned air (PCA) to aircraft while on the parking stand. Destination 2050 estimates that a 0.3% reduction of emissions per flight can be achieved through these measures.[37] The technology is available, and this is a measure where the airport operator can take the lead and invest, without having to involve partners to the same degree as in other support areas. The European Union is currently working on setting targets for the supply of electricity to stationary aircraft as part of the European Commission proposal for a new Regulation for the deployment of alternative fuels infrastructure (AFIR).
Enable	• Revise airport operating rules to minimise the permitted APU running times and develop a hierarchy for the use of on-stand energy sources with a view to promoting the use of FEGP and PCA. • Encourage airlines to revise and update airline standard operating procedures to ensure use of FEGP and PCA in preference to use of APUs. • Develop and deliver training and awareness programmes to ground service providers and airline personnel on the benefits and practical aspects of FEGP and PCA use. • Liaise with airlines and ground service providers on a regular basis to discuss FEGP and PCA performance and any operational issues. • Implement a financial charging structure to encourage use of FEGP and PCA where practicable, for example, charging

[36] Destination 2050, p. 70
[37] Ibid.

	every airline using a fixed fee regardless of whether they use FEGP and PC. • Control the application of the APU restrictions included in the AIP.
Deliver	• Provide FEGP and/or PCA system capable of adequately supporting power/aircraft cabin air conditioning requirements of aircraft systems for all relevant aircraft types, which can therefore substitute for APU use.
Co-benefits	No on-site emissions of air pollutants are produced by FEGP and PCA systems and they are much quieter than a running APU.
Challenges	• Providing FEGP and PCA infrastructure is a significant cost to an airport operator although this can be recovered over time by charging for its use. • Making a business case can be particularly challenging for aircraft stands used infrequently for turnarounds, such as remote stands. In addition, making a business case can be difficult where the local climate means there are few hot and cold days. • Similar to reduced engine taxi procedures, it is challenging to monitor and enforce compliance with restrictions on APU use. • Some airlines with short turnaround times choose not to use FEGP because it is assumed to cause a delay. • To maximise benefits in terms of emissions reductions, electricity should be sourced from renewables.
Stakeholders	Aircraft operators Ground service providers

Support area 8	**Low emissions GSE and vehicles**
Description	In addition to FEGP and PCA, other options are available to substitute APUs. They include, for instance, the use of electric Ground Power Units (GPU). Hydrogen-based solutions are also being developed. While depending on the type of electricity used, electric GPU can yield up to 100% of CO_2 emissions reductions, diesel-powered GPU also allow saving roughly 95% of CO_2 emissions compared to APUs.[38] GPU are usually operated by independent ground handling companies, as are other types of low emissions GSE/vehicles that can enable further decarbonisation of ground operations. Therefore, the role of the airport operator mainly consists of ensuring the necessary supporting infrastructure is available.
Enable	• Support assessing the feasibility of and defining the business for various APU substitution options; ACI World's Airport Ground Energy Systems Simulator (AGES-S) tool can help airports quantify the emissions and cost benefits associated

[38] Zurich Study 2018

	with the implementation of different APU substitution options.[39] • Help define metering and invoicing mechanisms for the use of charging facilities. • Assess feasibility of differentiated license fees for ground handling companies, so as to incentivise those using low emissions equipment. • Explore the use of green electricity generated on-site to directly power GSE/ground vehicles or produce hydrogen for the latter.
Deliver	• Provide electric charging infrastructure for electric GSE and ground vehicles. • Provide hydrogen infrastructure for GSE and ground vehicles, • Directly invest in a low emissions GSE pool.
Co-benefits	The use of low emissions GSE, and especially electric equipment, contributes to reduce emissions of air pollutants and noise.
Challenges	• Sufficient electrical capacity needs to be available to enable widespread use of electric GSE/ground vehicles. • Time and logistics for battery charging need to be optimised so as to enable the best possible use of equipment. • To maximise benefits in terms of emissions reductions, electricity used by GSE/vehicles directly in the hydrogen production process should be sourced from renewables.
Stakeholders	Ground service providers Aircraft operators ANSP

Support area 9	**Optimised GSE logistics and movements of ground vehicles**
Description	Similar to aircraft, the handling of GSE and movements of ground vehicles airside can be optimised so as to reduce fuel burn and associated emissions.
Enable	• Define no-idle policies. • Raise staff awareness and provide training on ways to enable more efficient GSE and ground vehicles operations.
Deliver	
Co-benefits	• Reduced air pollutant emissions. • Savings on fuel costs for ground handlers. • Potentially higher lifetime of equipment due to more efficient use.
Challenges	• Existing airport layout might limit opportunities to improve GSE logistics/movements of ground vehicles. • Safety and operational efficiency constraints have to be taken into account.
Stakeholders	Ground service providers Aircraft operators ANSP

[39] The tool can be downloaded here: https://aci.aero/about-aci/priorities/environment/ages-s/

Support area 10	Continuous Descent Operations (CDO) & Continuous Climb Operations (CCO)
Description	Continuous descent and climb operations refer to aircraft following a continuous flight profile – as far as possible. Full CDO and/or CCO is not always feasible because of safety reasons (i.e. time and distance separation), weather or capacity. Harmonised definitions and metrics for CDO and CCO were agreed in 2015.[40] They have been shown to reduce fuel use (and hence emissions) and aircraft noise. It has been reported that a typical flight with level segments could benefit from average CO_2 reductions of up to 145kg for a CDO and 48kg for a CCO.[41] The difference reflects the higher inefficiencies in the descent phase.
Enable	• Liaise with stakeholders on implementation of CDO and CCO, e.g. by convening a working group where issues around implementation can be shared and resolved (for example in the context of CEM). • Develop reporting metrics for CDO and CCO, set a target and publish performance. • Produce an airport 'Code of Practice' for CDO and CCO where it may be a technical document describing procedures, actions and roles of individual stakeholders. It can be included in the Aeronautical Information Publication (AIP).
Deliver	
Co-benefits	Reductions in emissions of air pollutants and aircraft noise where these should be assessed alongside CO_2 emission reductions to understand any additional benefits or trade-offs.
Challenges	Engagement with airlines and the ANSP is key.
Stakeholders	ANSP Aircraft operators

[40] https://www.eurocontrol.int/concept/continuous-climb-and-descent-operations
[41] EEA/EASA/EUROCONTROL (2019) European Aviation Environmental Report 2019.

Category 3: Sustainable Aviation Fuels (SAF)

Since drop-in SAF was certified for civil aviation in 2009, over 100,000 flights have used SAF worldwide as of today[42]. There are two types of SAF dependent on the production process. One is produced from biomaterials (biofuel or biojet) and the other is produced from synthetic processes (synthetic fuel, Power to Liquid (PtL)). During combustion, SAF used in aircraft emit similar amounts of carbon to fossil-derived fuel but produce less emissions overall when the full life cycle is considered. SAF produced from biomaterials achieves life cycle carbon reductions from uptake of CO_2 from the atmosphere during their growth. For synthetic fuel, the emissions savings arise from capture and use of CO_2 in fuel production. These savings are particularly high if electricity from renewable sources is used for that process.

All SAF must be assessed based on carbon reduction potential against fossil-derived aircraft fuel across the full life cycle where a minimum of 65-70% reduction in GHGs is required for transport fuels in the EU's Renewable Energy Directive[43] and 10% is specified by ICAO for eligible fuels in CORSIA[44]. Research indicates SAF offer lower emissions of many air pollutants as well. The term 'sustainable' refers to a set of environmental and social criteria relating to the feedstock and production pathway to ensure fuels do not harm the environment or impact negatively on communities, lead to biodiversity loss, competition for water and with food production[45].

There are currently nine certified pathways for sustainable aviation fuels[46] where all SAF must be blended with fossil-derived fuel to a maximum of 50% (10% in the case of two pathways) i.e. 'drop-in' fuels. Therefore, there is a different and more complicated supply chain with two sources of fuel produced at different locations and a requirement for blending facilities.

Destination 2050 estimates that SAF could account for 6% of total kerosene consumption in European aviation in 2030, rising to 83% in 2050. Taking account of the anticipated use of other energy sources, in particular liquid hydrogen, leads to a 66% share of SAF in the projected total energy consumption in 2050.[47] In 2050, this is expected to result in a 34% reduction in CO_2 emissions of European aviation compared to business as usual, with an additional 12% emissions reduction expected as a result of the higher fuel costs and associated impacts on demand for air transport. To accommodate the required level of SAF production, large capital investments in fuel production infrastructure and substantial policy and public funding support are needed.

To support the market uptake of SAF, the European Commission issued a proposal for an EU-wide blending mandate including a progressive increase from 2% to 63% between 2025 and 2050 (i.e. 2% in 2025; 5% in 2030; 20% in 2035; 32% in 2040; 38% in 2045 and 63% in 2050)[48]. At a national level, already from 2020, jet fuel suppliers in Norway must blend 0.5% of SAF with aircraft fuel. In 2022, France, Norway and Sweden had a mandate of 1%.

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[42] https://www.atag.org/our-activities/sustainable-aviation-fuels.html
[43] EU's Renewable Energy Directive (EU) 2018/2001 https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive/overview
[44] https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO%20document%2005%20-%20Sustainability%20Criteria.pdf
[45] For example, in Europe, criteria are set out in the EU's Renewable Energy Directive (EU) 2018/2001
[46] Conversion processes (icao.int)
[47] Destination 2050, p. 151
[48] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52021PC0561

Support area 11	Sustainable Aviation Fuels (SAF)
Description	Airport operators are not selling or purchasing fuel and only very few airports are involved in fuel distribution. They rarely own fuel infrastructure on-site (e.g. fuel farms, hydrant systems, trucks), and mostly just provide the land for the fuel farm operator to own and manage this infrastructure. Blend-in SAF are certified by ASTM D7566 and as such do necessarily comply with all safety and technical standards for Jet A-1. Blended SAF is Jet A-1 and therefore treated in exactly the same manner as Jet A-1 – there are no issues in terms of handling, safety or technical quality. Given the importance of SAF in aviation's decarbonisation pathway, airport operators should nevertheless seek opportunities to support them as far as possible in the light of the operational structure and economic conditions of the airport.
Enable	• Engage with SAF producers and aircraft operators to discuss potential initiatives to support SAF uptake beyond the blending mandate - e.g. through working group, feasibility study. • Help each actor in the jet fuel supply understand its role in SAF provision and implications - e.g. customs requirements for imported SAF. • Help establish accounting and reporting mechanism according to which airlines will be able to claim emissions reductions from the use of SAF.
Deliver	• Invest in SAF storage tanks, blending facilities and (ideally local) production plants, where possible and relevant. • Where applicable and feasible, contribute to cover additional costs of SAF compared to kerosene.
Co-benefits	SAF have been shown to produce lower emissions of local pollutants and non-CO_2 effects of aircraft emissions during the cruise phase.
Challenges	Selecting the most appropriate SAF feedstock, pathway and partners is complicated. There is a variety of considerations, including resources available, certified blended fuel, sustainability criteria, transport logistics and costs.
Stakeholders	SAF producers Jet fuel suppliers Aircraft operators

Case studies

Several European airports are already implementing SAF initiatives with partners:

- In January 2016, **AVINOR**'s Oslo Airport became the first airport in the world where SAF was dropped into the main fuel farm and distributed in the hydrant and dispenser system. AVINOR has several SAF projects ongoing and has entered into an agreement with technology company Qantafuel to purchase SAF made from forestry residues to be produced in a new pilot plant that will be partly funded by state enterprise Enova.

- SAF is also being used to refuel aircraft at several of **Swedavia's airports**, including Stockholm Arlanda. This work was part of Swedavia's strategy to transform the industry and provide fossil-free Swedish air travel by 2045. The project relied on used cooking oil from the Finnish producer Neste. In 2019, Swedavia also launched a Sustainable Aviation Fuel Programme whereby airlines can apply for up to 50% coverage of the cost premium by the airport operator, for SAF uplifted at one of its airports.

- **Royal Schiphol Group** (RSG) is investing with its partner SkyNRG to build a bio kerosene plant dedicated to the production of sustainable jet fuel by using regional waste and residual streams of raw materials (such as used cooking oil). The feedstocks used in this process are expected to reduce CO_2 emissions by 85% compared to traditional fossil-derived fuel and the plant is due to commence operations in 2022.

  Another SAF project is a multi-partner study for the production of synthetic jet fuel obtained from CO_2 (via direct air capture), water and renewable electricity. The European consortium is led by EDL Anlagenbau Gesellschaft mbH and RSG contributes financially and provides expertise. It is expected to result in the construction of a small installation on the grounds of Rotterdam The Hague Airport (part of RSG), which will be able to produce approximately 1,000 litres of SAF per day.

- In January 2020, in a first-of-a-kind project in Switzerland, Jet Aviation, **Zurich Airport** and Neste also offered SAF to business jet flights operating during the annual meeting of the World Economic Forum (WEF) in Davos.

- As part of a broad project consortium, the renewable energy company Ørsted and **Copenhagen Airport** aim to develop a hydrogen and sustainable transport fuel facility. The project has the potential to displace 5% of fossil fuels at Copenhagen Airport by 2027 and 30% by 2030.

  Copenhagen Airport is also leading the EU-funded **ALIGHT** project, an international, multi-stakeholder, four-year project, which addresses essential aspects on the scale-up and promotion of SAF as well as the development and integration of smart energy systems for airports.

- In April 2021, **Clermont-Ferrand Airport**, operated by **VINCI Airports**, announced that a 33% SAF blend based on used cooking oil is being made available at the airport, with Michelin Air Services being the first client. As of June 2021, SAF is also being supplied to **Munich Airport**.

- In November 2021, **Brussels Airport** launched its **Stargate Project**, which includes building a biofuel blending installation at the airport, testing electric and hydrogen ground handling material as well as electric taxiing and a new innovation that will make engine test runs much quieter, and extending their intermodality hub. Brussels Airport is working with 21 partners from all over Europe, including three other airports: **Athens International Airport**, **Budapest Airport** and **Toulouse Blagnac Airport**.

- SAF is used on a regular basis, at high blending ratio (up to 30%) at **Paris-Le Bourget** airport since mid-2021. As of 2022, two fuel providers out of three operating in Paris-Le Bourget are delivering SAF, thereby contributing to the fast decarbonisation of business aviation.

- During the May 2022 Sustainable Flight challenge, Air France proved it was possible to halve overall CO_2 emissions of short and long-haul flights (Paris-Charles de Gaulle to Lisbon; Paris-Charles de Gaulle to Montreal), with a 30% SAF batch among others.

Category 4: Air Passengers

Support area 12	Air passengers
Description	Airports are an important contact point for passengers with many of them making use of the airport's website for information and bookings. Moreover, all passengers spend time in airport terminal buildings. This creates opportunities for an airport to advise and support passengers in reducing emissions from their flights. Examples include supporting passengers in compensating for their flight emissions through carbon offsetting or SAF purchase. All offset projects should be suitably verified to ensure they conform with sustainability criteria and strict rules on robustness and integrity.
Enable	• Provide advice to passengers on the airport's website on how to reduce the weight of their luggage, thereby reducing aircraft fuel burn and emissions, for instance through videos. • Publicly report on steps taken by passengers at the airport to reduce emissions from aircraft operations. • Provide passengers who choose to offset their emissions with some form of recognition, such as a certificate. • Encourage passengers to offset their flight emissions by providing an easily accessible portal on the airport's website where the information presented is clear and appealing or by installing a compensation booth in the terminal.
Deliver	• Working with partner(s) to establish projects locally that will resonate with passengers. It has been shown that people are more likely to offset their emissions if they can relate to the type and location of an offset project.
Co-benefits	• Some carbon offset projects can have additional benefits, such as reducing indoor smoke (clean cooking stoves in developing countries) or improvements in natural systems (peat restoration). • Promoting offsetting options can overall help increase the environmental awareness of passengers, potentially supporting behaviour change beyond aviation.
Challenges	Carbon offsets (as described above, not carbon removals) should be described as an interim measure, and not the final solution for a net zero aviation industry. If the passenger is to purchase SAF, a related cooperation needs to be established with airlines to ensure the uptake. Ensure there are no overlaps with airline offsetting or SAF purchasing programmes. Obtaining formal verification of local carbon offset projects can be challenging because of the variety of projects and verification systems[49].
Stakeholders	Carbon offset providers Aircraft operators

[49] For further information, see the ACI Airport Carbon Accreditation Offsetting Manual https://www.airportcarbonaccreditation.org/library.html.

Category 5: Negative Emissions Technologies (NETs)

Negative Emissions Technologies are a variety of processes where CO_2 is removed from the atmosphere and stored. These processes may be natural or technological, or a combination of both. It is envisaged some carbon emitting activities/sectors will fully decarbonise by 2050, while others such as aircraft operations, are expected to be reliant on NETs to some extent.

Natural NETs (forestry, agriculture) are less costly than technological ones, closer to deployment but more vulnerable to reversal (e.g. forest protection, risks from fires, etc.) and are limited in availability. There is also a time lag for forests to grow and thus sequester carbon. Examples of natural NETs are:

- Afforestation/reforestation where tree growth takes up CO_2 from the atmosphere.
- Biochar where partly burnt biomass is added to soil and absorbs additional CO_2.
- Soil carbon sequestration where land management changes increase the soil carbon content, resulting in a net removal of CO_2 from the atmosphere.
- Other land-use / wetlands where restoration or construction of high carbon density, anaerobic ecosystems remove CO_2 from the atmosphere.

NETs based on technologies are more costly than natural processes. They require significant R&D and have not been proven at scale, but are less vulnerable to reversal. They include:

- Accelerated weathering where natural minerals react with CO_2 and bind them into new minerals.
- Direct air capture where CO_2 is removed from ambient air and stored underground, such as old oil and gas fields.
- Ocean alkalinity enhancement where alkaline materials are added to the ocean to enhance atmospheric drawdown and negate acidification.
- CO_2 conversion to durable carbon where CO_2 is removed from the atmosphere and bound to long-lived materials.

There is also the potential to combine natural and technological processes.

- Bioenergy with Carbon Capture and Storage (BECCS) where growing plants turn CO_2 into biomass that fuels energy systems; and CO_2 from conversion is stored underground.

Direct air capture can also be used in production of hydrogen and synthetic fuels.

Airports can support further R&D in these and new NETs, as well as the development of associated accounting mechanisms and quality criteria. Ultimately, the deployment of NETs at or in the vicinity of airports can offer the opportunity to not only remove airport operators' but also airline emissions from the atmosphere.

Annex 1 - Glossary

A-CDM	Airport Collaborative Decision Making
AGES-S	ACI World's Airport Ground Energy Systems Simulator
AIP	Aeronautical Information Package
APU	Auxiliary Power Unit
ANSP	Air Navigation Service Provider
ATAG	Air Transport Advisory Group
ATM	Air Traffic Management
BECCS	Bioenergy with Carbon Capture and Storage
CCO	Continuous Climb Operations
CDM	Collaborative Decision Making
CDO	Continuous Descent Operations
CDR	Carbon Dioxide Removal
CEM	Collaborative Environmental Management
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CO_2	Carbon dioxide (carbon)
EASA	European Union Aviation Safety Agency
ETS	Emissions Trading Scheme
EU	European Union
GHG	Greenhouse Gases
ICAO	International Civil Aviation Organisation
SAF	Sustainable Aviation Fuels
SDG	Sustainable Development Goal
SESAR	Single European Sky ATM Research
NDC	Nationally Determined Contribution
NET	Negative Emissions Technologies
NOx	Oxide of Nitrogen
RSG	Royal Schiphol Group
UNFCCC	United Nations Framework Convention on Climate Change

Annex 2 – Checklist of Supporting Measures

Support Area		**Considered?**	**Implemented?**
1	Fleet renewal and retrofit of in-service aircraft		
2	New aircraft propulsion systems and design		
3	Integrated electric taxiing		
4	Reduced engine taxi		
5	Reduced taxi times		
6	Electric taxiing by vehicle		
7	Continuous Descent Operations & Continuous Climb Operations		
8	APU substitution		
9	Sustainable aviation fuel		
10	Air passengers		
11	Carbon removal and storage		

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ACI EUROPE represents over 500 airports in 55 European countries. Our members facilitate over 90% of commercial air traffic in Europe.

In response to the Climate Emergency, in June 2019 our members committed to achieve Net Zero carbon emissions for operations under their control by 2050, without offsetting.

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