Proceedings of the Second Hydrogen Airports Conference

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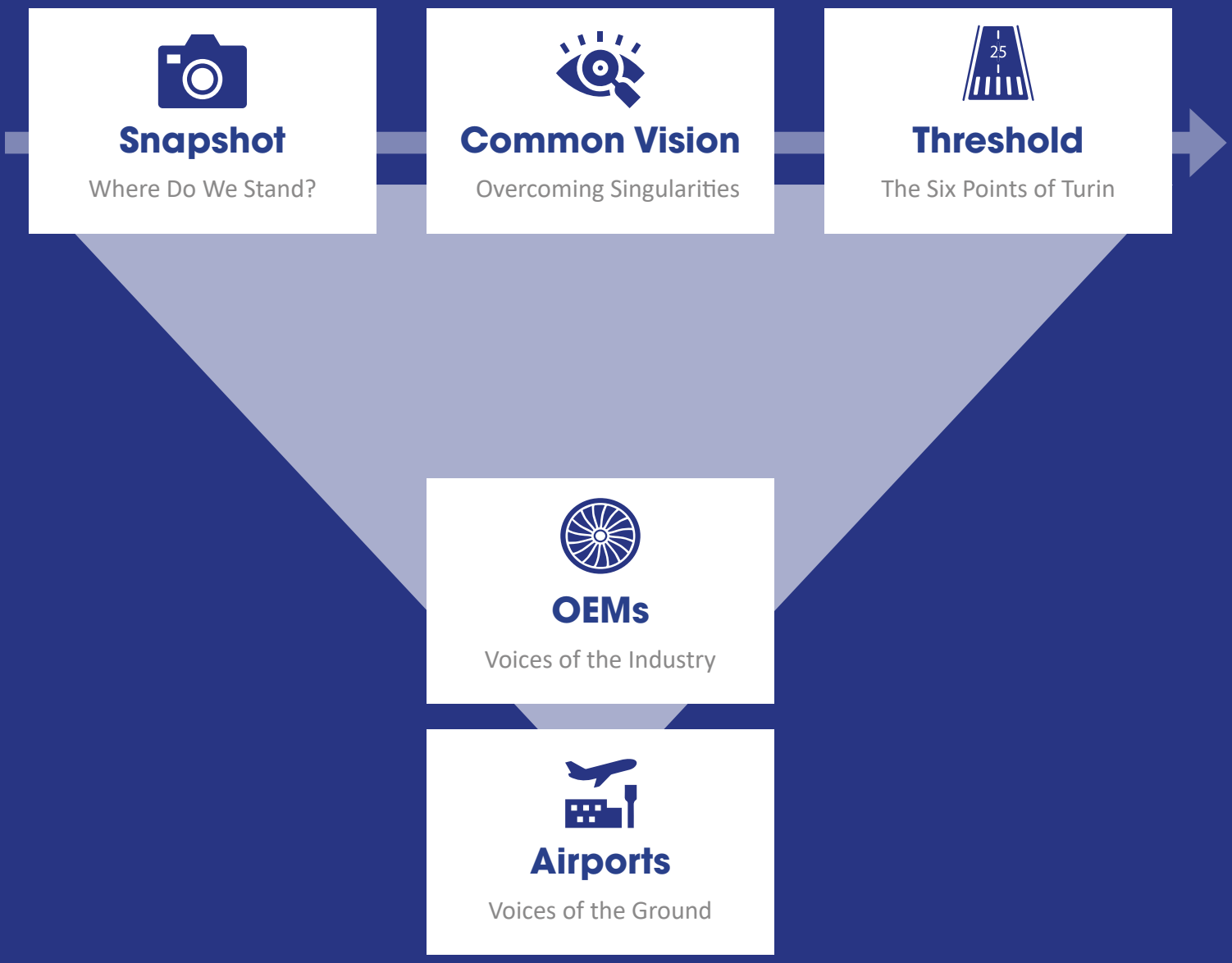
Introduction

Airports across Europe are at the forefront of the aviation clean energy transition, setting ambitious targets to decarbonise their operations and aircraft emissions as part of the broader industry and European Commission goals to reach carbon neutrality by 2050, supported by different interim targets to assess progress. In this context, the advent of a hydrogen-powered aircraft has the capacity to revolutionise air travel by making zero-emission flight a reality.

In pursuit of this goal, key stakeholders convened at the Second Hydrogen Airports Conference (HAC24), held at Turin Airport on 11 October 2024, to review recent achievements, refine a common vision, and chart actionable next steps for integrating hydrogen into airport operations and aviation as a whole.

While the shift away from fossil fuels is a shared imperative among aviation stakeholders, achieving meaningful impact within the short timeframe remains a challenge. Sustainable Aviation Fuel (SAF) is a critical component of this transition but cannot fully meet the demands of a growing aviation sector on its own. SAF's less sustainable environmental footprint and its corresponding non-CO_2 emissions further reduce its appeal. Hydrogen offers a complementary pathway with an equally vital role, particularly in light of the planned introduction of the first production model hydrogen-powered passenger aircraft.

Unlike SAF, hydrogen adoption necessitates substantial changes to airport infrastructure, ground handling operations, regulations, and financing models. These interrelated challenges must be addressed, requiring collaboration across the aviation ecosystem. Considering this, it is of utmost importance that aviation's demand for electricity and hydrogen is integrated into national and European energy strategies to ensure that airports are effectively connected to critical nodes in electric grids and hydrogen distribution networks.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Snapshot

Where are we on the way to 2035?

The First Hydrogen Airports Conference in Brussels in 2023 motivated early innovators to progress towards a shared vision through parallel efforts. The consensus among stakeholders was that it was not too early to begin emphasising the need for small-scale hydrogen implementation in airport operations. This approach aims to build momentum and extract insights from smaller hydrogen airport projects. During the HAC24 at Turin Airport, participants noted that useful small-scale projects had been successfully implemented and demonstrated. Simultaneously, regulatory challenges, financing, and the hydrogen supply chain, particularly the issues of high prices and limited availability of green hydrogen, were identified as the primary barriers to progress. The subsequent chapters will review the questions addressed and perspectives shared at the 2024 Turin conference.

Common Vision

Numerous initiatives and alliances are providing expertise from across the aviation sector, industry, and regulators, united by a common goal: to drive innovation, foster collaboration and competitiveness, and advance significantly towards net-zero aviation by 2050. AZEA is one of the key drivers, addressing all relevant market segments and technologies. The “AZEA Vision” for 2050 is crucial in ensuring EU market readiness for hydrogen aircraft and advancing the realisation of hydrogen flight. However, overarching vision’s realisation is obstructed by several uncertainties and risks. To overcome these challenges, initiatives are following a roadmap-based approach that progresses from conceptual development to fully hydrogen-ready airports. Early collaboration among diverse stakeholder groups, including aviation industry leaders, airport operators, regulatory bodies, and technology providers, has proved essential for the successful integration of hydrogen into airport operations and the achievement of net-zero aviation by 2050. The UK Civil Aviation Authority’s ongoing Hydrogen Sandbox project exemplifies this collaborative effort to incorporate the novel fuel into aviation. The project particularly focuses on aircraft, airports, airlines, and airspace, stipulating regular meetings and collaboration with industry partners to ensure hydrogen regulation is adopted and enacted in a timely manner. Though challenging, the link between the industry and regulators remains important due to their interdependence in developing scalable solutions.

The Role of EU-Funded Airport Projects

Hydrogen's potential to reduce environmental impacts positions it as a strong candidate to replace fossil fuels in energy production. Yet, its precise role in aviation remains undetermined, meaning early implementers are forced to invest in hydrogen applications amid high volatility. Hydrogen-related standards and regulations for airport operations are inadequate, and the limited quantity and high cost of hydrogen hinder the development of competitive business cases. Solving these limiting factors will require stakeholder trials and knowledge-sharing to scale the technology. In this context, external funding from the EU and national sources can accelerate the transition to hydrogen-ready airports by driving small-scale operations, assessing their impact, and sharing the results with all relevant stakeholders. To accelerate the timely implementation of AZEA's vision, projects need to avoid silos by fostering collaboration, regularly exchanging knowledge, and providing consolidated feedback to the industry on the essential insights needed to develop standard practices for hydrogen use in airport operations.


Areas of Responsibility
TULIPS
to70
2nd Hydrogen Airports Conference

Voices of the Industry

BeyondAero

French startup BeyondAero plans to manufacture the first hydrogen-electric business jet, the 'BeyondAero One'. Fuelled by gaseous hydrogen, the inaugural aircraft will seat six passengers at a maximum 1500km range. Per BeyondAero, the company has identified and targeted a market gap, stating that 80% of inner-European business aviation routes are under 1800km. The startup hopes the BeyondAero One's future EASA CS-23 certification will ease limitations, paving the way for 2029 EASA approval and 2030 market entry. While its business-scale powertrain has yet to be developed, the company successfully demonstrated an ultralight hydrogen powertrain during its first fully hydrogen-electric test flight in February 2024. Building on this success, BeyondAero seeks to manufacture and test the full-scale powertrain, thereby overcoming current challenges in positioning gaseous hydrogen tanks and cooling systems on its aircraft. The company projects future growth, aiming to double its workforce to 90 employees by 2025.

The startup's data shows that 90% of European business flights operate from the continent's top 15% business aviation airports. This suggests that if these airports adopt hydrogen infrastructure, 90% of inner-European business aviation routes could be served by the fuel. Consequently, BeyondAero used the 2024 Hydrogen Airports Conference to advocate for airport investment in hydrogen, enabling efficient refuelling for its aircraft once operational. While hydrogen refuelling is technically possible, it remains too time-intensive to be cost-effective, with the startup requiring 700-bar refuelling stations for financial feasibility.

ZeroAvia

Starting in 2026, British-American hydrogen-electric propulsion and fuelling systems manufacturer ZeroAvia plans to fit Cessna Caravan C208B aircraft with gaseous hydrogen powertrains before equipping larger ATR72 aircraft with its "ZA2000" liquid hydrogen counterpart. Concurrently, the company's infrastructure team is building gaseous and liquid hydrogen refuellers in the United Kingdom and the United States, with gaseous hydrogen's introduction preceding that of liquid hydrogen due to the difference in scales of liquid required for the two types of hydrogen operation.

ZeroAvia has invested significant time into meetings with European, UK, and US governments, as well as industry players, to secure funding and deliberate price support mechanisms. In collaboration with Airbus and Canada's three busiest airports – Toronto (YYZ), Vancouver (YVR), and Montreal (YUL) –, the company has been looking into infrastructure and land use requirements alongside techno-economic assessments to make hydrogen accessible at large-scale airports. Ultimately, ZeroAvia hopes to execute a corresponding pilot project at YYZ, YVR, or YUL. In Europe, the manufacturer has voiced interest in partaking in the European Union's Hydrogen Valley projects.

Explanatory Note

While not represented by an official conference speaker, a KLM Royal Dutch Airlines representative also had the opportunity to inform conference participants about the Dutch flag carrier's holistic collaboration with ZeroAvia and the upcoming 2026 KLM-ZeroAvia demonstrator.

Ikigai

Per UK net-zero consultancy group Ikigai, the primary demand for hydrogen infrastructure stems from truck and bus manufacturers and operators, whose cash flows also help advance hydrogen's role in aviation. In the UK, these vehicle manufacturers' efforts resonated with the national government, leading lawmakers to support hydrogen price cuts that resulted in price parity between diesel and hydrogen. Considering these developments, Ikigai is seeking grant support in the months following HAC24 to further hydrogen-sector developments and address the challenge of high upfront costs that result in a lack of scalability in the hydrogen supply chain.

Ikigai's representative clarified that it is challenging to pinpoint specific areas of hydrogen investment as several hydrogen-related projects are running simultaneously. The resulting ambiguity's knock-on effect is evident in the difficulty of assessing and forecasting the timing when investors inject capital. Concomitantly, the consultancy pointed out that while questions about when and where hydrogen investments occur are frequently posed, the critical question of who invests in hydrogen GSE is rarely asked.

Finally, the consultancy has teamed up with Glasgow Airport to run a hydrogen demonstrator after determining previous trials of battery electric infrastructure to be unfeasible due to range and pricing issues. The hydrogen demonstrator is part of a larger effort to support the upscaling of a hydrogen supply chain that includes multimodal trials that ensure the corresponding infrastructure's viability.

EasyJet

UK multinational low-cost carrier EasyJet is working towards a 2050 net-zero carbon emission target and has developed a corresponding roadmap to reach this goal. By partnering with aircraft and engine manufacturers Airbus and Rolls-Royce, the airline wants to play a pivotal role in advancing zero-emission aircraft technologies, focusing on hydrogen. EasyJet was the first airline to join Airbus' zero-E program and hopes its short-to-medium-haul operations will significantly benefit from its active contribution to hydrogen infrastructure development. Moreover, the carrier's collaboration with Airbus allows it to actively shape the aircraft design and hydrogen transition processes. These circumstances also

prompt the airline to collaborate with airports and hydrogen supply chains to ensure alignment with technological advancements and viable investments in hydrogen infrastructure. EasyJet's efforts also help reassure airports that their investments in hydrogen infrastructure will be worthwhile. Ultimately, the airline's conference representative voiced that the catalyst for EasyJet's distinct position as an active zero-E investor lies in its awareness of amassing environmental challenges and, consequently, called for change.

Voices of the Ground

What measures are airports planning to support hydrogen implementation, and how will these measures affect current operations?

Several EU-funded projects are driving the transition to hydrogen-ready airports, bringing AZEA's vision to life and fostering collaboration between airports, OEMs, and industry partners. HAC24 hosted four of these projects, which unite airports and OEMs across Europe: TULIPS, Stargate, GOLIAT, and OLGA.

TULIPS

At Rotterdam-The Hague Airport (RTM), TULIPS has realised an 8.6-kilogram/125-litre liquid hydrogen storage and dispensing facility. This achievement, coupled with reliable liquid hydrogen deliveries from partner company "Air Products" and an approved environmental permit request, has paved the way for small-scale research and development operations at the airport. Securing the permit has also enabled RTM to brief its staff on hydrogen operations and provide additional training for its fire brigade.

In addition to the hydrogen infrastructure requirements for future aircraft, TULIPS has completed part of its demonstrations of hydrogen use for ground operations and energy storage at airports. The project tested the world's first hydrogen-powered ground power unit (hGPU) at Schiphol Airport and installed the first fully operational airside green hydrogen production facility at an Italian airport. The

hydrogen is produced by an electrolyser powered by a local solar power plant and stored in a 30-bar pressurised tank. The hydrogen is used to replace oil/methane in the facility's heating system. Both solutions were demonstrated to conference attendees and are currently being tested for upscaling.

Stargate

In collaboration with German OEM MULAG, logistics company DHL, and fuelling station operator VIL/Waterstofnet, the Stargate consortium tested a hydrogen tow tractor with a 0.1kg hydrogen per kilowatt-hour consumption rate and 8.7-minute refuelling time at Brussels Airport. Their tests concluded that effective hydrogen implementation at airports requires a thorough understanding of several key factors, including how ground handlers will utilise hydrogen, the required energy, power grid specifications, the development and commercial availability of hydrogen GSE, and the evolution of the total cost of hydrogen GSE ownership. Concomitantly, testing also illustrated the need for regulators, OEMs, and airports to find common ground on implementing regulations that satisfy all participating parties. Using Stargate's case as an example, risk reduction mechanisms only permit the hydrogen tow tractor's refuelling during daylight hours, creating dissatisfaction among its operators as this significantly increases its downtime. Additionally, Stargate's representative advocated for the standardisation of hydrogen as a fuel source, as it plays a vital part in ensuring common hydrogen usage and the clean energy transition.

GOLIAT

Consisting of seven airports, the GOLIAT consortium's objectives encompass analysing small-scale liquid hydrogen aircraft ground operations at Lyon St-Exupery (LYS), Stuttgart (STR), and Rotterdam-The Hague (RTM) Airports. Capacitated by a collaboration with German OEM H2FLY, STR will receive its first test planes in 2025, with RTM and LYS following in 2026 and 2027, respectively. Building upon these analyses is the development and demonstration of high-performance liquid hydrogen refuelling equipment and, ultimately, the standardisation of future liquid hydrogen mobile refuelling, storage, and supply, culminating in certified liquid hydrogen refuelling procedures at airports.

OLGA

The hydrogen pilot project at Milan Malpensa Airport (MXP), part of the OLGA project, has faced significant challenges due to evolving market conditions since its official launch in 2021. Rising costs, limited availability of hydrogen-powered vehicles, and an overestimated demand have necessitated a reassessment of the initial plan.

SEA has recently assumed responsibility for implementing green hydrogen production, demonstrating its commitment to hydrogen as a critical energy carrier for aviation. Consequently, the project has been revised to emphasise flexibility and scalability.

Instead of the initially planned 700kW electrolyser, SEA will deploy a modular system with a capacity of 500kW, offering extended operating hours and the ability to scale production as demand grows. This modular approach is based on insights from the Sustainable Aviation Vectors for Energy Transition (SAVES) project, which supports airport decarbonisation. The project is promoted and coordinated by the Italian Civil Aviation Authority (ENAC), with technical support from the National Agency for New Technologies, Energy, and Sustainable Economic Development (ENEA).

This new strategy ensures the feasibility of the 15-month pilot phase while aligning with current market realities. The project's revised approach emphasizes scalability, replicability, and adaptability, positioning SEA to meet future hydrogen demands effectively.

Avinor Airports

Norway's government-owned airport operator Avinor has delineated SAF as well as electric and hydrogen flight as its three focus areas for future development. Avinor will receive regulatory and financial support from the Norwegian government, which is providing a total NOK 1 billion/EUR ~84.5 million to support the aviation sector's transition to zero-emission operations and regulatory facilitation through its subordinate civil aviation authority.

Focusing on hydrogen, Avinor's representative highlighted the necessity for collaboration with stakeholders to assess spatial and market needs for hydrogen storage and infrastructure. The country's climatic conditions further require the

airport operator to account for winter weather impacts on hydrogen logistics. As part of the assessment process, a test arena covering all domestic Avinor airports will be established, providing information and a foundation for an anticipated upscaling of hydrogen technology. Given that investment strategies regarding renewable power and hydrogen production are currently on the front burner and the former's importance in the production of green hydrogen, Avinor needs to vocalise its renewable energy and hydrogen needs to reassure the market of green hydrogen's viability.

SEA Milan Airports

Per SEA Milan Airports' representative, MXP anticipates 10 to 12 daily hydrogen-operated flight movements accommodating up to 100 passengers each by 2040. Furthermore, the airport expects to be fully hydrogen-ready by 2043. SEA is vehement in its belief that investing in hydrogen infrastructure is worthwhile, declaring that building a hydrogen refuelling station pays off if as little as two percent of a 1000-unit strong GSE fleet runs on hydrogen. MXP's current deliberation on whether to build a 15-kilometer hydrogen pipeline is symbolic of the initiative the airport is taking to develop hydrogen infrastructure. Still, SEA Milan Airports points out the significance of regulators and hydrogen-transition stakeholders collaborating to create a roadmap that secures the provision of sufficient infrastructure financing.

Hamburg Airport

In cooperation with Lufthansa Technik, Hamburg Airport has been running practical tests on a decommissioned Lufthansa Airbus A320 refitted with hydrogen fuel cells. Echoing his fellow airport representatives, Hamburg Airport's speaker highlighted the regulatory hurdles and tedious application processes the airport had to negotiate to get the green light on hydrogen testing and equipment utilization. While the airport's apron is currently certified for 300 kilograms of liquid hydrogen usage, precautionary measures, including additional fencing around the airport's liquid hydrogen ground power unit (hGPU), have been imposed by German authorities to ensure operations comply with the governing regulations. Concurrently, Hamburg Airport's representative emphasised the relevance of communication between OEMs and airport operators, as the airport relies on OEM data to develop its hydrogen infrastructure.

KLM Equipment Services (KES) and Royal Schiphol Group

KES and Schiphol Airport have been collaborating to develop sustainable GSE operations at the Netherlands' busiest airport. Commencing with electric-GPU (eGPU) tests, the partners identified several challenges they would need to overcome, ranging from a congested grid to limited resources, widebody aircraft power supply issues, and fleet management challenges, as the performance of two eGPUs approximately equals that of a single diesel GPU. Exploring alternatives, KES and Schiphol have rented and operated a hydrogen trailer with a 900-kilogram green hydrogen capacity and an 11-minute total refueling time. A total 99 incident-free turnarounds were completed using a TULIPS-developed hydrogen GPU (hGPU) by the time of HAC24, curtailing GSE-caused CO_2 emissions by 50 to 60 kilograms[1].

F2i

Italy's biggest independent infrastructure fund manager, F2i, is vital in supporting several Italian airports' relations with the government and financial institutions. Moreover, the fund manager deems its continuous investments in airport infrastructure as both unprecedented, given ESG/sustainable finance frameworks, and essential to ensure readiness for value creation by 2040. A challenge remains in convincing investors, who must declare sustainability and ESG objectives per Art. 8 of the EU's Sustainable Finance Disclosure Regulation, to allocate funds to sustainable airport development despite a forecasted increase in aviation demand.

[1] Royal Schiphol Group's diesel GSE operates on biodiesel, effectively cutting CO_2 emissions by 90% compared to conventional diesel-operated GSE. Therefore, the airport's biodiesel operations are used as the reference point for comparison.

Demonstrating a Hydrogen Reality

The conference culminated in a demonstration of the innovative use of hydrogen in airport operations. Participants were able to inspect the world‘s first operational hGPU as well as Italy‘s first airside green hydrogen production facility.

Following the successful trial at Schiphol, the viability of the hGPU will be further demonstrated through trials at different types of airports before final conclusions and guidelines are issued in 2025. The hGPU presented serves as a working prototype that confirms the technical feasibility of the unit. This is a crucial milestone as airports in the TEN-T network must fully decarbonise the ground power supply of stationary aircraft by 2030 at the latest. With this innovation, European airports now have a third option in addition to extending grid connections with static converters and using eGPUs. This has the potential to bridge the gap for a minority of airports where neither option is feasible. In addition to the technical aspects, a regulatory framework was developed, and a risk and safety assessment was carried out. In addition to testing the actual turnaround, TULIPS also tested different types of refuelling procedures, with corresponding guidelines for local operators under development. A final event to jointly demonstrate the hGPU, a hydrogen tow tractor, and a mobile refuelling station will take place at Schiphol Airport in autumn 2025.

Meanwhile the hydrogen production plant will facilitate the study of interactions between key smart grid components, including a photovoltaic system, storage systems (batteries and an electrolyser with hydrogen storage), a fuel cell capable of operating on methane and hydrogen, the electrical grid, and the fire station’s energy requirements.

Although the photovoltaic system's annual energy output could theoretically meet the building's needs, variations in daily and seasonal distribution prevent full utilisation. The pilot plant aims to optimise the use of renewable energy by storing surplus energy in batteries or converting it into hydrogen to power the fuel cell, thereby decoupling renewable energy production from consumption. The fuel cell will operate in combined heat and power (CHP) mode, supplying electricity and heat in the form of hot water.

The green hydrogen production site will undergo a testing and evaluation period to assess its potential for upscaling to meet the heating demands of larger airport sections, providing insights for future energy scenarios. Additionally, this project includes a study on regulatory frameworks and safety requirements, the findings of which could pave the way for the use of hydrogen on the airside.

Threshold - The Six Points of Turin

No Unique Strategy

The simultaneous pursuit of multiple projects enables the development of diverse hydrogen strategies, which should be leveraged to form a hydrogen alliance. This alliance would encompass different sustainability pathways and foster synergies between them.

Collaboration and Knowledge-Sharing

HAC24 speakers/representatives expressed the need for more collaboration and knowledge-sharing. While regulators were urged to facilitate, OEMs and airport operators were encouraged to engage with them to accelerate the deployment of sustainable GPU and aircraft. OEMs should share data and collaborate to mitigate risks and create business opportunities for hydrogen as a standard fuel.

Start Small Grow Big

The modest size of the hydrogen projects can be deceptive when viewed independently. However, their impact is cumulative, accelerating the scientific understanding that provides the evidence base for hydrogen infrastructure development and funding. This approach allows stakeholders to overcome barriers to deployment and make hydrogen mainstream for airport and aircraft operations.

Work in Parallel

Several HAC24 parties are working on hydrogen-related projects in parallel – a welcome development, as parallel efforts drive competitiveness in innovation and pricing and stimulate scientific progress, making the hydrogen market more lucrative for all participants.

External Funding

HAC24 highlighted the need for external funding to reduce the risks associated with the introduction of hydrogen into airport operations. Without a regulatory framework, OEMs and airport operators are reluctant to invest. Yet, regulators rely on reliable data to provide said framework. External funding helps bridge the gap between the parties by providing the financial incentive for OEMs to collect and produce data for regulators. European Union funding is important, as research strategies align with policy ambitions. Airports themselves must also take a proactive role by investing in hydrogen infrastructure and technology. Moreover, interaction between mainland European and UK markets is essential.

Mapping the Path to Hydrogen Adoption

Currently, hydrogen is too expensive to be a viable fuel source for airports and aircraft. However, HAC24 speakers predict that forthcoming regulations and investments will drive hydrogen fuel costs below €4 per kilogram. Additionally, advancements in technology are expected to boost confidence in the safety of hydrogen. Stakeholders are ready to develop hydrogen infrastructure as the basic conditions are already in place. OEMs, airport operators, and regulators must continue to find common ground so market players can build a financially viable hydrogen infrastructure in aviation.

Outlook / Next Conference

The process of collaboration and knowledge-sharing on hydrogen airports will continue in the coming years. The Third Hydrogen Airports Conference, featuring stakeholders from across the value chain, is scheduled for Q4 2025.

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