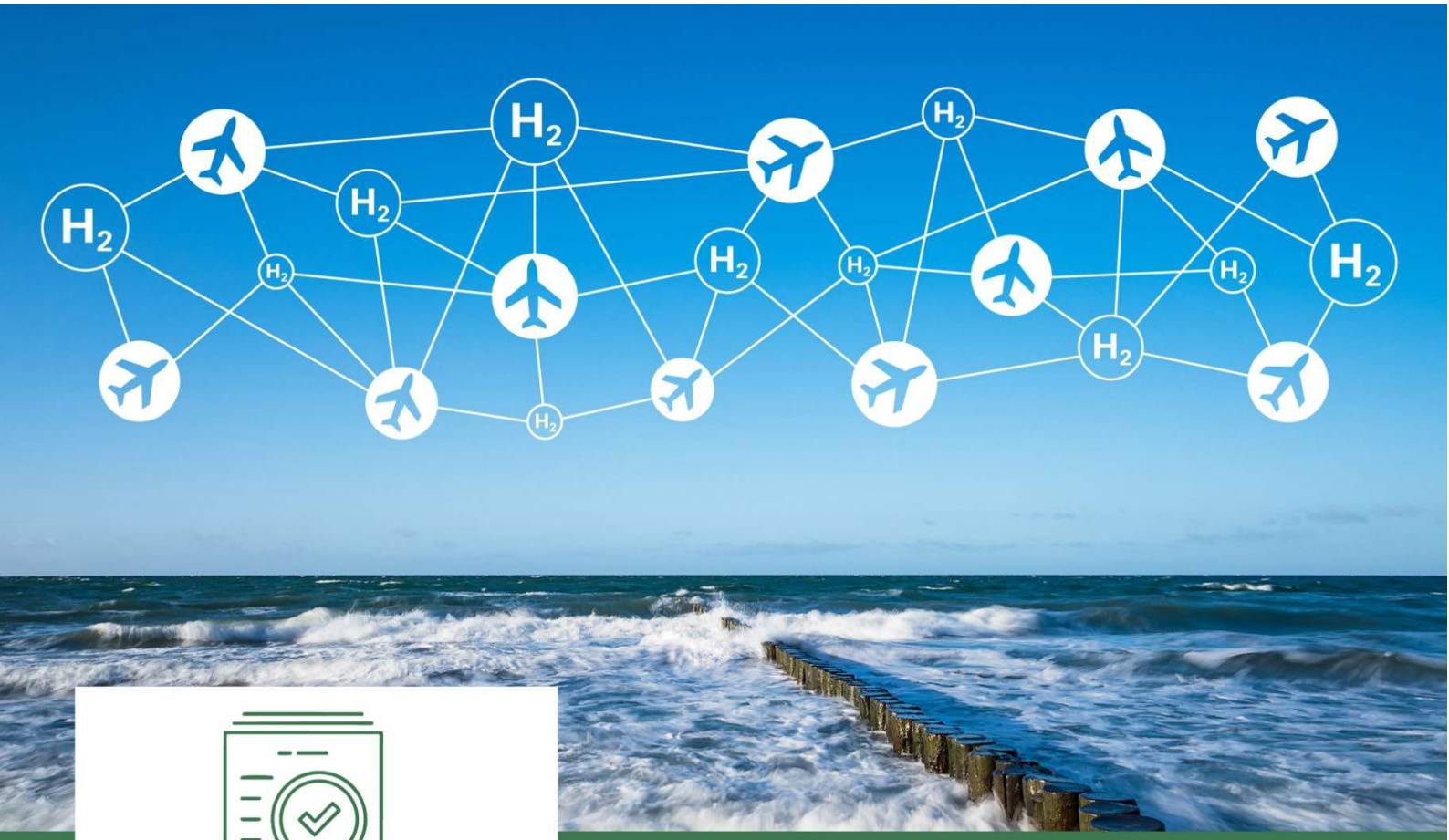
Interreg Baltic Sea Region

Co-funded by the European Union

SMART GREEN MOBILITY
BSR HyAirport

Summary report



Summary Report BSR HyAirport project

The project is a transnational cooperation under the Interreg Baltic Sea Region Programme aiming to prepare airports for storing, handling and delivering green hydrogen for aviation and airport operations.

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List of Abbreviations

BSR	Baltic Sea Region
LH2	Liquid hydrogen
GH2	Gaseous hydrogen
GSE	Ground support equipment
SAF	Sustainable Aviation Fuels
PEM	Proton Exchange Membrane
CHP	Combined Heat and Power
MEGC	Multiple Element Gas Container
ICE	Internal combustion engine

Executive Summary

The transition to climate-neutral aviation requires not only new aircraft technologies but also timely preparation by airports, infrastructure operators, fuel suppliers, airlines, and government agencies. While hydrogen is regarded as one of the most promising energy carriers for the decarbonisation of regional and short-haul aviation, its successful deployment depends on the coordinated development of aircraft, infrastructure, regulations and operational procedures. One of the key challenges is aligning the development of hydrogen aircraft with the preparation of the supporting airport ecosystem. The BSR HyAirport project was established to support this early preparation and to help create the conditions necessary for the future deployment of hydrogen-powered aviation and airport operations.

Implemented under the Interreg Baltic Sea Region Programme from November 2023 to October 2026, the project brought together airports, airlines, hydrogen stakeholders, research institutions, industry partners and public authorities from across the regions around the Baltic Sea. The overall objective was to create the technical, operational, regulatory and economic foundations necessary for the safe and efficient integration of hydrogen into airport environments and future aviation systems. Rather than focusing solely on theoretical concepts, the project aimed to generate practical readiness through the development, testing and validation of real-world solutions.

While numerous hydrogen-related initiatives, studies and pilot projects have already been carried out in recent years, many of them have addressed similar initial questions regarding infrastructure, safety, operations, supply chains and business cases. BSR HyAirport aimed to consolidate these findings, structure existing knowledge, identify remaining gaps and transform the results into practical methodologies, tools and guidance. In this way, the project sought to create a common starting point that future airports and stakeholders can build upon. The project reviewed the current landscape of standards and guidelines, identified existing gaps and areas of uncertainty, and translated fragmented information into practical methodologies and implementation approaches.

The project followed a structured approach consisting of three complementary work packages. In Work Package 1, partners analysed legal, regulatory and safety requirements, assessed hydrogen demand scenarios, developed airport supply chain concepts, investigated storage and refuelling solutions, prepared operational procedures for hydrogen-powered aircraft, and created methodologies for business case evaluation. Building on these foundations, Work Package 2 focused on piloting and evaluating hydrogen solutions under real operational conditions. Demonstration activities addressed different parts of the airport hydrogen ecosystem, including hydrogen-powered ground support equipment, hydrogen production and supply concepts, aircraft handling procedures and supporting infrastructure.

The pilot activities were not conducted as stand-alone demonstrations. Instead, they served as a mechanism for validating and refining the concepts, methodologies and assumptions developed during the analytical phase of the project. This combination of gap analysis, methodological development and real-life testing enabled the partnership to evaluate the practical applicability of proposed solutions, identify implementation barriers and generate evidence-based recommendations for future deployments. The pilots generated valuable operational experience, enabled the validation of assumptions developed during the analytical phase and provided evidence on technical feasibility, safety requirements and implementation challenges. Through these demonstrations, the project moved beyond theoretical preparedness towards practical implementation.

Work Package 3 concentrated on transferring project results to stakeholders throughout the Baltic Sea Region and beyond. The project disseminated methodologies, pilot results, business case approaches, operational concepts and lessons learned to airports, authorities, infrastructure providers, hydrogen suppliers and aviation

stakeholders. As a result, the project created not only individual pilot solutions but also a transferable framework that can support future hydrogen projects across different airport environments. Airports, authorities and industry stakeholders can build on the methodologies, guidance and lessons learned generated within BSR HyAirport, thereby accelerating implementation processes and avoiding duplication of effort.

The project demonstrated that the transition towards hydrogen-powered aviation must be viewed as a gradual process. Initial hydrogen applications at airports can already contribute to reducing emissions from ground operations while simultaneously building competencies, operational experience and stakeholder confidence. The lessons learned confirm that early preparation is essential, as infrastructure planning, safety approvals, organisational adaptation and investment decisions require long lead times.

Through its transnational partnership and collaborative approach, the project strengthened cooperation across the aviation and hydrogen value chains and contributed to establishing a common understanding of future hydrogen aviation requirements in the Baltic Sea Region. Beyond the technical outputs and pilot activities, one of the project's key achievements was the creation of a strong network connecting airports, airlines, hydrogen suppliers, technology providers, research organisations and public authorities. The project created opportunities for partners to learn directly from each other's experiences, exchange practical solutions and jointly address challenges. By bringing together stakeholders with different perspectives and levels of experience, BSR HyAirport facilitated the transfer of knowledge between regions, reduced duplication of effort and accelerated organisational learning across the partnership. The communication channels and cooperation mechanisms established during the project provide a valuable foundation for future initiatives, investments and implementation projects beyond the project lifetime.

The project further demonstrated that airports can play a particularly important role in accelerating the development of the hydrogen aviation ecosystem. By focusing on the early-use cases, airports can begin building hydrogen demand, operational experience and infrastructure long before larger commercial hydrogen aircraft enter service. This not only supports airport decarbonisation objectives but can also represent a strategically and economically sound investment by positioning airports within emerging regional hydrogen supply chains and energy ecosystems. Early airport deployments can help create the initial market demand needed to stimulate investments in hydrogen production, transport and distribution infrastructure. In this way, airports have the potential to act as catalysts for market development, helping to trigger the broader adoption of hydrogen technologies across the aviation sector and setting in motion the wider transition towards hydrogen-powered aviation.

The project resulting knowledge, tested solutions and stakeholder network provide an important basis for future investments and further implementation activities, supporting the long-term transition towards climate-neutral aviation and sustainable regional connectivity. Continued cooperation between the project partners and associated organisations will help ensure that the experiences gained within BSR HyAirport can be further developed, scaled up and transferred to airports and regions across the Baltic Sea Region and beyond.

1. Project Background and Strategic Context

1.1 Aviation and climate-neutral mobility in the Baltic Sea Region

Efficient and reliable air transport is an essential prerequisite for economic development, regional cohesion and cross-border connectivity in the Baltic Sea Region (BSR). Due to the region's geographical structure, characterised by long distances, peripheral areas, island regions and numerous cross-border economic linkages, aviation plays a critical role in maintaining accessibility for citizens and businesses. Many regional and short-haul connections are vital for social and economic integration within the region.

At the same time, the aviation sector faces increasing pressure to contribute to European climate objectives and the transition towards climate-neutral mobility. While improvements in aircraft efficiency and the increasing use of Sustainable Aviation Fuels (SAF) are expected to reduce emissions, additional technological innovations will be required to achieve long-term decarbonisation targets. Hydrogen has emerged as one of the most promising options for reducing greenhouse gas emissions in aviation, particularly for regional and short-haul operations that are highly relevant for the Baltic Sea Region.

Beyond its potential use as an aviation fuel, hydrogen can also contribute to the decarbonisation of airport operations. Applications include hydrogen-powered ground support equipment, service vehicles, backup energy systems and other airport infrastructure. Consequently, hydrogen is increasingly viewed as an important component of future airport energy ecosystems and sustainable mobility strategies.

The transformation towards hydrogen-powered aviation therefore represents not only a technological challenge but also a strategic opportunity for airports and regions to strengthen their contribution to climate-neutral transport while maintaining connectivity and competitiveness, as well as form an energy hub within the region.

1.2 Why airports need to prepare early

The introduction of hydrogen-powered aviation will require significant changes to airport infrastructure, operational processes and safety management systems. Unlike conventional aviation fuels, hydrogen requires dedicated solutions for production, transportation, storage, handling and refuelling. Airports will therefore play a central role in enabling the future hydrogen aviation ecosystem and will be the link between production and consumer.

Preparing for hydrogen deployment is a long-term process involving technical, organisational, economic and regulatory challenges. New infrastructure must be planned and approved, safety procedures need to be developed, personnel require specialised training, and operational concepts must be validated before regular hydrogen operations can commence. Many of these activities require extensive stakeholder involvement and lengthy approval procedures, meaning that preparation needs to start well before hydrogen-powered aircraft enter commercial service.

Furthermore, airports must gain practical experience with hydrogen technologies to understand operational implications, infrastructure requirements and safety considerations. Pilot projects and demonstration activities provide valuable opportunities to test solutions under controlled conditions, identify barriers and develop organisational readiness. Such experiences are essential for reducing uncertainty and supporting future investment decisions. Airports in this case can play a crucial role in providing a safe and enclosed environment for demonstrating new products and services.

Hydrogen deployment is expected to occur progressively. Initial applications are likely to focus on airport ground operations and hydrogen-powered airport equipment, followed by more advanced storage and supply concepts and, ultimately, the servicing of hydrogen-powered aircraft. Early preparation enables airports to follow this evolutionary pathway and develop the necessary competencies and infrastructure step by step.

1.3 Project rationale

The transition towards hydrogen-powered aviation is characterised by a fundamental coordination challenge. The successful introduction of hydrogen aircraft depends on the availability of hydrogen infrastructure at airports, while airports are hesitant to invest in such infrastructure before enough hydrogen-powered aircraft are commercially available. Similarly, airlines require confidence that airports can provide reliable hydrogen services before committing to new aircraft technologies, and hydrogen suppliers need predictable demand before investing in production and distribution capacities. Consequently, aircraft manufacturers, airlines, airports, hydrogen suppliers, infrastructure operators and regulatory authorities must progress in parallel to enable the emergence of a viable hydrogen aviation ecosystem.

This challenge is particularly relevant in the Baltic Sea Region, where many airports operate regional and short-haul routes that are considered promising early markets for hydrogen-powered aviation. However, significant uncertainties remain regarding infrastructure requirements, operational procedures, safety regulations, economic feasibility and supply chain organisation. Without practical experience and coordinated planning, these uncertainties may delay investment decisions and hinder the deployment of hydrogen technologies.

BSR HyAirport was initiated to address these challenges through a collaborative and transnational approach. Rather than focusing solely on technological development, the project sought to prepare airports and stakeholders for the practical implementation of hydrogen-based aviation solutions. The project recognised that airports must begin planning and testing infrastructure concepts well before hydrogen-powered aircraft enter regular commercial service and start discussions with both producing companies for Aircrafts and Infrastructure as well as Airlines and permitting authorities. At the same time, regulators, industry partners and hydrogen suppliers need practical evidence and validated concepts to support future decision-making and standardisation efforts.

To overcome these barriers, the project focused on developing and validating practical solutions for the regional supply, storage, handling and refuelling of green hydrogen at airports. The project combined analytical work on legal, safety, operational and economic aspects with pilot and demonstration activities under real-world conditions. Through this approach, BSR HyAirport aimed to reduce uncertainty, generate operational experience and create transferable knowledge that can support airports across the Baltic Sea Region in preparing for future hydrogen operations.

The project therefore served as an important enabling step towards hydrogen-powered aviation. By bringing together airports, industry representatives, technology providers, research organisations and public authorities, BSR HyAirport established a platform for the joint development, implementation and testing of hydrogen solutions. This collaborative approach was intended to accelerate preparedness across the aviation value chain and create the conditions necessary for the future deployment of hydrogen-powered aircraft and airport applications throughout the Baltic Sea Region.

2. Project objectives

2.1 Overall objective

The overall objective of the BSR HyAirport project was to prepare airports in the Baltic Sea Region for the future integration of green hydrogen as an energy carrier for aviation and airport operations. The project aimed to establish the technical, operational, regulatory and economic foundations required for the introduction of hydrogen-powered aircraft and hydrogen-based airport applications.

Recognising that hydrogen aviation will require significant changes to airport infrastructure, safety procedures, supply chains and operational processes, the project focused on building practical readiness rather than solely conducting theoretical research. Through transnational cooperation, BSR HyAirport sought to provide airports and stakeholders with the knowledge, methodologies and practical experience needed to support the safe and efficient deployment of hydrogen technologies in the aviation sector. https://interreg-baltic.eu/project/bsr-hyairport/

2.2 Specific objectives

To achieve its overall objective, BSR HyAirport pursued a set of specific objectives covering the entire hydrogen aviation ecosystem.

Objective 1: Assess Legal, Regulatory and Safety Requirements

To identify and analyse the legal, regulatory and safety frameworks relevant to the production, transportation, storage, handling and use of hydrogen at airports. The project aimed to identify existing requirements, highlight regulatory gaps and provide guidance for the implementation of hydrogen-related airport activities.

Objective 2: Evaluate Airport Hydrogen Supply Chain Concepts

To evaluate and develop practical concepts for supplying airports with green hydrogen based on local demand and regional conditions. This included analysing hydrogen demand scenarios, assessing local production opportunities, investigating storage solutions and evaluating transportation options for different airport contexts.

Objective 3: Prepare Airports for Hydrogen Aircraft Operations

To develop operational concepts and procedures for handling and servicing hydrogen-powered aircraft. The objective included analysing airport processes, defining refuelling concepts, assessing safety requirements and identifying operational measures necessary for integrating hydrogen-powered aircraft into airport environments.

Objective 4: Develop and Test Hydrogen-Powered Airport Applications

To assess, pilot and evaluate hydrogen-powered airport equipment and associated infrastructure under real operational conditions. Through practical demonstrations, the project aimed to validate technical feasibility, operational performance, safety aspects and infrastructure requirements for hydrogen applications at airports.

Objective 5: Evaluate Economic Feasibility and Business Cases

To develop tools and methodologies supporting airport decision-makers in evaluating the economic viability of hydrogen adoption. This included analysing investment requirements, operating costs, infrastructure needs and future hydrogen demand scenarios to support strategic planning and investment decisions.

Objective 6: Pilot, Validate and Refine Solutions

To test and evaluate developed concepts through pilot activities at partner airports and related demonstration sites. The objective was to generate practical experience, validate assumptions, identify implementation challenges and refine proposed solutions under real-world conditions.

Objective 7: Transfer Knowledge and Support Wider Adoption

To ensure that project results, methodologies and lessons learned can be transferred to airports, authorities, infrastructure providers and other stakeholders across the Baltic Sea Region and beyond. Through communication, capacity-building and stakeholder engagement activities, the project aimed to facilitate the broader uptake of hydrogen solutions in aviation.

Objective 8: Strengthen Transnational Cooperation on Hydrogen Aviation

To establish a collaborative platform bringing together airports, industry, technology providers, public authorities and research institutions for the joint development, implementation and testing of hydrogen solutions. Through this cooperation, the project aimed to address shared challenges and accelerate the transition towards hydrogen-powered aviation across the Baltic Sea Region.

3. Project Partnership and Target Groups

3.1 Project partners

BSR HyAirport was implemented through a transnational partnership bringing together airports, research organisations, industry partners and hydrogen stakeholders from across the Baltic Sea Region.

The project involved partners from seven Baltic Sea Region countries: Germany, Poland, Lithuania, Latvia, Estonia, Finland and Sweden. Under the leadership of Hamburg Airport as Lead Partner, the consortium combined expertise from airport operations, infrastructure development, hydrogen technologies, mobility solutions, research and innovation. This broad partnership ensured that technical, operational, safety-related and regulatory aspects of hydrogen implementation could be addressed from multiple perspectives.

A particular strength of the project was the participation of airports with different operational profiles, ranging from international to regional airports. This enabled the project to assess hydrogen-related challenges and opportunities under diverse operational conditions and ensured that the developed solutions would be relevant for a broad range of airport environments. The partnership further included organisations representing the hydrogen sector, research institutions and specialised service providers. Their expertise supported the development of methodologies, technical concepts, pilot activities and business case



Figure 1.: Project Partners

evaluations. Through this collaboration, the project was able to combine practical airport experience with scientific knowledge and technological innovation.

The transnational character of the partnership was essential because future hydrogen aviation will require coordinated action across national borders, involving common standards, compatible infrastructure concepts and shared operational practices. BSR HyAirport therefore served not only as a development project but also as a platform for regional cooperation and knowledge exchange.

3.2 Associated Organisations

In addition to the core project partnership, BSR HyAirport was supported by a broad network of associated organisations representing stakeholders from across the aviation and hydrogen value chains. The project involved 24 associated organisations that contributed expertise, operational experience and strategic perspectives throughout the project implementation.

These organisations included airports, aviation stakeholders, public authorities, industry representatives, hydrogen suppliers, NGOs, research institutions, business associations and other actors relevant to the future deployment of hydrogen technologies in aviation. Their participation helped to ensure that project activities remained aligned with practical market needs and emerging regulatory developments.

Associated organisations played an important role in validating the project output, providing feedback on developed concepts and supporting the transfer of project results into professional networks. They also contributed to stakeholder engagement activities, workshops, conferences and pilot demonstrations, thereby strengthening the practical relevance and transferability of the project outcomes.

The active involvement of associated organisations enabled the project to reach a wider audience beyond the formal partnership and helped establish a strong foundation for the long-term use and further development of the project results after the end of the funding period.

United Kingdom	Belgium	The Netherlands	Denmark	Sweden	Finland
ZeroAvia Inc.	Airports Regions Council	Groningen Airport Rotterdam Airport	Everfuel A/S	Swedish Transport Administration	▪ Ministry of Transport and Communication ▪ VITERA OY

Estonia	Latvia	Poland	Germany
▪ Estonian Aviation Academy ▪ Estonian Association of Hydrogen Technologies ▪ Estonian Aviation Cluster ▪ Estonian Transport Administration ▪ University of Tartu ▪ Diamond Sky ▪ Regional Jet OÜ ▪ Estonian Air Navigation Services	▪ Liepaja Airport ▪ Ministry of Transport Republic of Latvia ▪ Civil Aviation Agency ▪ Ministry of Environmental Protection and Regional Development ▪ Air Baltic Corporation AS ▪ Fokker Next Gen Latvia	▪ Wielkopolska Hydrogen Platform ▪ ORLEN	▪ Ministry of Economic Affairs, Transport, Employment, Technology and Tourism Schleswig-Holstein ▪ Hamburg Aviation ▪ Ministry of Economy and Innovation, Hamburg ▪ ZAL Center of Applied Aeronautical Research

3.3 Target groups

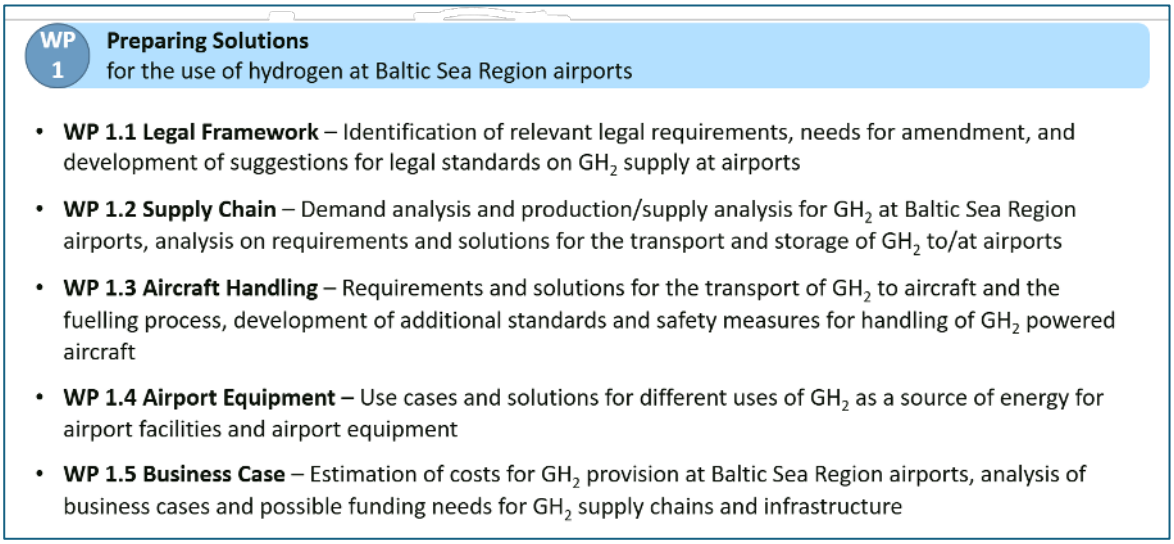
	Target group
1	**Infrastructure and public service provider** Airports and other entities involved in the supply of Hydrogen for air transport or other use cases at airports.
2	**National public authority** Public owner of airports, authorities responsible for air transport / airport operations, authorities responsible for environment protection.
3	**Regional public authority** Public owner of airports, authorities responsible for air transport / airport operations, authorities responsible for environment protection
4	**Interest groups** Environment protection interest groups, airport neighborhood interest groups, interest groups for airport development.
5	**SMEs** Technology and energy/hydrogen supplier

4. Project structure and methodology

4.1 Three-phase project logic



4.2 Work Package overview



WP 2 Piloting and Evaluating Solutions
for the use of hydrogen at Baltic Sea Region airports

- **WP 2.1 Supply Chain** – Piloting proposed GH_2 supply chain logistics to selected Baltic Sea Region airports and testing on-site storage solutions for GH_2 at airports
- **WP 2.2 Aircraft Handling** – Testing and evaluating concepts on handling of GH_2 powered aircraft and proposed processes for aircraft refuelling at Baltic Sea Region airports including demonstration flights on routes of scheduled air transport
- **WP 2.3 Airport Equipment** – Piloting and assessing proposed solutions for GH_2 powered ground equipment at Baltic Sea Region airports
- **WP 2.4 Business Case** – Reviewing and amending the business case concepts based on findings of pilots and tests on GH_2 uses at Baltic Sea Region airports

WP 3 Transferring Solutions
for the use of hydrogen at Baltic Sea Region airports

- **WP 3.1 Communication** – Communicating and transferring ready solutions to target groups both inside and outside of the partnership and encouraging use by target groups
- **WP 3.2 Durability Plan** – Elaborating further use of project results by project partners and planning of activities to keep solutions functional beyond project duration

4.3 Methodological approach

BSR HyAirport followed an integrated and iterative methodological approach combining analytical research, technical assessment, pilot implementation and stakeholder engagement. The objective was not only to investigate the future use of hydrogen in aviation theoretically, but also to develop and validate practical solutions that can be transferred to airports across the Baltic Sea Region. The methodology therefore combined conceptual work in Work Package 1, practical piloting activities in Work Package 2, and dissemination and transfer activities in Work Package 3.

The project started with extensive literature reviews, regulatory assessments and expert consultations to identify existing knowledge, technological developments and regulatory requirements related to hydrogen aviation. These activities formed the basis for the legal assessments, supply chain analyses, aircraft handling concepts, airport equipment studies and business case methodologies developed in WP1. The cooperation with other European Projects like TULIPS, OLGA and Stargate proved fundamentally helpful.

A central element of the methodological framework was the collection and analysis of operational data from project partner airports, airlines and technology providers. This information was used to establish airport-specific and regional baseline conditions and to support the development of transferable methodologies. Within the Supply Chain work package, for example, hydrogen demand assessments were developed using operational fleet data, airport characteristics and traffic information rather than relying solely on generic market forecasts.

The project applied scenario-based modelling approaches to address the uncertainties associated with the deployment of hydrogen technologies in aviation. Different market uptake, technology adoption and infrastructure development scenarios were analysed to estimate future hydrogen demand, infrastructure

requirements, production capacities and transport needs. This approach allowed project partners to evaluate a range of possible development pathways rather than relying on a single forecast.

Technical assessments were subsequently conducted to translate demand estimates into practical infrastructure concepts. These analyses considered local hydrogen production, storage requirements, transport options, handling procedures, airport equipment applications and operational safety aspects. Cost and business case methodologies were developed in parallel in order to evaluate the economic implications of different hydrogen deployment pathways.

The conceptual work was complemented by real-world pilot activities implemented at several partner airports. The pilot projects tested hydrogen-powered airport equipment, supply chain solutions and operational procedures under real airport conditions. These demonstrations provided practical experience, generated operational data and allowed project partners to verify assumptions developed during the analytical phase. Pilot results were subsequently evaluated and fed back into the overall project methodology, creating a continuous learning process between analysis and implementation.

Finally, stakeholder involvement was integrated throughout the project. Airports, airlines, technology suppliers, research institutes, regulators and public authorities contributed expertise, reviewed results and participated in dissemination activities. This ensured that the project output reflects both technical requirements and practical implementation needs while supporting the future transferability and durability of the developed solutions.

In summary, the BSR HyAirport methodology combined:

- literature and regulatory analysis
- partner data collection
- demand and scenario modelling
- technical infrastructure assessments
- business case evaluations
- pilot planning and implementation
- real-world demonstrations
- evaluation and validation of results
- stakeholder engagement and knowledge transfer

Together, these elements created a comprehensive methodological framework capable of supporting both strategic planning and practical implementation of hydrogen solutions at airports.

5. Results of WP 1 – Preparing solutions

5.1 Legal Framework

Within the BSR HyAirport project, the Legal Framework Work Package delivered a comprehensive assessment of the regulatory conditions required for the deployment of gaseous hydrogen in airport environments. The work consisted of an assessment of the European Union legal framework and a comparative review of the national legal frameworks of eight Baltic Sea Region countries. Together, these studies examined the legal requirements and barriers related to hydrogen production, storage, transportation, refuelling infrastructure, airport operations, and future hydrogen-powered aviation.

The analysis covered eight countries across the Baltic Sea Region: Estonia, Latvia, Lithuania, Poland, Denmark, Sweden, Finland, and Germany. A detailed review of legislation, strategic planning documents, technical standards, and regulatory responsibilities was conducted, complemented by consultations with participating airports. The objective was to identify legal barriers, regulatory gaps, institutional challenges, and opportunities for harmonisation that could support the future introduction of hydrogen technologies at airports.

At the European level, the studies confirmed that the EU has established an increasingly ambitious policy framework supporting hydrogen deployment, driven by the European Green Deal, Fit for 55, REPowerEU, ReFuelEU Aviation, AFIR, and the Hydrogen and Decarbonised Gas Market Package. Collectively, these initiatives aim to achieve climate neutrality by 2050, accelerate renewable hydrogen production, and create a European hydrogen market. REPowerEU alone targets the production of 10 million tonnes of renewable hydrogen within the EU and an additional 10 million tonnes of imports annually by 2030, while AFIR requires hydrogen refuelling stations along major transport corridors at intervals of no more than 200 km.

The studies found that, despite strong policy support, there are currently no explicit legal barriers prohibiting hydrogen deployment at airports anywhere within the EU. However, the existing regulatory framework remains fragmented because most aviation, construction, environmental and safety legislation was originally designed for conventional fuels rather than hydrogen applications. As a result, airport operators must navigate a complex combination of aviation, chemical, environmental, construction and energy regulations that do not always address hydrogen-specific risks and operational requirements.

A recurring finding throughout the analysis concerned the absence of hydrogen-specific technical standards in airport legislation. Existing rules such as Commission Regulation (EU) 139/2014 on aerodromes, ICAO Annex 14, ATEX regulations, the Pressure Equipment Directive, and the Seveso III Directive provide important safety requirements but contain only limited references to hydrogen use in operational airport environments. Consequently, many hydrogen projects currently rely on voluntary standards such as ISO 19880-1 for gaseous hydrogen refuelling stations, ISO 14687 for hydrogen fuel quality, and the developing aviation-specific SAE AIR8466 standard for airport hydrogen fuelling systems. The lack of binding aviation-specific hydrogen rules creates uncertainty regarding facility design, certification procedures, safety distances, emergency planning and operational approval processes.

From a technical safety perspective, the studies highlighted hydrogen's unique characteristics as a major regulatory challenge. Airport hydrogen systems commonly involve compressed hydrogen at pressures of up to 700 bar, requiring specialised pressure equipment, explosion protection systems, monitoring technologies, ventilation strategies, and emergency response procedures. While existing ATEX and pressure equipment regulations provide an initial legal basis, dedicated hydrogen aviation safety standards remain largely under

development. This issue becomes particularly important for future hydrogen-powered aircraft, for which EASA was still developing certification frameworks and dedicated certification roadmaps during the study period.

Another major area of investigation concerned environmental permitting and impact assessment procedures. Across almost all BSR countries, Environmental Impact Assessments (EIAs) are required for larger hydrogen production and storage facilities. However, existing EIA frameworks generally do not contain hydrogen-specific assessment methodologies. Important issues such as electrolysis water demand, hydrogen leakage risks, explosion scenarios, airport-specific safety impacts, and integration with protected airport zones are often addressed through general environmental legislation rather than dedicated hydrogen guidance. This creates uncertainty for both project developers and permitting authorities, potentially extending project timelines.

The comparative analysis of national frameworks revealed a high degree of fragmentation across the Baltic Sea Region. Most countries currently regulate hydrogen activities through existing legislation covering hazardous chemicals, industrial facilities, aviation safety, environmental protection and construction law. As a result, hydrogen infrastructure often requires approvals from multiple authorities, including aviation administrations, environmental agencies, construction regulators, technical inspectorates and municipal planning authorities. This fragmented governance structure was identified as one of the most significant barriers to efficient project development.

One of the most common issues identified was the lack of dedicated zoning provisions for hydrogen facilities. In many countries, airports are classified as transport infrastructure zones that do not explicitly permit industrial hydrogen production or energy generation. Consequently, airports wishing to establish electrolysers, storage facilities or refuelling systems often require amendments to local spatial plans or individual planning exemptions. Similar challenges were identified regarding airport protection zones, where existing aviation safety regulations can restrict the installation of hydrogen infrastructure within certain distances of runways, navigation equipment or other critical airport assets.

The analysis also reviewed future hydrogen transport infrastructure. While EU legislation now creates a legal basis for dedicated hydrogen transmission systems through Directive (EU) 2024/1788 and Regulation (EU) 2024/1789, national implementation remains incomplete in most countries. The future European Hydrogen Backbone (EHB) foresees approximately 39,700 km of hydrogen pipeline infrastructure by 2040, with around 60% based on repurposed existing gas pipelines. Nevertheless, many airports are currently outside planned hydrogen backbone corridors, meaning that road-based hydrogen supply will likely remain necessary during the early deployment phase.

Among the eight countries analysed, Germany emerged as the most advanced regulatory environment for hydrogen deployment. The combination of the National Hydrogen Strategy, Hydrogen Acceleration Act, Federal Emission Control Act, Hazardous Substances Ordinance, and Energy Industry Act provides relatively clear pathways for hydrogen infrastructure development, permitting, safety management and transportation. Other countries generally possess strategic ambitions for hydrogen development but continue to face significant legal gaps regarding zoning, permitting, safety standards, environmental assessments and hydrogen transport infrastructure.

Based on the findings, the studies developed a comprehensive set of recommendations at both EU and national level. Key recommendations included the development of dedicated hydrogen-specific airport safety regulations, harmonised certification standards, centralised approval mechanisms, streamlined permitting procedures, aviation-specific environmental assessment criteria, dedicated funding mechanisms for airport hydrogen infrastructure, integration of airport hydrogen facilities into TEN-T and hydrogen corridor planning, and stronger coordination roles for EASA and other European institutions. The studies also recommended the

establishment of pilot projects, regulatory sandboxes and demonstration facilities to build operational experience before large-scale deployment.

Overall, the Legal Framework work package demonstrated that the successful deployment of hydrogen at airports is not limited by a lack of political ambition or strategic direction, but rather by the absence of harmonised, hydrogen-specific regulatory frameworks. The studies concluded that airports can already begin implementing hydrogen projects under existing legislation, provided robust risk management and compliance procedures are applied. However, achieving large-scale and economically efficient deployment across the Baltic Sea Region will require substantial regulatory harmonisation, streamlined approval processes, and the development of dedicated hydrogen standards that address the unique operational requirements of the aviation sector.

Report on European Union Legal Framework: https://interreg-baltic.eu/wp-content/uploads/2026/11/Report-on-European-Union-Legal-Framework-WP-1.1-Legal-Framework-1.pdf?project=bsr-hyairport

Report on National Frameworks: https://interreg-baltic.eu/wp-content/uploads/2026/11/Report-on-National-Frameworks-WP-1.1-Legal-Framework.pdf?project=bsr-hyairport

5.2 Supply Chain

One of the most important findings of the BSR HyAirport Supply Chain work package is that meaningful hydrogen demand at airports is likely to emerge much earlier than often assumed. While previous discussions around hydrogen aviation have largely focused on future Airbus or Boeing replacement aircraft, the project demonstrates that the first relevant use cases are expected to come from ground support equipment, airport vehicles, general aviation, business aviation, and regional aviation with smaller hydrogen-powered aircraft. This shifts the discussion from a long-term aviation vision to a near- and medium-term infrastructure planning challenge that airports can already begin addressing today.

The analysis further reveals that hydrogen has the potential not only to decarbonise aviation but also to strengthen regional connectivity. Through the identification of potential hydrogen-operated routes across the Baltic Sea Region, the project highlights how hydrogen-powered aircraft could support the reactivation of previously discontinued connections and enable entirely new regional services. As a result, hydrogen should not solely be viewed as a climate solution but also as a potential enabler for the revitalisation of regional air transport and improved accessibility between regions.

Another significant finding concerns the factors that may limit future hydrogen deployment. Contrary to common perceptions, neither land availability nor water consumption emerged as critical barriers at most airports. Instead, the analysis consistently identifies electricity supply and grid capacity as the primary challenges for large-scale hydrogen production. While airports generally possess sufficient space for electrolysers and storage systems and can obtain the required water volumes, future hydrogen deployment will depend heavily on access to renewable electricity, grid infrastructure, and flexible energy management concepts. This shifts the focus of airport planning from hydrogen itself towards broader energy system integration.

The project also highlights that hydrogen adoption in aviation is likely to be significantly more gradual than often assumed. Due to the long operational lifetime of aircraft and slow fleet renewal cycles, hydrogen demand is expected to grow steadily rather than through a rapid market transformation. This finding implies that airports should avoid planning infrastructure for immediate large-scale demand and instead focus on modular, scalable solutions that can expand alongside market development. A phased approach is therefore

considered significantly more realistic than the deployment of large, fully developed hydrogen infrastructures from the outset.

In the area of hydrogen logistics, the project reached a particularly important conclusion regarding transport infrastructure. Despite frequent discussions about future hydrogen pipeline networks, the analysis shows that most airports currently lack both direct pipeline connections and suitable rail freight infrastructure. Given the expected demand levels during the introduction phase, truck transport emerges as the most practical and economically viable solution for hydrogen supply in the foreseeable future. Rail and pipeline transport may become increasingly relevant as demand grows and infrastructure develops, but road-based delivery will remain the backbone of airport hydrogen supply during the early stages of market deployment.

Another key insight is that there is no universal hydrogen supply chain model that can be applied to all airports. The optimal solution depends strongly on local circumstances, particularly airport demand levels, proximity to hydrogen production hubs, and the availability of transport and energy infrastructure. As a result, future airport hydrogen strategies will need to be tailored to individual site conditions rather than relying on a one-size-fits-all approach. This finding reinforces the need for flexible planning methodologies that can be adapted to different airport environments and development pathways.

Perhaps the most significant overall achievement of the Supply Chain work package is the creation of a structured and transferable planning framework for airports. Rather than requiring every airport to independently analyse demand, production, storage, transport, and infrastructure requirements from the beginning, BSR HyAirport consolidates existing knowledge into a coherent methodology supported by practical tools and decision-making frameworks. Airports are therefore provided with a clear pathway that starts with demand assessment, continues through infrastructure sizing and production planning, and ultimately supports transport and supply chain decisions. This common foundation enables future projects to focus on implementation and local adaptation rather than repeating the same fundamental analyses and assumptions.

5.2.1 Demand Analysis

Aircraft

The Demand Analysis work package investigates how hydrogen demand in aviation could develop over the coming decades and provides a transferable methodology that airports can use to estimate future hydrogen requirements. Rather than attempting to predict exact future demand, the study follows a scenario-based and data-driven approach that acknowledges the significant uncertainties surrounding aircraft development, technology readiness, certification timelines, market adoption, and the future availability of green hydrogen. The objective is therefore not to produce a forecast, but to identify plausible pathways that can support infrastructure planning, supply chain design, and investment decisions.

A key outcome of the project is the development of a methodology that enables airports to assess hydrogen demand separately for aviation operations and airport-related activities. This creates a structured basis for future planning and helps airports translate operational assumptions into potential hydrogen requirements.

Because the future development of hydrogen aviation remains highly uncertain, the report deliberately focuses on scenarios rather than forecasts. The underlying assumption is that smaller hydrogen-powered aircraft will enter service well before larger commercial aircraft. As a result, regional and short-haul aviation are expected to become the first market segments where hydrogen can be deployed at scale. The report therefore concentrates on regional scheduled routes and general aviation as the most relevant early-use cases.

For scheduled aviation, project partners identified potential routes that could realistically be served by hydrogen-powered aircraft. Across the Baltic Sea Region, a total of 69 potential hydrogen-powered routes

were identified across 21 airports. Of these, 24 routes represent previously discontinued connections that could be reactivated, while 15 routes are entirely new route opportunities. The average route length is approximately 170 nautical miles, indicating a strong focus on regional connectivity. For the analysis, two representative aircraft categories were assumed: a 10-seat aircraft, similar in size to a hydrogen-powered Cessna Grand Caravan, with an estimated hydrogen consumption of 0.20 kg per nautical mile, and a future 30-seat aircraft with an estimated consumption of 0.36 kg per nautical mile. These assumptions form the basis for calculating future hydrogen demand across the region.

The analysis suggests that hydrogen-powered aviation could help revitalize regional air transport by reopening underserved routes, creating new connections, and maintaining essential air links that have become difficult to operate economically with conventional technology. As aircraft availability increases throughout the 2030s, hydrogen demand is expected to grow alongside the expansion of these regional route networks.

A second major component of the report focuses on non-scheduled aviation, using Hamburg Airport's General Aviation Terminal (GAT) as a detailed case study. The analysis is based on approximately 18,000 flight movements recorded during 2024, covering around 250 different aircraft types and approximately 500 destinations worldwide. To identify flights that could realistically transition to hydrogen propulsion, the dataset was systematically filtered to include only outbound flights, flights shorter than 1,500 kilometres, and aircraft types considered suitable for future hydrogen conversion. Helicopters, military aircraft, and large commercial jets were excluded from the analysis. This process reduced the dataset to approximately 6,600 outbound flights, which served as the foundation for the subsequent demand calculations.

The demand assessment was conducted using a highly detailed bottom-up methodology. Instead of applying generic conversion factors, the study calculated fuel consumption for every individual flight using aircraft-specific performance data and route-specific distance information. This approach resulted in an estimated annual fuel consumption of approximately 3.79 million litres of conventional aviation fuel for the relevant fleet. Based on hydrogen consumption assumptions derived from current hydrogen aircraft development programmes such as those by ZeroAvia and Beyond Aero, the report estimates a theoretical maximum demand of approximately 495,000 kg of gaseous hydrogen per year if all applicable flights were converted to hydrogen propulsion immediately.

The study also makes clear that such a complete and immediate transition is highly unrealistic. Aircraft remain in service for long periods and are replaced only gradually. The report assumes an average aircraft lifetime of approximately 29 years, corresponding to an annual fleet replacement rate of only 3.42%. This means that hydrogen-powered aircraft will enter the fleet progressively over several decades rather than through a rapid market transformation. Fleet renewal is therefore identified as one of the key drivers of long-term hydrogen demand growth.

Another important finding is the strong seasonality of aviation activity. The analysis shows that flight volumes in summer are significantly higher than during winter months, creating noticeable fluctuations in future hydrogen demand throughout the year. This seasonal pattern highlights the importance of designing hydrogen infrastructure, storage systems, and supply chains that can accommodate peak demand periods rather than simply average annual demand levels.

The report further emphasizes that future hydrogen demand will be influenced by several external factors. Competing technologies such as Sustainable Aviation Fuels and battery-electric aircraft could slow hydrogen adoption, particularly on short-haul routes. At the same time, regulatory frameworks, certification processes, renewable energy availability, hydrogen production costs, and demand from competing sectors will shape the pace of market development. Airports therefore need to remain flexible and continuously adapt their strategies as technology and market conditions evolve.

Airport Equipment

The Demand Analysis for Airport Equipment complements the aircraft demand assessment by focusing on all non-aircraft applications of hydrogen at airports. Its primary objective is to provide a transparent, practical,

and transferable methodology that airports can use to estimate future hydrogen demand from ground support equipment, operational vehicles, and stationary energy systems. Rather than forecasting exact future consumption, the report establishes a scenario-based framework that allows airports of different sizes and operational profiles to develop initial hydrogen demand estimates and use them as a basis for supply chain planning.

The report identifies airport equipment as one of the most realistic and operationally feasible entry points for hydrogen adoption. Unlike aircraft, many ground handling vehicles and airport support systems can potentially transition to hydrogen technology much earlier and with lower technical barriers. As a result, airport equipment is viewed as an important steppingstone for airports to gain practical experience with hydrogen technologies, build operational know-how, and prepare the broader airport ecosystem for future hydrogen applications.

A central outcome of the report is the development of a standardized methodology that can be applied by virtually any airport. The approach begins with the creation of a detailed inventory of existing airport equipment, including vehicle fleets, ground support equipment, backup generators, and other stationary systems. Airports are encouraged to categorize equipment into groups such as baggage tractors, pushback vehicles, ground power units, backup generators, and other operational assets. The methodology is intentionally designed to be scalable so that users can adjust assumptions based on fleet size, usage intensity, and conversion scenarios.

The analysis starts with collecting baseline energy consumption data. Airports are encouraged to use actual operational information wherever available, such as fuel consumption records, operating hours, mileage data, electricity consumption, or other energy-use indicators. Recognising that this information is often incomplete or inconsistent, the methodology allows airports to use representative industry values and proxy data where detailed measurements are unavailable. This ensures that airports can still generate meaningful demand estimates even when comprehensive operational data does not exist.

The methodology then converts current fuel and energy consumption into a common energy basis before estimating the amount of hydrogen required to perform the same operational tasks. Importantly, the report does not simply compare energy content. Instead, it takes into account the efficiency differences between conventional technologies and hydrogen-powered alternatives. Hydrogen fuel cell systems are generally assumed to be significantly more efficient than conventional combustion engines, allowing the same operational output to be achieved with less energy input. To support users, the project developed an Excel-based calculation tool that incorporates typical efficiency assumptions while still allowing airports to adapt the values to their own equipment and operating conditions.

For mobile equipment and vehicles, the methodology primarily focuses on replacing fossil-fuel-powered systems with hydrogen alternatives. It provides a simplified but practical approach to estimating hydrogen demand by converting current diesel or gasoline consumption into hydrogen equivalents and adjusting for technology efficiency. The report emphasizes that these calculations should be considered rough planning estimates rather than detailed engineering analyses. The methodology is therefore intended to provide an initial understanding of future hydrogen requirements rather than support procurement decisions or total cost of ownership calculations.

The assessment also acknowledges that battery-electric solutions already play an important role in airport decarbonisation. Consequently, hydrogen demand calculations are primarily focused on assets that currently rely on fossil fuels, while electric vehicles are generally considered already decarbonised unless airports specifically intend to transition them to hydrogen-based systems to address operational or infrastructure limitations.

Beyond mobile equipment, the report highlights the importance of considering stationary and semi-stationary hydrogen applications. Although these applications are less mature today, future hydrogen demand may also arise from backup power generation, emergency energy systems, building heating, combined heat and power systems, or other fixed infrastructure at airports. The methodology therefore allows airports to include these

potential hydrogen consumers in their scenarios by converting existing energy demand into equivalent hydrogen requirements. While such applications may not be the most cost-effective decarbonisation option today, they are included to provide a more comprehensive picture of potential future hydrogen demand.

A key strength of the report is the direct integration of demand assessment with hydrogen supply chain planning. The estimated hydrogen demand generated through the methodology can be used as input for decisions regarding local production, storage, and transport solutions. To support this process, the project developed an additional simulation model that links hydrogen demand to renewable electricity generation, electrolyser sizing, storage requirements, and self-sufficiency scenarios. By combining estimated hydrogen demand with local renewable energy resources, airports can better understand whether future demand can be covered through on-site production or whether external hydrogen supply will be required.

The report repeatedly stresses that the methodology is designed as a planning tool rather than a forecasting or financial model. The results are intended to provide a first approximation of hydrogen demand under different deployment scenarios and to establish a consistent foundation for subsequent work on hydrogen production, storage, transport, and business case analyses. The flexible structure of the methodology allows it to be updated as technology develops, hydrogen-powered equipment becomes commercially available, and more detailed operational data emerges.

Overall, the report concludes that airport equipment represents one of the most attractive early opportunities for hydrogen deployment within the airport environment. By introducing hydrogen in ground operations before large-scale aviation applications emerge, airports can gradually build experience, reduce implementation risks, and prepare the infrastructure and operational processes that will ultimately support broader hydrogen use across the aviation sector. The methodology developed within the project provides a practical first step for airports seeking to understand and prepare for their future hydrogen requirements.

Report on Demand analysis – Aircraft: https://interreg-baltic.eu/wp-content/uploads/2026/06/BSR_HyAirport_WG_1_2_1_Demand_Analysis_Aircraft.pdf?project=bsr-hyairport

Report on Demand analysis – Airport equipment: https://interreg-baltic.eu/wp-content/uploads/2026/08/BSR_HyAirport_WG_1_2_1_Demand_Analysis_Airport_equipment.pdf?project=bsr-hyairport

5.2.2 Production and Storage

The Local Production & Storage working group examines whether airports can produce and store green hydrogen on-site and what infrastructure, resources, and operational requirements would be needed to support this transition. The report focuses specifically on gaseous hydrogen produced via on-site electrolysis, while excluding liquid hydrogen pathways, off-site production, and external hydrogen logistics chains. The objective is to provide airports with a practical and transferable framework for assessing local hydrogen production, storage requirements, infrastructure design, and resource availability under both current and future demand scenarios. The analysis is deliberately designed as a planning and sizing methodology rather than a business case or cost assessment.

The study assumes that airport vehicles, ground support equipment, emergency power systems, and selected stationary energy applications represent the most immediate and realistic scope of application for hydrogen. A key element of the methodology is the use of actual operational energy consumption data rather than theoretical models. Existing fossil fuel consumption is converted into energy units and then translated into hydrogen demand while accounting for efficiency differences between conventional combustion technologies and hydrogen-powered systems. The resulting hydrogen demand figures are subsequently used to determine electricity requirements for hydrogen production, electrolyser sizing, storage capacity needs, and renewable

energy integration requirements. Because the methodology relies on operational data rather than airport size alone, it can be applied consistently across airports with very different operational profiles.

Particular emphasis is placed on understanding temporal demand patterns. The report highlights that airport activity follows strong seasonal trends and that infrastructure should therefore be sized according to realistic peak demand rather than annual averages. To ensure operational reliability, the methodology uses peak months as the reference point for infrastructure sizing, creating a conservative planning basis for hydrogen production and storage systems. This approach ensures that future hydrogen infrastructure can continue operating reliably even during periods of maximum airport activity.

The resulting demand analysis demonstrates that hydrogen requirements vary significantly across airports, reflecting differences in airport size, vehicle fleets, and operational intensity. While the exact values differ by location and scenario, the report shows that hydrogen demand remains within a range that can be supplied by airport-scale electrolysis systems. Even under future high-demand scenarios, including increased traffic levels and expanded hydrogen deployment, the resulting production volumes remain manageable within a local production framework.

Based on these demand estimates, the report evaluates the technical requirements for hydrogen production using Proton Exchange Membrane (PEM) electrolysis, which is considered one of the most suitable technologies for airport applications due to its operational flexibility and ability to integrate renewable electricity generation. Using an assumed system efficiency of approximately 80%, hydrogen production requires around 41.7 kWh of electricity per kilogram of hydrogen produced. Depending on airport size and demand level, the study estimates that electrolyser capacities ranging from approximately 0.3 MW to 6 MW would be sufficient to cover current and future airport ground operation requirements.

To ensure a reliable energy supply, the report also examines on-site hydrogen storage. Storage is sized around a two-day operational reserve, providing resilience against renewable generation fluctuations, maintenance activities, or temporary supply interruptions. Depending on demand levels, storage requirements range from relatively small systems at regional airports to several tonnes of hydrogen at larger hubs. Even under future high-demand scenarios, the required storage volumes remain well within the range of commercially available technologies.

An important outcome of the analysis is the finding that land availability is unlikely to become a major limitation for hydrogen deployment at airports. The report assesses space requirements for electrolysers, storage systems, safety zones, and supporting infrastructure based on industrial reference projects and international safety standards. Even under high-demand scenarios, total land requirements remain below one hectare, demonstrating that local hydrogen production can generally be accommodated within the technical and utility areas already available at most airports. This finding supports the conclusion that local hydrogen infrastructure is spatially compatible with typical airport layouts and leaves room for future expansion.

A major focus of the report is the integration of renewable energy into hydrogen production. The analysis evaluates the potential contribution of on-site renewable electricity generation, particularly photovoltaic systems and, where appropriate, wind energy. The findings indicate that airports can generate a significant share of the electricity required for hydrogen production locally. Across the assessed scenarios, renewable energy generation generally exceeds average daily hydrogen-production electricity demand by a factor of approximately 1.5 to 1.8, creating favorable conditions for flexible electrolyser operation and energy buffering through hydrogen storage. However, the report also notes that renewable energy alone cannot guarantee continuous production due to variability in weather conditions, making storage systems and grid interaction important components of future hydrogen supply concepts.

The study further evaluates water requirements for electrolysis. Although hydrogen production depends directly on water availability, the findings show that water demand remains modest relative to overall airport consumption. Even in larger deployment scenarios, water requirements are considered manageable through conventional municipal water supplies, provided appropriate water treatment and purification systems are

implemented. Water availability is therefore not identified as a significant barrier to airport-based hydrogen production.

Beyond technical sizing, the report also examines infrastructure planning and safety considerations. It concludes that hydrogen production systems can be integrated safely into airport environments when designed according to established international standards such as ISO 19880-1 and relevant ATEX requirements. The assessment identifies hydrogen leaks, ignition risks, overpressure events, electrical failures, and human factors as the principal risk categories. However, the report concludes that these risks are well understood and can be controlled through established engineering measures, monitoring systems, emergency response procedures, appropriate zoning concepts, and staff training. No fundamental safety barriers to hydrogen deployment at airports were identified.

The assessment of airport resource availability highlights electricity as the primary challenge for hydrogen deployment. Existing grid connections at many airports are already heavily utilised and may not be capable of supporting large-scale hydrogen production without upgrades. As a result, the report emphasises the importance of combining renewable generation, hydrogen storage, battery systems, and flexible electrolyser operation to reduce dependence on grid expansion. In contrast, water availability and land constraints are generally considered manageable across most airport environments studied within the project.

Overall, the report concludes that local green hydrogen production and storage at airports is both technically feasible and operationally achievable. Required electrolyser capacities, storage volumes, land requirements, water consumption, and renewable energy integration remain within realistic limits under both current and future demand scenarios. Airports therefore have the potential to act as early anchor customers within regional hydrogen ecosystems while simultaneously preparing for future hydrogen-powered aviation. A phased deployment pathway, beginning with ground support equipment and airport operations before expanding toward aircraft applications, is presented as a low-risk and technically robust strategy for achieving long-term decarbonisation.

Supply Chain Synthesis report: https://interreg-baltic.eu/wp-content/uploads/2026/09/BSR-HyAirport_Supply-Chain-Synthesis-Report.pdf?project=bsr-hyairport

5.2.3 Transport

The Transport Work package evaluates how airports in the Baltic Sea Region can be supplied with green hydrogen during the early stages of hydrogen aviation deployment. The study focuses on identifying economically viable transport solutions and assessing their suitability under the specific conditions expected at airports over the coming decade. The analysis covers the three mainland-based transport options for hydrogen: truck, pipeline, and rail transport. A key objective of the report is to support airport decision-makers in planning future hydrogen logistics by providing both a cost estimate and a practical decision-making framework.

The Transport report concludes that the most appropriate hydrogen transport solution depends primarily on three factors: airport hydrogen demand, distance to the nearest hydrogen hub, and the availability of transport infrastructure. As no universal solution exists, transport strategies must be tailored to local conditions and future demand scenarios.

Hydrogen can be transported either as gaseous hydrogen or liquid hydrogen. Gaseous hydrogen typically requires compression to pressures between 200 and 500 bar and is transported in specialized high-pressure containers. Typical truck capacities range from approximately 400 to 1,100 kg of hydrogen. Liquid hydrogen, by contrast, must be cooled to -253°C and transported in cryogenic tanks. Due to its significantly higher energy density, LH_2 trucks can transport between 2,000 and 4,500 kg per trip. However, liquefaction requires

substantial energy input, and storage is associated with evaporation losses of approximately 1 to 5 percent per day.

A comparison of transport technologies shows that each mode has distinct advantages and limitations. Truck transport offers low investment requirements, high flexibility, and rapid deployment. Pipeline transport provides the lowest operational costs and the highest scalability but requires very significant upfront investment and extensive infrastructure. Rail transport represents a potential intermediate solution, particularly for medium transport volumes and medium-distance routes, provided suitable freight rail infrastructure is available.

Airport-specific requirements play a major role in transport planning. Airports are characterized by strict safety requirements, limited available space, fluctuating demand patterns, and high reliability expectations. Therefore, hydrogen logistics must be integrated into existing airport operations while ensuring compliance with aviation safety and regulatory standards.

A central part of the report is the analysis of current and planned hydrogen infrastructure across participating airports. The infrastructure map developed within the project illustrates the geographical relationship between airports, hydrogen hubs, and future hydrogen transport corridors.

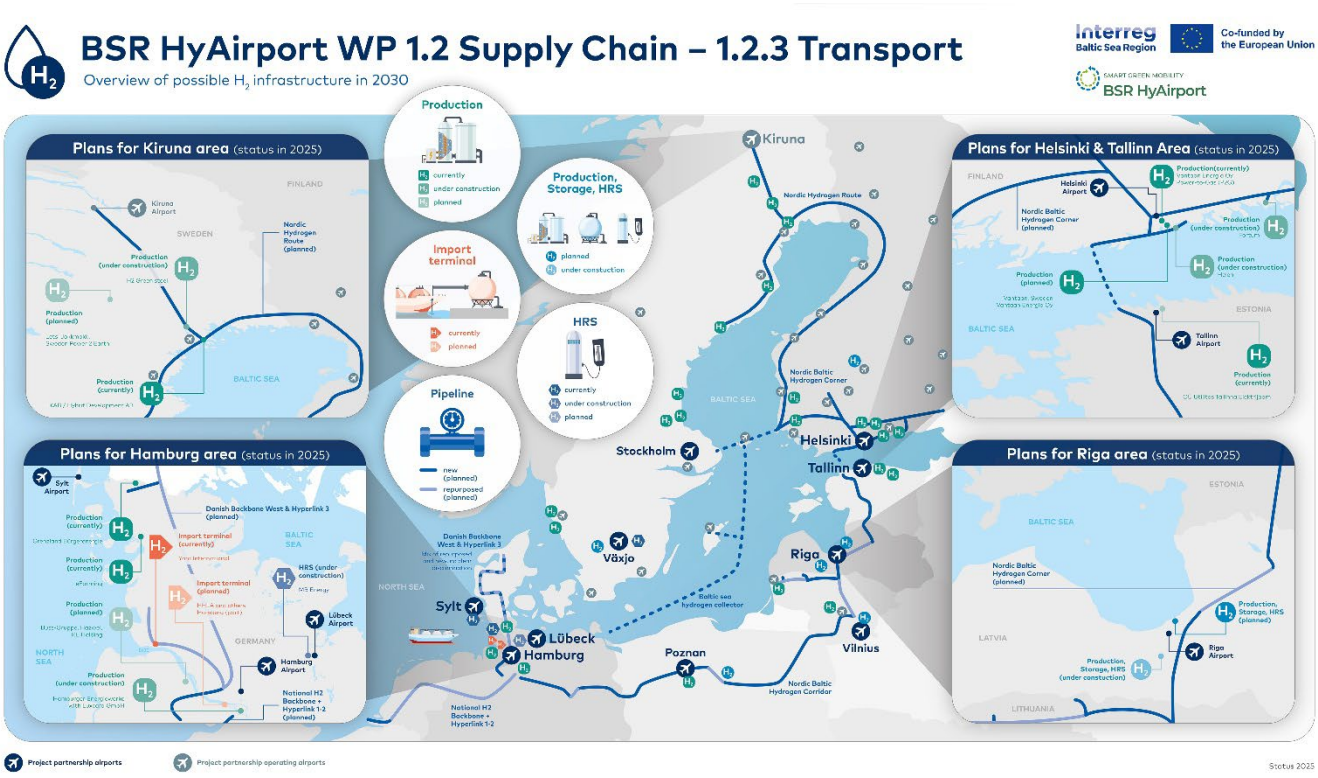


Figure 2.: Overview of possible H2 infrastructure in 2030 in the Baltic Sea Region.

NOTE: The map shows a preliminary overview and makes no claim to completeness. It shows a selection of hydrogen infrastructure in the Baltic Sea region in the future. It cannot be verified whether the hydrogen hubs and pipeline connections built or planned will actually go into operation, as it has not been confirmed by the respective operators to the project partners.

The map shows that hydrogen infrastructure in the Baltic Sea Region remains highly decentralized, with most airports located approximately 150 to 200 km from existing or planned hydrogen hubs. The analysis also highlights that future hydrogen availability will depend heavily on the continued development of regional production facilities, import terminals, storage locations, and refuelling stations. An opportunity could be the European Hydrogen Backbone, which is a group of European gas network operators who want to build a cross-border hydrogen transport network.

The assessment further reveals that none of the participating airports currently have a direct hydrogen pipeline connection. Hamburg Airport is the only airport with a concrete future connection strategy linked to the development of Hamburg's hydrogen network. Most airports also lack freight rail connections, which

significantly limits the short-term feasibility of rail-based hydrogen supply. Consequently, truck transport remains the only immediately deployable solution for most airports.

To evaluate transport economics, the working group adapted a cost model developed by Fraunhofer IFF and Hamburg University of Applied Sciences. The project-specific assumptions for the cost model included a hydrogen demand of approximately one ton per week, transport distances of up to 400 km, and a primary focus on gaseous hydrogen. Furthermore, the model considered only transport-related costs and excluded production, storage, and refuelling infrastructure costs. The resulting Fraunhofer analysis demonstrates that truck transport using a 350-bar gaseous hydrogen trailer is the most cost-efficient option under the project specific demand conditions expected during the introduction phase of hydrogen aviation. The model further shows that pipelines only become economically competitive at considerably higher demand levels, while liquid hydrogen transport may become advantageous for longer transport distances.

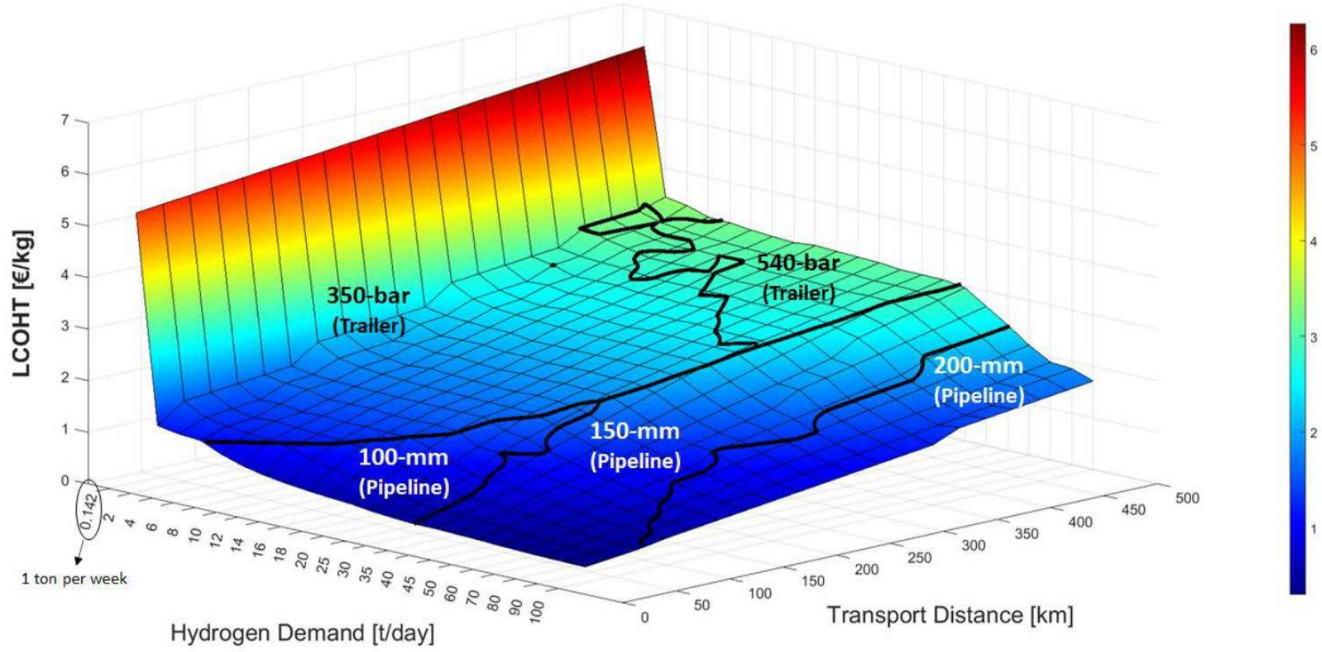


Figure 3.: Least LCOHT as a function of hydrogen demand and transport distance.

The figure confirms that for low demand scenarios, which are expected at airports during the early rollout phase, road transport remains the most economical solution. Based on the adapted Fraunhofer calculations, transport costs for a 350-bar hydrogen trailer range from approximately €5.23/kg at 25 km to approximately €6.27/kg at 500 km. This indicates a relatively moderate increase in transport costs with distance but also highlights the importance of locating airports close to hydrogen supply hubs. The Hamburg Airport case study illustrates this effect. When supplied from the ammonia import terminal in Brunsbüttel, located approximately 85 km away, the weekly transport costs are around €5,363. When supplied from the hydrogen production facility in Hamburg-Moorburg, approximately 30 km away, transport costs decrease to around €5,242. Transport from the Port of Hamburg, located approximately 20 km away, reduces costs further to approximately €5,219. Given an assumed green hydrogen market price of around €10/kg, transport costs account for roughly one-third of total delivered hydrogen costs, making transport logistics a major economic factor.

From the insights it can be concluded that truck transport will be the backbone of airport hydrogen supply throughout the early market introduction phase. Despite frequent discussions about future hydrogen pipeline networks, the existing infrastructure simply does not yet support large-scale pipeline-based airport supply. The transport mode selection is fundamentally determined by hydrogen demand, distance to supply hubs, and available infrastructure. These three parameters drive both technical feasibility and economic performance. Moreover, proximity to hydrogen hubs creates a significant competitive advantage for airports, as transportation costs represent a substantial share of total hydrogen expenditure. Pipelines remain the long-

term strategic solution, particularly for high-demand airports, but widespread implementation will depend on future infrastructure investments. Finally, the hydrogen economy is still at an early stage of development. Many planned hydrogen hubs, transport corridors, and pipeline projects remain under development, which means airports should adopt flexible, phased investment strategies that can evolve alongside the wider hydrogen market.

Transport report: https://interreg-baltic.eu/wp-content/uploads/2026/07/Report-on-WP-1.2-Supply-Chain-1.2.3-Transport.pdf?project=bsr-hyairport

5.3 Aircraft Handling

The Aircraft Handling work package assessed the operational implications of introducing hydrogen-powered aircraft at airports, focusing on the complete turnaround process, including refuelling, aircraft servicing, apron operations, passenger handling, emergency response, maintenance activities and hangar operations. The focus was on compressed gaseous hydrogen aircraft, which are expected to enter commercial operation before larger liquid hydrogen-powered aircraft.

The work demonstrated that many existing airport handling processes can be retained for hydrogen-powered aircraft. Passenger boarding, baggage handling, catering, cleaning, de-icing and several other ground handling activities are expected to remain largely unchanged. However, hydrogen-specific procedures, equipment, safety measures and personnel competencies will need to be integrated into existing operational frameworks.

Aircraft refuelling was identified as one of the most significant operational changes. The project analysed various hydrogen refuelling concepts, including mobile fuel trucks, on-airport fuelling stations and future hydrant systems. For the initial introduction of hydrogen-powered aircraft, flexible truck-based solutions were considered the most practical option, while fixed hydrogen infrastructure may become viable as demand increases. Refuelling procedures were assessed based on emerging industry concepts and standards, including high-pressure gaseous hydrogen refuelling architectures and associated safety requirements.

A major finding was that hydrogen introduces a fundamentally different hazard profile compared to conventional aviation fuels. Key challenges include high-pressure storage systems, leak detection requirements, invisible flames, hydrogen venting, cryogenic hazards for liquid hydrogen applications, and expanded safety zones around aircraft and fuelling equipment. These characteristics require adapted emergency procedures, dedicated safety concepts, specialised equipment and targeted staff training.

The work further highlighted the importance of aircraft-specific characteristics such as tank location, refuelling interfaces, venting systems and pressure-relief devices. These factors influence stand design, turnaround processes, safety distances and the ability to conduct parallel ground handling activities during refuelling operations.

Complementing the operational work, a dedicated regulatory assessment was carried out. The analysis reviewed international, European, national and industry regulations and compared them against the requirements of hydrogen-powered aircraft operations. The results showed that the current regulatory framework remains predominantly focused on conventional Jet A-1 operations and is not yet fully prepared for hydrogen aviation. Significant regulatory gaps were identified across fuelling procedures, emergency response, training requirements, apron operations, aerodrome oversight and hydrogen infrastructure approval processes.

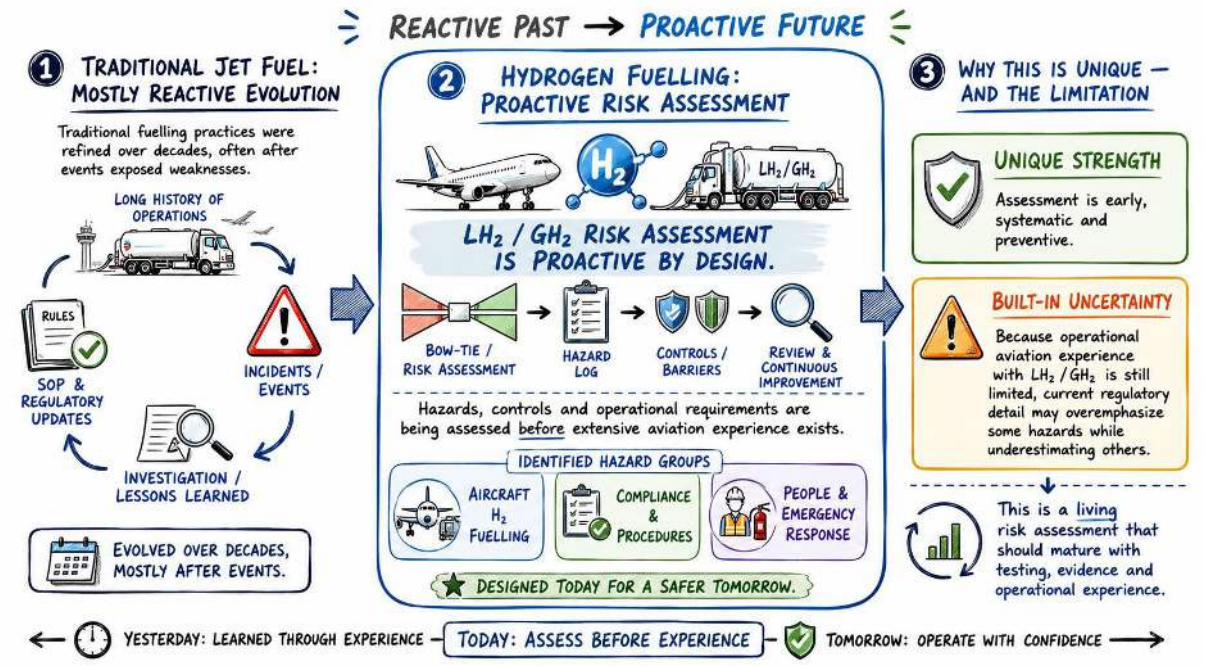


Figure 4.: Change of Management for Hydrogen operations

To address these gaps, the project applied a structured Management of Change approach, identifying operational impacts, hazards and mitigation measures associated with hydrogen aircraft handling. This process resulted in a set of recommendations covering operational procedures, infrastructure requirements, safety management measures and training needs for airports preparing for hydrogen operations.

Shortcomings were identified in existing emergency planning and firefighting frameworks, which currently do not adequately address hydrogen-specific hazards such as invisible flames, cryogenic releases, venting events and high-pressure system failures. The assessment also highlighted the need for dedicated hydrogen competencies for operational staff, emergency responders and airport management personnel.

For maintenance and hangar operations, the project identified additional requirements related to ventilation systems, hydrogen detection technologies, hazardous area management, ignition source control and emergency preparedness. Existing experience from hydrogen vehicle maintenance facilities provides a valuable starting point for developing future airport concepts.

Overall, the work package concluded that the introduction of hydrogen-powered aircraft is operationally feasible and that most airport handling processes can be adapted from existing practices. However, successful implementation will require significant preparation in the areas of refuelling procedures, safety management, emergency response, training, infrastructure planning and regulatory development.

Aircraft handling report: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport_Aircraft-Handling-1.pdf?project=bsr-hyairport

5.4 Airport Equipment

The working group Airport Equipment examined the potential role of gaseous hydrogen in airport operations. The studies conducted demonstrated that mobile airport equipment and vehicles, as well as stationary energy

applications in airport terminals, provide a holistic perspective on the future integration of hydrogen at airports in the Baltic Sea region.

The feasibility study on the general use of gaseous hydrogen in airport machinery investigated the technical, operational, economic, and infrastructural feasibility of hydrogen-powered airport vehicles and ground support equipment. The analysis covered hydrogen fuel cell systems, hydrogen combustion engines, vehicle availability, hydrogen infrastructure concepts, regulatory aspects, and operational requirements. A detailed market assessment showed that hydrogen-powered airport equipment is still at an early commercialization stage, with very limited series production available today. However, manufacturers across several vehicle categories, including baggage tractors, heavy-duty trucks, cargo handling equipment, apron buses, and winter maintenance machinery, have announced hydrogen-powered products expected to enter the market within the next five years. The study also assessed the infrastructure required to support airport hydrogen operations, including 350-bar and 700-bar refuelling systems, storage concepts, dispenser configurations, and airport-wide hydrogen distribution networks. In addition, the study analysed the relative advantages of fuel-cell and hydrogen-combustion technologies. Fuel cells were found to achieve efficiencies between 45–60%, making them particularly suitable for low- and medium-load applications typical of many airport vehicles. Hydrogen combustion engines, by contrast, showed efficiencies between 30–45%, but offer advantages for high-load applications because they can be integrated more easily into existing vehicle platforms and maintenance structures. The study therefore concluded that both technologies could play complementary roles depending on vehicle duty cycles and operational requirements. A key component of the study was an illustrative Total Cost of Ownership (TCO) analysis comparing battery-electric and hydrogen-powered baggage tractor fleets under different airport operating conditions. The results demonstrated that hydrogen-powered fleets can become economically attractive when fast refuelling and increased equipment availability generate measurable productivity gains. In high-utilisation scenarios, hydrogen reduced vehicle downtime and staffing requirements sufficiently to compensate for higher infrastructure costs. However, under lower utilisation conditions, battery-electric solutions remained economically preferable, highlighting the importance of application-specific assessments.

The second study on the use of GH_2 in airport terminal operations focused on stationary hydrogen applications within airport energy systems. The study evaluated the feasibility of using hydrogen fuel cells for backup power generation and CHP systems in airport terminals. Through extensive literature reviews, technology assessments, and case calculations based on data from BSR airports, the study examined hydrogen demand, storage requirements, energy performance, emissions reduction potential, and investment implications. For backup power applications, the study estimated that a large airport could replace conventional fossil-fuel-based emergency generators with hydrogen fuel cell systems requiring approximately 35.5 tonnes of hydrogen annually, equivalent to around 600 MWh of backup electricity generation. Depending on the hydrogen production pathway, this could reduce annual CO_2 emissions by up to 439 tonnes, with green hydrogen delivering the highest emissions savings. For terminal energy supply, the study evaluated a hydrogen-based CHP system sized at approximately 14 MW hydrogen input capacity. Such a system could theoretically provide around 59 GWh of electricity and 36 GWh of heat annually, covering a substantial share of a large airport's terminal energy demand. The analysis estimated annual hydrogen consumption of approximately 3,300 tonnes, while avoiding roughly 8,000 tonnes of CO_2 emissions per year compared to conventional energy systems. Recognising the scale of this investment, the study also investigated a smaller and more realistic 3 MW CHP configuration, which could supply around 20 GWh of energy annually and achieve approximately 1,800 tonnes of CO_2 savings per year, making it a potentially attractive first implementation step for airports.

Beyond the technical calculations, both studies reviewed hydrogen production pathways, storage technologies, transportation concepts, airport infrastructure requirements, safety considerations, and emerging hydrogen developments in aviation. The analyses consistently highlighted that successful hydrogen deployment requires coordinated development of production capacity, supply chains, airport infrastructure, regulatory frameworks, and operational procedures. They also confirmed that hydrogen demand from airport equipment and terminal operations could serve as an important early-use case, helping airports establish

hydrogen ecosystems before large-scale hydrogen aviation becomes commercially available. This combined body of work provides a detailed roadmap for airports considering hydrogen adoption and demonstrates that both mobile and stationary hydrogen applications can contribute significantly to long-term airport decarbonisation strategies, while simultaneously supporting the development of future hydrogen-based aviation infrastructure.

Overall, hydrogen offers significant decarbonisation potential for airport operations. Both studies confirmed that hydrogen can contribute substantially to reducing emissions from airport activities. For mobile equipment, hydrogen-powered vehicles can replace diesel-powered GSE and maintenance vehicles, while fuel cell-based terminal applications can eliminate emissions from backup power and heating systems when supplied with green hydrogen. Technology readiness varies between applications. Hydrogen solutions are already available or emerging for passenger cars, light commercial vehicles, material handling equipment, forklifts, baggage tractors, and selected heavy-duty vehicles. In contrast, some specialised airport equipment, including certain rescue and aircraft handling vehicles, still require further development and demonstration before large-scale deployment. Economic viability depends on operational use cases. Hydrogen applications deliver the strongest business case where operational advantages can be realised. Fast refuelling, reduced downtime, improved availability, lower space requirements, and reduced peak electricity demand can offset higher vehicle and infrastructure costs.

Feasibility study on the general use of gaseous hydrogen in airport machinery: https://interreg-baltic.eu/wp-content/uploads/2025/03/Report_BSRHyAirport_Feasability_Study_gaseous_hydrogen_airport_equipment_2025.pdf?project=bsr-hyairport

Feasibility study on the use of GH2 in Airport Terminal Operations: https://interreg-baltic.eu/wp-content/uploads/2025/03/REPORT-2024-Use-of-GH2-in-Airport-Terminal-Operations.pdf?project=bsr-hyairport

5.5 Business Case

The Business Case work package aimed to support airports and aviation stakeholders in understanding the economic implications of future hydrogen aviation. To achieve this, the project developed the BSR Hydrogen Airport Business Case Tool as a practical decision-support instrument that enables users to explore and evaluate different hydrogen deployment scenarios. The tool was designed to support strategic planning and investment discussions rather than to provide fixed forecasts or definitive predictions.

	Users	Aim of the tool
Main users	Airport sustainability, strategy & planning teams	To inform and develop scenarios, adapt inputs, assumptions and understand the behind different hydrogen aircraft role out and route planning for the airport.
	Airport C-Level	To understand the business case behind hydrogen aviation and make investment decisions in future research, pilots and infrastructure.
Secondary users	Airlines	To inform their decision making on future aircraft investment.
	Fuel suppliers	To understand at what stage and in what quantities hydrogen may be required by the airport.
	Governments	To understand the need for additional policy or incentive support, including the stage of development and to what stakeholder

Figure 5.: Users of the BSR Hydrogen Business case tool.

The tool is intended primarily for airport sustainability, strategy and planning teams, but can also support airport management, airlines, fuel suppliers, energy providers, and public authorities. By allowing users to explore different development pathways, it helps stakeholders understand how future hydrogen aviation may affect infrastructure requirements, operational concepts, and investment priorities.

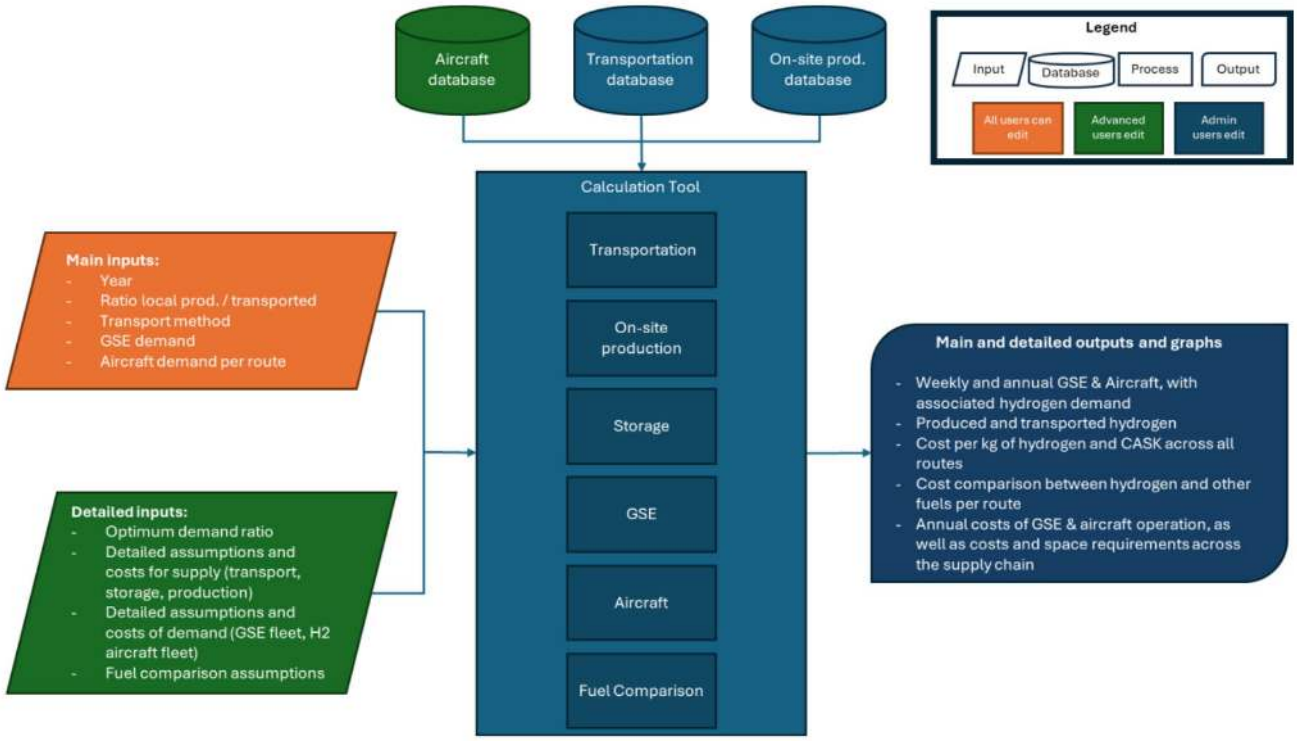


Figure 6.: Structure of the tool.

A key feature of the business case approach is the integration of multiple elements of the hydrogen aviation value chain within a single assessment framework. The tool considers hydrogen demand from both aircraft operations and hydrogen-powered ground support equipment, linking future aviation activity with airport energy requirements. This enables airports to analyse hydrogen adoption from a system-wide perspective rather than focusing on individual technologies in isolation.

On the supply side, the tool evaluates different hydrogen sourcing options, including on-site production and external supply. It further considers transportation methods, hydrogen storage requirements, liquefaction options, and associated infrastructure needs, allowing users to assess alternative supply chain configurations and identify potential bottlenecks or investment needs.

The business case framework also incorporates operational and economic aspects of future hydrogen aircraft fleets. Different aircraft types, route categories, passenger volumes, and traffic scenarios can be analysed to estimate future hydrogen demand and associated costs under varying aviation development pathways. This allows airports to explore how hydrogen uptake could evolve between 2030 and 2050 under different market assumptions.

In addition, the tool includes comparisons between hydrogen aviation and alternative energy pathways such as Sustainable Aviation Fuels, conventional Jet A-1 fuel, and battery-electric aviation. This enables stakeholders to position hydrogen within the wider portfolio of aviation decarbonisation measures and better understand the conditions under which hydrogen may become a competitive solution.

A particular strength of the tool is its transparency and flexibility. Key assumptions can be adjusted by the user to reflect local conditions, including electricity prices, hydrogen procurement costs, transport distances, infrastructure configurations, and operational cost assumptions. This enables airports to tailor analyses to their specific circumstances and continuously updates scenarios as technology, regulation, and market conditions evolve.

Overall, the Business Case Tool provides a structured framework for analysing the technical, operational, and economic dimensions of hydrogen aviation at airports. By combining demand, supply, storage, transportation, infrastructure, and operational considerations within a single assessment environment, it supports evidence-based decision-making and long-term planning for future hydrogen aviation development.

Business case Report: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport_Business-Case.pdf?project=bsr-hyairport

Business Case tool: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport-Business-Case-Tool_v2.0.zip?project=bsr-hyairport

6. Results of WP2 – Piloting and Evaluating Solutions

6.1 Pilot Approach

Pilot area	Work Package	Location(s)	Demonstration type	Main result
Supply chain	WP 2.1	Hamburg, Helsinki, Riga, Kaunas, Tallinn	GH_2 delivery, storage, dispenser use	Tested/evaluated supply-chain solutions
Supply chain	WP 2.1	Poznan	Hydrogen production, storage, compression and refuelling	Tested/evaluated supply-chain solutions
Aircraft handling	WP 2.2	Rotterdam	Hydrogen aircraft refuelling and taxi test participation	Operational insights into aircraft handling
Aircraft handling	WP 2.2	N.A.	Evaluation of concept document by aircraft manufacturer	Evaluated concept document for airport handling and fuelling of hydrogen-powered aircraft
Airport equipment	WP 2.3	Hamburg, Helsinki, Riga, Kaunas, Tallinn	Hydrogen-powered vehicle equipped for snow removal	Realised and tested hydrogen-powered equipment
Business case	WP 2.4	N.A.	Tool update and evaluation using pilot data	Evaluated business case calculations

Table 1.: Pilot Demonstration Matrix.

6.2 Supply Chain Pilots

Within the Supply Chain work package, a series of pilot demonstrations were conducted at five Baltic Sea Region airports: Hamburg, Helsinki, Riga, Tallinn, and Kaunas. The objective was to validate practical hydrogen supply concepts for airport operations and to gain real-world experience with hydrogen logistics, storage, refuelling processes, permitting procedures, and operational integration. The pilots focused on supplying hydrogen for hydrogen-powered airport vehicles and ground support equipment, thereby testing critical elements of future airport hydrogen ecosystems under operational conditions.

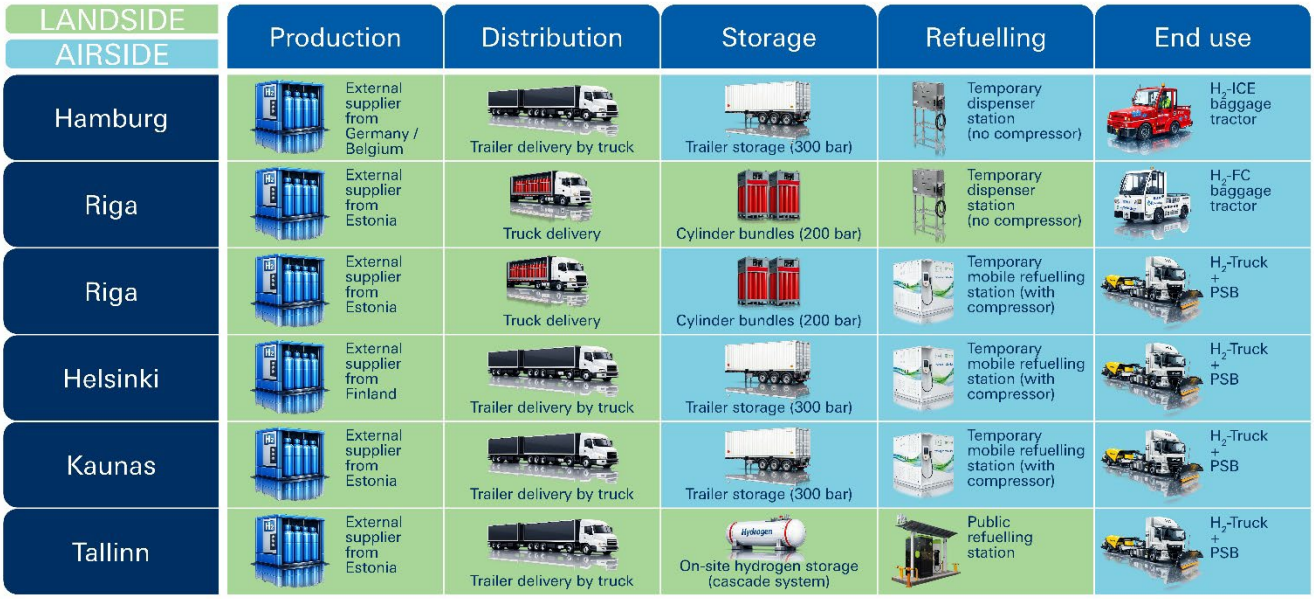


Figure 7.: Project-related hydrogen supply chain solutions.

The demonstrations covered a wide range of supply chain configurations. Hamburg and Helsinki implemented temporary on-airport hydrogen storage and refuelling solutions using container-based gaseous hydrogen delivery systems, while Riga tested a mobile hydrogen refuelling station supplied by hydrogen cylinder bundles. Tallinn evaluated a different concept based on off-site refuelling at a public hydrogen station and subsequent operation of hydrogen-powered airport equipment. Together, these pilots provided valuable insights into technical feasibility, operational performance, safety requirements, regulatory processes, and economic implications of hydrogen deployment at airports.

A common finding across all demonstrations was that road transport currently represents the most practical hydrogen delivery solution for small-scale airport applications. Hydrogen was supplied externally and transported to airports using trucks carrying either Multiple Element Gas Containers (MEGCs), high-pressure hydrogen containers, or cylinder bundles. The pilots demonstrated that truck-based delivery can be implemented reliably and safely, particularly for early-stage deployment and demonstration-scale projects where hydrogen demand remains relatively low.

The Hamburg pilot illustrated the advantages of a trailer-based hydrogen supply concept integrated directly into airport operations. Hydrogen was delivered via a mobile MEGC system with a storage capacity of approximately 360 kg of gaseous hydrogen, serving simultaneously as storage and refuelling infrastructure. Refuelling of the hydrogen-powered baggage tractor required approximately 10–15 minutes per refuelling event, demonstrating operationally acceptable performance for pilot-scale ground support operations. However, the demonstration also highlighted limitations associated with pressure-equalisation-based refuelling systems, which restricted the achievable vehicle filling level and would become increasingly inefficient for larger fleets with higher daily hydrogen demand.

Similarly, the Helsinki pilot demonstrated the feasibility of container-based hydrogen logistics under challenging winter airport conditions. Approximately 320 kg of green hydrogen produced at Finland's first industrial-scale hydrogen production facility in Harjavalta was transported around 200 km to the airport and stored temporarily on the apron. The pilot confirmed that hydrogen can be delivered, stored, and dispensed safely within an airport environment while complying with airport security, rescue service, and hazardous goods requirements. The project also highlighted the importance of technical compatibility between hydrogen containers, hoses, and refuelling equipment, emphasising the need for greater standardisation of hydrogen interfaces.

The Riga pilot provided particularly valuable lessons regarding technical limitations of small-scale hydrogen storage systems. Due to the unavailability of the planned tube trailer, hydrogen was supplied using cylinder bundles containing approximately 9 kg of hydrogen at 200 bar pressure. While this approach enabled the demonstration to proceed, significant operational disadvantages became apparent. Once pressure equalisation between storage and vehicle tanks was reached, the refuelling process slowed considerably. In some cases, dispensing an additional 1 kg of hydrogen required more than one hour, resulting in total refuelling times exceeding 75 minutes for only around 5.4 kg of hydrogen transferred. These results demonstrated that low-pressure storage concepts are poorly suited for operational airport environments and that compressor performance is a critical factor for efficient hydrogen refuelling.

The Tallinn pilot focused less on dedicated on-airport hydrogen infrastructure and instead evaluated operational impacts associated with external hydrogen supply. Hydrogen-powered winter maintenance equipment was refuelled at a public hydrogen station outside the airport and then returned to operations. While technically successful, the pilot clearly demonstrated the operational disadvantages of external refuelling. Vehicle operators had to leave secured airport areas, travel to the external station, complete refuelling, and subsequently pass through security procedures again upon returning to the airport. The study concluded that infrastructure limitations, rather than vehicle technology itself, currently represent the primary constraint to hydrogen deployment in airport operations.

From a regulatory perspective, the pilots provided valuable experience regarding permitting and approval procedures. Hamburg and Helsinki required comprehensive safety documentation, risk assessments, emergency response planning, and regulatory approval processes lasting approximately three to four months. In contrast, Riga faced less complex approval requirements due to the relatively small hydrogen quantities involved, while Tallinn required no significant additional hydrogen-specific permits because no dedicated airport hydrogen infrastructure was installed. These differences demonstrate that regulatory complexity is driven primarily by infrastructure scale and integration level rather than by hydrogen use itself.

Safety was one of the most important aspects investigated during the demonstrations. Across all pilot locations, extensive risk assessments, emergency planning procedures, airport rescue service coordination, and site-specific safety management measures were implemented. Notably, no hydrogen-related safety incidents occurred during any of the demonstrations. This consistent safety record across multiple airports and different supply concepts provides strong evidence that hydrogen can be handled safely within airport environments when appropriate technical and organisational measures are applied.

The pilots also generated important economic insights. Hydrogen costs were substantially higher than values commonly assumed in theoretical studies due to the small scale of deployment, limited supplier availability, and the temporary nature of the infrastructure. Reported hydrogen prices ranged from approximately €11–12/kg in Finland and Estonia to €35–40/kg for small-scale delivered hydrogen in Latvia. Additional costs arose from mobile storage systems, refuelling equipment rental, logistics, installation, permitting, and specialised technical support. The findings suggest that economies of scale, infrastructure standardisation, and increasing market maturity will be essential for improving the financial viability of airport hydrogen supply chains.

Overall, the pilots demonstrated that hydrogen supply chains for airport operations are technically feasible today. The primary challenges identified were not related to safety or vehicle performance but rather to infrastructure availability, operational integration, logistics efficiency, and market maturity. Airports equipped with temporary on-site hydrogen storage and refuelling solutions achieved significantly better operational performance than airports relying on external refuelling concepts. The demonstrations therefore support a phased development pathway, beginning with mobile hydrogen supply solutions, progressing to dedicated on-airport refuelling facilities, and ultimately evolving towards permanent hydrogen production, storage, and

distribution infrastructure capable of supporting future large-scale hydrogen-powered airport operations and aviation applications.

Report Demonstrations for Transport Solutions: https://interreg-baltic.eu/wp-content/uploads/2026/11/Report-on-Demonstrations-for-Transport-Solutions-WP-2.1-Supply-chain.pdf?project=bsr-hyairport

6.3 Aircraft Handling Demonstration

The WP 2.2 Aircraft handling focused on validating the proposed procedures and operational assumptions through an external expert review and the participation on a practical demonstration activity. The implementation concept developed within the project was submitted to Beyond Aero, a French developer of hydrogen-powered aircraft, as a proof of concept. The review aimed to assess whether the operational assumptions, airport procedures and safety considerations developed within BSR HyAirport were compatible with the requirements currently foreseen by an aircraft manufacturer. Feedback received from Beyond Aero was incorporated into the final implementation concept and provided an important validation of the proposed airport handling procedures.

Furthermore, project partners participated in a hydrogen-powered aircraft taxi demonstration conducted at Rotterdam The Hague Airport (RTM). The objective of this activity was to gain practical insights into the operational, safety, infrastructure, and regulatory requirements associated with handling hydrogen-powered aircraft in an airport environment. The demonstration provided a great opportunity to observe real hydrogen aviation operations and evaluate how future airport procedures may need to evolve to accommodate hydrogen-powered aircraft. Particular attention was given to understanding the preparatory activities required before hydrogen operations can take place at an airport, including permitting procedures, safety assessments, stakeholder coordination, and infrastructure requirements. The knowledge gained was intended to support the development of recommendations and planning activities within the BSR HyAirport project.

The demonstration was conducted within the framework of the Rotterdam The Hague Innovation Airport DutchH_2 Aviation Hub (RIHA) programme and involved collaboration between RTM, AeroDelft, TU Delft, and Air Products Benelux. The aircraft was developed by AeroDelft. They are a student team working on propulsion systems that run on hydrogen using fuel cells. They use a converted propeller plane that is intended to be powered first by gaseous hydrogen and later by liquid hydrogen. The tested aircraft was a modified Sling 4 two-seat aircraft equipped with a hydrogen fuel cell propulsion system. RTM acted as host airport and was responsible for operational planning, safety coordination, and the integration of the test into the airport environment. The test included three principal activities: hydrogen refuelling, powertrain testing, and aircraft taxiing. The primary goal was not to demonstrate full flight capability but rather to validate the functionality and operational integration of hydrogen propulsion technologies during ground operations.

The aircraft was equipped with a hydrogen storage system containing approximately 6 kg of gaseous hydrogen at 700 bar, while the refuelling system operated using a simplified configuration based on pressure equalisation rather than active compression. Hydrogen was supplied at a flow rate of approximately 10 g/s, with refuelling pressures around 180 bar, which was sufficient for the taxi test requirements. The fuelling process followed the SAE J2601 hydrogen refuelling standard, demonstrating that existing hydrogen fuelling technologies can be adapted successfully for small-scale aviation applications. The simplified refuelling concept reduced technical complexity and enabled rapid system deployment and commissioning while maintaining compliance with recognised hydrogen refuelling standards.

The demonstration also provided valuable insights into the infrastructure required for hydrogen aircraft handling. Despite the relatively small scale of the test, dedicated hydrogen safety zones had to be established around both the vent stack and the fuelling connection point. Separate protection zones were required around the refuelling system and venting infrastructure to manage potential hydrogen releases during operations. These operational safety areas represented an important difference from conventional aircraft handling procedures and highlighted the need for airports to integrate hydrogen-specific safety concepts into future apron planning and operational procedures. In addition, ATEX zones were established around the hydrogen infrastructure and aircraft systems. Access to these areas was restricted to authorised and trained personnel, underlining the importance of specialised operational procedures for future hydrogen aviation activities.

From a regulatory and safety perspective, the demonstration highlighted the extensive preparations required before hydrogen-powered aircraft can begin operations. The approval process included a quantitative risk assessment (QRA), compliance with relevant safety guidelines for hydrogen, the planning of emergency response measures, and a formal review by environmental and safety authorities. In addition, a hydrogen dispersion analysis was conducted to model the behavior of a potential hydrogen release and to determine appropriate safety distances, operating procedures, and risk mitigation measures.

As part of the environmental permitting process, the primary focus was on protecting the surrounding communities rather than airport personnel, as the population outside the airport grounds is generally unfamiliar with the risks associated with hydrogen. Various categories of recipients, including particularly vulnerable facilities such as hospitals and schools, as well as residential and commercial areas, were assessed using risk contour modeling to determine acceptable risk levels and safety requirements.

These assessments played a crucial role in obtaining regulatory approval for the demonstration project and represent key elements of future hydrogen operations at the airport. The preparatory work spanned approximately seven months, with the approval process alone taking about three months. As part of the approval process, compliance with the PGS-35 guidelines was demonstrated, an emergency plan was developed, and specialized risk contour modeling was conducted to assess the impact on the surrounding area and vulnerable facilities such as schools and hospitals.

In addition, the airport conducted its own operational safety assessment, which took into account scenarios such as collisions between aircraft and ground equipment. As part of this assessment, the airport also examined whether a potential release of hydrogen could interfere with air traffic control or disrupt other airport operations. An emergency response plan developed specifically for the hydrogen-powered aircraft complemented the overall safety concept.

The demonstration also highlighted the importance of involving various stakeholders early on, including environmental agencies, airport operators, hydrogen suppliers, emergency services, and aviation authorities. According to the organizers, the Civil Aviation Authority merely required notification of the planned activities, and no further regulatory concerns were raised during the process.

The taxi demonstration itself was successfully completed, with the hydrogen-powered aircraft exhibiting stable and predictable operational behavior throughout the test. No deviations from standard taxiing procedures were observed, and the aircraft demonstrated performance characteristics comparable to those of conventional airport operations. Importantly, no safety-related incidents involving hydrogen occurred during any phase of refueling, powertrain testing, or taxiing. From the perspective of the airport and air traffic control, the aircraft was treated largely like a conventional aircraft and integrated into normal airport operations, demonstrating that hydrogen-powered aircraft can be integrated into existing operational frameworks.

One of the most important findings of the demonstration was the confirmation that hydrogen-powered aircraft can be integrated into existing airport environments with the help of appropriate safety procedures and temporary infrastructure solutions. Although the test was limited to ground operations, it provided practical evidence that the operational challenges associated with handling hydrogen-powered aircraft are

manageable and can be addressed through established risk assessment methods, designated safety zones, refueling procedures, and emergency preparedness measures. The project also demonstrated that the current regulatory framework and airport management systems already provide a foundation for the operation of hydrogen-powered aircraft, provided that the specific hazards associated with hydrogen are appropriately assessed and mitigated.

Aircraft handling report: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport_Aircraft-Handling-1.pdf?project=bsr-hyairport

6.4 Airport Equipment Demonstrations

One of the key pilot streams within the BSR HyAirport project focused on the practical demonstration of hydrogen-powered airport equipment. The objective was to move beyond theoretical feasibility studies and evaluate how hydrogen technologies perform under real operational conditions at airports. The demonstrations covered both hydrogen fuel cell and hydrogen combustion engine technologies and involved several categories of ground support and maintenance equipment across the Baltic Sea Region. The pilots were designed not only to assess vehicle performance but also to evaluate operational integration, refuelling concepts, safety procedures, infrastructure requirements and organisational readiness for hydrogen deployment at airports.

The pilots addressed different operational use cases. Hamburg Airport focused on a retrofitted baggage tractor powered by a hydrogen ICE hybrid drivetrain, while Riga Airport tested a hydrogen fuel cell baggage tractor in day-to-day baggage and cargo handling operations. In parallel, Helsinki, Riga, Kaunas and Tallinn airports jointly evaluated a hydrogen fuel cell-powered heavy-duty winter maintenance vehicle equipped with snow plough and sweeper-blower systems. Together, these demonstrations covered both lightweight ground support equipment and heavy-duty airfield maintenance applications. In addition, Helsinki Airport participated in the Nordic Hydrogen Bus Roadshow, demonstrating a hydrogen fuel cell bus in airside passenger transport operations and extending the project scope to passenger-related airport applications.

The baggage tractor at Hamburg Airport tractor was converted from compressed natural gas to a hydrogen-powered hybrid system using a hydrogen-fuelled rotating disc engine and an electric motor. The vehicle was operated between May 2025 and April 2026 in regular airport service and dedicated performance tests. To enable operations, a temporary hydrogen refuelling facility was installed on-site using a mobile hydrogen trailer and dispenser system. The pilot generated more than 200 operating hours of data and demonstrated that retrofitting existing airport equipment can provide a viable pathway towards lower-emission operations while extending the lifetime of existing assets. Particular attention was given to permitting, risk assessments and infrastructure approval processes. The demonstration showed that temporary hydrogen infrastructure can be safely integrated into airport environments but requires significant preparation, including safety analyses, emergency planning, staff training and coordination with relevant authorities and airport stakeholders.



Figure 8.: Hydrogen-powered baggage tractor in Hamburg.

At Riga Airport, a hydrogen fuel cell baggage tractor was deployed in cargo and baggage handling operations. The demonstration focused on operational suitability, fuel consumption, safety procedures and user acceptance. Hydrogen was supplied via a temporary mobile refuelling system, allowing airport staff to gain hands-on experience with hydrogen logistics and refuelling procedures. The vehicle performed reliably throughout the pilot and was positively evaluated by operators. The demonstration also confirmed successful cold-start capability and generated practical experience regarding hydrogen handling under winter conditions. Operational limitations were mainly related to refuelling logistics and vehicle dimensions rather than the fuel cell system itself.



Figure 9.: Hydrogen-powered baggage tractor in Riga.

The heavy-duty winter maintenance demonstrations started at Helsinki Airport, where a Hyzon hydrogen fuel cell truck equipped with a snow plough and sweeper-blower was tested under demanding Nordic winter conditions, including temperatures down to -24°C. A temporary mobile hydrogen refuelling station was installed airside, allowing the project to evaluate both vehicle performance and hydrogen infrastructure requirements. The vehicle successfully completed winter maintenance operations and provided valuable data on hydrogen consumption, reliability and cold-weather performance. The Helsinki pilot demonstrated that hydrogen-powered maintenance equipment can perform operationally relevant airfield tasks under severe winter conditions, while also highlighting the need for further optimisation of battery management, thermal management and refuelling equipment designed for very low temperatures.



Figure 10.: Hydrogen-powered truck equipped with a snow plough and sweeper-blower.

The same vehicle was subsequently demonstrated at Riga Airport, where it was used in active snow-clearing operations under varying winter conditions. The Riga pilot confirmed the vehicle's suitability for operational winter maintenance tasks and generated additional data on fuel consumption, operational efficiency and refuelling logistics. While the vehicle completed all planned tasks successfully, the pilot identified reduced efficiency at temperatures below -10°C and highlighted the importance of improved energy management and thermal control strategies for future deployments in Northern Europe.

At Kaunas Airport, the vehicle was integrated into apron maintenance activities. While weather conditions limited opportunities for extensive snow-clearing operations, the pilot enabled the airport to assess operational integration, safety procedures and hydrogen refuelling concepts. Hydrogen was supplied through a temporary mobile refuelling station located outside the operational airside area, highlighting practical challenges related to vehicle access and infrastructure placement. The demonstration further provided valuable insights into airport approval procedures, staff training requirements and the operational implications of locating hydrogen infrastructure outside the airport security area.

Finally, Tallinn Airport focused on operational validation and user acceptance. Due to limited snowfall, testing concentrated on vehicle handling, manoeuvrability and operational suitability. Unlike the other pilots, hydrogen was sourced from an existing public hydrogen station outside the airport, demonstrating both the feasibility and limitations of relying on off-site refuelling infrastructure. The Tallinn pilot confirmed strong operator acceptance and reliable vehicle performance while highlighting the significant operational effort associated with off-airport refuelling and the benefits of dedicated airport-based hydrogen infrastructure.

In addition to ground handling and maintenance equipment, the project demonstrated hydrogen-powered passenger transport through participation in the Nordic Hydrogen Bus Roadshow. At Helsinki Airport, a hydrogen fuel cell bus was successfully deployed for airside passenger transport operations between aircraft stands and terminal facilities. The demonstration represented the first documented use of a hydrogen-powered vehicle in Nordic airside passenger transport operations and showed that hydrogen-powered passenger transport can be integrated into airport operations without affecting established operational procedures.

Across all demonstrations, the project confirmed that hydrogen-powered airport equipment can be safely integrated into airport environments and operated within existing airport Safety Management Systems. The pilots showed that comprehensive risk assessments, dedicated staff training and clearly defined operational procedures are sufficient to enable safe handling of hydrogen vehicles and temporary refuelling infrastructure.

No major hydrogen-related safety incidents occurred during the demonstrations. The pilots further demonstrated that hydrogen deployment should be considered as a complete operational system involving vehicles, refuelling infrastructure, emergency procedures, maintenance concepts, personnel qualification and airport safety management processes.

A particularly important finding was the consistently positive feedback from operators. Drivers highlighted the smooth driving characteristics and overall comfort of hydrogen fuel cell vehicles.

The pilots also demonstrated that hydrogen can be especially attractive for heavy-duty airport applications, such as winter maintenance vehicles, where battery-electric solutions may face challenges related to range, vehicle weight, charging times or continuous high-power demand. The successful operation of hydrogen-powered snow-clearing equipment under real airport conditions therefore represents an important milestone for the decarbonisation of airport operations. At the same time, the demonstrations revealed that most operational challenges originated not from the hydrogen systems themselves but from supporting systems such as batteries, energy management systems and auxiliary equipment.

At the same time, the demonstrations highlighted several barriers to wider deployment. The largest challenge was not the vehicles themselves but the supporting infrastructure. Temporary refuelling solutions proved technically feasible but often resulted in longer refuelling times, limited flexibility and significant logistical effort. All participating airports concluded that permanent on-airport hydrogen infrastructure will be required for large-scale commercial deployment.

The winter maintenance demonstrations provided valuable insights into hydrogen operation under Nordic climate conditions. Testing in Helsinki and Riga confirmed that hydrogen-powered airport equipment can perform operational tasks in temperatures ranging from mild winter conditions to below -20°C. However, the pilots also identified challenges related to energy management, component reliability and refuelling performance during severe cold weather. The results highlighted the importance of further optimisation of thermal management systems, fuel cell operation and refuelling infrastructure to ensure high reliability and operational efficiency in northern European airports.

Airport Equipment Demonstrations report: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport_Airport-Equipment.pdf?project=bsr-hyairport

6.5 Business Case Evaluation

The practical application of the BSR Hydrogen Airport Business Case Tool was evaluated through a series of airport-specific case studies across the Baltic Sea Region. These case studies were designed to test the usability of the tool under different regional conditions and to assess how factors such as electricity prices, hydrogen market maturity, transport distances, infrastructure concepts, and demand volumes influence the economic feasibility of hydrogen adoption. In addition, the business case calculations were continuously refined and validated using insights generated through the pilot and demonstration activities conducted within Work Package 2 of the BSR HyAirport project. The demonstrations provided valuable practical experience regarding hydrogen handling, infrastructure requirements, logistics concepts, and operational considerations, helping to improve assumptions used within the tool and increasing confidence in the overall assessment methodology.

The analysis demonstrated that there is no single hydrogen business model that can be applied universally across airports. Instead, the economic viability of hydrogen depends strongly on local conditions, particularly energy prices, availability of hydrogen suppliers, transport infrastructure, and expected hydrogen demand. The

case studies therefore confirmed the importance of airport-specific assessments when planning future hydrogen investments.

Across all airports analysed, hydrogen demand emerged as one of the most important cost drivers. Larger annual hydrogen volumes generally resulted in lower unit costs, reflecting economies of scale in production, storage, transportation, and infrastructure utilisation. As hydrogen demand increases, fixed investment costs can be distributed across larger fuel volumes, improving overall economic performance. At the same time, the demonstrations and business case analyses highlighted that infrastructure expansion does not occur linearly. Additional storage facilities, production units, liquefaction equipment, safety systems, or refuelling assets become necessary once certain demand thresholds are exceeded, which can temporarily increase unit costs despite growing demand. This underlines the importance of phased and modular infrastructure planning.

The case studies also highlighted considerable differences between mature and emerging hydrogen markets. Airports located in regions with relatively developed hydrogen ecosystems, such as Germany, benefited from more competitive procurement options and greater availability of external hydrogen supply. In these cases, delivered hydrogen often represented a viable strategy for early deployment phases. In contrast, airports in the Baltic States generally face limited hydrogen availability, higher transport costs, and less developed supply chains. Under current market conditions, the analyses frequently indicated that on-site hydrogen production could become more competitive than external procurement, particularly when renewable electricity is available at favourable prices. This finding was especially relevant for airports in Latvia, Estonia, and Lithuania, where future hydrogen demand may initially remain too small to support efficient large-scale supply chains. The Tallinn and Riga case studies demonstrated particularly large cost differences between procurement and local production options, illustrating how strongly hydrogen economics are influenced by regional market maturity and the availability of established supply chains. At the same time, pilot activities confirmed that hydrogen is already commercially accessible in these markets, even though large-scale supply networks are still in an early stage of development.

Another important finding was the significant influence of electricity costs on hydrogen economics. Since electrolysis represents a major component of the hydrogen production process, even relatively small differences in electricity prices, grid fees, and taxation can substantially impact final hydrogen supply costs. The sensitivity analyses confirmed that electricity-related costs remain one of the key determinants of future hydrogen competitiveness. Beyond pure electricity prices, the analysis also highlighted the importance of grid availability and electrical infrastructure. Even airports with attractive electricity prices may face limitations if sufficient grid capacity is unavailable to support large-scale electrolysis. Consequently, supply strategy decisions must consider both electricity cost and electricity availability.

The evaluation showed that operational expenditure assumptions have a strong effect on overall hydrogen production costs. Across multiple case studies, increasing OPEX assumptions resulted in significant increases in hydrogen cost per kilogram, underlining the importance of efficient operation, maintenance strategies, and infrastructure utilisation. These findings suggest that achieving low operational costs will be just as important as reducing capital expenditure when developing future hydrogen projects.

The comparison between gaseous hydrogen and liquid hydrogen scenarios demonstrated that large-scale aviation applications may increasingly favour liquid hydrogen due to higher energy densities and more efficient transport of large fuel volumes. However, the analyses also showed that liquefaction introduces significant additional costs and infrastructure requirements. This indicates that the transition from gaseous to liquid hydrogen will represent not only a technological challenge but also an important economic decision for airports planning future hydrogen aviation operations. The business case analyses further indicated that future hydrogen competitiveness in aviation cannot be evaluated based on fuel price alone. Route length, aircraft size, seat capacity, utilisation rates, maintenance costs, infrastructure concepts, and future carbon

pricing mechanisms strongly influence the economic outlook for hydrogen-powered aviation. The modelling performed within the project suggests that liquid hydrogen may become competitive with Sustainable Aviation Fuel under favourable future conditions, while competitiveness with conventional jet fuel remains dependent on substantial technological progress and supportive regulatory frameworks.

Beyond the direct comparison of supply pathways, the demonstrations also reinforced the strategic role airports may assume within future regional hydrogen ecosystems. The results suggest that airports could evolve from purely transport infrastructure providers into regional energy hubs coordinating hydrogen production, storage, distribution, refuelling operations, and renewable energy integration. While this transformation may create new business opportunities and value chains, it also requires long-term planning, coordinated stakeholder engagement, and significant investment commitments.

Overall, the case studies confirmed that hydrogen deployment at airports is highly context-dependent and that economic feasibility varies considerably across locations and development stages. The evaluation demonstrated the value of the Business Case Tool as a strategic planning instrument capable of comparing alternative development pathways and identifying the most promising hydrogen supply concepts for individual airports. The results further suggest that while current hydrogen costs remain relatively high due to the early stage of market development, increasing production volumes, improving infrastructure, technological learning effects, and supportive policy frameworks have the potential to significantly improve the business case for hydrogen aviation in the coming decades.

Business case Report: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport_Business-Case.pdf?project=bsr-hyairport

Business Case tool: https://interreg-baltic.eu/wp-content/uploads/2026/11/BSR-HyAirport-Business-Case-Tool_v2.0.zip?project=bsr-hyairport

7. Key Findings and Lessons Learned

7.1 Technical Feasibility

A central finding of BSR HyAirport is that hydrogen technologies for airport applications are already technically feasible today. The pilots throughout the project confirmed that hydrogen-powered vehicles, ground support equipment and airport maintenance machinery can be deployed successfully within existing airport environments. No major technological barriers were identified that would prevent airports from introducing hydrogen-based applications during the coming years.

The project also showed that hydrogen should not be considered a single technology solution. Fuel cells, hydrogen combustion engines, local hydrogen production, delivered hydrogen and future aircraft applications each have different strengths and limitations. Successful deployment will therefore require airports to combine technologies according to local operational needs rather than relying on a uniform implementation model.

7.2 Operational Feasibility

The demonstrations confirmed that hydrogen can be integrated into airport operations. A particularly important finding was the high level of operator acceptance. Across all vehicle demonstrations, drivers reported positive experiences regarding vehicle performance, driving comfort, acceleration, noise levels and usability. In many applications, hydrogen-powered equipment was perceived as operationally equivalent or even superior to conventional diesel-powered alternatives.

The project further demonstrated that airports could begin gaining practical hydrogen experience long before hydrogen-powered commercial aircraft enter service. Ground support equipment, maintenance vehicles, airport service fleets, backup power systems and potentially general aviation applications provide realistic entry points for building operational knowledge and organisational readiness. This creates an opportunity for airports to develop hydrogen capabilities gradually rather than waiting for future aircraft developments.

At the same time, the pilots highlighted that operational challenges are currently more strongly linked to infrastructure than to vehicle technology itself. Refuelling logistics, hydrogen availability, infrastructure placement and supply chain organisation frequently had a greater impact on operational performance than the vehicles being tested.

The demonstrations conducted in Nordic winter conditions additionally confirmed that hydrogen applications can operate in harsh climates. However, the tests also underlined the need for further optimisation of thermal management systems, cold-weather refuelling solutions and component reliability for severe winter operation.

7.3 Economic Feasibility

The economic analyses demonstrated that hydrogen deployment at airports is highly dependent on scale, local conditions and development timing. No universal business case exists, and economic feasibility must be evaluated individually for each airport.

One of the most important findings is that hydrogen demand is likely to emerge much earlier than often assumed. While public discussions frequently focus on future hydrogen-powered commercial aircraft, the project found that airport vehicles, ground support equipment, general aviation and regional aviation are likely to become the first meaningful hydrogen consumers. This creates opportunities for airports to develop hydrogen ecosystems before large-scale aviation demand materialises.

The project also confirmed that economies of scale will be critical for future competitiveness. Current hydrogen costs remain heavily influenced by temporary infrastructure, low utilisation rates and immature supply chains. As production volumes increase, infrastructure utilisation improves and market competition grows, hydrogen economics are expected to improve substantially.

A further key insight is that future airport hydrogen strategies should remain flexible. Given the uncertainty surrounding aircraft market entry dates, regulatory developments and hydrogen market evolution, phased investments with modular expansion capability represent a significantly lower-risk strategy than large-scale upfront infrastructure development.

7.4 Safety and Regulatory Findings

The project found no fundamental safety barriers to hydrogen deployment at airports. Across all demonstration activities, hydrogen was handled safely and no major hydrogen-related incidents occurred. This

provides strong evidence that hydrogen can be integrated into airport environments using established engineering controls, risk management measures and operational procedures.

However, the project identified regulatory uncertainty as one of the most important barriers for future implementation. Existing legislation generally allows hydrogen deployment, but regulatory frameworks remain fragmented because they were primarily designed for conventional fuels and not for airport hydrogen applications. The studies within the project consistently highlighted the absence of harmonised airport-specific hydrogen standards. Airports currently need to navigate complex combinations of aviation, environmental, construction, hazardous goods and energy regulations, often requiring engagement with multiple authorities and approval processes. This increases project complexity and implementation timelines.

An important lesson learned is that safety itself is often not the limiting factor. Instead, uncertainty regarding responsibilities, approval pathways and regulatory interpretation frequently creates greater implementation challenges than the technical safety requirements. Harmonised standards and clearer regulatory frameworks therefore represent an important enabler for wider deployment.

7.5 Key Lessons for Airports

Perhaps the most important lesson from the BSR HyAirport project is that airports should not wait for hydrogen-powered commercial aircraft before beginning their preparations. Airport readiness is not primarily an infrastructure challenge but an organisational challenge that requires months of preparation and stakeholder coordination. The project clearly demonstrated that successful hydrogen deployment should follow a phased pathway. Airports can start with small-scale applications such as ground support equipment, service vehicles, local storage systems and pilot refuelling solutions. These early applications provide valuable practical experience, develop organisational competencies and reduce uncertainty about future investment decisions.

A second critical lesson is that infrastructure should be designed to grow with demand. The analyses consistently showed that hydrogen adoption is likely to be gradual rather than disruptive. Consequently, scalable and modular concepts are more appropriate than infrastructure designed for speculative long-term demand. The project also highlighted that hydrogen deployment requires ecosystem thinking. Airports cannot prepare for hydrogen alone. Future success depends on close collaboration with airlines, hydrogen suppliers, technology providers, emergency services, regulators and public authorities. One of the most valuable outcomes of BSR HyAirport was therefore the creation of a transnational network that connects these stakeholders and facilitates future implementation activities.

Ultimately, BSR HyAirport showed that the transition towards hydrogen aviation should not be viewed as a single infrastructure project but as a long-term transformation process. Airports that begin developing capabilities, partnerships and operational experience today will be significantly better positioned to support the future introduction of hydrogen-powered aviation.

8. Transferability and Scalability

8.1 Application at Other Airports

One of the central objectives of BSR HyAirport was not only to develop and test hydrogen solutions at individual pilot airports, but also to create transferable methodologies, tools and practical experiences that can

support airport preparedness across the Baltic Sea Region and beyond. A key outcome of the project is that most findings are not airport-specific, but can be adapted to airports of different sizes, operational profiles and geographical locations.

The project demonstrated that hydrogen deployment does not need to start with large-scale aviation applications. Ground support equipment, airport service vehicles, and regional aviation can serve as realistic entry points for airports wishing to gain operational experience with hydrogen technologies. A major contribution of the project is the development of transferable planning methodologies covering hydrogen demand assessment, supply chain configuration, local production and storage sizing, airport infrastructure planning, aircraft handling procedures and business case evaluation. Rather than requiring airports to repeat basic analyses and assumptions independently, BSR HyAirport provides a structured framework that can be adapted to local circumstances and development pathways.

The demand assessment methodologies developed within the project are particularly transferable because they are based on operational airport data rather than predefined airport categories. Airports can therefore use the methodologies regardless of their size, traffic volume or geographical location. Similarly, the Business Case Tool allows airports to evaluate hydrogen deployment scenarios using their own local assumptions regarding energy prices, transport distances, infrastructure concepts and demand forecasts.

The project also demonstrated that there is no single hydrogen implementation model suitable for all airports. Factors such as airport size, proximity to hydrogen production hubs, access to renewable electricity, available transport infrastructure and expected hydrogen demand significantly influence the preferred deployment pathway. Consequently, transferability should not be understood as replicating identical solutions, but rather as applying common methodologies and lessons learned in local circumstances.

From a regulatory and operational perspective, the project confirmed that the risk assessment methodologies, permitting approaches, safety concepts, training frameworks and Management of Change processes developed during the demonstrations can provide valuable guidance for future hydrogen projects at other airports. The successful implementation of pilots at airports with diverse operational environments demonstrates the broad applicability of these approaches.

8.2 Pathways Towards Scale-Up

The project findings indicate that hydrogen deployment at airports is most likely to occur through a gradual and phased expansion process rather than through large-scale infrastructure investments from the outset. Both the analytical work and the pilot demonstrations showed that hydrogen demand will develop progressively as technologies mature, markets evolve and operational experience increases.

The first scale-up phase is expected to focus on airport-controlled applications. These include ground support equipment, airport vehicles, maintenance fleets and stationary energy systems. Such applications allow airports to develop hydrogen competencies, establish supply chains, gain experience with permitting procedures and validate operational concepts while hydrogen demand remains relatively modest.

The second phase is likely to involve the expansion of hydrogen infrastructure and the integration of larger hydrogen consumers. As demand grows, temporary supply concepts such as delivered hydrogen and mobile refuelling stations can gradually evolve into dedicated airport hydrogen hubs featuring permanent storage facilities, larger refuelling systems and potentially local hydrogen production. The project's production and storage analyses demonstrated that such developments are technically achievable at most airports, provided sufficient renewable electricity and grid capacity are available.

A third phase may include the introduction of hydrogen-powered regional and general aviation aircraft. The project identified regional aviation as one of the most promising early markets for hydrogen aviation and

demonstrated that many airports within the Baltic Sea Region already possess route structures that are compatible with future hydrogen aircraft concepts. This could enable the gradual development of regional hydrogen aviation networks supported by airport hydrogen infrastructure that initially served airport operations.

The long-term scale-up pathway envisages the establishment of integrated airport hydrogen ecosystems. In such a scenario, airports would no longer be passive fuel consumers but active participants in regional hydrogen value chains, combining local renewable energy generation, hydrogen production, storage, refuelling infrastructure and diverse hydrogen end-users. The project's analysis suggests that airports have the potential to become important anchor customers within future regional hydrogen economies.

However, successful scale-up will depend on several enabling factors. Continued reductions in hydrogen production costs, expansion of renewable electricity generation, development of transport infrastructure, regulatory harmonisation and standardisation of hydrogen technologies will all be essential. The project also highlighted the importance of maintaining close cooperation between airports, airlines, hydrogen suppliers, industry partners and public authorities throughout the scale-up process.

A key lesson from BSR HyAirport is that infrastructure should be designed for scalability from the beginning. Modular production systems, expandable storage concepts and flexible refuelling solutions provide airports with the ability to respond to uncertain demand growth while avoiding overinvestment. This approach reduces implementation risks and allows airports to expand hydrogen capabilities in line with actual market development.

Ultimately, the project demonstrated that the transition towards hydrogen aviation should be viewed as an evolutionary process rather than a single infrastructure project. The airports that begin building knowledge, partnerships and small-scale hydrogen applications today will be best positioned to support the future scale-up of hydrogen-powered aviation and airport operations in the decades ahead.

9. Communication and Stakeholder Engagement

Stakeholder engagement was an integral part of BSR HyAirport and played a key role in ensuring that project results reflected practical implementation needs and could be transferred beyond the project partnership. The project brought together 16 partners and 24 associated organisations representing airports, airlines, hydrogen suppliers, technology providers, research organisations, public authorities and industry stakeholders from across the Baltic Sea Region.

Throughout the project, a wide range of stakeholder activities was organised, including workshops, conferences, stakeholder meetings and pilot demonstrations. These activities enabled continuous exchange between project partners and external stakeholders, while providing opportunities to validate methodologies, discuss regulatory challenges and present pilot results.

A particular strength of the project was the close connection between analytical work and practical demonstrations. Stakeholders were involved not only in reviewing regulatory, operational and business case methodologies, but also in observing and discussing real-world pilot activities. This helped ensure that the developed solutions addressed actual airport needs and implementation challenges.

The public outreach activities for example via the project website and LinkedIn profile further supported the dissemination of project results to airports and aviation stakeholders across the Baltic Sea Region. Through these channels, BSR HyAirport increased awareness of hydrogen aviation and provided access to methodologies, pilot experiences and lessons learned.

Perhaps the most important long-term outcome was the creation of a strong hydrogen aviation network connecting airports, industry, authorities and research organisations. This stakeholder community provides a valuable foundation for future hydrogen projects, investments and implementation activities beyond the project lifetime and supports continued cooperation on the transition towards hydrogen-powered aviation.

10. Durability and Long-Term Impact

The long-term value of BSR HyAirport lies in the capabilities, methodologies and stakeholder structures that have been created and will remain available after the end of the project. The project moved the discussion on hydrogen aviation from a conceptual level to a practical implementation level and established a foundation that future projects can directly build upon.

A key durability effect is the creation of a comprehensive and transferable knowledge base covering regulation, safety, supply chains, airport infrastructure, aircraft handling, hydrogen-powered airport equipment and economic assessment. Future airports can use the methodologies, tools and guidance developed within BSR HyAirport instead of repeating the same initial studies and feasibility assessments. This significantly reduces barriers for future hydrogen implementation projects.

Equally important is the organisational learning achieved by the participating airports. Through risk assessments, permitting procedures, pilot implementation, infrastructure deployment and operational testing, airports gained practical experience that cannot be obtained through studies alone. This knowledge remains within the organisations and will support future hydrogen-related investment and implementation decisions.

The project also created a durable stakeholder network across the Baltic Sea Region. Airports, hydrogen suppliers, technology developers, research organisations, public authorities and industry stakeholders established working relationships and communication channels that will continue beyond the project lifetime. This network provides an important platform for future pilot projects, investment initiatives and regulatory development activities.

Several project outputs are designed for continued use after project completion. These include the hydrogen demand assessment methodologies, supply chain planning approaches, business case tool, aircraft handling concepts and operational lessons learned from the pilot demonstrations. Together, these outputs provide a practical toolbox for airports preparing for hydrogen deployment.

The project's most significant long-term impact is the increased preparedness of airports for future hydrogen-powered aviation. BSR HyAirport demonstrated that airports do not need to wait for commercial hydrogen aircraft before taking action. Airport equipment, hydrogen supply chains and supporting infrastructure can already be developed and tested today, allowing airports to build competencies and confidence in advance of future aviation demand.

The project further contributed to reducing uncertainty around hydrogen deployment. By validating concepts under real operational conditions, BSR HyAirport provided evidence that hydrogen can be produced, transported, stored, refuelled and used safely in airport environments. This reduces perceived implementation risks and provides a stronger basis for future investment decisions.

In the longer term, the project supports the development of a regional hydrogen aviation ecosystem in the Baltic Sea Region. The methodologies, partnerships and operational experience created through BSR HyAirport can accelerate future infrastructure projects, support regulatory harmonisation and facilitate the introduction of hydrogen-powered aircraft and airport operations.

11. Recommendations for Airports

The BSR HyAirport project demonstrated that airports can already begin preparing for hydrogen today, even though hydrogen-powered commercial aircraft are not yet in service. Hydrogen readiness should be seen as a long-term transformation process that gradually evolves from small-scale airport applications towards integrated hydrogen aviation ecosystems. Based on the project findings, airports should follow a phased implementation pathway that balances learning, risk reduction and infrastructure development.

Immediate Actions (0-3 Years)

Develop a hydrogen readiness strategy and roadmap

Airports should develop airport-specific hydrogen roadmaps defining potential use cases, infrastructure requirements, stakeholder responsibilities, investment needs and decision points. Hydrogen planning should be integrated into existing airport master planning and decarbonisation strategies. The project showed that preparing for hydrogen is not primarily an infrastructure challenge but an organisational one. Long lead times for permitting, stakeholder coordination, staff training and strategic planning mean that airports need to establish a clear direction long before significant hydrogen demand emerges. A structured roadmap helps prioritise actions, coordinate internal resources and avoid ad-hoc decision-making as technologies and regulations evolve. A focus on lateral use cases and combination of appliances through synergy effects can provide a valuable pathway for a economic feasible business case.

Assess future hydrogen demand

Before making investment decisions, airports should evaluate potential hydrogen demand from airport vehicles, ground support equipment, stationary energy applications and future aircraft operations. The methodologies developed within BSR HyAirport provide a suitable starting point for this assessment. The project demonstrated that hydrogen demand is likely to emerge first from airport-controlled applications and regional aviation rather than large commercial aircraft. Understanding likely demand volumes and growth pathways is therefore essential for selecting appropriate infrastructure concepts and avoiding both underinvestment and over dimensioning.

Establish internal hydrogen competencies

Dedicated hydrogen working groups should be established involving operations, engineering, safety, sustainability, emergency response and infrastructure departments. Building organisational competence should be prioritised before large-scale infrastructure investments are considered. Throughout the project, airports found that successful implementation depended heavily on cross-functional cooperation and internal expertise. Hydrogen affects multiple areas of airport operations, making early organisational learning and knowledge building a critical success factor.

Introducing first pilot applications

Airports should use hydrogen-powered ground support equipment, maintenance vehicles or airport service fleets as early learning opportunities. These applications enable operational experience with hydrogen handling, refuelling and safety management while requiring relatively limited infrastructure investments. The pilot demonstrations showed that airport equipment provides one of the most realistic entry points for hydrogen deployment and allows airports to build practical experience before hydrogen-powered aircraft enter service. In addition, smaller pilot projects help organisations understand permitting processes, stakeholder interactions and infrastructure requirements under real operational conditions.

Prepare safety and emergency procedures

Hydrogen-related scenarios should be integrated into Safety Management Systems (SMS), emergency response plans and training programmes. Airport rescue and firefighting services should be involved from the

beginning of project development. While the project found no fundamental safety barriers to hydrogen deployment, it highlighted the need for dedicated procedures addressing hydrogen-specific risks such as high-pressure systems, leak detection, venting events and invisible flames. Early preparation will facilitate future approvals and increase organisational confidence in hydrogen operations.

Medium-Term Actions (3-10 Years)

Deploy scalable hydrogen infrastructure

Hydrogen infrastructure should be developed in modular steps. Airports should initially focus on truck-delivered hydrogen, mobile storage systems and flexible refuelling solutions before investing in larger permanent installations. Infrastructure should be designed for future expansion. The project consistently showed that hydrogen demand is likely to increase gradually over time and that future market uptake remains uncertain. Modular approaches reduce investment risks and allow airports to adapt infrastructure in line with actual demand growth rather than speculative forecasts.

Assess opportunities for local hydrogen production

Where sufficient renewable energy resources and grid capacity are available, airports should evaluate the feasibility of on-site hydrogen production and storage. Local production can improve supply security, create operational flexibility and strengthen the airport's role within regional hydrogen ecosystems. The project demonstrated that land and water availability are generally manageable constraints, whereas electricity access becomes the determining factor for local hydrogen production. Airports therefore need to understand under which circumstances local production may be more advantageous than external supply.

Strengthening regional supply chain partnerships

Airports should actively cooperate with hydrogen producers, energy providers, logistics operators, neighbouring industries and public authorities to support the development of regional hydrogen value chains. Future hydrogen deployment depends on the coordinated development of production, transport and consumption infrastructure. The project highlighted that airports cannot create hydrogen ecosystems independently and that early cooperation helps reduce supply risks, improve investment planning and accelerate market development.

Prepare infrastructure for future aircraft operations

Airports should begin evaluating future stand concepts, hydrogen refuelling areas, safety distances, turnaround procedures and airside logistics requirements for hydrogen-powered aircraft. Although large-scale hydrogen aircraft are not expected in the near term, infrastructure planning and regulatory approval processes require many years of preparation. Early concept development enables airports to identify potential operational constraints and integrate hydrogen requirements into future airport development projects.

Address electricity and energy challenges

The project identified electricity availability and grid capacity as more significant constraints than land or water availability. Airports should therefore proactively plan for increased electricity demand, renewable energy integration and energy system flexibility. Hydrogen production, electrification and broader airport decarbonisation efforts will all increase future electricity requirements. Long-term planning for energy infrastructure is therefore essential to avoid future bottlenecks and enable cost-effective hydrogen deployment.

Long-Term Actions (10+ Years)

Develop integrated hydrogen airport ecosystems

As hydrogen demand grows, airports should evolve from individual hydrogen applications towards integrated systems combining renewable electricity generation, hydrogen production, storage, refuelling and multiple hydrogen end-users. The project showed that airports have the potential to become important anchor

customers within regional hydrogen economies, creating synergies between aviation, airport operations and regional energy systems. Such integration can improve resilience, supply security and economic viability.

Support the introduction of hydrogen-powered aviation

Airport infrastructure should gradually expand from supporting airport operations towards enabling hydrogen-powered regional, general and eventually commercial aviation. However, investments should remain aligned with actual aircraft market uptake and regulatory developments. The project demonstrated that hydrogen aviation is likely to emerge progressively, making phased expansion more appropriate than large upfront investments. Airports that have already gained operational experience will be in a stronger position to support future hydrogen aircraft operations.

Continuously adapt infrastructure and operational concepts

Hydrogen technologies, regulations and market conditions will continue to evolve. Airports should regularly review assumptions, update infrastructure plans and maintain flexible investment strategies to ensure long-term resilience and cost-efficiency. The project highlighted significant uncertainties regarding future demand, aircraft timelines, infrastructure standards and hydrogen supply chains. Continuous adaptation will therefore remain essential throughout the transition process.

Position airports as strategic energy hubs

In the long term, airports should not only act as consumers of hydrogen but also as active participants within regional energy systems. Through renewable energy generation, hydrogen production, storage and distribution, airports can contribute to wider decarbonisation efforts while strengthening their own energy resilience and business opportunities. The project demonstrated that airports are uniquely positioned to become important nodes within future regional hydrogen ecosystems.

12. Conclusion

One of the key findings of the project is that meaningful hydrogen demand at airports is likely to emerge earlier than often assumed. While public discussions frequently focus on future commercial hydrogen aircraft, the analyses conducted within BSR HyAirport indicate that initial demand is expected to arise from airport vehicles, ground support equipment, maintenance fleets, stationary energy applications, general aviation and regional aviation. This suggests that airports have opportunities to begin gaining experience with hydrogen technologies before hydrogen-powered commercial aircraft enter service. The project further demonstrated that a range of hydrogen applications can already be implemented under real airport conditions. Through pilot activities conducted at several airports, hydrogen was successfully transported, stored, dispensed and used in operational applications. The demonstrations confirmed the technical feasibility of hydrogen-powered airport equipment and provided practical insights into operational integration, infrastructure requirements, permitting procedures and safety management. Importantly, no fundamental technical or safety barriers were identified that would prevent airports from introducing hydrogen-related applications in the coming years, provided that appropriate safety measures and regulatory requirements are addressed. At the same time, the project confirmed that the transition towards hydrogen involves considerably more than the deployment of new technologies. Organisational readiness, stakeholder coordination, permitting procedures, supply chain development and regulatory clarity emerged as equally important factors. Many implementation challenges identified during the project were related to questions of governance, responsibilities, approval processes and organisational preparedness rather than technical performance alone. This highlights the need for airports and stakeholders to adopt a holistic approach when planning future hydrogen projects.

Beyond those findings, the project contributed to establishing a common knowledge base on airport hydrogen preparedness within the Baltic Sea Region. At the beginning of the project, many airports faced similar

questions regarding hydrogen demand, infrastructure requirements, safety procedures, regulatory obligations and business case development. While a growing body of research and demonstration projects already existed, information was often fragmented across different studies, organisations and sectors. BSR HyAirport brought together existing knowledge, supplemented it with new analyses and practical demonstrations, and translated the results into methodologies, tools and recommendations that can support future airport projects.

An important outcome of the project is the transferability of the developed approaches. The methodologies for hydrogen demand assessment, supply chain planning, infrastructure sizing, aircraft handling preparation and business case evaluation were specifically designed to be adaptable to different airport contexts. As a result, airports wishing to explore hydrogen solutions can build on the experiences and tools developed within BSR HyAirport rather than having to start with entirely new assessments. The transnational character of the project also played an important role. Airports within the Baltic Sea Region differ considerably in size, operational profile, national regulatory environment and level of hydrogen market development. Bringing together partners from different countries enabled the comparison of approaches, identification of common challenges and exchange of practical experiences. This helped to broaden the applicability of the project results beyond the individual pilot locations and contributed to a shared understanding of hydrogen preparedness across the region.

Perhaps most importantly, the project created a community of stakeholders that now shares a common understanding of the challenges and opportunities of hydrogen aviation. The relationships, trust and cooperation mechanisms established during the project will continue to support future innovation, investment and implementation efforts long after the project has ended. By creating both practical knowledge and a durable international network, BSR HyAirport has laid important foundations for the long-term transition towards hydrogen-powered aviation and more sustainable airport operations.

Overall, BSR HyAirport demonstrated that preparations for hydrogen-powered aviation can begin well before hydrogen aircraft enter commercial service. The project confirmed the technical feasibility of several airport-related hydrogen applications, improved understanding of regulatory and operational requirements, generated practical experience through pilot demonstrations and developed planning tools that can support future implementation activities. In this way, the project contributed to reducing uncertainty surrounding airport hydrogen deployment and provided airports and stakeholders with a practical basis for future decision-making. By creating a common starting point for airports and stakeholders, the project supports future efforts to integrate hydrogen into aviation and contributes to the long-term transition towards more sustainable airport operations and aviation systems.

References

Overview of all reports here: https://interreg-baltic.eu/project/bsr-hyairport/

Acknowledgements

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