Interreg
Baltic Sea Region
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SMART GREEN MOBILITY
BSR HyAirport

Supply Chain

Report on

WP 1.2 Supply chain 1.2.1 Demand Analysis - Aircraft

Content

Introduction and objectives

Work Package 1.2 "Supply Chain" consists of three sub-work packages / working groups:

- WG 1.2.1 "Demand Analysis"
- WG 1.2.2 "Local production & storage"
- WG 1.2.3 "Transport"

Overall objective of WG 1.2.1 is to develop a methodology for the estimation of GH_2 demand for different use cases at airports. This chapter focuses on the demand for scheduled and non-scheduled (irregular or ad-hoc) flights. Other cases of use are the fuelling of GH_2-powered vehicles (e.g. for ground handling) at airports or the need for GH2 to provide back-up power and for cooling or heating of buildings.

The BSR HyAirport project focusses on GH_2 as new aircraft types or engine retrofitted aircraft using GH_2 will entry into service much earlier in comparison to larger aircraft types that will replace the current Airbus A320 family or Boeing 737 family. This will most likely not happen before the middle of the next decade.
Flights with smaller aircraft using GH_2 might start already at the end of this decade. Two market segments of aviation that will have demand for GH_2 has been distinguished:

- Scheduled flights
- Non-scheduled flights or the "General Aviation" (including Business Aviation).

First, it has been planned within the BSR HyAirport project to consider only the demand of scheduled flights as those flights contribute to the accessibility of regions. At least for some parts of the Baltic Sea Region, scheduled flights are very important as the Baltic Sea is a natural barrier for fast travel and in other regions fast land-based transport with other modes of transport is not available. In the last two decades many former scheduled air transport routes have been closed due to a bad economy of small aircraft caused by high costs for fuel and staff. GH_2 might offer the change to re-introduce climate neutral operations on those routes or even the chance to open new routes that have not been offered before.

Non-scheduled flights of the General Aviation represent only a smaller number of passengers. Those flights typically use small aircraft with less than 10 seats. At the beginning of the BSR HyAirport, it has been planned not to consider this market segment as it provides only a smaller contribution to the improvement of accessibility of regions. Due to higher emissions per passenger, the project concluded that this market segment should be considered as well.

In the following chapters the methodology for demand calculations for both market segments and examples calculations are described. The results, named "scenarios", may be used as input to the work of other working groups of the BSR HyAirport project, e.g. WG 1.2.2 Supply chain - Local production & storage, WG 1.2.3 Supply chain - Transport, WG 1.5 Business Case. In doing so, the report serves as a foundational input to the planning and design of hydrogen supply chains, infrastructure investments, and associated business models at BSR HyAirport project partner airports and beyond.

It is important to emphasize that the analysis presented here does not aim to deliver a definitive forecast. Rather, it provides a plausible, data-driven approximation ("scenario") of future hydrogen demand under clearly stated assumptions, informed by the best available evidence and industry benchmarks. The considerable uncertainty surrounding regulatory developments, technological progress, and market adoption pathways is explicitly acknowledged throughout the analysis. This transparency ensures that the report can function as a practical reference point supporting the Lead Partner of the BSR HyAirport project, Hamburg Airport, and its partners in testing assumptions, identifying risks and opportunities, and navigating the complex transition toward a more sustainable aviation future.
The results of WG 1.2.1 Demand Analysis will be part of the Deliverable of the BSR HyAirport project D1.2 "Report on solutions for the creation of hydrogen supply chains to / at airports".

Scheduled routes demand model

Introduction

This chapter presents an estimation of gaseous hydrogen (GH_2) demand for scheduled regional flights. The focus is on flights to and from BSR HyAirport project partner airports, with demand assumptions based on potential future routes identified by project partners but can also be used by any other Airport planning party. Project partner airports represent a certain "market intelligence" that considers many specific local factors that influence demand for air transport routes. Rather than competing with high-frequency, large-capacity routes, GH_2-powered aircraft in the 10- to 30-seat range may be best suited for newly established routes, the reactivation of previously discontinued connections, or the continued operation of existing regional services under hydrogen propulsion.

Data Overview – Identification of routes for scheduled air transport

The analysis is based on input provided by partner airports. BSR HyAirport project partners were asked to identify potential routes for the years 2030 and 2035 that could feasibly be served by hydrogen-powered aircraft with either 10 or 30 seats. The approach to identify routes and to assume frequencies of flights as base for demand calculations has been selected as the alternative way to calculate demand by assuming a specific rate of replacement of conventional powered flight might lead to wrong results. The market segment of regional scheduled flights with aircraft types with 50 or less seats declined in the last two decades. Many airlines in this market segment have stopped operating and many routes have been closed. Calculations for GH2-demand using a yearly increasing percentage for the replacement of conventional fuels for a currently only in a small extend existing market segment would lead to wrong results.
The availability of GH_2-powered aircraft types may offer the chance for a re-vitalisation of the previously operated routes that are not operated any more due to lack of suitable aircraft for viable operations. The calculations made are based on the belief that scheduled flights operating with aircraft types with less than 50 seats will operate more frequent again, and on more routes than today.

Additionally, routes currently operated with a very low, not attractive frequency and too large aircraft capacity for the route might be operated with a more suitable aircraft capacity. Last but not least, routes currently operated with small, but not GH_2-powered aircraft, e.g. from Tallinn to the Estonian islands, might be operated with GH_2-powered aircraft. The identification is based on the market knowledge of BSR HyAirport partner airport. Specific business cases have not been calculated and have not been discussed with potential airliners outside the project partnership as the main purpose of this work package is the methodology for calculation of the future demand for GH_2 and the generation of input data for other work packages of the BSR HyAirport project.

The 10-seat aircraft could be a Cessna Grand Caravan (Cessna 208). The 30-seat aircraft is an assumed aircraft type that could be in operation in the year 2030. As of today, the BSR HyAirport does not know exactly the entry into service of GH_2-powered aircraft types, the production rate of those future aircraft types and which airlines will operate GH_2-powered aircraft.

In total, BSR HyAirport project partners identified 69 scheduled routes from 21 origin airports that could be operated in the year 2030. 24 of 69 routes are re-activated routes and 15 routes are new routes that did not operate on a scheduled base before. The average length of the identified routes is 170 nautical miles.

City / Airport	Airport Code	Number of routes 2030	thereof reactivated route	thereof new route	Average distance (nm)
Gothenburg	GOT	2	1		198
Hamburg	HAM	7	4	2	212
Helsinki	HEL	7	2		144
Joensuu	JOE	1			194
Kajaani	KAJ	1			248
Kardla	KDL	1			82
Kuopio	KUO	1			178
Kuressaare	URE	1			119
Oulo	OUL	1	1		383
Poznan	POZ	6	2	2	223
Savonlinna	SVL	1			148
Stockholm-Arlanda	ARN	3	2		161
Stockholm-Bromma	BMA	1			178
Sylt	GWT	8	2	4	151
Tallinn	TLL	6	2		109
Tampere	TMP	3	1	1	119
Turku	TKU	3	1	1	115
Vaasa	VAA	2			160
Växjö	VXO	11	5	4	182
Vilnius	VNO	1			103
Visby	VBY	2	1	1	170
	Total	69	24	15	

Table 1 – Identified routes, year 2030

The assumed number of annual departures is 42.216 in 2030. Until 2035, an increase to 61.740 departures is assumed.

City / Airport	Airport Code	Number of routes 2030	Number of departures per year (2030)	Number of departures per year (2035)
Gothenburg	GOT	2	510	1.150
Hamburg	HAM	7	1.566	5.976
Helsinki	HEL	7	10.538	15.216
Joensuu	JOE	1	1.428	1.428
Kajaani	KAJ	1	1.040	1.128
Kardla	KDL	1	312	312
Kuopio	KUO	1	1.428	1.860
Kuressaare	URE	1	1.040	320
Oulo	OUL	1	364	728
Poznan	POZ	6	832	2.288
Savonlinna	SVL	1	1.860	728
Stockholm-Arlanda	ARN	3	1.628	5.047
Stockholm-Bromma	BMA	1	900	1.500
Sylt	GWT	8	780	1.124
Tallinn	TLL	6	1.492	5.552
Tampere	TMP	3	5.218	3.276
Turku	TKU	3	3.368	3.751
Vaasa	VAA	2	1.404	2.288
Växjö	VXO	11	5.977	6.700
Vilnius	VNO	1	200	928
Visby	VBY	2	331	440
	Total	69	42.216	61.740

Table 2 – Identified routes, departures year 2030 and year 2035

Those selected routes are not based on any feasibility calculation nor planned or discussed with any airline merely selections by the Project Partners made on basic assumptions, mainly range and attractivity. The main purpose is to get a starting point for calculating the demand of possible hydrogen consumption and testing the derived methodology. Therefore the results have a large variation on plausibility and feasibility.

Methodology for GH_2 demand calculation

The demand for GH_2 for the identified routes can be calculated with the help of the monthly / yearly frequency of flights, the sector length and the consumptions rate of aircraft types (measured in kg/ nautical mile, nm).
The following fuel consumption rates has been used:

	Seats	Engines	Range	Consumption kg/nm
Grand Caravan	10	1	250 nm	0,20
30 seater (similar to Saab 340)	30	2	430 nm	0,36

Table 3 - Fuel consumption rates

The demand estimation is based on a straightforward calculation. For each identified route, the annual number of flights is multiplied by the route distance and the fuel consumption of the corresponding aircraft type (10- or 30-seater), as stated above.

Tankering

For certain routes, tankering can be assumed. Tankering involves refuelling at the point of departure for both the flight outbound and the return flight. Since there is no reliable data on tankering behaviour of GH$_2$ aircraft yet, and the distances of the routes are short, any additional fuel consumption resulting from extra fuel weight is neglected. In tankering cases, the GH$_2$ demand for the route must therefore simply be doubled.

Results Scenario 2030 and Scenario 2035

Number of annual departures and annual GH2-demand for scheduled GH2-powered flights from BSR HyAirport project partner airports in 2030.

City / Airport	Airport Code	Number of routes 2030	Average distance (nm)	Number of departures per year (2030)	Annual demand GH2 (kg) 2030
Gothenburg	GOT	2	198	510	30.789
Hamburg	HAM	7	212	1.566	211.506
Helsinki	HEL	7	144	10.538	752.639
Joensuu	JOE	1	194	1.428	99.929
Kajaani	KAJ	1	248	1.040	100.862
Kardla	KDL	1	82	312	10.243
Kuopio	KUO	1	178	1.428	119.313
Kuressaare	URE	1	119	1.040	14.825
Oulo	OUL	1	383	364	50.237
Poznan	POZ	6	223	832	151.522
Savonlinna	SVL	1	148	1.860	21.620
Stockholm-Arlanda	ARN	3	161	1.628	138.653
Stockholm-Bromma	BMA	1	178	900	53.456
Sylt	GWT	8	151	780	34.056
Tallinn	TLL	6	109	1.492	83.004
Tampere	TMP	3	119	5.218	74.805
Turku	TKU	3	115	3.368	60.418
Vaasa	VAA	2	160	1.404	136.559
Växjö	VXO	11	182	5.977	220.811
Vilnius	VNO	1	103	200	9.280
Visby	VBY	2	170	331	3.146
	Total	69		42.216	

Table 4 – GH$_2$-demand for scheduled routes at BSR HyAirport partner airports, year 2030

Number of annual departures and annual GH2-demand for scheduled GH2-powered flights from BSR HyAirport project partner airports in 2035.

City / Airport	Airport Code	Number of departures per year (2030)	Number of departures per year (2035)	Annual demand GH2 (kg) 2030	Annual demand GH2 (kg) 2035
Gothenburg	GOT	510	1.150	30.789	41.805
Hamburg	HAM	1.566	5.976	211.506	386.335
Helsinki	HEL	10.538	15.216	752.639	768.795
Joensuu	JOE	1.428	1.428	99.929	99.929
Kajaani	KAJ	1.040	1.128	100.862	100.862
Kardla	KDL	312	312	10.243	10.243
Kuopio	KUO	1.428	1.860	119.313	119.313
Kuressaare	URE	1.040	320	14.825	5.888
Oulo	OUL	364	728	50.237	100.473
Poznan	POZ	832	2.288	151.522	151.522
Savonlinna	SVL	1.860	728	21.620	30.268
Stockholm-Arlanda	ARN	1.628	5.047	138.653	299.328
Stockholm-Bromma	BMA	900	1.500	53.456	53.456
Sylt	GWT	780	1.124	34.056	29.448
Tallinn	TLL	1.492	5.552	83.004	144.323
Tampere	TMP	5.218	3.276	74.805	145.168
Turku	TKU	3.368	3.751	60.418	125.384
Vaasa	VAA	1.404	2.288	136.559	166.984
Växjö	VXO	5.977	6.700	220.811	230.765
Vilnius	VNO	200	928	9.280	59.846
Visby	VBY	331	440	3.146	23.491
	Total	42.216	61.740		

Table 5 - GH$_2$-demand for scheduled routes at BSR HyAirport partner airports, year 2030 and year 2035

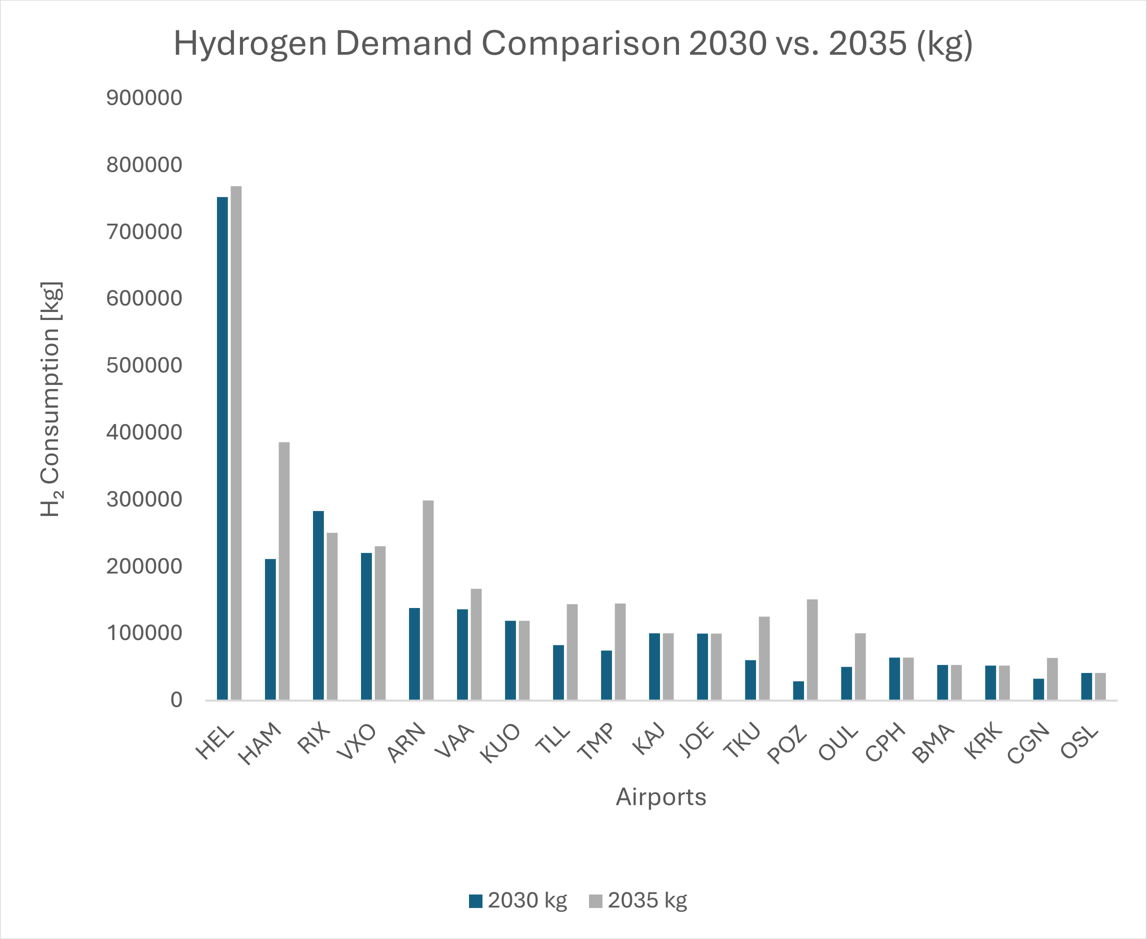


Figure 1 - GH2 Demand per Airport (no tankering)

Table 3 and 4 summarize the projected hydrogen demand across the identified routes for scheduled air transport. The data highlights key differences in demand levels depending on route length, frequency, and aircraft type.
Among the airports analysed Helsinki exhibits the highest hydrogen demand (~752,000 kg in 2030), primarily due to the high expected frequency of 13,954 flights / year of 30 seat aircraft.

Oulu represents an outlier, expecting the establishment of just a single route to Stockholm (ARN), with a frequency of 14 times per week or 728 times per year. However, the distance of 383 nm leads to a demand of ~100,000 kg in 2030 and with 21 flights per week ~150,000 kg in 2035.

As outlined in the beginning of this report, these estimates are first possible ideas for having usable data for methodology application and do not reflect any market research, business cases nor plannings.

Non-scheduled flights demand model

Introduction

This chapter provides a structured and analytically robust assessment of the potential demand for gaseous hydrogen (GH_2) at the General Aviation Terminal (GAT) of Hamburg Airport. It was commissioned as part of the airport's broader decarbonization strategy and contributes to the BSR HyAirport initiative - a transnational program supporting airports across the Baltic Sea Region in preparing for the adoption of hydrogen-powered aviation. The analysis is designed to establish a transparent and data-driven baseline, enabling the airport and its stakeholders to evaluate strategic options, identify key enablers, and engage in informed decision-making in an environment of considerable technological and market uncertainty.

Focusing on the GAT, which primarily serves private and business aviation - a segment with disproportionately high per-passenger emissions and a heterogeneous fleet structure, the analysis pursues three core objectives. First, it quantifies the current fuel consumption of all outbound flights from the GAT, based on detailed aircraft- and flight-level data.

Second, it estimates the theoretical CO_2 reduction potential that could be achieved by substituting conventional jet fuel with hydrogen. Third, it develops a plausible long-term transition model reflecting expected adoption dynamics, fleet renewal rates, and operational constraints.

Data overview

The foundation of this analysis is a comprehensive dataset provided by Hamburg Airport, capturing the full scope of flight movements at the General Aviation Terminal (GAT) over the course of the calendar year 2024. In total, the dataset comprises approximately 18,000 individual records, reflecting the diverse operational profile of general and business aviation activity at the GAT.

The data set offers a high level of granularity and completeness, including key variables such as flight direction (inbound and outbound), aircraft type - covering around 250 distinct models ranging from small piston aircraft and turboprops to business jets and helicopters - as well as origin and destination airports, which span roughly 500 unique locations worldwide. Each movement is timestamped at daily resolution, allowing for precise temporal analyses and the identification of seasonal patterns in flight activity.

To complement the operational data, a dedicated aircraft reference database was developed to capture the technical and operational characteristics required for a robust estimation of hydrogen demand. This reference database consolidates, for each aircraft model observed in the dataset, publicly available and verifiable information on typical fuel consumption rates, average service life, and categorization according to their suitability for hydrogen-based propulsion. Fuel consumption values were derived from manufacturer specifications, institutional sources such as ICAO and FAA, and relevant industry publications. The average service life of aircraft was determined to provide a realistic basis for modelling fleet replacement dynamics over time.

Taken together, the dataset and the supplementary aircraft reference database provide a solid and transparent analytical foundation. They combine breadth - by representing the full spectrum of GAT operations - with depth, enabling aircraft- and flight-specific differentiation critical to developing realistic and actionable hydrogen demand scenarios. This rigorous data basis ensures that subsequent analyses rest on transparent assumptions and robust evidence.

Methodology

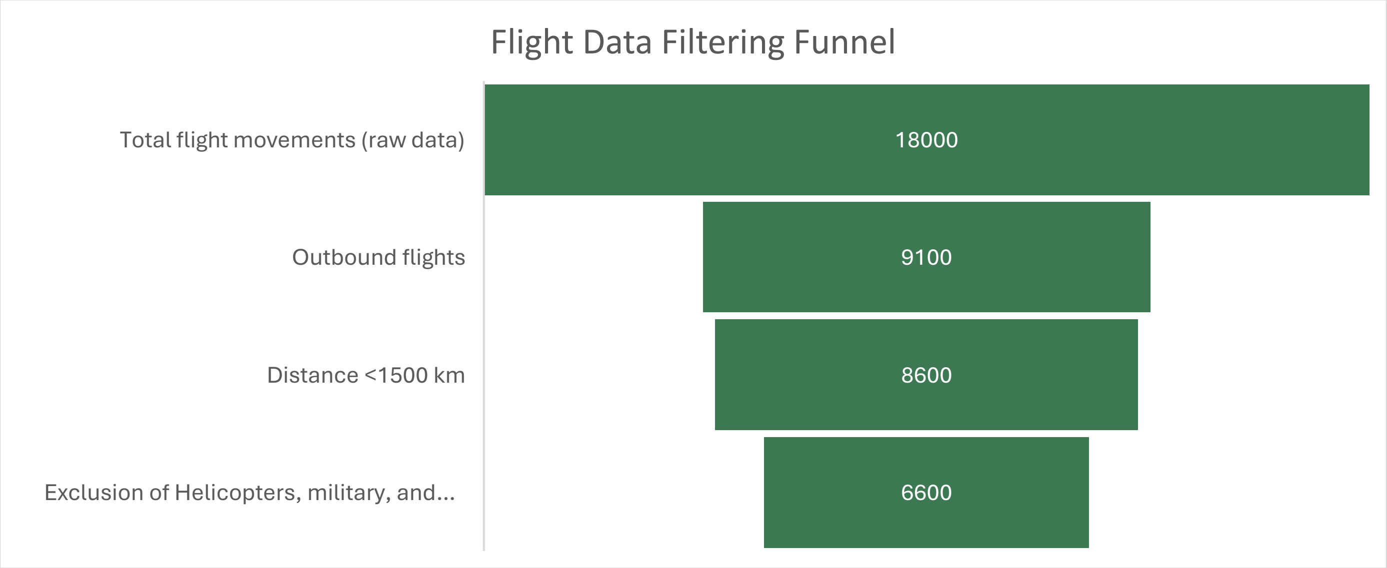
The methodology applied in this analysis follows a bottom-up, data-driven approach designed to deliver a transparent and differentiated estimation of current fuel consumption and the theoretical potential for hydrogen substitution. Recognizing the heterogeneity of aircraft types, operational patterns, and route distances in general and business aviation, the analysis is conducted at the most granular level possible - leveraging flight-level data in combination with aircraft-specific performance characteristics.

At its core, the methodology integrates two analytical dimensions: the technical properties of each aircraft model and the operational details of each individual flight. The former provides specific fuel consumption rates and service life assumptions, while the latter captures actual flight distances and frequencies. By combining these dimensions, the analysis produces an accurate estimate of total fuel consumption for all relevant outbound flights and translates it into hydrogen-equivalent demand under clearly stated assumptions.

The following sections detail each step of the approach, beginning with the filtering of the raw dataset to focus on flights relevant to the analysis, followed by the classification of aircraft types, calculation of point-to-point distances, and the derivation of fuel and hydrogen consumption at flight and aggregate levels.

Filtering the data

To ensure the analysis was both targeted and methodologically sound, the raw dataset of approximately 18,000 recorded flight movements at the General Aviation Terminal was systematically cleaned and filtered. This step was critical to aligning the scope of the data with the specific objectives of the study and isolating those flights most relevant for estimating realistic demand for gaseous hydrogen (GH_2). The filtering process followed a structured, stepwise approach, illustrated in the adjacent funnel.



In a first step, only outbound flights were retained, as these determine the on-site fuelling requirement at Hamburg Airport and thus directly inform potential hydrogen demand. This reduced the dataset to approximately 9,100 movements.

Subsequently, flights covering a distance of over 1,500 kilometres were excluded. This threshold reflects the expected maximum operational range of hydrogen-powered aircraft in the general and business aviation segment. Removing these longer flights further reduced the dataset to around 8,600 movements.

Finally, all helicopter movements, military operations, and large commercial jets were filtered out, as these aircraft types either fall outside the foreseeable scope of hydrogen adoption or have operational characteristics incompatible with the intended analysis. After this final step, the analytical dataset comprised approximately 6,600 outbound flights, which form the basis for all subsequent calculations of fuel consumption and hydrogen substitution potential.
This deliberate and transparent filtering process ensured that the analysis was focused on the relevant segment of operations, those flights and aircraft types most likely to be addressed by future hydrogen-powered solutions and provided a robust foundation for deriving actionable insights.

Total GH2 demand

Rather than applying a generic energy conversion factor to aggregate kerosene consumption - a method that would have yielded only a coarse approximation of potential hydrogen demand - deliberately a more differentiated and aircraft-specific approach has been developed. This allowed to reflect the operational heterogeneity of the fleet and produce results that are both analytically rigorous and actionable for planning purposes.
The methodology rested on two core analytical tasks, systematically executed for each of the approximately 6,600 filtered outbound flights in the dataset:

First, aircraft type research to determine the specific fuel consumption of every individual aircraft model present in the dataset has been conducted. For each type, the typical consumption rate in litres per 100 km, using multiple authoritative and verifiable sources has been researched. These included:

- manufacturer technical specifications and product data sheets
- international institutional datasets and reports (e.g., ICAO, FAA, EASA)

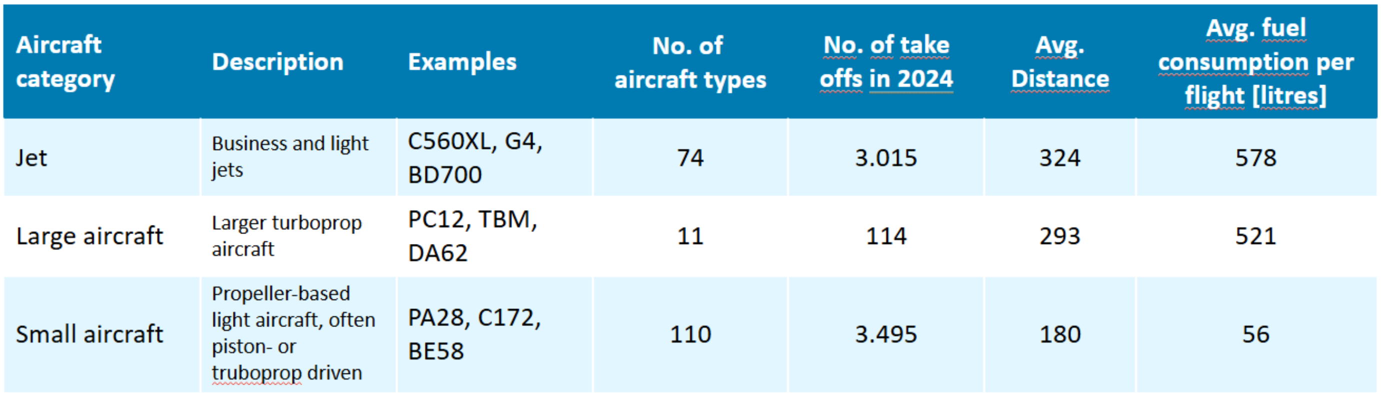
published aviation benchmarks from peer-reviewed studies and industry whitepapers.
This ensured that the resulting consumption figures were representative of real-world operations while maintaining a transparent and traceable evidence base.

Second, a detailed distance estimation, calculating the actual point-to-point flight distance between Hamburg Airport and each destination airport recorded in the dataset has been carried out. Distances were computed as great-circle distances (shortest path over the earth’s surface) using validated aviation tools consistent with industry practice, ensuring accuracy and comparability across the entire sample.

By integrating these two dimensions - aircraft-specific fuel performance and route-specific flight distance - a granular, flight-level estimate of total kerosene consumption for the relevant segment has been produced. This resulted in an estimated annual fuel consumption of approximately 3.79 million litres, providing a robust and realistic foundation for modelling GH_2 demand scenarios tailored to the unique characteristics of the GAT fleet and its operations.
To enable a differentiated and realistic estimation of potential demand for GH_2, a clear categorization of the diverse fleet and derived category-specific hydrogen consumption assumptions has been established. This approach balances analytical rigor with pragmatic applicability, allowing to reflect both the technical heterogeneity of the fleet and the current state of knowledge on hydrogen propulsion technologies.

More than 200 aircraft types observed in the dataset has been classified into three representative categories, based on their mass, propulsion type, and typical operational range. The classification was informed by authoritative sources including FAA and ICAO aircraft registries, manufacturer documentation, and industry benchmarks. The categories were defined as follows:

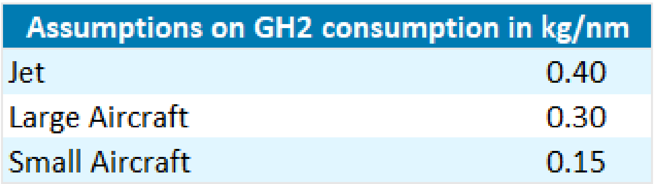
- Jet aircraft: business and light jets (e.g., C560XL, G4, BD700), characterized by high speed, longer range, and relatively high per-flight fuel consumption.
- Large aircraft: larger turboprop aircraft (e.g., PC12, TBM, DA62), typically used for regional operations with moderate fuel requirements.
- Small aircraft: propeller-driven light aircraft, often piston- or turboprop-powered (e.g., PA28, C172, BE58), operating at lower speeds over shorter distances and with significantly lower fuel consumption per flight.



Aircraft category	Description	Examples	No. of aircraft types	No. of take offs in 2024	Avg. Distance	Avg. fuel consumption per flight [litres]
Jet	Business and light jets	C560XL, G4, BD700	74	3.015	324	578
Large aircraft	Larger turboprop aircraft	PC12, TBM, DA62	11	114	293	521
Small aircraft	Propeller-based light aircraft, often piston- or truboprop driven	PA28, C172, BE58	110	3.495	180	56

Table 6 - Aircraft Categories

For each category, a representative GH_2 consumption rate expressed in kilograms of GH_2 per nautical mile (kg/nm) has been determined. These assumptions were based on the latest reported figures from leading hydrogen aircraft development programs, including data from ZeroAvia's retrofitted Cessna Grand Caravan (0.2 kg/nm) and Beyond Aero's light jet concept (0.27 kg/nm). Building on these benchmarks and adjusting for category-specific operational characteristics, the following conservative assumptions were adopted:



Assumptions on GH2 consumption in kg/nm	
Jet	0.40
Large Aircraft	0.30
Small Aircraft	0.15

Table 7 - Assumed GH2 Consumption rates

These category-level consumption factors were then multiplied by the actual point-to-point distances of all flights in the filtered dataset, providing a robust estimate of total GH_2 demand. The combination of this carefully defined categorization and evidence-based assumptions ensures that the resulting demand figures are both technically plausible and aligned with industry expectations for the near- to mid-term development of hydrogen-powered aviation.

The applied approach, based on aircraft categorization and category-specific hydrogen consumption assumptions, results in an estimated annual demand of approximately 495,391 kg of gaseous hydrogen for the relevant outbound flights at Hamburg Airport. This figure reflects a pragmatic and evidence-based approximation, derived from manufacturer data and aligned with the operational profile of the analysed fleet. The methodology provides a transparent and robust foundation for further scenario development and strategic assessment.

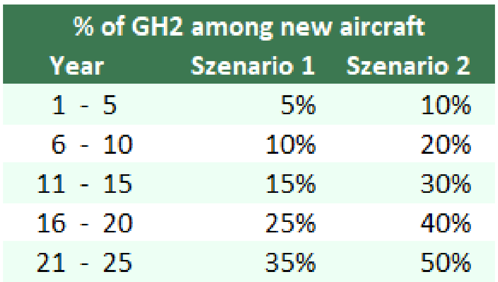
Actual demand (2025-2050)

The estimated 495,391 kg of hydrogen demand represents the maximum theoretical potential for the analysed outbound flights at Hamburg Airport at the GAT, assuming an immediate and complete replacement of the relevant fleet with hydrogen-powered aircraft. In practice, such a scenario is not realistic in the short term, given the long service life of aircraft and the expected pace of technology adoption.

Based on model-specific lifetime data, aircraft of the size and type relevant to this analysis exhibit an average service life of approximately 29 years, which implies an annual fleet replacement rate of just 3.42%. Consequently, only a small proportion of the fleet can realistically be replaced each year.

In addition, not all decommissioned aircraft are expected to be replaced by hydrogen-powered models. While initial calculations assumed a constant adoption rate of 25% among new deliveries, this assumption was subsequently refined to better reflect a gradual market ramp-up.

To capture this dynamic, two progressive adoption scenarios were defined, reflecting a low and a high trajectory of hydrogen uptake over the next 25 years. The scenarios assume steadily increasing shares of hydrogen-powered aircraft among new deliveries, as summarized below:



% of GH2 among new aircraft		
Year	Szenario 1	Szenario 2
1 - 5	5%	10%
6 - 10	10%	20%
11 - 15	15%	30%
16 - 20	25%	40%
21 - 25	35%	50%

Table 8 - GH2 Aircraft Replacement Rate

These scenarios provide a more nuanced and realistic basis for projecting the evolution of hydrogen demand over time, aligned with expected technology readiness, market acceptance, and regulatory developments.

In addition to fleet replacement dynamics, the analysis also considers the seasonal distribution of outbound flights, as this directly affects the monthly hydrogen demand profile. As illustrated in the chart below, flight activity at Hamburg Airport's GAT shows pronounced seasonality, with the highest outbound volumes observed in the summer months of June and July - approximately twice the level of the lowest months, January and December.

Understanding this seasonal pattern is critical for planning the design and capacity of hydrogen supply chains, as it highlights the need for infrastructure that can accommodate significant peaks in demand during the summer travel period, while maintaining operational efficiency during lower-demand months.

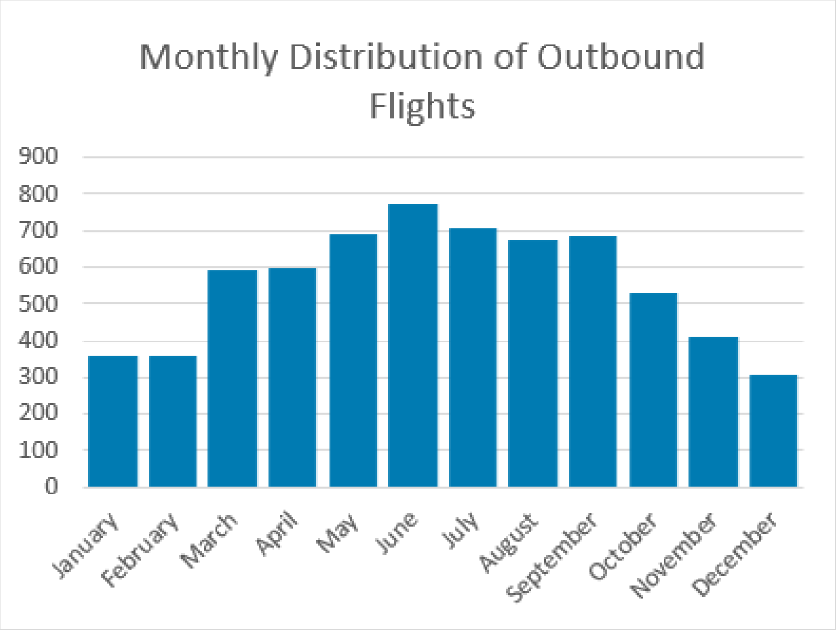


Figure 2 - Monthly Distribution of Outbound Flights

Results

Applying the described methodology - combining the aircraft categorization, progressive replacement scenarios, seasonal flight patterns, and assumptions on hydrogen consumption - the development of annual GH_2 demand at Hamburg Airport for non-scheduled flights through 2050 has been calculated.
Two scenarios were modelled to reflect different trajectories in the adoption of hydrogen-powered aircraft:

- Scenario 1 (low uptake): reflecting more conservative assumptions regarding market readiness, regulatory support, and infrastructure deployment.
- Scenario 2 (high uptake): reflecting more optimistic assumptions regarding technology adoption, supported by stronger policy incentives and faster fleet turnover.

In both scenarios, the total demand grows steadily over time, reflecting the gradual replacement of the existing fleet and the projected growth in flight activity. The analysis further considers two distinct assumptions regarding the development of nautical miles flown: a 1.5 % annual growth (CAGR) and a zero-growth scenario, to account for potential stagnation or moderate expansion in the general aviation market.

1,5% CAGR

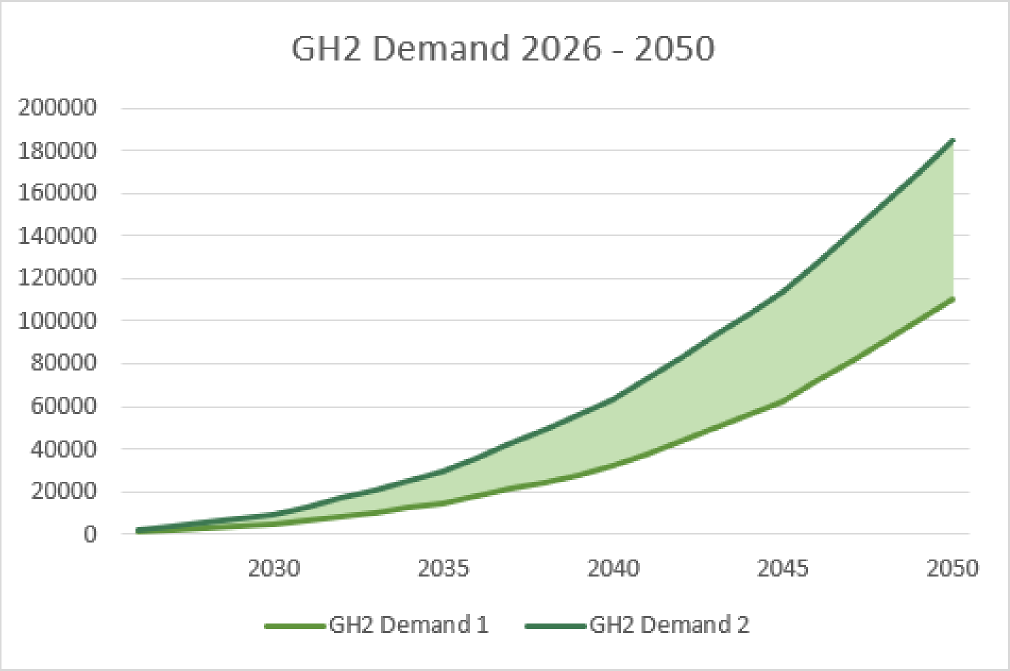


Figure 3 - GH2 Demand 2026 – 2050 - 1.5% CAGR

The results highlight the significant increase in annual hydrogen demand over time, with the upper scenario reaching nearly 190,000 kg/year by 2050. The widening range between the scenarios underscores the importance of accounting for uncertainty and building flexibility into infrastructure and supply planning.

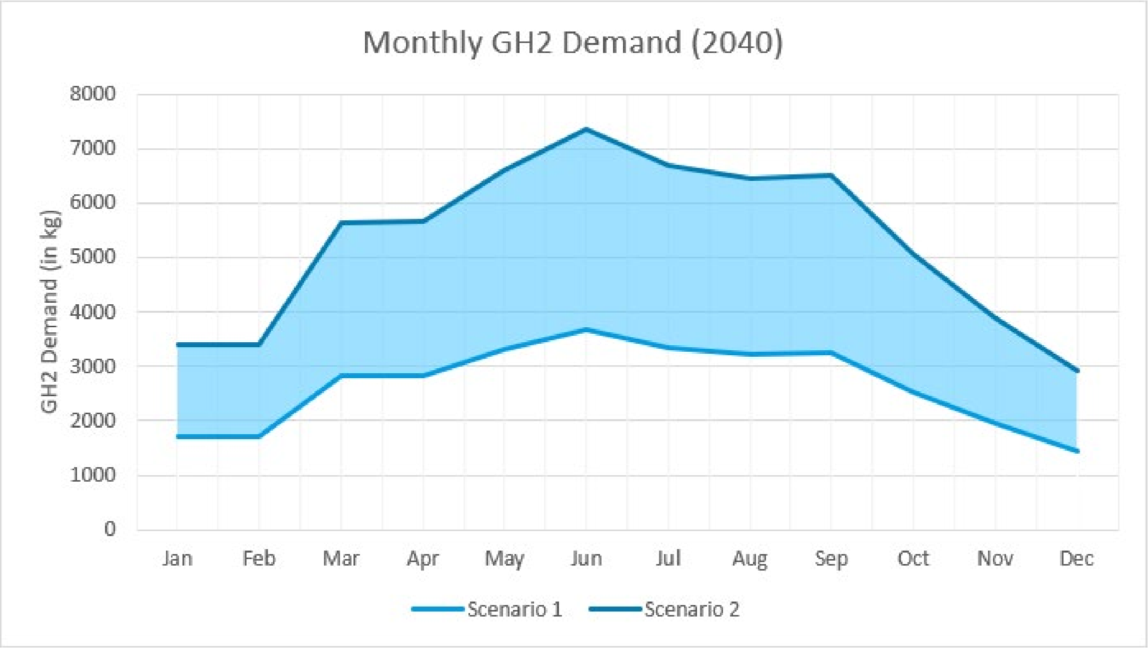


Figure 4 - Monthly GH2 Demand (2040) – 1.5% CAGR

On a monthly level, the demand profile for 2040 exhibits pronounced seasonality, mirroring current flight patterns. Peak demand occurs in June and July, at more than double the levels seen in the low-demand months of January and February. This indicates that future hydrogen infrastructure must be designed not only to meet growing annual volumes but also to accommodate sharp seasonal fluctuations efficiently.

	2030	2035	2040	2045	2050
GH2 Fleet Share (in %)					
Scenario 1 (Low)	0,86%	2,57%	5,13%	9,41%	15,39%
Scenario 2 (High)	1,71%	5,13%	10,26%	17,10%	25,65%
GH2 Demand (in kg)					
Scenario 1 (Low)	4.563	14.747	31.773	62.752	110.621
Scenario 2 (High)	9.126	29.493	63.546	114.095	184.368
Median	6.844	22.120	47.659	88.423	147.495

Table 9 - Fleet Share and Demand Development – 1.5% CAGR

The detailed scenario results presented in the table quantify both the projected fleet share of hydrogen-powered aircraft and the corresponding annual hydrogen demand at Hamburg Airport under the 1.5 % CAGR assumption. By 2050, the share of hydrogen-powered aircraft in the relevant fleet is expected to reach approximately 15–26 %, depending on the scenario. This gradual increase reflects the progressive replacement dynamics embedded in the methodology and highlights the long lead times inherent to fleet transitions.

In absolute terms, the annual hydrogen demand grows from around 4,500–9,100 kg in 2030 to between 110,000 kg (Scenario 1) and 184,000 kg (Scenario 2) by 2050. The median trajectory indicates a demand of approximately 147,000 kg in 2050.

Zero growth case

Under the zero-growth assumption, which assumes no increase in nautical miles flown over time, the projected hydrogen demand follows a similar trajectory in shape but at a lower absolute level compared to the 1.5 % CAGR scenario.

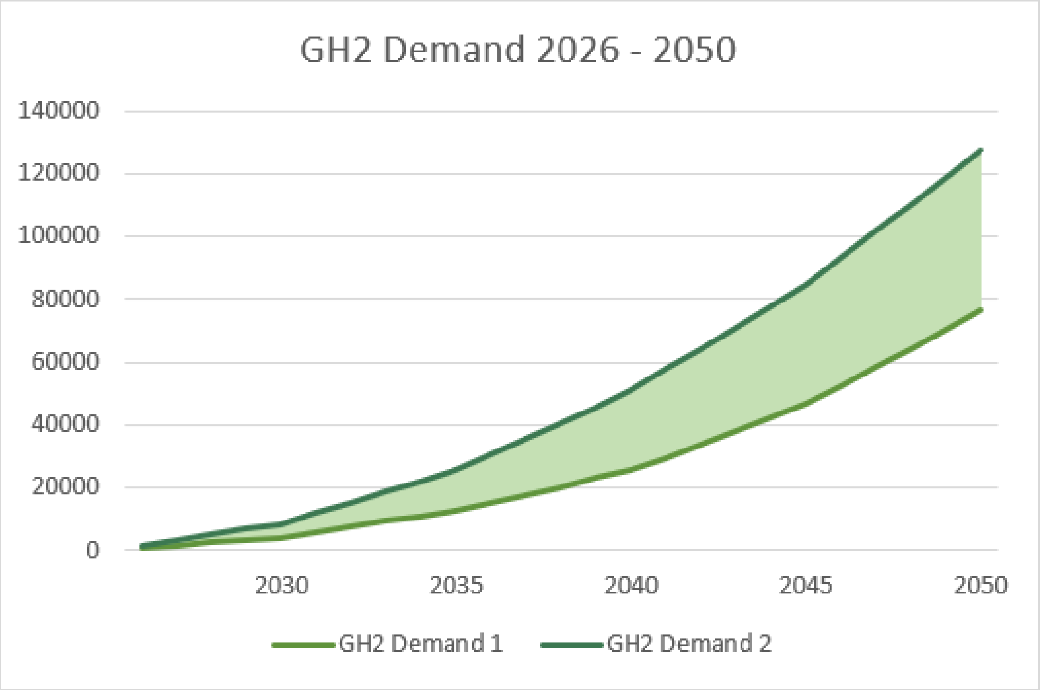


Figure 5 - GH2 Demand 2026 – 2050 - zero growth

As shown in Figure 4, the annual demand for hydrogen still grows steadily, driven entirely by the gradual replacement of the fleet with hydrogen-powered aircraft. By 2050, demand reaches approximately 80,000–130,000 kg/year, depending on the scenario.

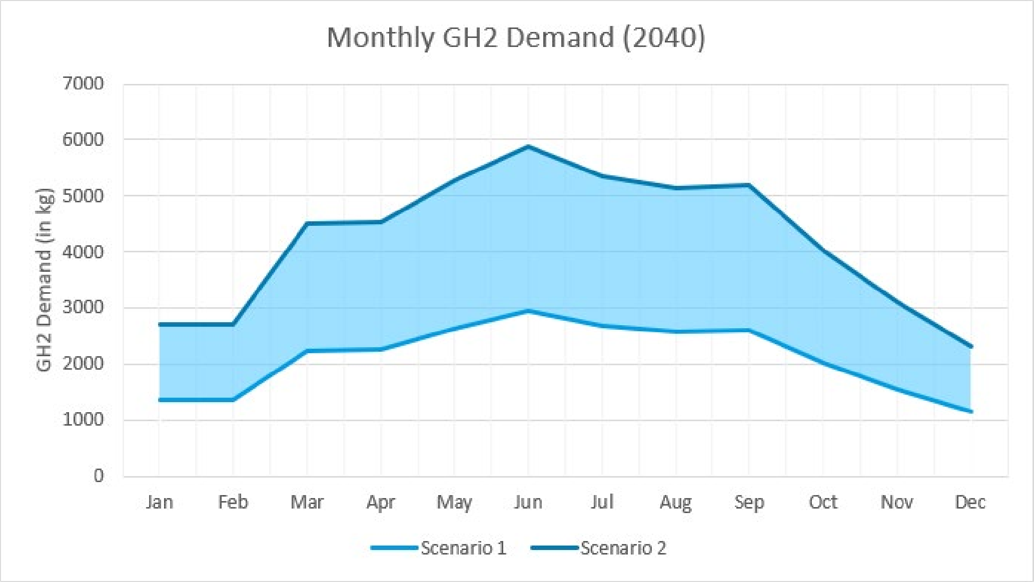


Figure 6 - Monthly GH2 Demand - zero growth

The monthly demand profile for hydrogen in 2040 under the zero-growth assumption is illustrated in the figure above. Similar to the 1.5 % CAGR scenario, the demand exhibits a pronounced seasonality, with peak values occurring in the summer months and lower levels during the winter.

In Scenario 2, monthly demand reaches close to 6,000 kg in June, more than double the demand observed in the lowest months, January and December. Even in the more conservative Scenario 1, the summer peak still significantly exceeds the winter minimum, underscoring the importance of planning for substantial intra-annual variability.

	2030	2035	2040	2045	2050
GH2 Fleet Share (in %)					
Scenario 1 (Low)	0,86%	2,57%	5,13%	9,41%	15,39%
Scenario 2 (High)	1,71%	5,13%	10,26%	17,10%	25,65%
GH2 Demand (in kg)					
Scenario 1 (Low)	4.236	12.707	25.414	46.592	76.241
Scenario 2 (High)	8.471	25.414	50.827	84.712	127.068
Median	6.353	19.060	38.120	65.652	101.654

Figure 7 - Fleet Share and Demand Development - zero growth

The projections under the zero-growth scenario reinforce a clear and steady trajectory for hydrogen adoption in general aviation — even in the absence of traffic growth. By 2050, the share of hydrogen-powered aircraft in the fleet is expected to reach 15–26 %, reflecting a gradual but persistent transition driven by fleet renewal and progressive technology adoption. This shift translates into a corresponding rise in annual hydrogen demand, increasing from approximately 4,200–8,500 kg in 2030 to between 76,000 kg (Scenario 1) and 127,000 kg (Scenario 2) by 2050. The median demand across both scenarios stabilizes around 101,000 kg annually at the end of the period.

These findings underscore a fundamental insight: even in a stagnant market, the replacement of conventional aircraft with hydrogen-powered alternatives will drive meaningful and predictable increases in fuel demand. For stakeholders, this highlights the imperative to plan for scalable, resilient infrastructure that can accommodate steady growth - and to prepare for upside potential should market dynamics accelerate beyond the conservative baseline.

External factors

Competing technologies

Hydrogen-powered aviation faces strong competition from two emerging technologies: battery-electric aircraft and sustainable aviation fuels (SAF). SAF, particularly those produced via Fischer–Tropsch synthesis, offer an environmentally sustainable drop-in solution compatible with current aircraft and fuelling infrastructure. Battery-electric aircraft, on the other hand, are well-suited for the same short-haul routes due to lower energy demands and simpler propulsion systems. This competition may reduce economies of scale for green hydrogen (GH_2), affecting its cost competitiveness and slowing infrastructure rollout.

Political & Regulatory environment

EU climate and emissions regulations are likely to drive a transition toward low-emission aviation, potentially boosting demand for hydrogen. Public subsidies are also supporting the development of sustainable technologies. However, strict certification requirements in the aviation industry may slow the approval and deployment of hydrogen-powered aircraft and infrastructure.

Energy sector development

The viability of hydrogen in aviation will depend heavily on developments in the broader energy sector. Large-scale production of green hydrogen requires substantial renewable energy capacity and widespread deployment of electrolysis technology. Additionally, competition from other sectors—such as heavy industry, shipping, and power generation—may constrain hydrogen supply or increase costs. These dynamics could limit the availability of affordable GH_2 for airports and airlines, posing a challenge to widespread adoption.

Conclusion

This report presents a structured estimation of potential gaseous hydrogen demand in regional aviation, combining two complementary analyses: one on scheduled regional routes proposed by BSR HyAirport partner airports and one based on general aviation activity at Hamburg Airport. Both analyses apply route-level and fleet-specific assumptions rather than generic replacement rates, leveraging operational data and partner-provided market intelligence to identify plausible scenarios.

The first builds on partner airport inputs, identifying 58 potential routes for 2030 and 66 for 2035, split between new, reactivated, and existing services. Seasonal variability and the heterogeneity of routes and fleet types drive substantial differences in projected demand. The second analysis quantifies demand from general aviation at Hamburg Airport, distinguishing aircraft categories, applying evidence-based consumption rates, and accounting for seasonal patterns. The scenario model illustrates how the transition to hydrogen-powered aviation could unfold over time, even under significant uncertainties. The analyses highlight that while the transition is likely to be a long-term endeavour, there is measurable potential for hydrogen to play a role in decarbonizing short-haul and regional aviation over the coming decades.

The results are subject to material uncertainties. Entry-into-service and production rates of hydrogen-powered aircraft remain undefined. Deployment patterns across routes and geographies are unclear, as are the long-term cost and availability of green hydrogen, which depend heavily on developments in the broader energy sector.
External factors are expected to shape adoption trajectories significantly. Battery-electric aircraft and sustainable aviation fuels (SAF) compete directly with hydrogen for short-haul routes, potentially reducing economies of scale and delaying infrastructure rollout. Regulatory frameworks in Europe will likely support the transition to low-emission aviation, but certification requirements and approval timelines may slow adoption. Green hydrogen's availability and price will depend on scaling renewable energy, electrolysis capacity, and balancing demand from other sectors such as industry and shipping.

Given these dynamics, the findings should be interpreted as a scenario-based baseline, not a forecast. To strengthen future analyses, expanding the data set to include more airports and validating partner assumptions would help mitigate bias. Planning efforts should remain flexible and phased, accommodating uncertainty in aircraft development, regulatory timelines, and energy market conditions. Close monitoring of competing technologies and alignment with evolving policy and energy-sector developments will be critical to refining infrastructure strategies and investment decisions over time.