H2Avia – Hydrogen in Aviation

Project of the federal funded aviation research program (LuFo) VI-2, FKZ 20E2106

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

H2Avia – Project description

H2Avia – Verbundvorhabenbeschreibung

Main Author: Fabian Peter (BHL)

Contributors: Antoine Habersetzer (BHL), Markus Nickl (BHL), Michael Lüdemann (BHL), Kathrin Ebner (BHL), Tim Effing (RWTH), Camli Badrya (TUBS), Matthias Haupt (TUBS), Marc Jünemann (TUHH), Nicolas Moebs (USTUTT)

Completion Date: 28.06.2021

Confidentiality: public

1. Contents

1. Contents 2
2. List of figures 2
3. Abbreviations 2
4. Executive summary 3
5. Project goals 4
6. Project structure and overall approach 6

2. List of figures

Figure 1: Main work package interactions. 6
Figure 2: Work breakdown structure 6

3. Abbreviations

Abbreviation / acronym	**Description**
BHL	Bauhaus Luftfahrt e. V.
CO2	Carbon Dioxide
H2	Hydrogen
LCA	Life Cycle Assessments
RWTH	RWTH Aachen University
T	Task
TUBS	Technische Universität Carolo-Wilhelmina zu Braunschweig
TUHH	Hamburg University of Technology
USTUTT	University of Stuttgart
WP	Work Package

4. Executive summary

This document contains the project description of the research project "H2Avia – Hydrogen in Aviation" which is funded by the federal funded aviation research program (German: Luftfahrt-forschungsprogramm) VI-2 (FKZ 20E2106) as it was handed in during the proposal phase. During the execution of the project, minor changes to time tables and contents have been implemented.

The participating entities of the project are:

- Bauhaus Luftfahrt e. V. (BHL) – Coordinator
- RWTH Aachen University (RWTH)
- Technische Universität Carolo-Wilhelmina zu Braunschweig (TUBS)
- Hamburg University of Technology (TUHH)
- University of Stuttgart (USTUTT)

Proposed duration: 01/2022 – 12/2024, granted duration: 05/2022 – 04/2024

Project overview:

The Paris Agreement demonstrates the willingness of nations worldwide to implement stringent legislation to mitigate climate change. Both the German government, in its National Hydrogen Strategy, and the European Union, in its "Hydrogen strategy for a climate-neutral Europe", highlight the potential of the cross-sector use of green hydrogen (H2) to achieve the goals of the Paris Climate Agreement.

Only by including the climate impact of the production of H2 can a meaningful assessment of the potential of an H2-powered aviation industry be made. For this reason, H2Avia will investigate the possible production processes and transport routes to the airport in terms of their economic and ecological aspects.

While the use of H2 as a primary energy source does not necessarily require a radical change in aircraft configuration, it does require several significant adjustments to components. These changes, and where appropriate technologies with high synergistic potential, will be investigated at a conceptual level and specifically for different aircraft sizes. Here, H2Avia focuses on H2-burning propulsion systems, H2 fuel supply, the fuselage and wing. Analytical methods are used which are as simple as possible and which are able to represent the unconventional aspects while still covering large parameter spaces and generating complete data sets.

After integrating fuel and aircraft life cycle analysis, a demand scenario based on fleet modelling is used to determine the effect of H2 aircraft introduction. In this way, the potential of a fleet of hydrogen-powered aircraft for climate impact can ultimately be specified and appropriate technological and policy measures can be derived.

5. Project goals

The Paris Agreement demonstrates the willingness of nations around the world to implement strong climate change mitigation legislation to limit the long-term increase in global average temperature to below 2.0°C and 1.5°C compared to pre-industrial levels. In the aviation sector, the International Air Transport Association has set ambitious targets for Carbon Dioxide (CO2)-neutral growth by 2020 and a 50% reduction in net CO2 emissions from aviation by 2050, compared to 2005 levels. Both the German government, in its National Hydrogen Strategy, and the European Union, in its "Hydrogen strategy for a climate-neutral Europe", highlight the potential of the cross-sectoral use of green H2 to achieve the goals of the Paris Climate Agreement. In addition to the use of renewable H2 to produce synthetic paraffin, the direct use of H2 is a long-term option as a fuel for aviation. In order to assess the long-term potential for this sector, it is necessary to consider both the possible overall transformation of this industry by H2 and the corresponding climate impact. As the primary energy source for regional, short-haul and long-haul aircraft, H2 is currently one of the most attractive technology options for achieving the ambitious climate targets set by policymakers and the aviation industry. Ultimately, the question of whether and how clear the advantage of transport aviation with H2 is for the climate impact has not yet been conclusively answered.

To ensure a holistic assessment, the production of H2 and its transport to and distribution at the airport must be considered. Furthermore, ground operations must be examined to see how they need to be adapted for the use of H2. H2 opens up numerous technology options for integration into the aircraft. In order to generate as reliable a statement as possible, the selection of technology options in H2Avia will be limited to those that are necessary for operation with H2, have a very high potential and can be modelled and evaluated in the project with a justifiable risk. Key components here are the primary propulsion, both in terms of energy conversion by heat engines and electrochemical conversion devices, the integration of the hydrogen tanks and the fuel system, and finally the adaptation of the wing primary structure through the anticipated design without integral tanks. Beyond the purely technological questions, the integration into the aircraft design and on the overall aircraft level must be considered for a holistic evaluation of the climate potential. In this way, the potential of a fleet of hydrogen-powered aircraft can ultimately be specified with regard to climate-impacting factors and the overall balance of H2 in aviation can be determined by means of corresponding life cycle assessments (LCA).

In accordance with the above, the overarching goals of the joint project can be summarised as follows:

- Quantify the contribution that H2 as the main energy source in aviation can make to achieve the climate targets.
- Determine the cost and climate impact of H2 production and transport and its use in airport ground operations.
- Identification and modelling of critical technologies required for the introduction of H2
- Integration of these technologies into all relevant aircraft classes
- Combining all building blocks into a holistic scenario using fleet modelling and LCA

In order to evaluate the necessary aspects as independently as possible, from the production of H2 to the technological system components in the aircraft and the overall aircraft design to the climate balance on a fleet basis, a network of five complementary research partners has been formed for the project:

- Bauhaus Luftfahrt – BHL is coordinator and involved as an interdisciplinary team focusing on alternative fuels, propulsion and aircraft technologies, aircraft design as well as fleet modelling and climate impact.
- RWTH Aachen University – RWTH (Institute of Aerospace Systems) contributes extensive expertise in the areas of overall aircraft design, technology integration and transport system analysis to the project.
- University of Stuttgart – USTUTT (Institute of Aircraft Design) contributes expertise in whole aircraft design and system integration for disruptive propulsion concepts.
- TU Braunschweig – TUBS (Institutes of Fluid Mechanics and Aircraft Design and Lightweight Construction) contributes with extensive experience in aerodynamic drag reduction and aero-structural optimisation.
- Hamburg University of Technology – TUHH (Institute of Aircraft Systems Engineering) contributes with its expertise to the integrated consideration of new system technologies and the holistic evaluation of architecture concepts for the on-board systems of aircraft at the overall system level.

The project is supported by MTU Aero Engines AG and Airbus Operations GmbH.

6. Project structure and overall approach

H2Avia is divided into four work packages: WP1 examines the manufacturing and infrastructure aspects of H2. WP2 examines the various technological system components for the use of H2 in aircraft, which are combined in WP3 into overall aircraft designs for the relevant aircraft classes. Finally, WP4 considers the overall balance of H2 in aviation. This process is shown in simplified form in Figure 1.

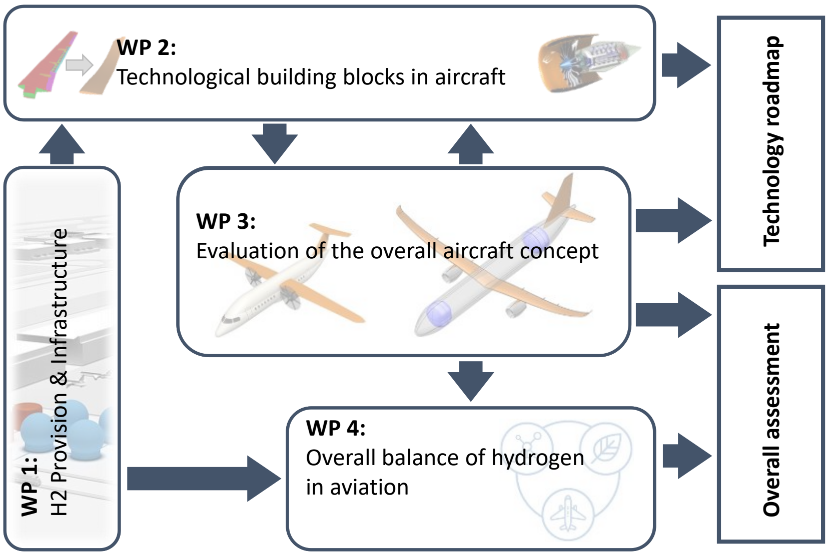

Figure 1: Main work package interactions.

The work breakdown structure is shown in Figure 2.

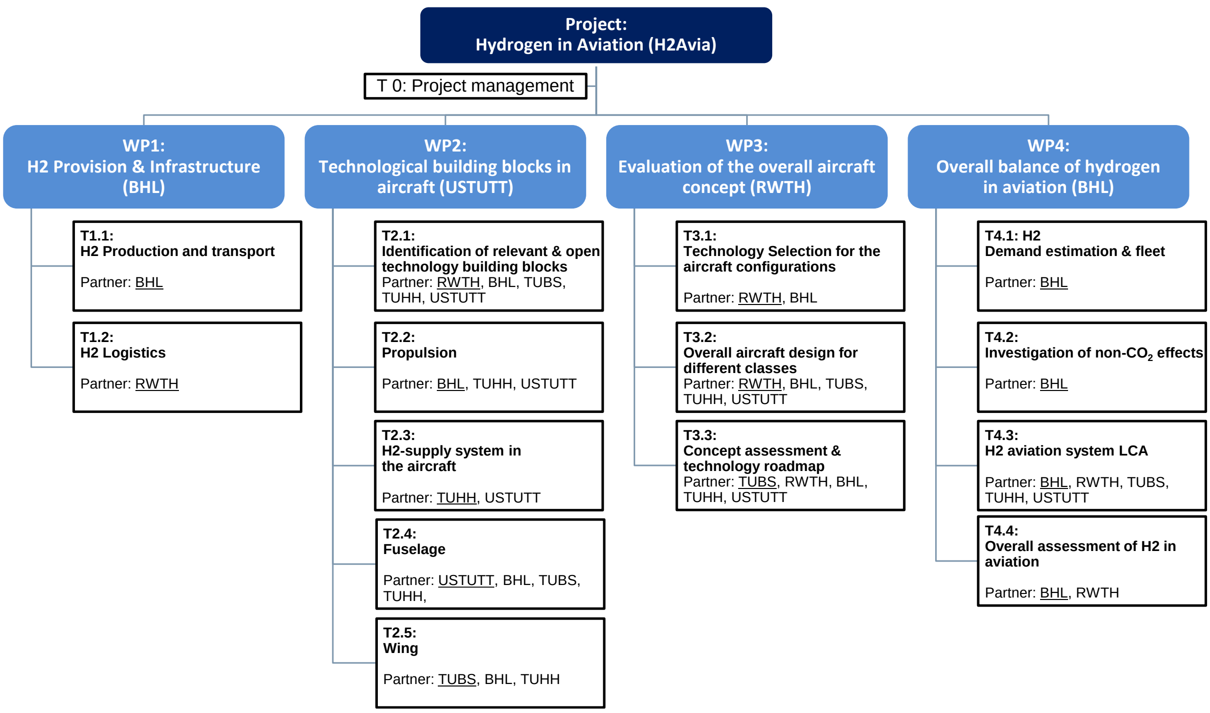

Figure 2: Work breakdown structure