REFUELING OF LH2 AIRCRAFT – PART 1: DESIGN AND ECONOMICS OF LH2 REFUELING SYSTEMS AT AIRPORTS

J. Hoelzen*, M. Flohr*, D. Silberhorn[†], J. Mangold[†‡], A. Bensmann*, R. Hanke-Rauschenbach*

* Leibniz Universität Hannover, Institute of Electric Power Systems, 30167 Hanover, Germany

[†] DLR, Institute of System Architectures in Aeronautics, 21129 Hamburg, Germany

[‡] University of Stuttgart, Institute of Aircraft Design, 70569 Stuttgart, Germany

Abstract

Green hydrogen (H2) just recently regained high attention of the aviation industry as a fuel for aircraft that does not cause carbon emissions and potentially decreases climate impact in flight significantly. While there are many challenges to be addressed in aircraft technology to fly with green H2 (H2) propulsion systems, a larger research gap is also identified around the setup of liquid hydrogen (LH2) refueling systems, their interconnection to the aircraft and implication on aircraft design. Since the existing fuel infrastructure for operating “fossil”-based aviation is already highly cost optimized, the same requirement is likely to be set for the development of a new LH2 fuel infrastructure. Therefore, this work aims to investigate supply and refueling systems for H2-powered aircraft at an airport and to determine cost-optimal setups. The research is split into two parts: In this first part, the general LH2 refueling system design at airports and its interconnection to on- or offsite H2 supply is considered. Building on this analysis, the interconnection between the refueling system and the aircraft as well as the impacts on aircraft operation are explored in the second part.

In this paper, the broader perspective of H2 supply and refueling systems for aircraft is provided. For this, three H2 demand scenarios at an exemplary airport are determined for 2050. Then, general requirements for LH2 refueling setups in an airport environment are derived and techno-economic models for H2 storage, liquefaction and transportation to the aircraft are designed. Finally, a cost trade-off study is undertaken for the design of the LH2 setup including LH2 refueling trucks and a cryogenic pipeline and hydrant system.

It is found that liquefaction of H2 is the major fuel cost factor at an airport with gaseous H2 import from off-site production locations. In contrast to that, the cost for LH2 storage and transportation to the aircraft account for only 1-2% and 3-5% of the total LH2 cost, respectively (FIG 1). The relative cost for H2 liquefaction and storage can be further decreased by increasing the LH2 demand either from aviation or through additional supply to other LH2 use cases around the airport. Furthermore, it is shown that a refueling system with cryogenic pipelines and hydrants could be a technological feasible and economically viable option for larger airports with a LH2 demand of more than 40,000 tons per year (point A highlighted in FIG 2). However, uncertainty around the exact capital expenditures (CAPEX) of such large-scale LH2 pipeline systems remains high and subject for future technology demonstration projects.

Keywords: Liquid Hydrogen, Refueling, Hydrogen Aviation, Hydrogen Fuel Supply

Contact: hoelzen@ifes.uni-hannover.de

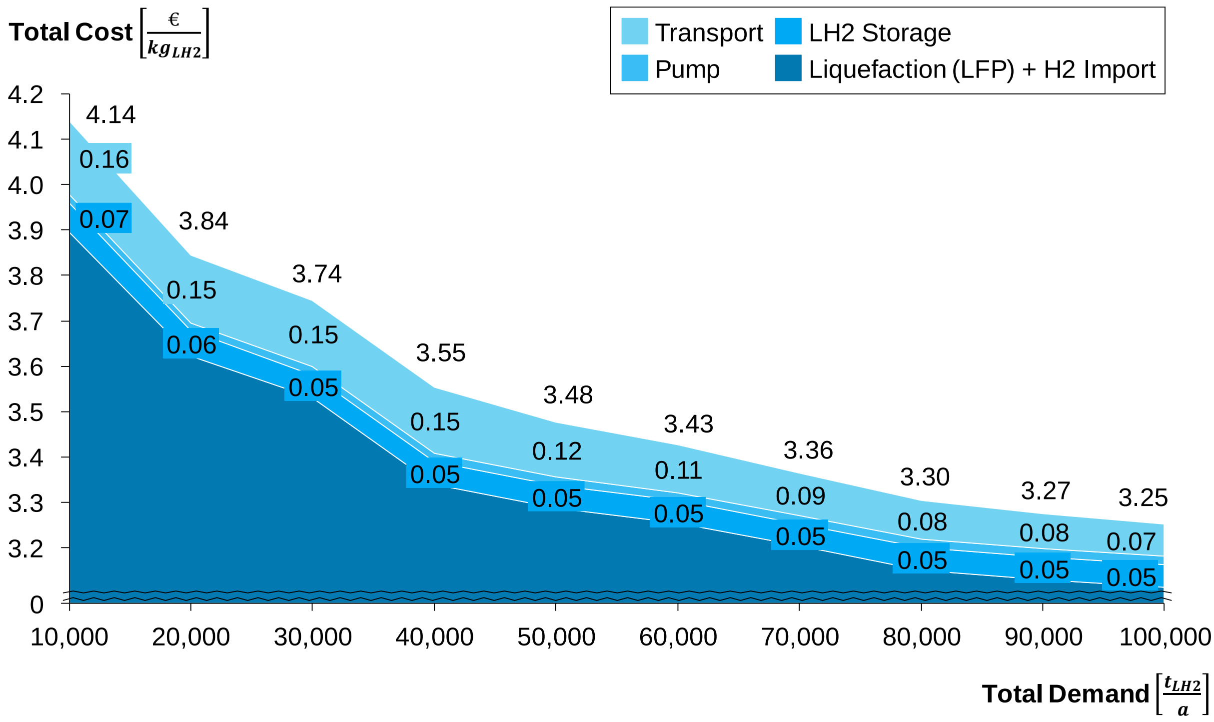

FIG 1: Total supply cost for LH2 at aircraft depending on total annual LH2 refueling demand

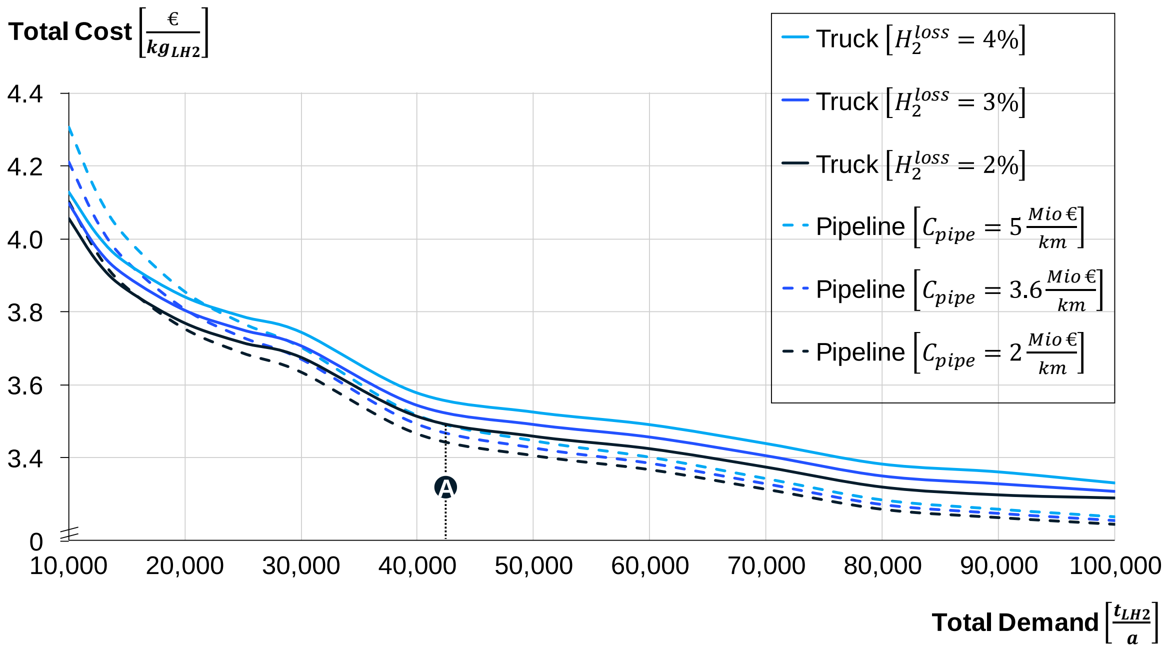

FIG 2: Total LH2 supply cost depending on total annual LH2 refueling demand and techno-economic assumptions for LH2 truck refueling and cryogenic pipelines; base case scenario with tipping point indicated at 42,000 tons of LH2 per annum