Germany-Korea Conference, Seoul, 31th October – 1st November 2023
Hydrogen utilization session

A project example

LIQUID HYDROGEN SYSTEM FOR AVIATION – DESIGN AND SIMULATIONS

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DLR

Overview

Part 1: Project Overview

Part 2: Design

- Integration of LH_2 Tank and LH_2 Supply System
- Arrangement view

Part 3: Simulations

- Overview Ecosim Pro
- Aircraft Tank Model
- Szenario 1 – Simple Tank Cycle
- Szenario 2 – Dynamic Fuel Cell Demand

Part 4: Outlook

PROJECT OVERVIEW

Picture Source: DLR

Hydrogen Aviation Lab

Ground demonstrator for usage of liquid hydrogen in a common airplane (A320)

Goals

- Demonstration of handling of an LH_2 system on board and at ground
- Operation of on-board systems with LH_2 as energy source and a fuel cell

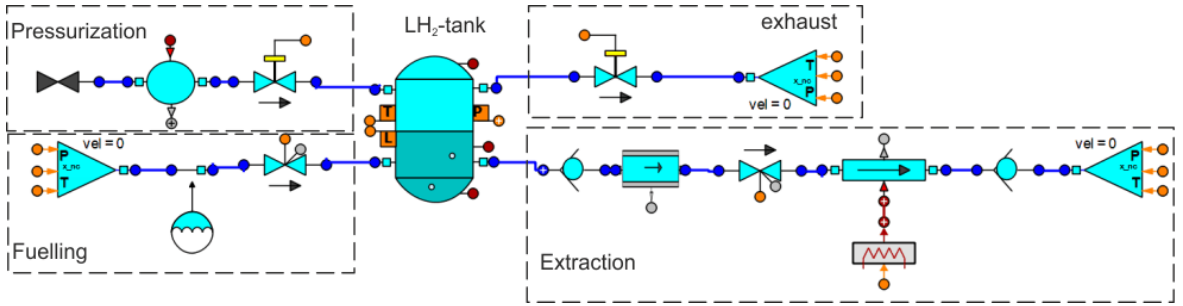
Partner

Lufthansa Technik | DLR | ZAL | Hamburg Airport | Hamburg

#MakeChangeFly

Scope of DLR Lampoldshausen

- Design und Erection of the complete H_2 system on board until fuel cell interface
- simulation of system behavior for various scenarios (fueling, taxiing, flight)
- Optimization regarding to
  - safety
  - efficiency
  - Boil-off



DESIGN

Integration of LH_2 Tank and H_2 Supply System

Functionality

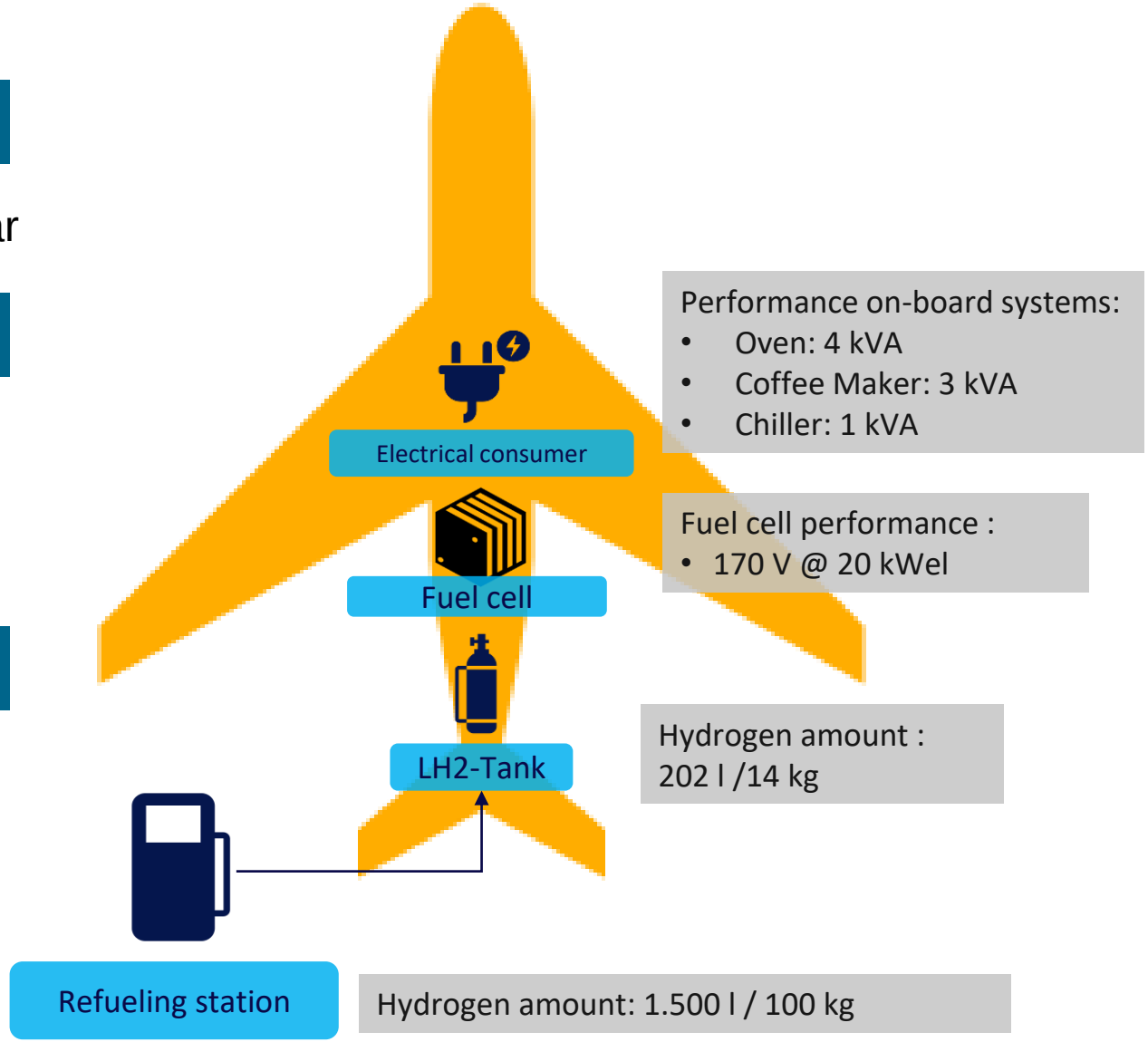
- Supply of fuel cell with GH_2 at 300K at 4bar

Components

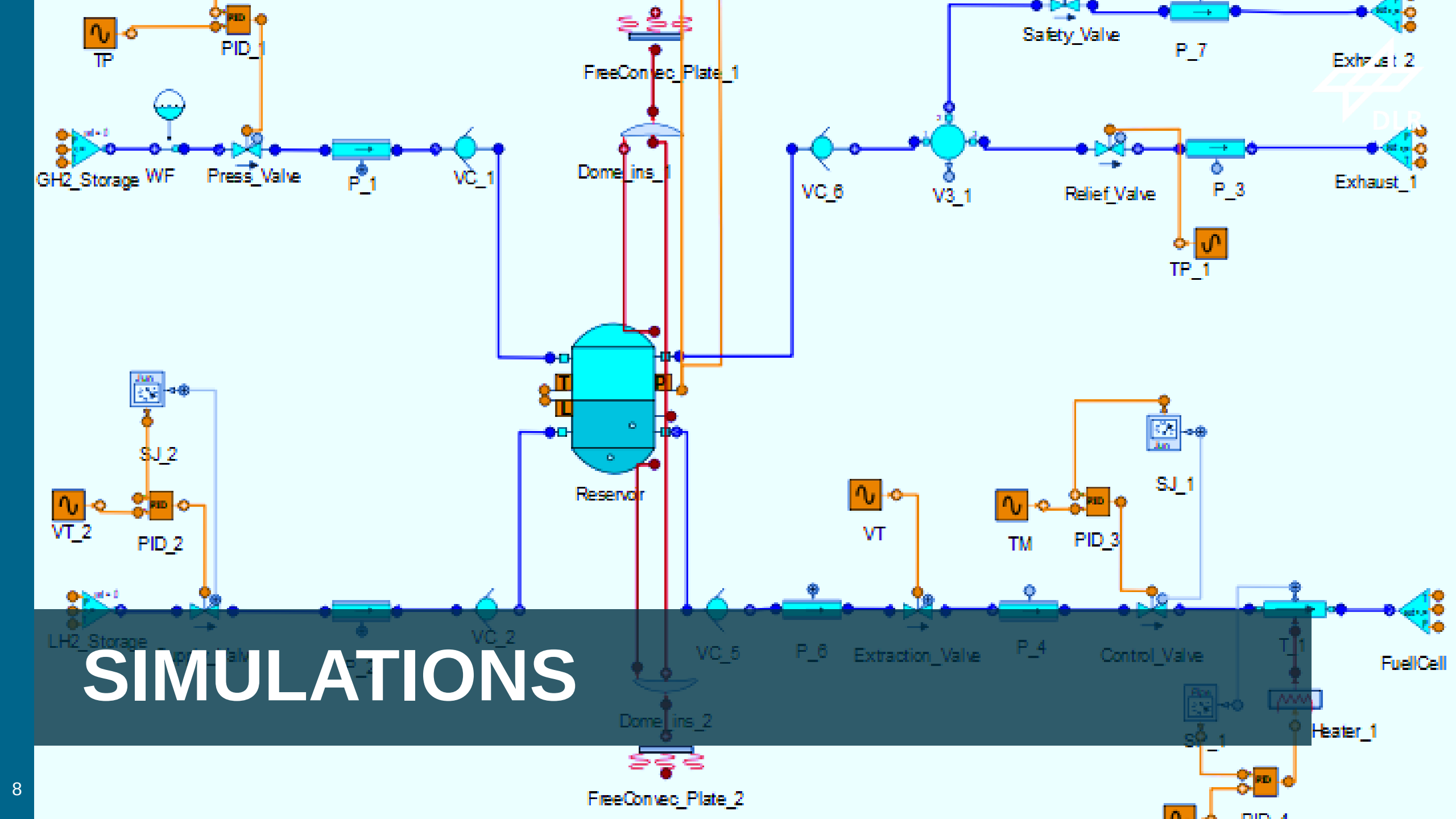
- 200l LH_2 tank
- Evaporator
- Pressure storage

Systems

- LH_2 filling system
- GH_2 withdrawal
- GH_2 tank pressurization
- GHe supply
- Exhaust/Vent System



Arrangement view



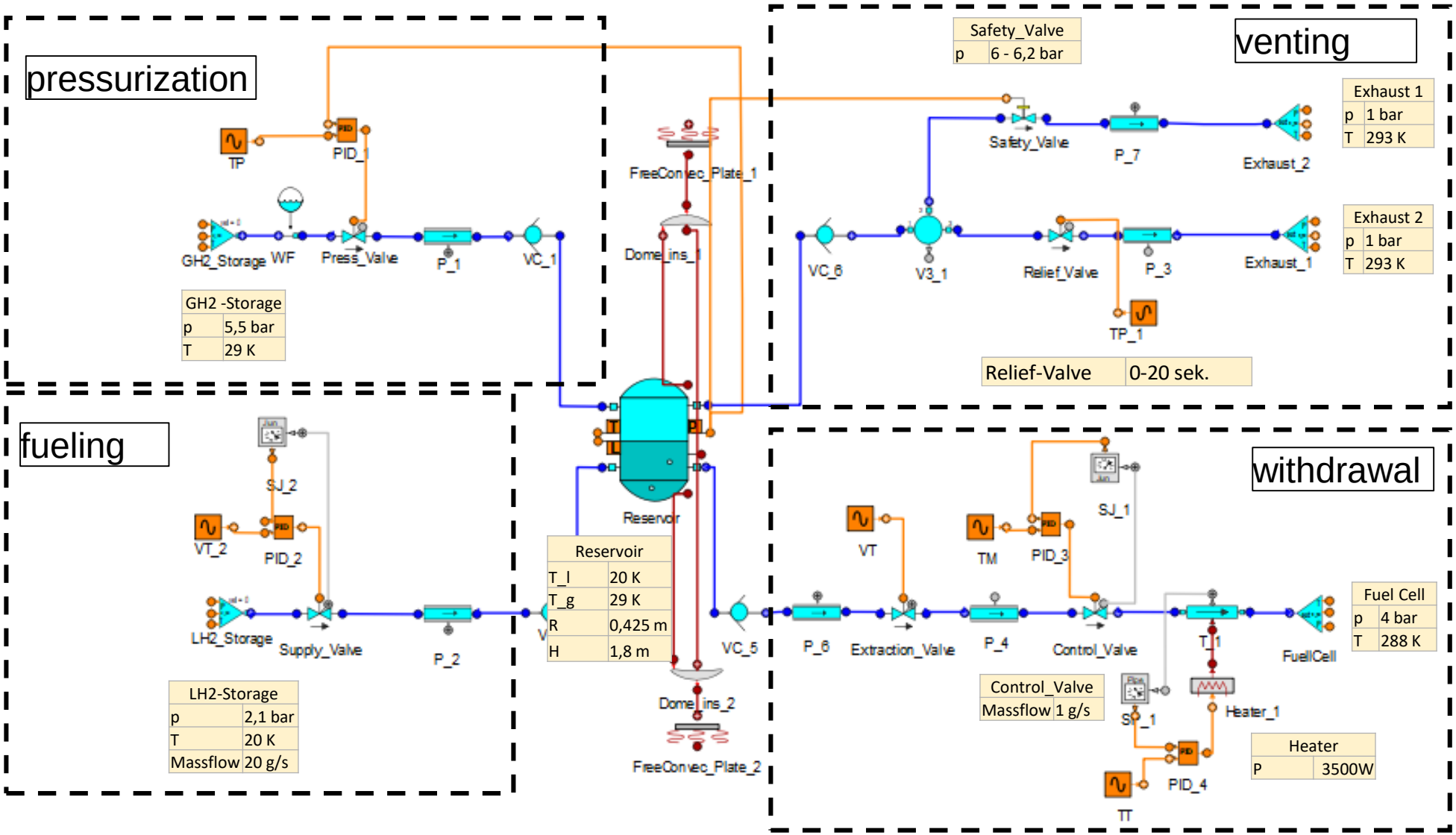
SIMULATIONS

Ecosim Pro

Overview

- Dynamic simulation tool developed by European Space Agency (ESA)
- Applications are
  - Space propulsion (ESPSS)
  - Environmental Control and Life Support Systems (ECLSS)
  - Gas turbines
  - Aircraft systems
  - Cryogenics (CERN)
  - Power plants

Aircraft Tank Model



Szenario 1 – Simple Tank Cycle

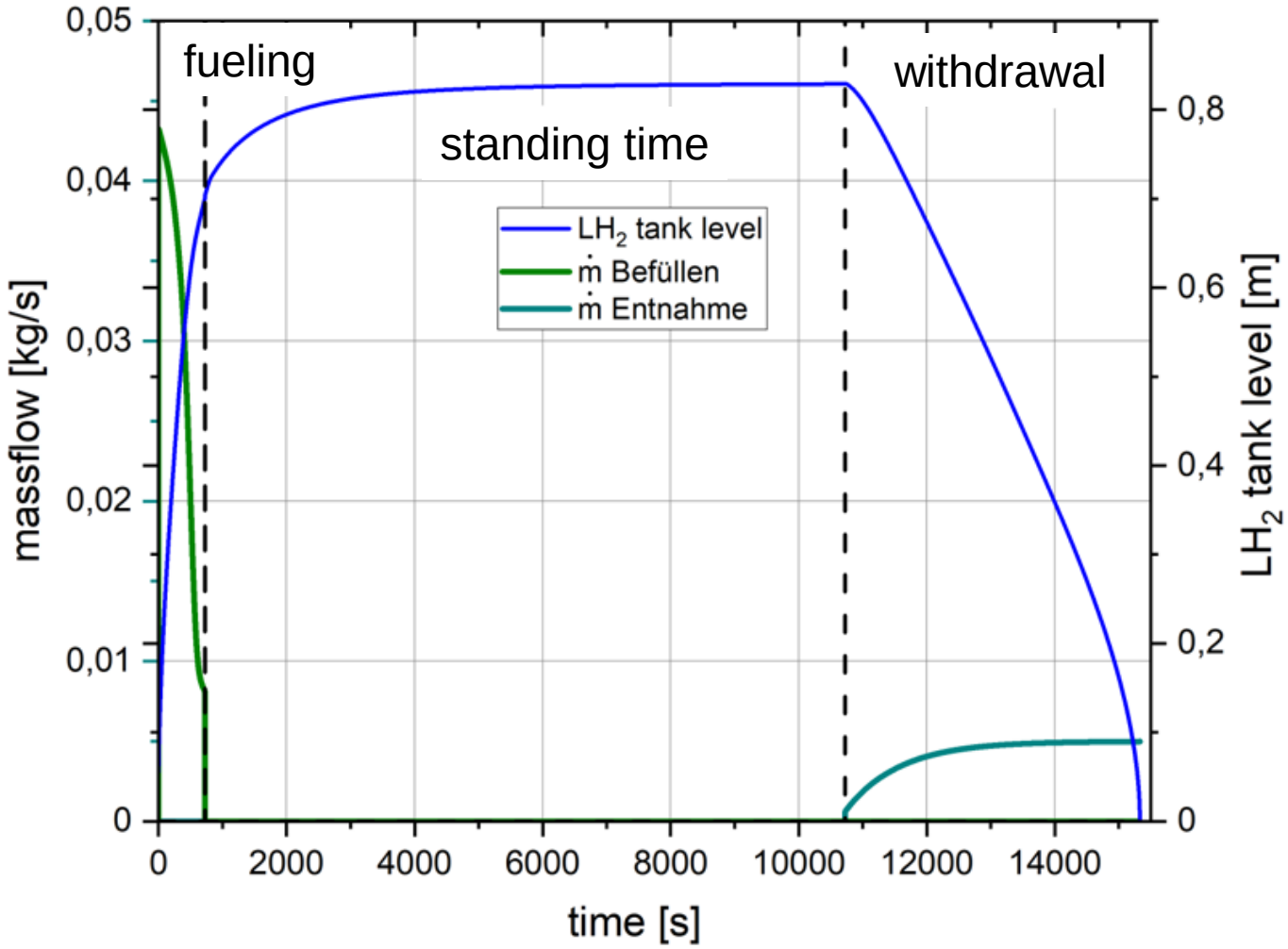
Modelling of a complete tank cycle

- Fueling phase with decreasing mass flow
- Standing time
- Withdrawal phase with increasing mass flow

Result

- Condensation of GH_2 while standing time

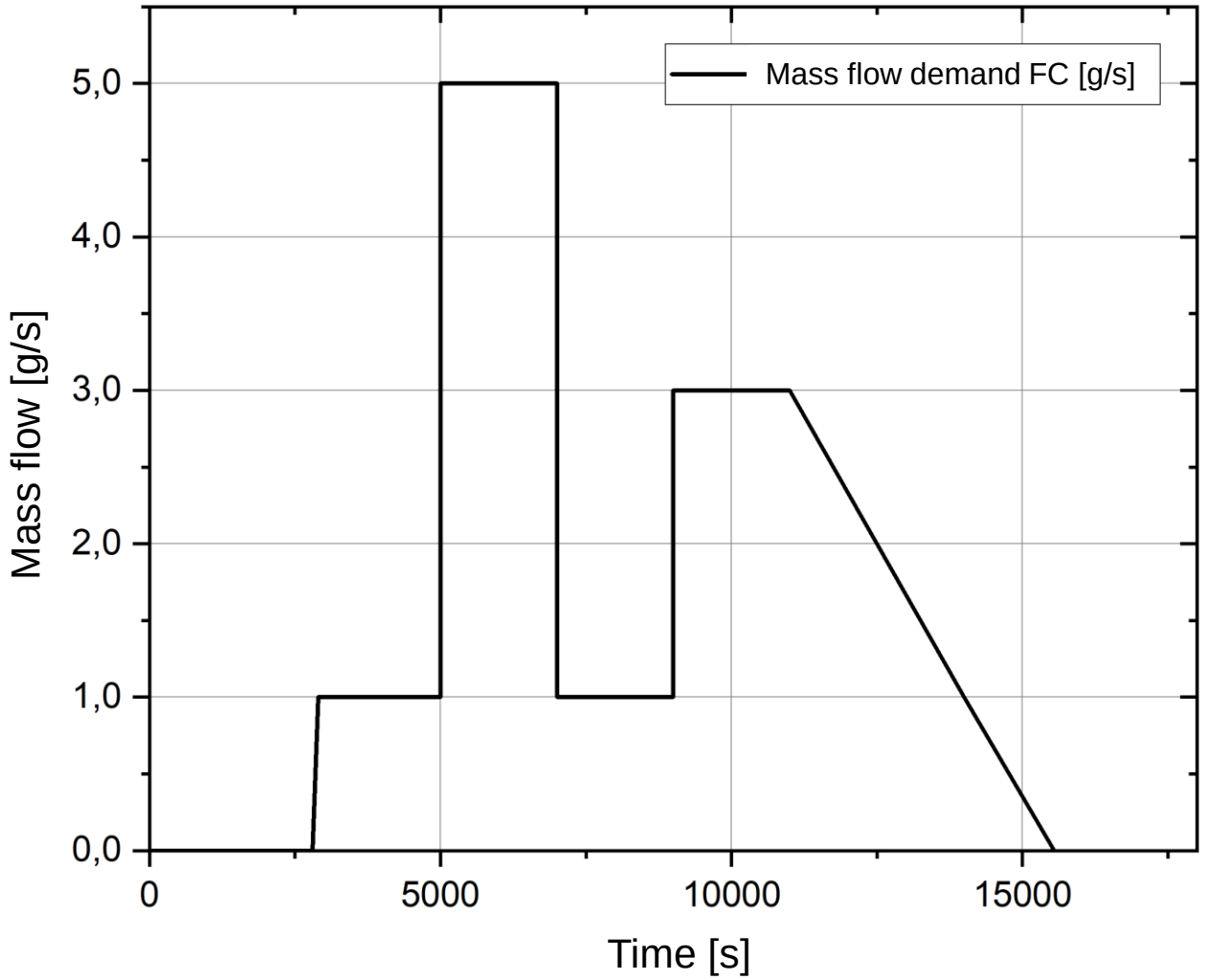
  → LH_2 level increases



Szenario 2 – Dynamic Fuel Cell Demand

Dynamic mass flow sequence

- Implement dynamic mass flow sequence at interface to FC with still 300K and 4 bar



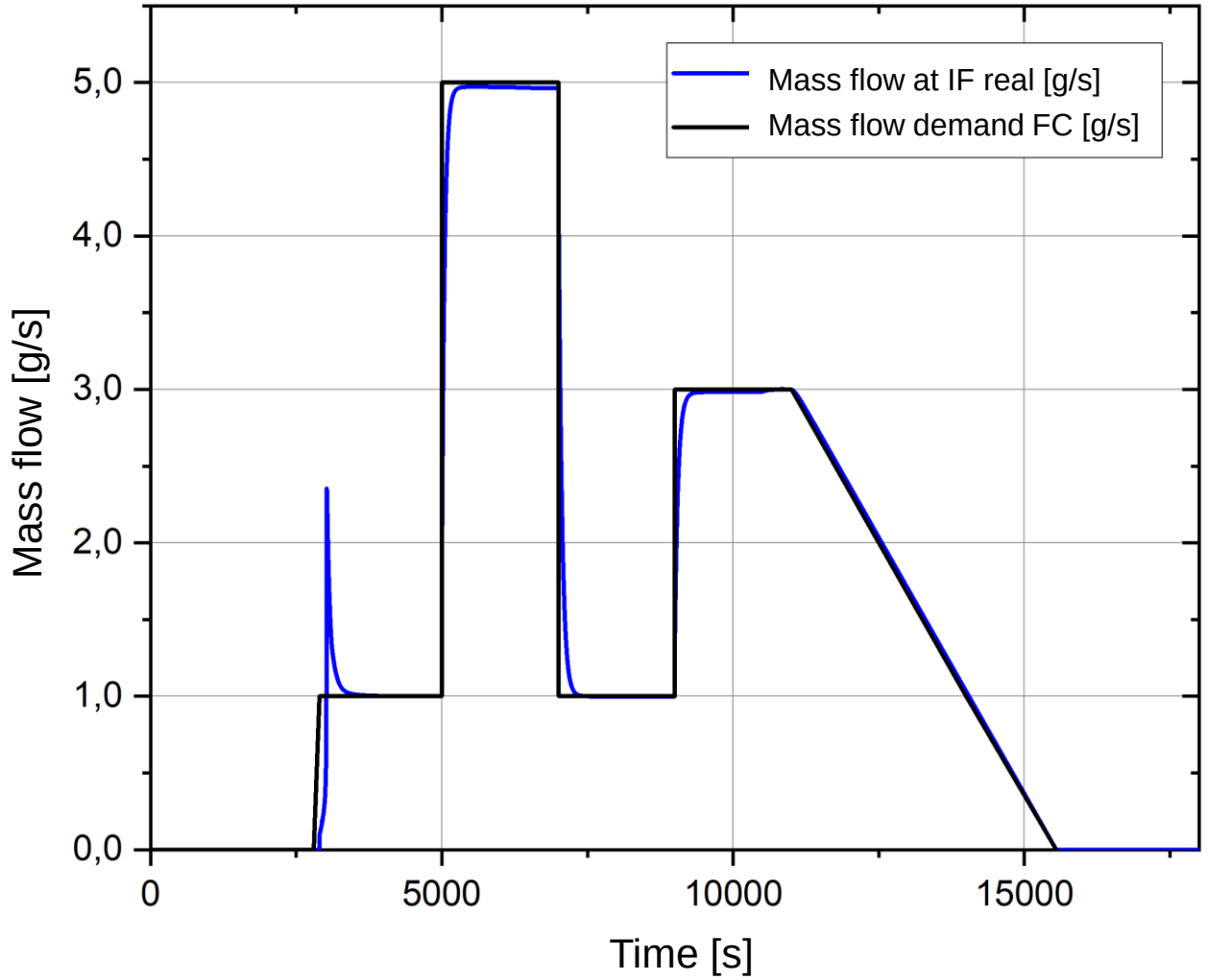
Szenario 2 – Dynamic Fuel Cell Demand

Dynamic mass flow sequence

- Implement dynamic mass flow sequence at interface to FC with still 300K and 4 bar

Results

- Mass flow regulation reacts very fast, PID can be optimized



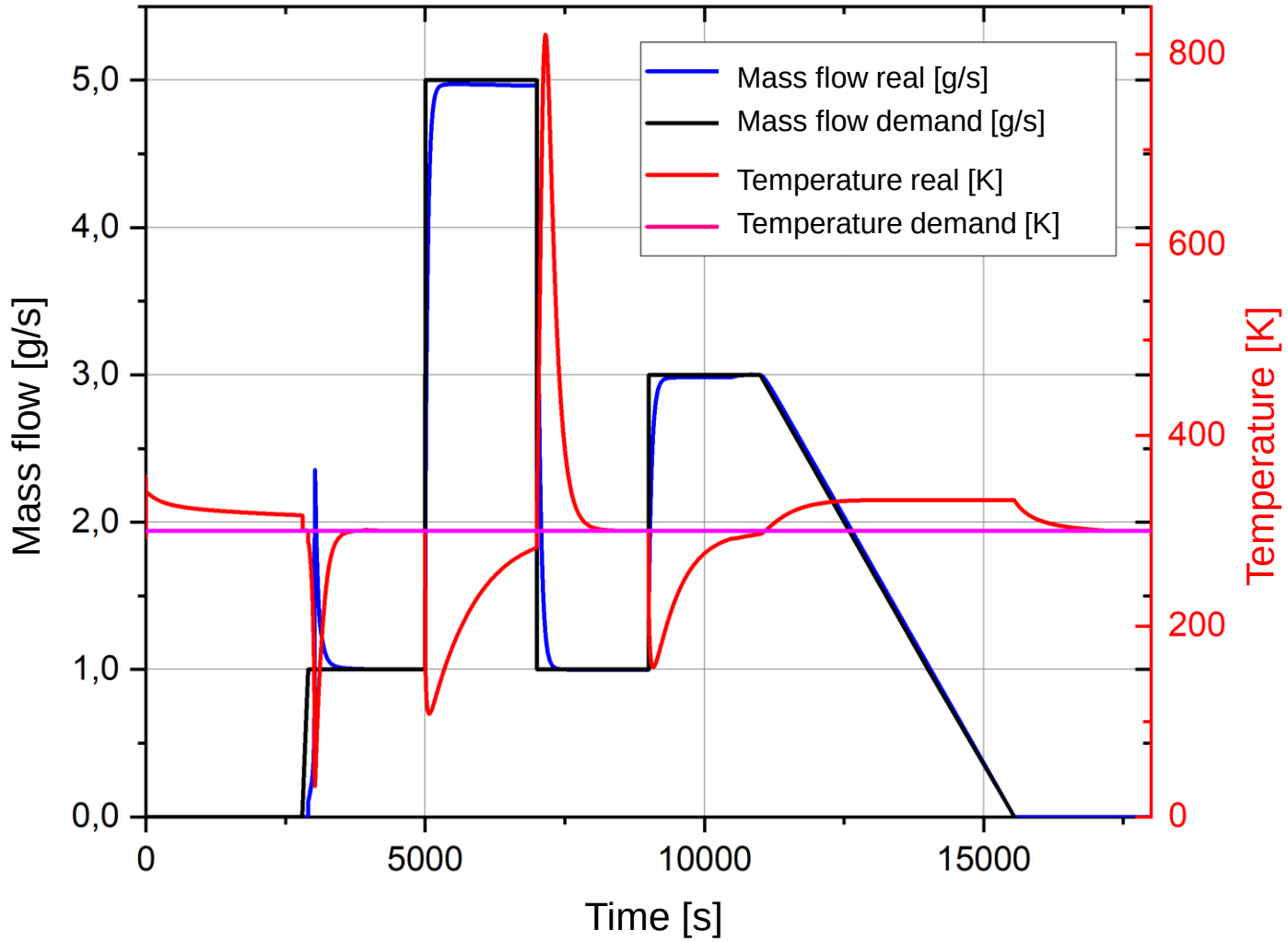
Szenario 2 – Dynamic Fuel Cell Demand

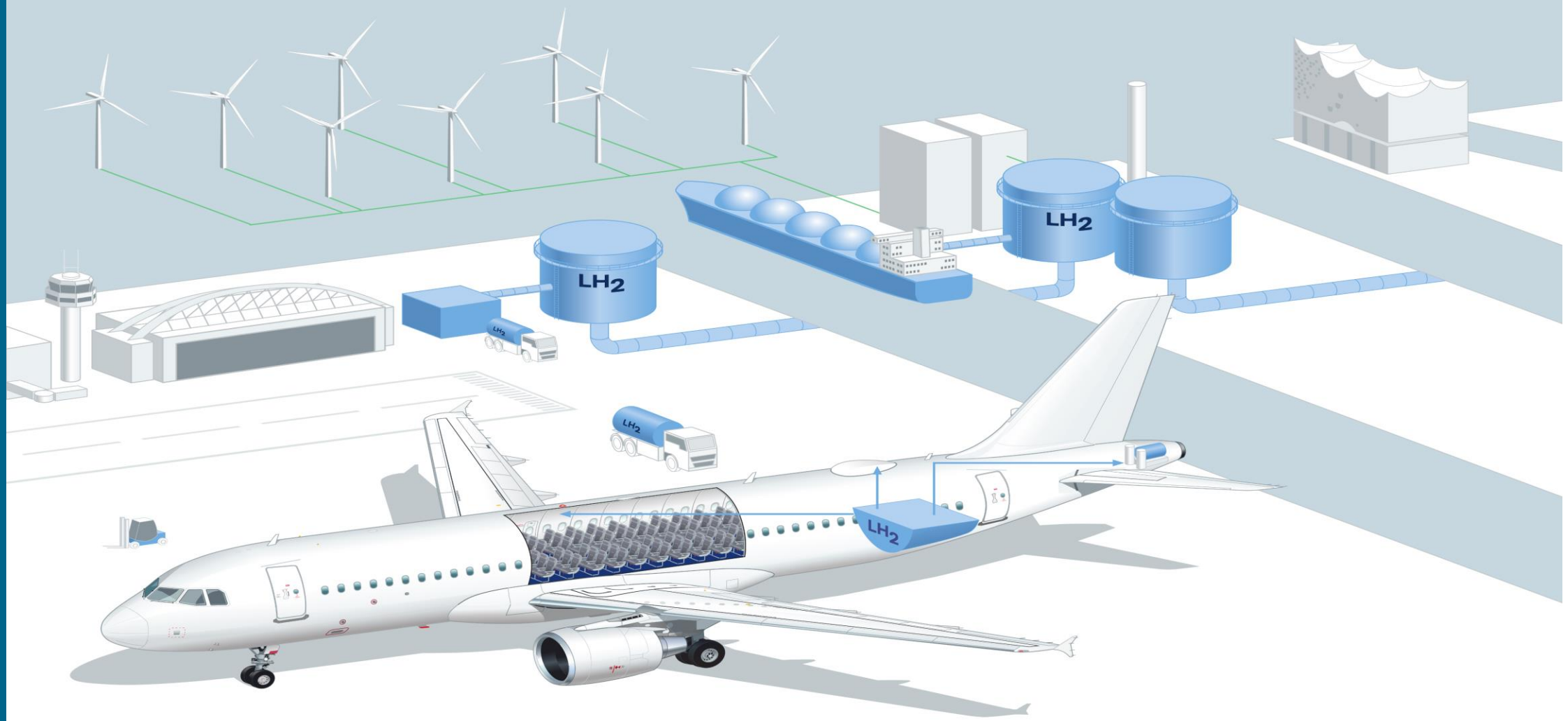
Dynamic mass flow sequence

- Implement dynamic mass flow sequence at interface to FC with still 300K and 4 bar

Results

- Mass flow regulation reacts very fast, PID can be optimized
- Used Evaporator reacts very slow
  - Critical temperature peaks
  - Optimization of PID regulator necessary





OUTLOOK

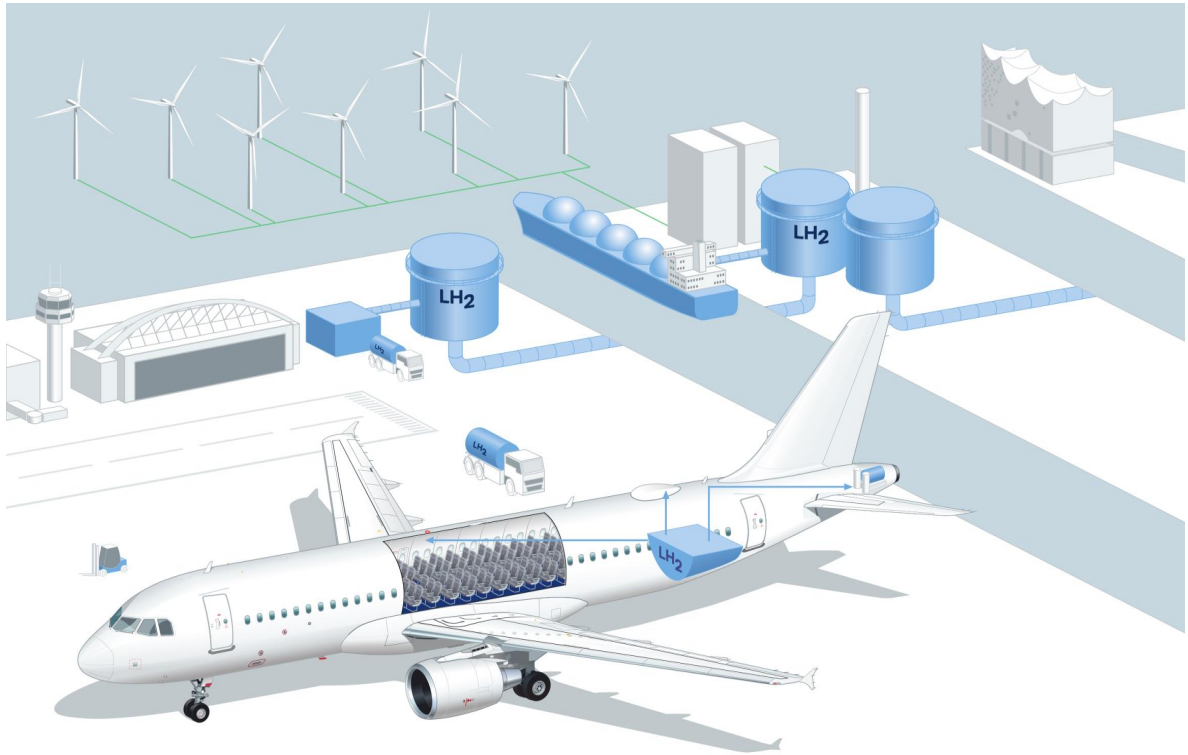
Outlook

2023

Finalization of procurement

2024

- Pre-cooling of refurbished LH_2 storage at DLR Lampoldshausen
- Assemby of complete LH_2 system inside the airplane
- Commissioning and testing
- Validation and expansion of numerical simulations



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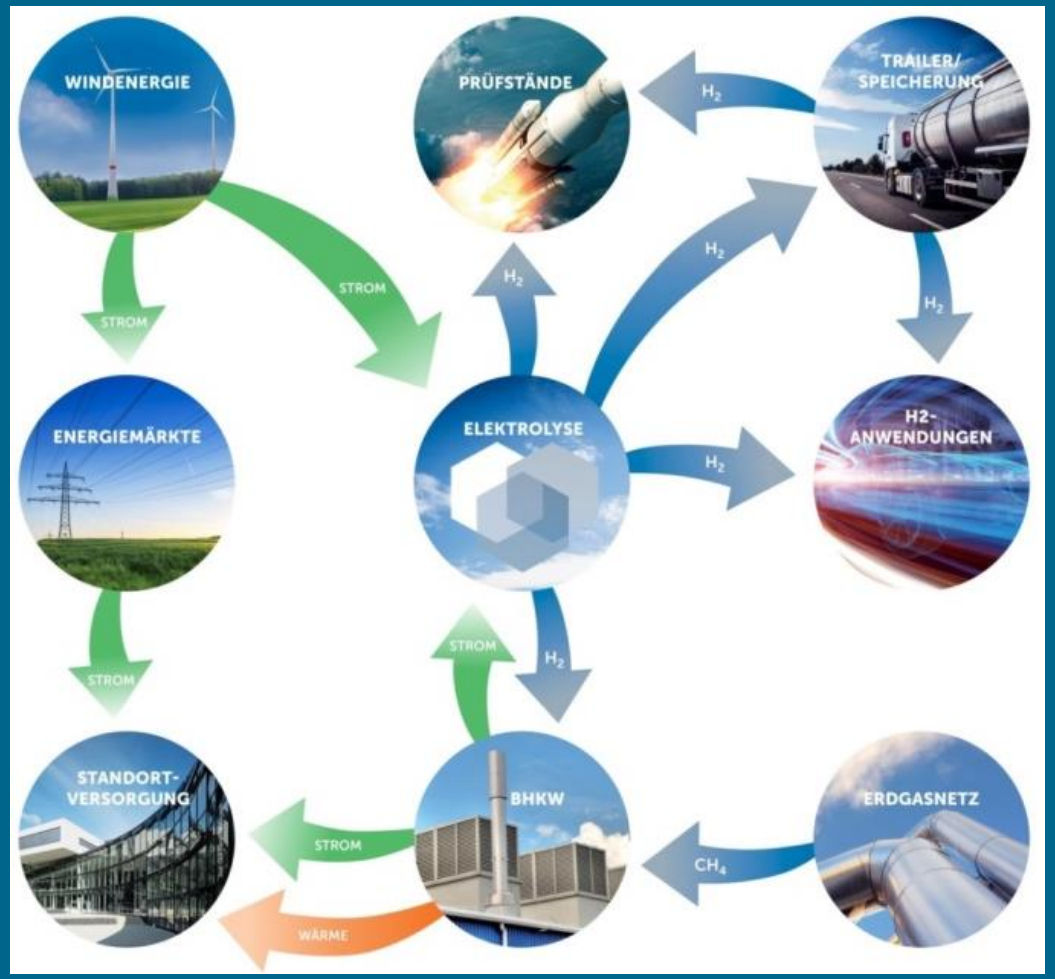

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