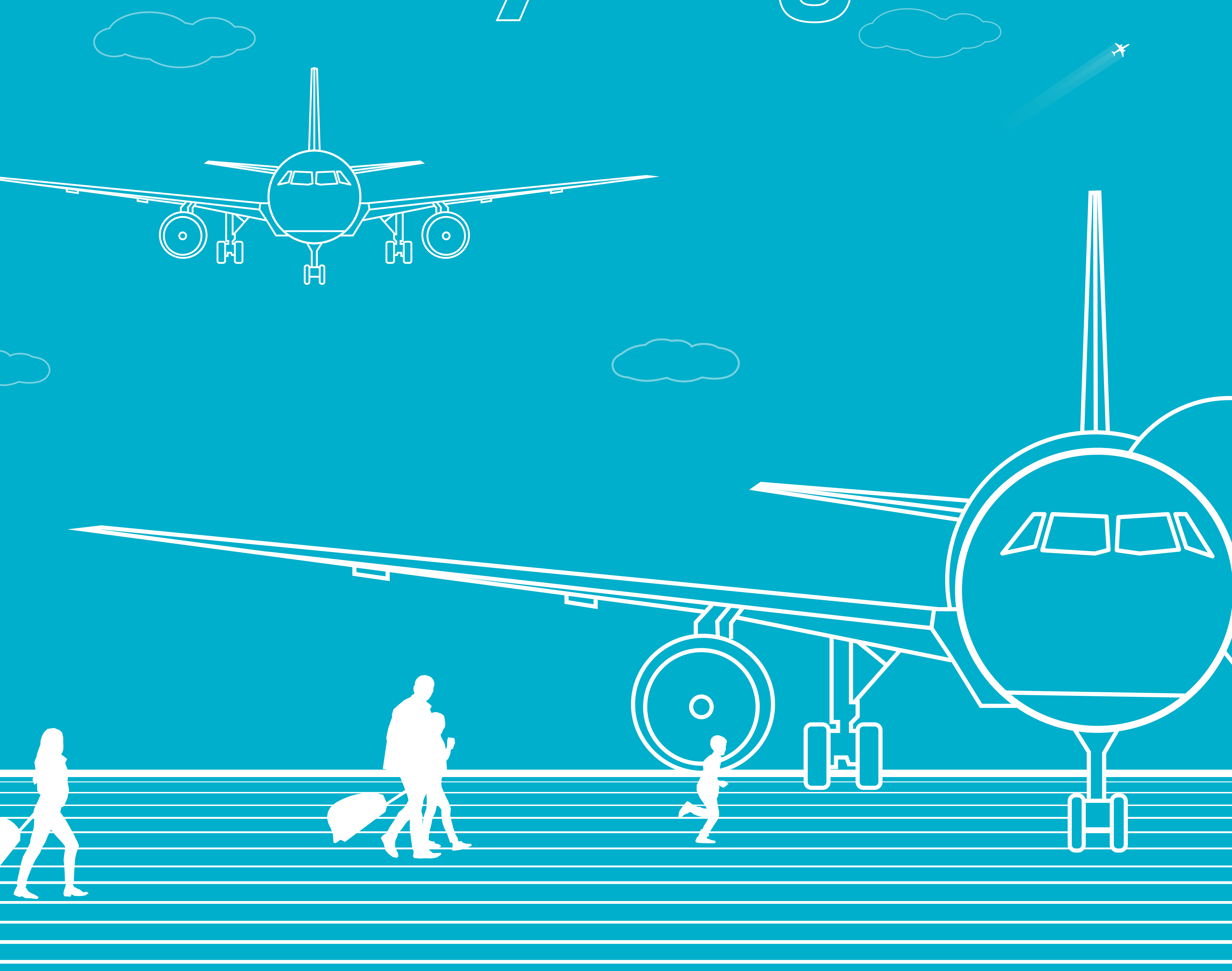
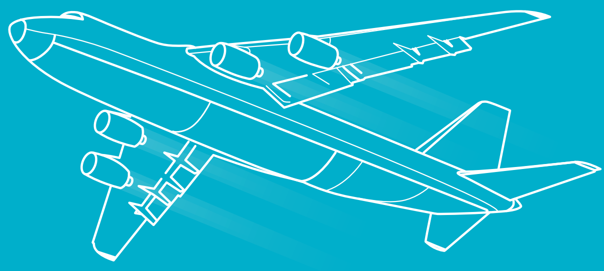
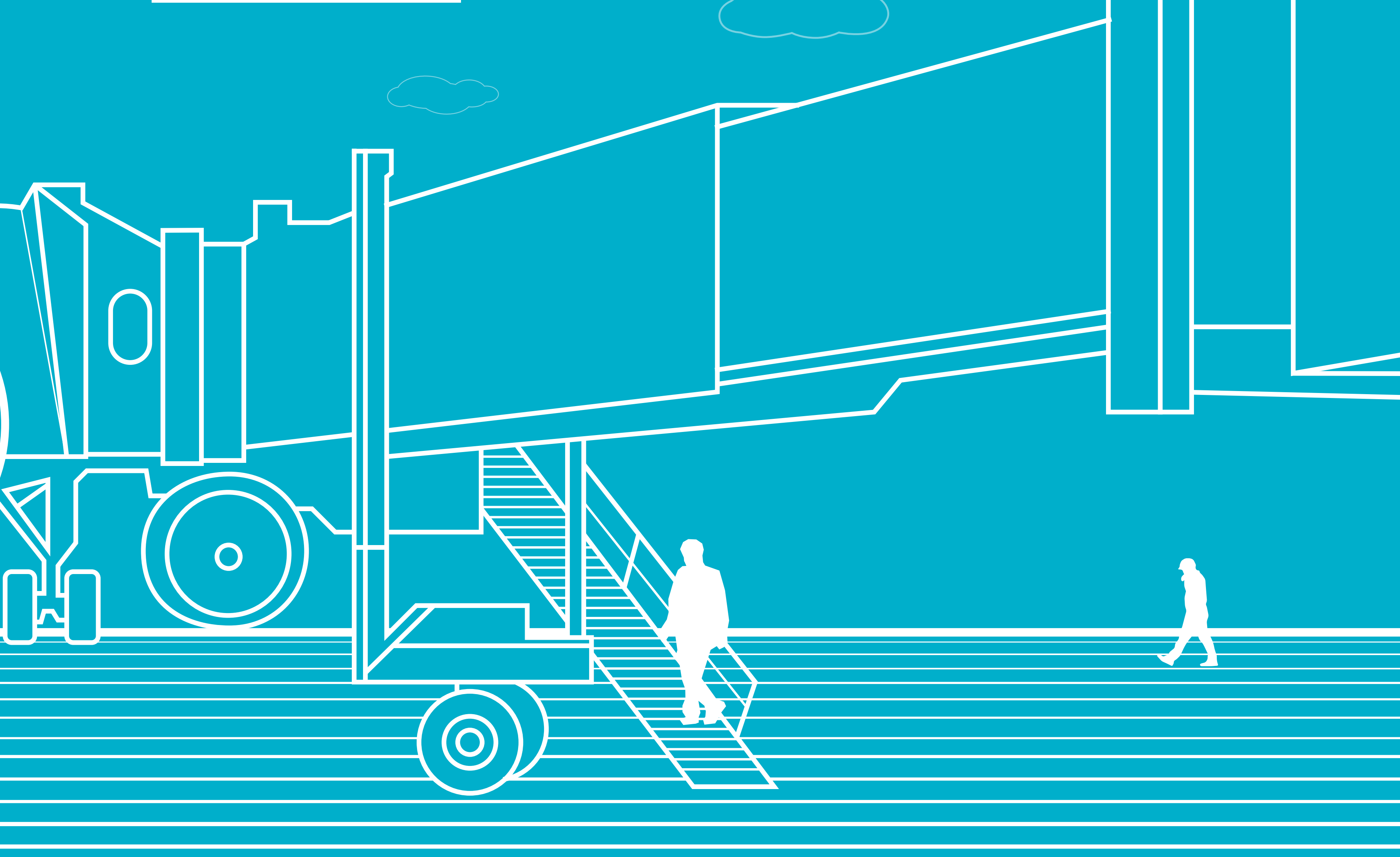
Into the future with hydrogen





An ambitious vision is on the horizon: hydrogen has the potential to enable climate-neutral flight operations. Lufthansa Technik is already laying the groundwork to get this new approach to flying airborne. In a real-world project, the company is testing everything needed to operate aircraft on the ground and in the air with liquid hydrogen (LH_2).



What sounds too good to be true could soon become a reality. That's because Lufthansa Technik, together with the German Aerospace Center (DLR), the Center for Applied Aeronautics Research (ZAL) and Hamburg Airport, is working flat out on research into the use of hydrogen in aviation. The use of hydrogen to power aircraft is just one of many practical fields that need to be tested. For the climate-neutral future of flying to become a reality, it is essential to carefully examine the conversion and maintenance processes of new aircraft and all the associated ground processes. Since hydrogen is already in use in the steel industry, cars and trains, the chances are very good that this can also be transferred to aviation. The practical phase of the project, in which an Airbus from the A320 family will be converted, is scheduled to start as early as the beginning of 2022. Airbus even plans to launch the first aircraft on the market by 2035.

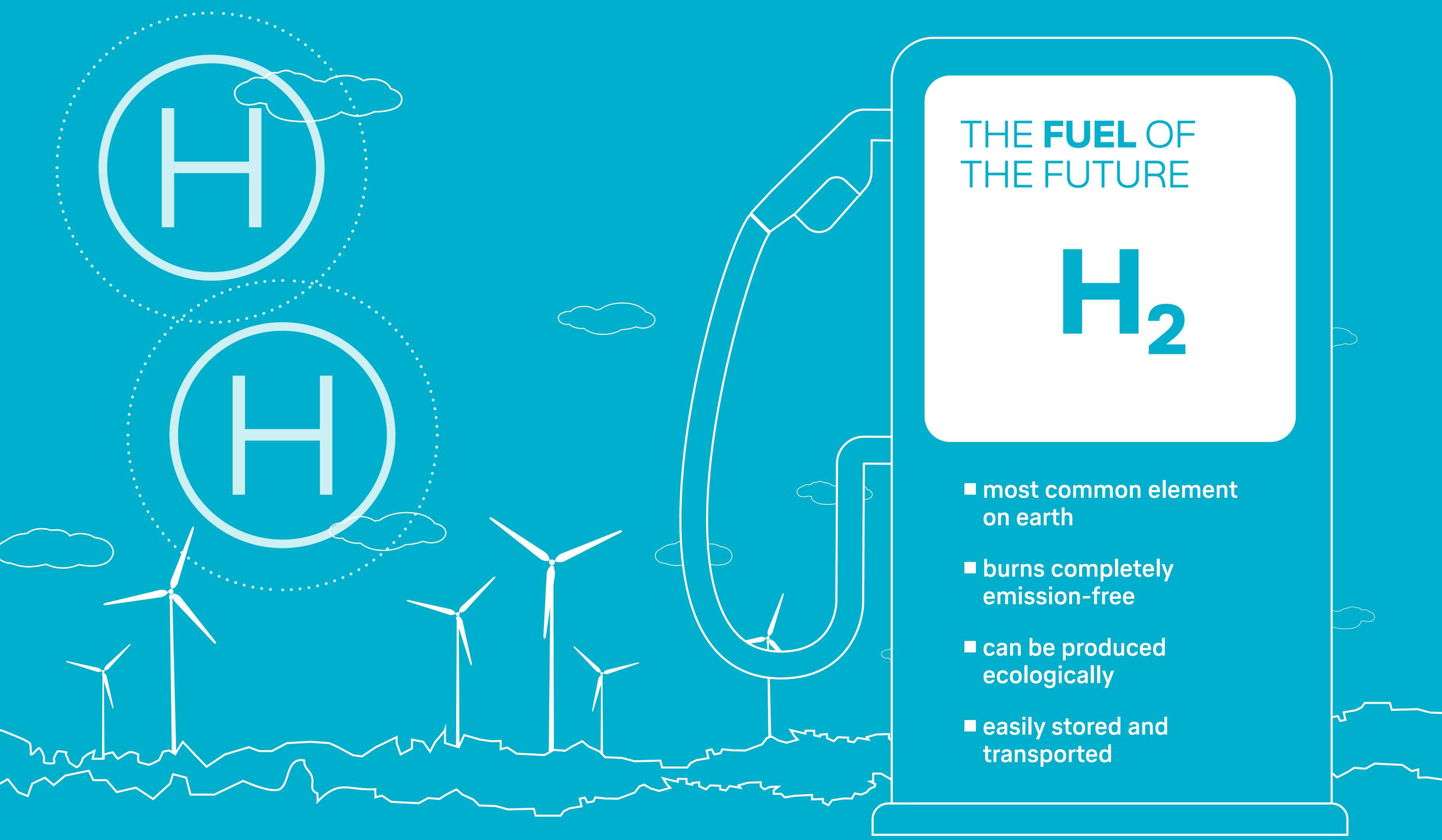
HYDROGEN TO REPLACE KEROSENE

However, a number of solutions still need to be found on the road from kerosene to hydrogen. The three main challenges for the use of hydrogen in aviation are:

1. Lack of space in the aircraft
Even when stored in its liquid form at -254° C, hydrogen is four times as voluminous as conventional fuels. For a long-haul aircraft, this means one thing above all: more space needs to be made available for the fuel. In addition, the tank properties differ from those of kerosene tanks. As a consequence, the underlying technical architecture of the entire aircraft has to be changed. This means redesigning the fuselage, modifying the engines and installing cylindrical tanks.

2. Effective propulsion
With electric propulsion, the size and power of the fuel cell systems pose a technical challenge. They still take up a lot of space and weight.

3. Green production of hydrogen
In nature, hydrogen exists almost only in compounds. As a fuel, it therefore needs to be produced artificially, requiring a lot of energy. Hydrogen is only truly green and emission-free if it is also produced with renewable energies. Although this is quite feasible from a technical point of view, innovations are still necessary before hydrogen can be widely used in aviation.



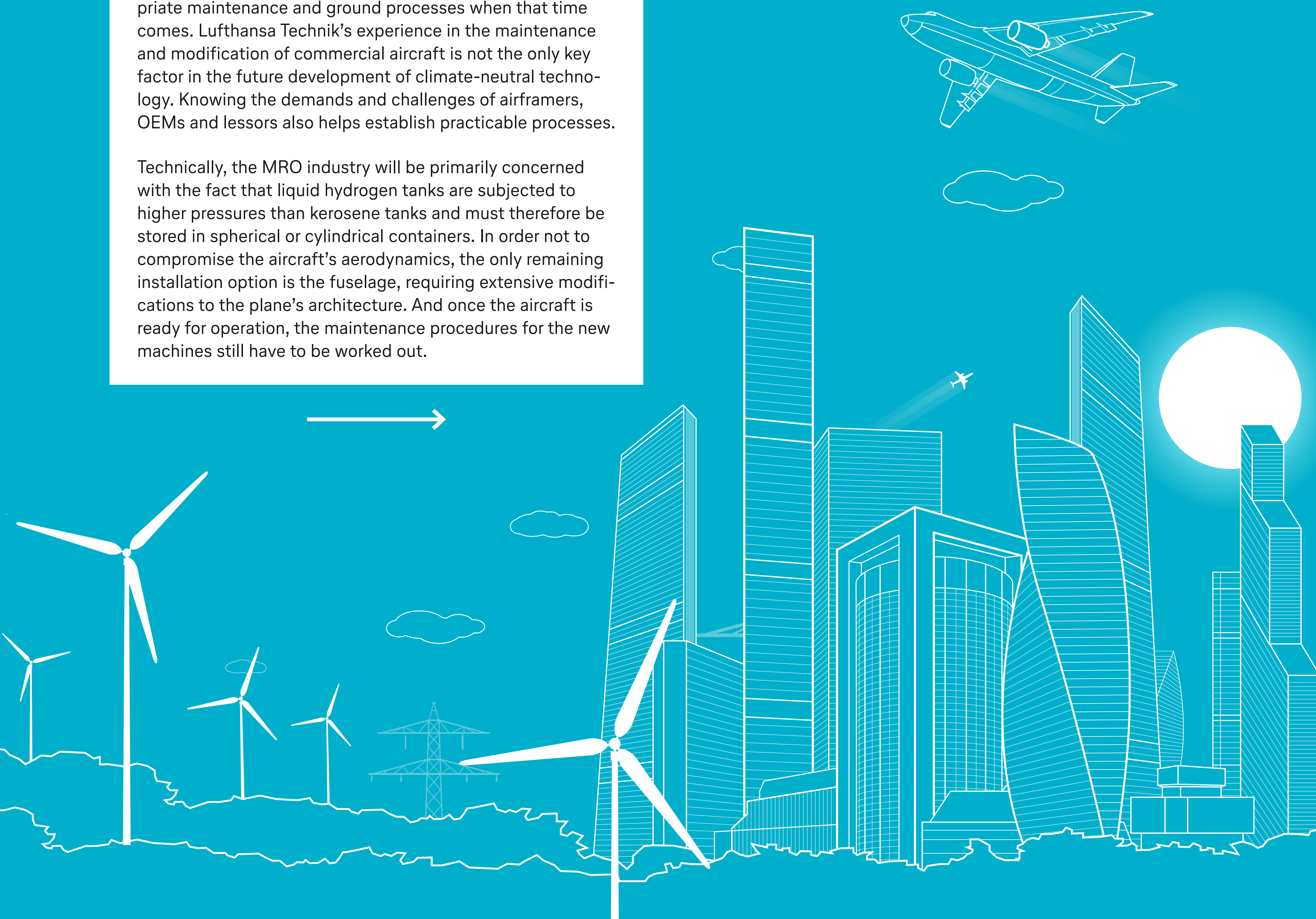
> **There is no alternative to transforming our industry toward climate-neutral flying. With this project, we aim to tackle this enormous technological challenge, also for the MRO industry, at an early stage. By doing so, we are actively safeguarding the future because we are already acquiring know-how today for the maintenance and ground processes of the day after tomorrow.**

Dr. Johannes Bußmann, Chairman of the Executive Board and CEO of Lufthansa Technik AG

CHALLENGES FOR THE MRO INDUSTRY

Once the first hydrogen-powered aircraft take to the air, experts will be needed to maintain, repair and refuel them. Lufthansa Technik is already gearing up to provide the appropriate maintenance and ground processes when that time comes. Lufthansa Technik's experience in the maintenance and modification of commercial aircraft is not the only key factor in the future development of climate-neutral technology. Knowing the demands and challenges of airframers, OEMs and lessors also helps establish practicable processes.

Technically, the MRO industry will be primarily concerned with the fact that liquid hydrogen tanks are subjected to higher pressures than kerosene tanks and must therefore be stored in spherical or cylindrical containers. In order not to compromise the aircraft's aerodynamics, the only remaining installation option is the fuselage, requiring extensive modifications to the plane's architecture. And once the aircraft is ready for operation, the maintenance procedures for the new machines still have to be worked out.



Whether on the ground or in the air, the use of hydrogen will require changes to airport infrastructure. All the stations must work hand in hand like a cog wheel to ensure operations run smoothly. It is also a call for the MRO industry to join forces to establish new certification procedures that guarantee maximum quality and safety for the entire airline operation.

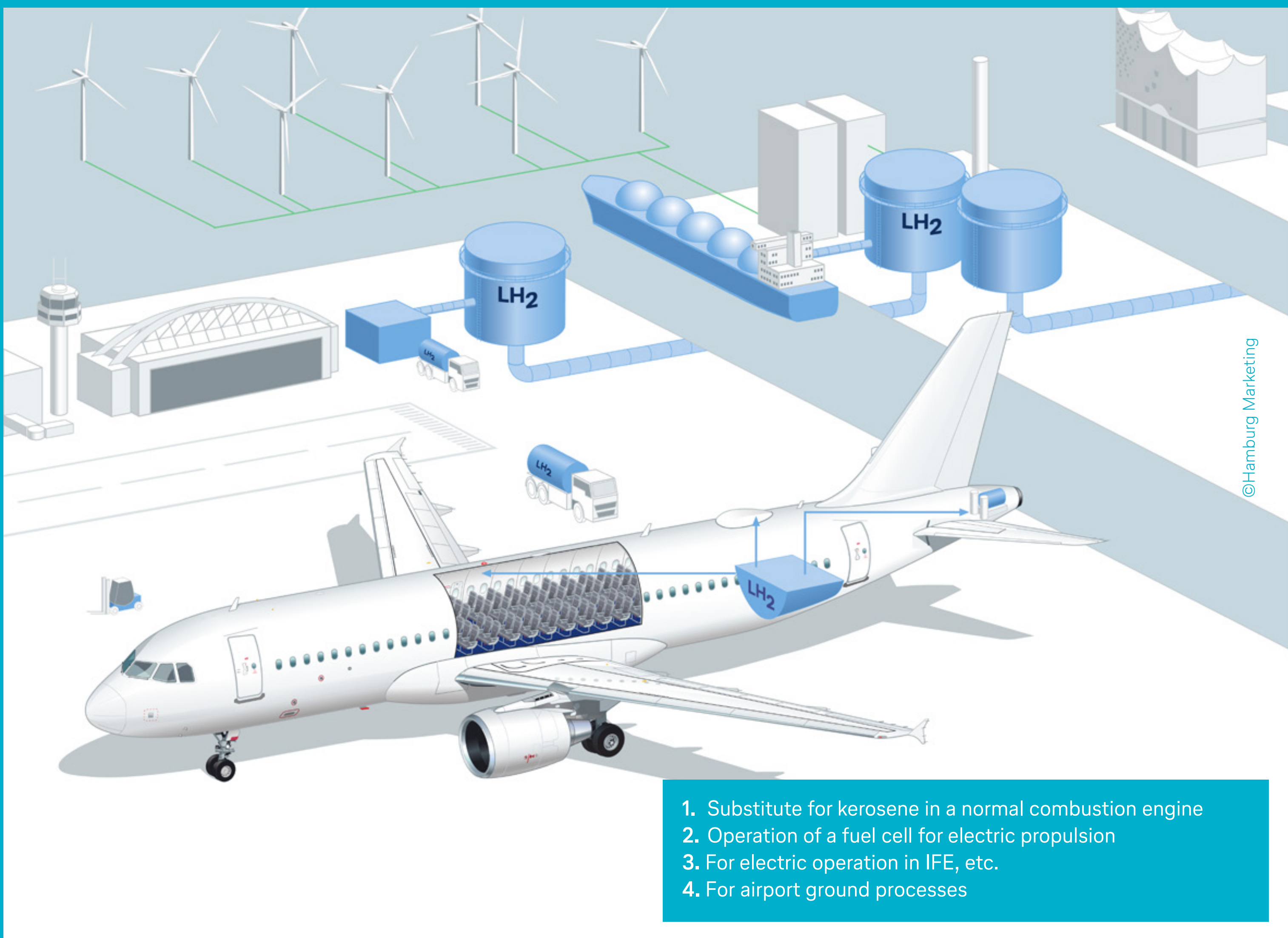
THE START HAS ALREADY BEEN MADE

Research into this pioneering technology for air travel has already passed several milestones. In the case of fuel cell-powered aircraft, for example, there have been specific proposals as to how the distribution of the fuel cell, tank and electric motor in the aircraft can be arranged most effectively - without jeopardizing the aircraft's anatomy or the efficiency of the technical processes in the machine.

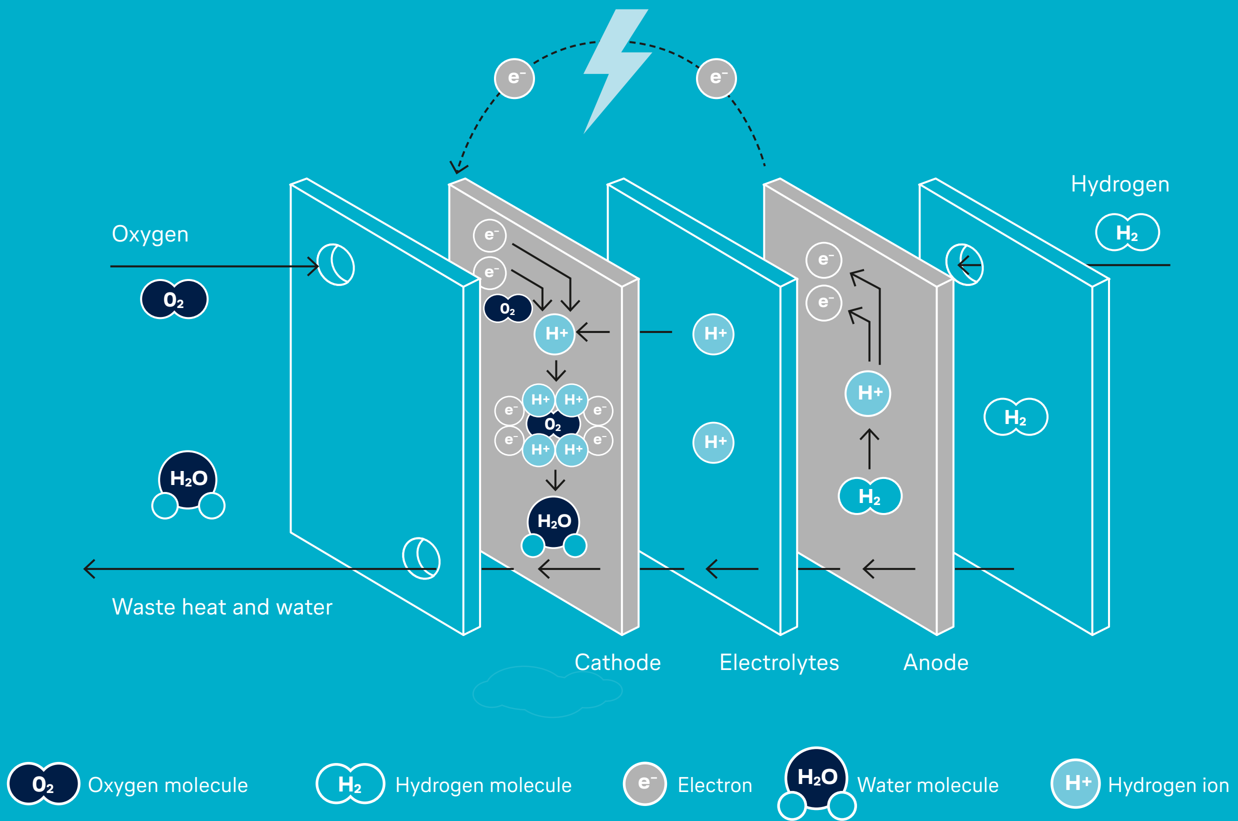
Installing the hydrogen tank close to the electric motor seems to offer the most advantages. Although this requires longer LH_2 piping, the electric cables can be shorter and existing cable technology can be used. It also facilitates the dissipation of waste heat in the nacelle. Materials such as titanium and platinum offer a potential solution to the problem of weight reduction.

A great deal is also already possible in the climate-neutral production of hydrogen. At numerous locations in Germany, so-called power-to-gas plants use water electrolysis to produce green hydrogen and make it transportable. However, the current capacity of renewable energies is not yet sufficient to produce enough green hydrogen. For air traffic to be significantly powered by hydrogen, considerable research is also required in this area. ■

FIELDS OF APPLICATIONS FOR LIQUID HYDROGEN



HOW A **FUEL CELL** WORKS



1. **Each fuel cell contains two plate-shaped electrodes (anode and cathode) separated by an electrolyte. The electrolyte can conduct ions but is impermeable to gases. The catalyst materials on the electrodes ensure that the supplied gases release ions. Hydrogen molecules (H2) decompose at the anode into hydrogen atoms, which in turn become positively charged hydrogen ions (H+) by releasing electrons.**
2. **The free electrons flow as a usable current via a conductor to the cathode. There they form negative oxygen ions (O_2-) with the oxygen atoms.**
3. **The hydrogen ions migrate through the electrolyte to the cathode, where they combine with the oxygen ions to form water, releasing heat in the process.**