

A DEPTH ANALYSIS OF HYDROGEN UTILIZATION IN THE AUTOMOTIVE SECTOR FROM A LONG-TERM PERSPECTIVE

PROBLEM

Transportation based on fossil fuels generates pollutant emissions and contributes to climate change. In this context, hydrogen and fuel cells emerge as clean alternatives for mobility. However, their large-scale adoption still faces challenges related to cost, infrastructure, storage, distribution, and technological reliability.

GENERAL OBJECTIVE

To analyze the use of hydrogen in the automotive sector from a long-term perspective, considering its applications, benefits, limitations, and commercialization challenges.

PROPOSAL

- This study develops a review of the current state and future perspectives of hydrogen as an energy carrier applied to the automotive sector. The analysis focuses on the main characteristics of fuel cells, especially Proton Exchange Membrane Fuel Cells — PEMFCs — due to their efficiency, low operating temperature, fast start-up capability, and suitability for mobile applications.
- In addition, different uses of hydrogen in private vehicles, public transportation, and heavy-duty transport are examined. The study considers examples such as the Hyundai Nexo, Toyota Mirai, hydrogen buses, and international initiatives such as H2Bus, H2ME, and JIVE, which reflect the progress of fuel cell vehicles in real mobility contexts.
- Finally, the study identifies the main challenges that limit the implementation of this technology, including manufacturing costs, the use of platinum catalysts, component durability, hydrogen refueling infrastructure, storage and distribution limitations, and the need for public policies that support its adoption.

RESULTS

The analysis shows that fuel cells can reduce the environmental impact of transportation by converting hydrogen into electricity, producing mainly water as the principal byproduct, along with heat. PEMFCs stand out as one of the most suitable technologies for the automotive sector due to their efficiency, fast start-up, and low operating temperature, generally between 60 and 80 °C.

Hydrogen also shows strong potential in buses and heavy-duty transportation, where larger storage capacity and shorter refueling times are key advantages. Projects in Europe, South Korea, and China show real progress in fleet applications; however, commercialization still faces challenges related to high manufacturing costs, platinum catalysts, system durability, hydrogen refueling infrastructure, and user acceptance.

CONCLUSIONS

- Hydrogen is an energy carrier with strong potential to support the decarbonization of the automotive sector, especially when it is produced from renewable or low-carbon energy sources.
- Fuel cells, particularly PEMFCs, efficiently convert hydrogen into electricity while producing water as the main byproduct, making them an attractive alternative to internal combustion systems.

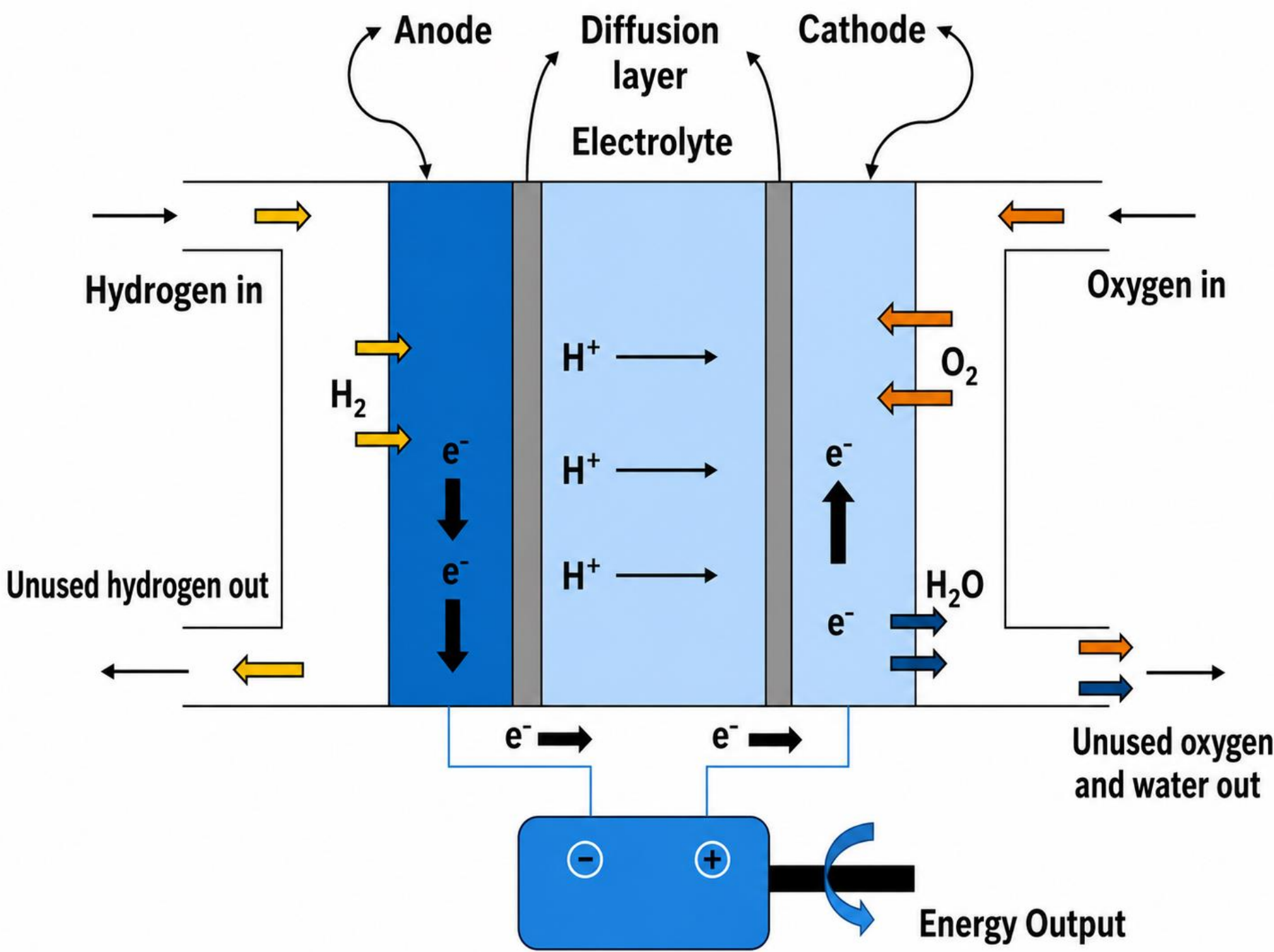


Figure 1. Operating principle of a fuel cell.

HYDROGEN FUEL CELL VEHICLE MARKET SIZE, 2022 TO 2032 (USD BILLION)

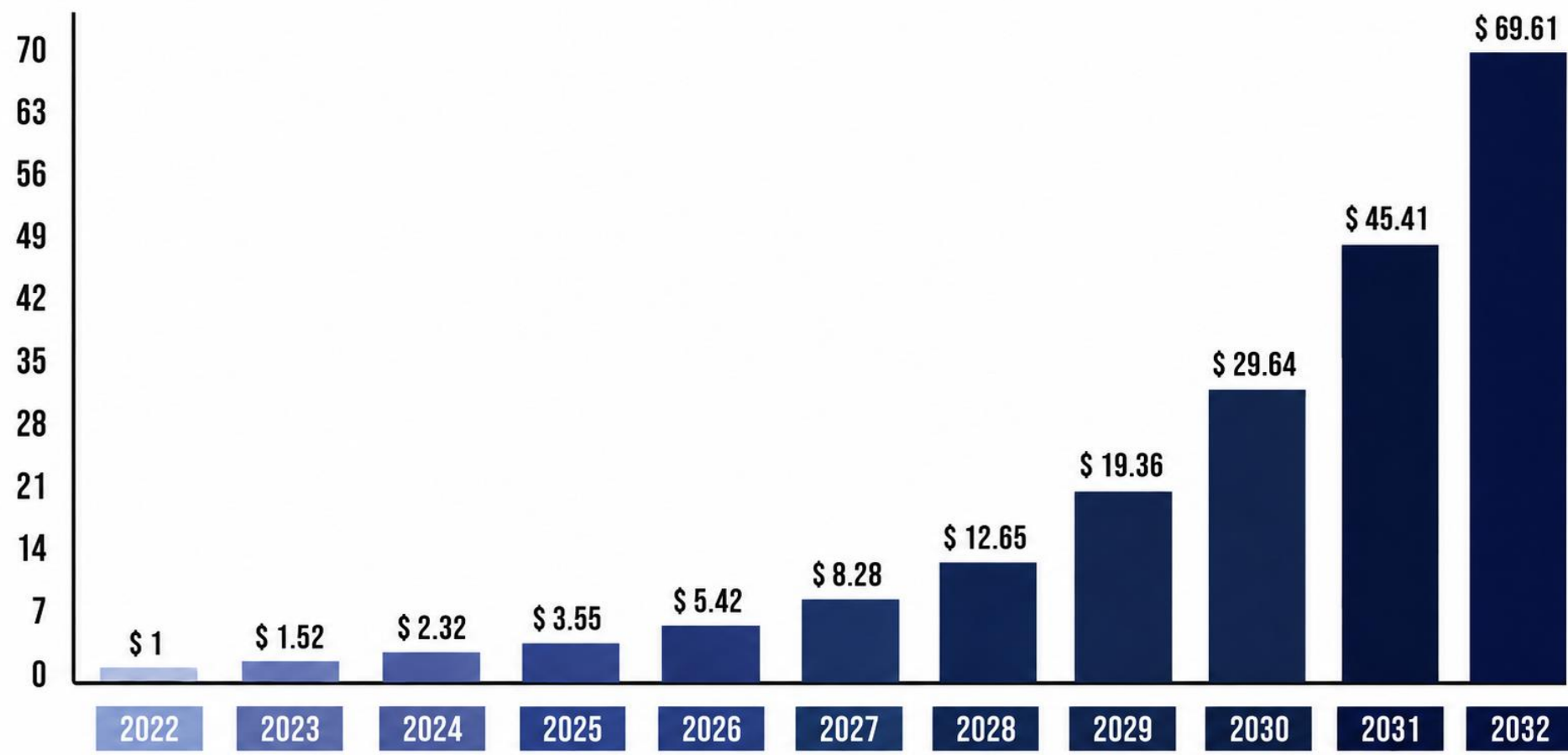


Figure 2. Hydrogen fuel cell vehicle market projection.

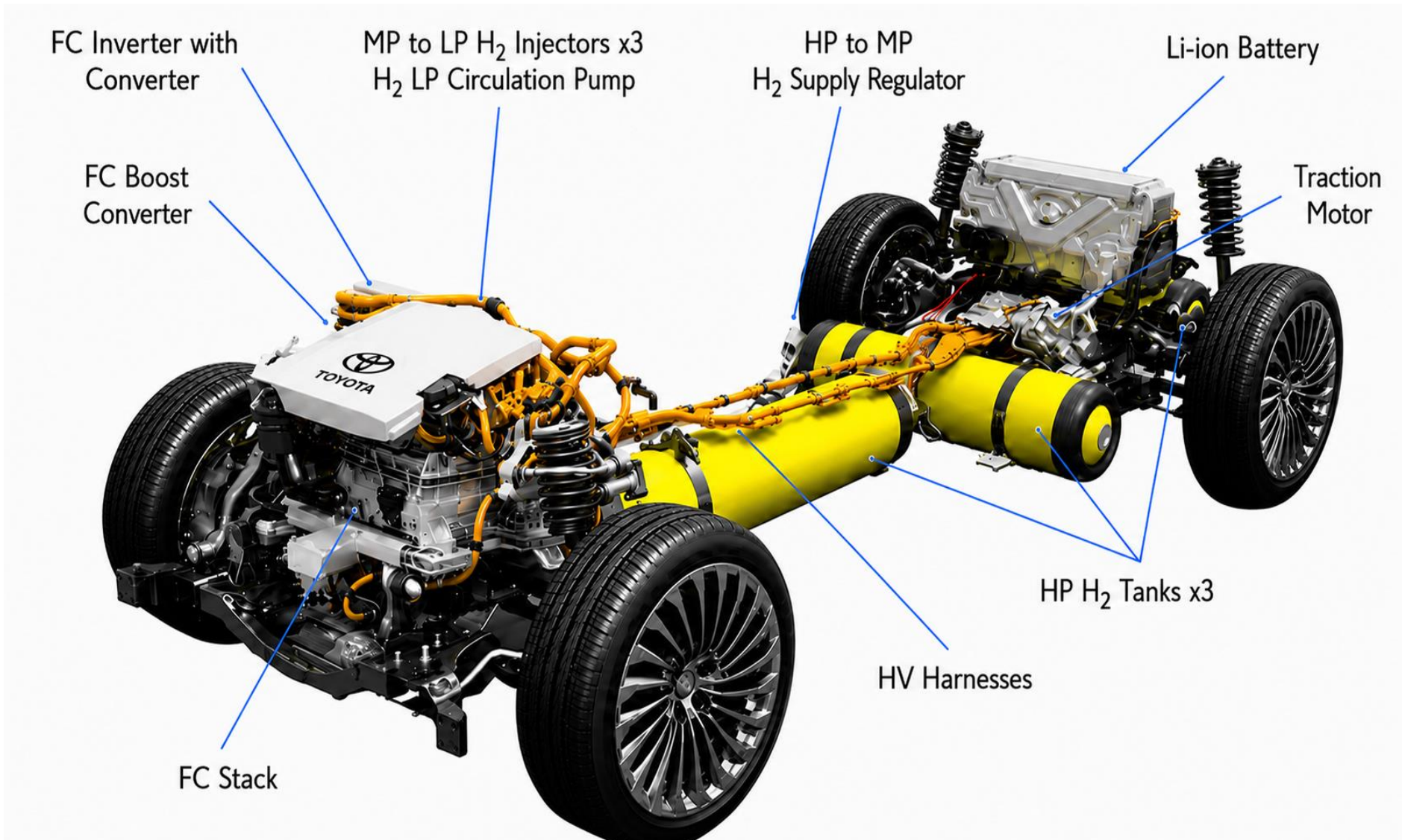


Figure 3. Fuel cell powertrain of the Toyota Mirai.

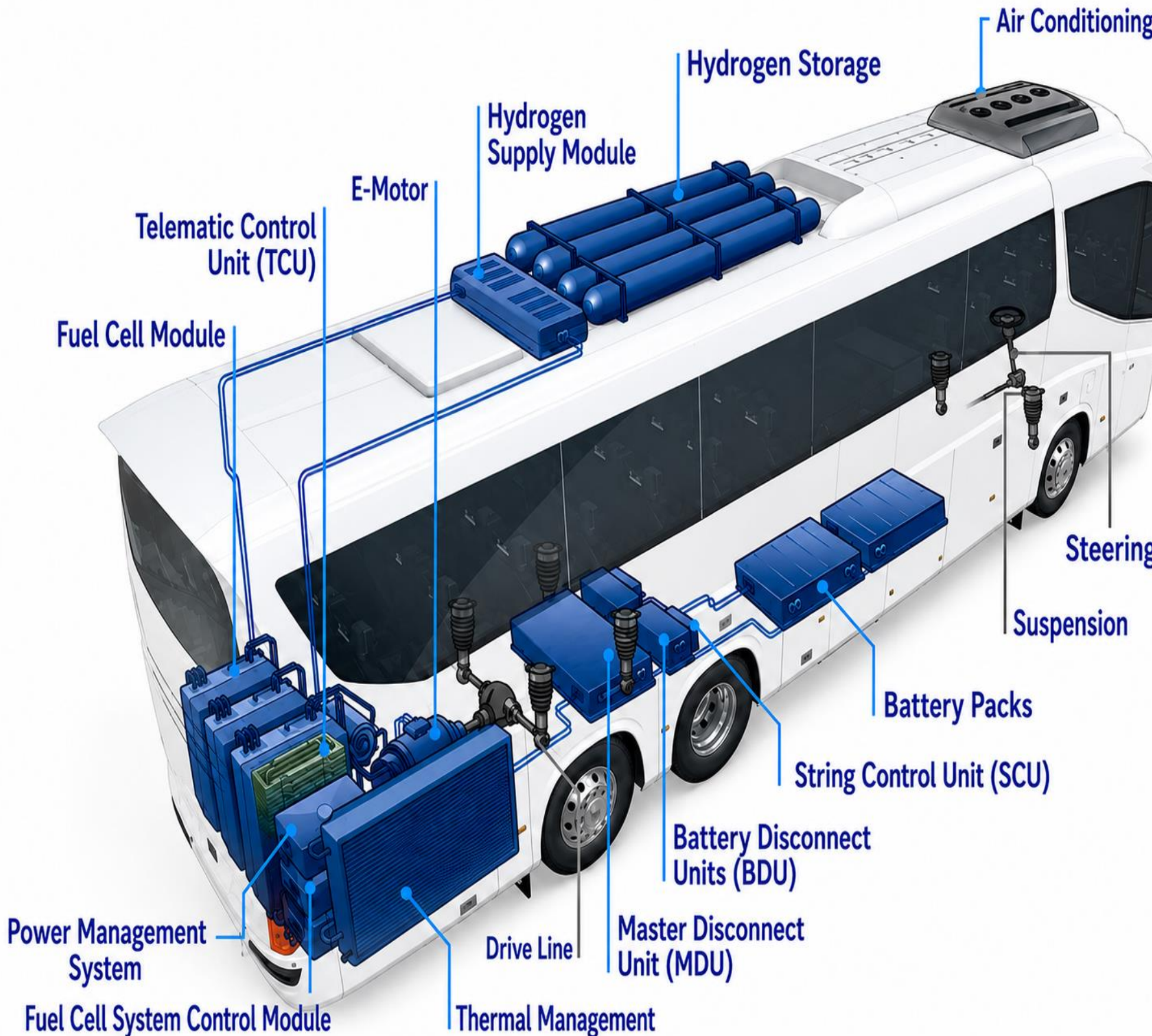


Figure 4. Distribution of a fuel cell electric bus.

- Hydrogen-based mobility is especially promising for public and heavy-duty transportation, where long driving range, high energy demand, and short refueling times are key operational requirements.
- Large-scale adoption will depend on reducing fuel cell costs, expanding hydrogen refueling infrastructure, improving sustainable hydrogen production, and addressing storage and distribution challenges.