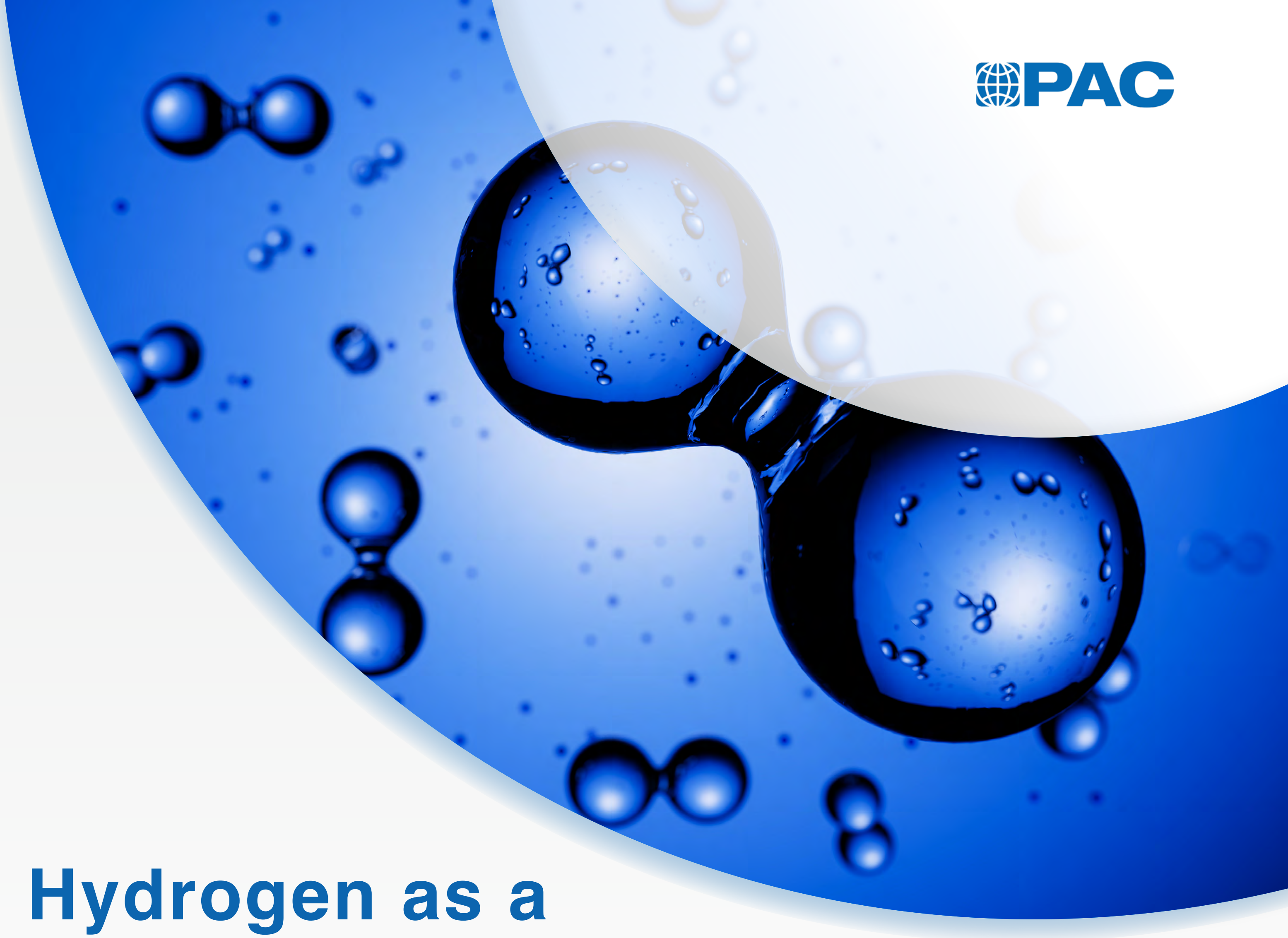

Hydrogen as a Renewable Fuel

Governments and businesses are increasingly committed to steep decarbonization targets, establishing hydrogen as a key component in the energy transition. As of this writing, McKinsey reports that 64 countries, representing 89% of global CO_2 emissions, have made net-zero pledges, while financial institutions and private sector enterprises also continue to increase their decarbonization aspirations. Going forward, the energy mix is projected to shift toward clean electricity, complemented by hydrogen and synthetic fuels.

Although the most abundant element, hydrogen primarily exists bonded to other elements on Earth. Separating and obtaining pure hydrogen requires an input of energy, and current methods include using water and electricity via electrolysis or from methane through steam reforming.

Once separated, hydrogen can either be burned directly in turbines or combine with oxygen in a fuel cell or battery to generate energy, producing water as the only by-product. It can also be used as an energy carrier in the form of ammonia or methanol to enable safe and long-distance transport.

Current industrial usages include hydrotreating of crudes and biomass in refining, as well as production of chemicals and fertilizers.

The production of hydrogen can also be broadly classified based on the emissions made during the process:

- **Black hydrogen** is produced by burning coal to power electrolysis.
- **Grey hydrogen** is produced by utilizing natural gas to power electrolysis.
- **Blue hydrogen** also uses natural gas to power electrolysis, but the CO_2 emitted is captured and either reused in another capacity or stored.
- **Green hydrogen** uses renewable resources like wind, solar, and hydropower to run the electrolysis. This form of hydrogen production is truly net-zero.

Developments and Investments

According to the Hydrogen Council, 359 large-scale hydrogen projects have been announced across the value chain by 2021 – over 80% of which are located in Europe while both Asia and Australia have significant projects. Over $150 billion USD is invested in mature projects and total investment is estimated to reach $500 billion USD by 2030.

End Applications

Multiple potential applications are envisioned in a future low-carbon economy. The most probable includes sectors that are difficult to electrify, such as long-haul trucking, international shipping, and steel manufacturing. There are also advancements in 'power-to-liquid' jet fuel for the aviation industry, and hydrogen could even be applied to powering private and public buildings.

Implementation

It is expected that hydrogen clusters will emerge with large-scale hydrogen off-takers at their core. Three cluster types are currently gaining traction – industrial centers that support refining, power generation, fertilizer and steel production, export hubs in resource-rich countries, and port areas for fuel bunkering, port logistics, and transportation.

Challenges

Multiple challenges to adopting hydrogen as a viable renewable fuel source exist, One of the biggest hurdles is investment. There is already a considerable number of countries and companies investing in hydrogen, but for it to become truly viable, more investment is required.

Storage and transport are also challenges. The weight and volume of hydrogen storage systems are presently too high, resulting in inadequate long-haul vehicle range compared to conventional petroleum. Due to the nature of hydrogen, storage tanks need to be larger than what is required for the same volume of petroleum, and also under high pressure to achieve practical energy density.

Finally, existing infrastructure needs to be updated, as it’s currently angled towards fossil fuels. Large scale adoption of hydrogen fuel cell technology for automotive applications will require new refueling infrastructure to support it. However, many existing pipeline infrastructure may be repurposed for hydrogen transportation.

Standardizations

Specification exists in different industries to define the quality of hydrogen. For example, EN 17124 specifies for fuel cell vehicles while ISO 14687 defines the characteristics in distribution networks. In all cases, the purity of hydrogen to be free of other materials needs to be monitored. These impurities can be other hydrocarbons (methane) or contaminants (nitrogen, sulfur, oxygen, CO, CO2, water, and other halogens).

PAC Solutions for Hydrogen

PAC has developed a number of applications based on gas chromatography to analyze the impurities in hydrogen.

The first tests for CO, CO_2, methane and other hydrocarbons, helium, nitrogen, oxygen, and argon. The second application tests for total and speciated sulfur compounds using GC-SCD.

Another system utilizes GC-MS to test for halogenated compounds, formic acid and formaldehyde.

Please contact PAC for more information and detailed discussion.

Reference materials

https://hydrogencouncil.com/wp-content/uploads/2021/07/Hydrogen-Insights-July-2021-Executive-summary.pdf

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https://www.twi-global.com/technical-knowledge/faqs/what-are-the-pros-and-cons-of-hydrogen-fuel-cells