

ABSTRACT:

Strategic Positioning of Ammonia Energy in the Hydrogen Supply Chain: A Systematic Analysis from Storage and Transport Medium to End-Use Fuel, and Industry Prospects

Ammonia (NH_3) is undergoing a strategic transformation from a conventional chemical feedstock to a pivotal energy carrier within the hydrogen economy, assuming dual roles as both a storage/transport medium and an indirect hydrogen source. This report systematically examines ammonia's strategic positioning and industrial prospects. As a chemical feedstock, ammonia benefits from mature global infrastructure, substantially lower liquefaction and storage energy penalties relative to liquid hydrogen, and an inherently carbon-free molecular structure. Its terminal application pathway proceeds via ammonia cracking to hydrogen, followed by hydrogen fuel cell power generation—ammonia decomposes into an H_2/N_2 mixture, in which the N_2 diluent is well-tolerated by proton exchange membrane fuel cells (PEMFCs). On the production front, electrochemical green ammonia synthesis has achieved a cost of approximately 500 USD per tonne, approaching parity with fossil-based grey ammonia, with 10,000-tonne-scale plants now operational. This modular electrochemical route further circumvents the transport costs inherent to centralized supply chains. Industrially, end-to-end green ammonia international delivery has been demonstrated, with integrated projects such as Da'an facility now in commercial operation. Global green ammonia demand is projected to grow from approximately 2.5 Mt in 2025 to 23 Mt by 2030. In summary, ammonia's role in the hydrogen supply chain is evolving from a transitional storage solution toward an independent zero-carbon hydrogen source, with its prospects contingent upon green ammonia cost reduction rates, ammonia-cracking/fuel-cell integration efficiency, carbon pricing mechanisms, and policy support across nations.

Keywords: ammonia energy; hydrogen carrier; green ammonia; green ammonia economics; electrochemical ammonia synthesis