CLEAN AMMONIA ON THE HORIZON

Pioneering Projects, Obstacles, & Shipping's Central Role

October 2023

In May 2020 when BP launched a feasibility study into the production and eventual export of green ammonia from Australia, the announcement perhaps didn't garner the attention it warranted as the world was dealing with the onset of the global pandemic. The news marked a massive shift in policy for an energy company at a time when the Green Agenda was just starting to take shape. In the years that followed, new projects were announced almost weekly as the feasibility of producing Green Ammonia as a carrier for clean hydrogen became more broadly subscribed.

At the heart of these developments was the growing push for more responsible forms of energy. The drivers can be seen at a number of levels; be it through individual corporations ESG's, growing commitment on the part of financial institutions to back green projects, and an increasingly informed consumer base. The tailwind could also be seen coming from politicians at an international level as they looked to garner support from younger constituents focused on addressing climate change. For a number of projects, it also represented new investment opportunities and job creation.

Since the electrolysis process used to produce Green Ammonia requires extensive amounts of renewable energy (Wind, Solar, Hydroelectric, etc.) many of the projects were planned far from target consumers in Europe and the Far East.

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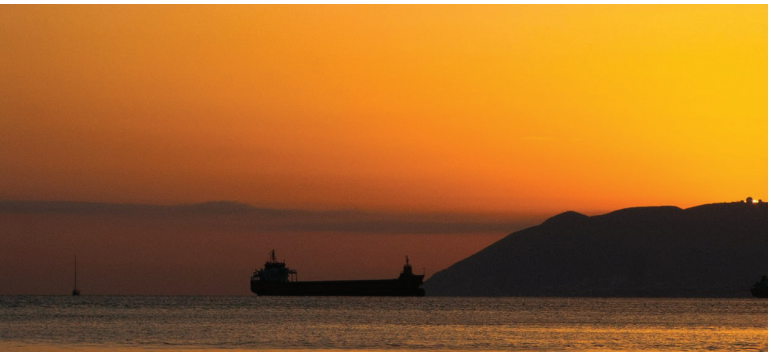
The extended distance between production and market started a secondary conversation on the infrastructure and transport required to get these critical products to market. Ammonia has moved for decades in gas tankers, but the scale required to meet these potential demands would require a substantial investment in purpose-built vessels that not only transported green ammonia but also burned it as a clean marine fuel.

The list of production projects peaked at some 173 different sites of varying size and scale but with the onset of the global recession, the viability of a number of them has been called into question. Perhaps the most difficult projects to bring to market in the current environment are the small to medium-sized green ammonia projects. Many have been placed on hold due to higher than anticipated capital costs and deep uncertainty in the product's sale price. These projects were initially expected to leverage their smaller scale and win the "race to market" but ultimately the financial numbers simply did not make sense without some type of subsidy from central governments in the producing and consuming regions.

Some of the most active and visible projects remain the largest. The Western Green Energy Hub (WGEH), located in Southwestern Australia, is forecast to produce 25 million tons of green ammonia per year with an investment of $100 Billion. The first phase of production is scheduled to start in 2031 but the partners are not expected to make a Final Investment Decision (FID) until 2027. A similar project, the Australia Renewable Energy Hub (AREH) is forecast to produce 9 million tons of green ammonia per year and was recently valued at $ 36 Billion. The AREH partners have scheduled their Final Investment Decision in 2025. At full capacity, the WGEH and AREH could triple the current shipping requirements for ammonia. The enormous scale of these projects should produce better economics than their smaller competitors and the delayed financial evaluation has proven to be a notable advantage.



Fertilizer producer OCI entered the clean ammonia market in 2022 and accelerated into a leading position within a year. The company partnered with industrial gas supplier Linde in August 2022 and set out to build a 1.1M ton blue ammonia plant in Beaumont, Texas. The partners approved the project ten months later and set an aggressive 2025 start date for production. OCI will invest $1 billion to build the plant. The company made a second bold move in September of this year when it partnered with New Fortress Energy to create a 160,000-ton green ammonia plant using New Fortress Energy's green hydrogen off-take and an existing production site. The project was approved in record time and the plant is expected to start in 2025 – 2026. The combined projects could result in 1.1M tons of new shipping requirements. Some of the economic uncertainty noted by the smaller projects was mitigated for OCI's U.S. projects through the $143 billion Inflation Reduction Act (IRA) which provides operating subsidies for companies that are cutting carbon emissions and developing new technology. The program is well suited to clean Ammonia projects where production costs are estimated to be +$100 per ton higher than conventional methods.

The NEOM project in Saudi Arabia is the leading and perhaps most visible green ammonia project today. The partnership between ACWA Power and Air Products is expected to produce 1.2M tons of green ammonia annually for export and cost about $8.4 billion. The project received final approval in May of this year and the first phase of production and shipping is set for 2026. ACWA and Air Products have also partnered with OQ in Oman to build a second green ammonia plant, capable of producing 1.0M tons per year. The project follows NEOM and has a 2029 start date. We forecast the NEOM project will result in a phased increase of 1.2M tons in new shipping requirements in the 2026 – 2027 timeframe.

One of the largest projected outlets for green and blue ammonia is the power industry but technical and infrastructure challenges remain. On the technical side, the ammonia will have to be "cracked" so that the hydrogen can be separated and used as a fuel. In Europe, the Port of Rotterdam created a consortium with 17 industry leaders to design processing capability for 1M tons per year of hydrogen or 6M tons of ammonia. The initial study recommended a single, large-scale cracker be built to optimize costs, but no funding commitments have been announced. A similar project was announced in Wilhelmshaven, Germany, but is not expected to start until the end of this decade. The challenge of transporting the hydrogen to the power grid and the conversion into power remains a significant challenge. In Japan and Korea, the power industry is planning to inject 20% ammonia into coal power plants to reduce the carbon footprint. The required infrastructure is under development.

Despite headwinds, the clean ammonia initiative is underway, and several industry leaders have stepped up to meet the challenge. The infrastructure supporting the current ammonia markets is not set up to absorb the massive increase in capacity so these bold projects will create new shipping opportunities and require innovation at critical points in the bulk marine supply chain. The downstream infrastructure required to integrate clean ammonia into the global power industry has become a critical path. Private companies can only do so much before government approvals and assistance are needed to complete the value chain. No matter how one sizes up the challenge, shipping is going to play a significant role in the solutions.

Quincannon Associates is actively tracking all major initiatives in the ammonia and hydrogen market. Contact ship@quincannon.com with any inquiries.

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For up to the minute market intelligence and support, please reach out to one of our shipping specialists.

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