James Fisher
Fendercare

A JF Fendercare whitepaper

Exploring the role of ship-to-ship transfers in the growth of ammonia as a sustainable fuel

Image courtesy of the Global Centre for Maritime Decarbonisation'

Introduction

As industries across the globe strive to meet net-zero targets, the use of sustainable fuel sources in the energy mix is becoming increasingly prominent. As a result, we are witnessing a global shift from fossil-fuel based energy systems to a use of low-carbon and renewable energy sources.

The potential of ammonia

Biofuels, which are produced from organic materials like plants, and Liquified Natural Gas (LNG), which produces far less carbon than traditional fossil fuels (40% less than coal, for example), are two examples of sustainable fuels helping to drive industries into a cleaner future.

On top of these fuels, ammonia has emerged as a key component in the race to meet these targets and drive a transition to clean energy. The gas is a frontrunner in the agriculture and chemical industry and is becoming increasingly prevalent in the energy sector. Currently around 176 million tonnes of ammonia are produced a year, with this expected to rise to 238 million metric tonnes by 2050.

The current production and trade of ammonia relies on fossil fuels - known as brown ammonia - and the infrastructure needed to produce it sustainably is not ready for what is known as green ammonia to be widely used yet. Currently less than 1% of the annually produced ammonia is done so using renewable energy sources.

However, its versatility as an energy carrier and future zero-carbon fuel, means ammonia has great potential to support the transition to low-carbon energy sources. As global demand grows, challenges are presented in the form of the costs of developing the infrastructure and technology needed to increase production.

Decarbonising the maritime industry

Ammonia is also highly volatile, adding safety challenges to those working with the gas. Despite this, ammonia presents a hugely promising solution to achieving carbon neutrality across all industries. Increasing production of green ammonia will massively reduce carbon emissions, and its versatility as an energy carrier make it a significant player in this global shift towards sustainability.

In the maritime industry, efforts to increase sustainability have been showcased through targets to reduce greenhouse gas emissions and be net-zero by 2050.

Along with the aforementioned fuels of LNG and biofuels, ammonia is emerging as a frontrunner in driving this. However, the marine industry's search for effective decarbonisation strategies has yet to determine which alternative fuel will take precedence, with options like dual-fuel systems, using LPG, LNG and methanol all under consideration as well as ammonia.

The role of ship-to-ship transfers

As demand for ammonia grows, ship-to-ship (STS) transfers offer a promising solution to ongoing questions surrounding the physical trade and movement of green ammonia. As ammonia's supply chain develops, STS transfers can help bridge the gap between growing demand and the infrastructure needed to supply it.

James Fisher Fendercare (JF Fendercare) responded to growing customer demand by utilising its experience and expertise to develop solutions in the STS market. Having been approved by many of the world's largest energy companies, JF Fendercare is on hand to support them with optimising their shipping and trading portfolios.

> "Ammonia has great potential to support the transition to low-carbon energy sources. As demand for ammonia grows, ship-to-ship transfers offer a promising solution to support supply chain development"

Background

History of ammonia: production and trade

Ammonia is a colourless, reactive gas and an important industrial chemical which is used as a building block for a range of products. It's produced by reacting hydrogen and nitrogen at high temperatures and pressures in a procedure known as the Haber-Bosch process.

Today, ammonia is predominantly used in nitrogen fertilisers, with over three quarters of global ammonia consumption coming out of the agriculture industry. It is also used in the production of plastics and synthetic fibres, among many other applications. The majority of this production however comes as a result of burning fossil fuels thus creating what is known as brown ammonia. As a result of this, greenhouse gas emissions are significant, with brown ammonia production accounting for 1% of global emissions and 20% of natural gas and coal demand. But, the developments in the decarbonisation of ammonia production using renewable sources, such as wind and solar energy, will mean that this green ammonia is 100% renewable and carbon free.

Historically, the trade of ammonia has taken place via port to port transfers, for use at fertiliser plants. Traded cargo parcels are relatively small, averaging between 2000 and 6000 cubic metres (m^3).

As demand has increased however, shipping companies are beginning to take steps to ensure greater cargos can be provided. Companies across the industry have begun investing in ammonia carriers with capacities of up to 93,000 m^3. As consideration of ammonia's potential as a hydrogen carrier and a future zero-carbon fuel, traded parcel sizes will continue to rise.

In the marine industry, research into the impact of zero-carbon fuel has been undertaken by the University of Oxford. The study has revealed that ammonia could be used to fulfil the fuel demands of over 60% of global shipping by targeting the top 10 regional fuel ports (ref. Environmental Change Institute/ University of Oxford), further accelerating the industry's growth rates.

> "An Oxford University study found that ammonia could be used to fulfil the fuel demands of over 60% of global shipping"

Global market overview

In 2023, global ammonia production was estimated at approximately 150 million metric tonnes, with the majority of this still being brown ammonia. Around 12% of this production is subsequently integrated into international trade.

Huge shifts in the trade flows of ammonia have been seen in recent years due to a number of geopolitical and regulatory changes. Most prominent of these events are undoubtedly the COVID-19 pandemic, civil war in Yemen and Russia-Ukraine war. These examples have affected the industry in a variety of ways from unsafe trade routes to labour shortages.

The production of green ammonia is primarily taking place in areas with vast renewable energy resources, whether that is wind, solar or hydropower. The main exporters of cargo are Australia and the Middle East.

The two are predicted to provide 40 million tonnes of green ammonia a year, accounting for around two thirds of the total volume of world trade. Northern Europe and North America are also emerging as key exporters.

In terms of demand, Japan and South Korea lead the line. Both have invested heavily in green technologies and are motivated by their decarbonisation initiatives. As well as building its capacity as a leading exporter of green ammonia, Europe will also be a major customer for suppliers of green ammonia. It is projected to be the second highest importer of cargo behind Japan and South Korea, with its main supplier being the Middle East. A large majority of the green ammonia exports from Australia are moving through the Indian Ocean and South China Sea, arriving at major ports in the Asia Pacific region.

Growth predictions

With industries around the world increasing decarbonisation efforts and striving to meet net zero targets, green ammonia is predicted to see significant growth over the next 5 years.
The current green ammonia market is valued at around at $750 million, with this expected to grow at a compound annual growth rate (CAGR) of 72% by 2032. Improvements in technology have allowed for greater efficiency and scale of green ammonia production.

In Australia, Fortescue Metals Group is leveraging the country's vast solar and wind capabilities to spearhead The Gibson Project, which is projected to produce 400,000 tonnes of green ammonia per year. Saudi Arabia has commenced work on the NEOM project, a smart city which includes plans for a $5 billion green ammonia and hydrogen facility. The plant, which will be powered by solar and wind energy, is set to produce 600 tonnes of green ammonia every day.

In North Europe, Norwegian chemical company, Yara, recently inaugurated Europe's largest green ammonia and hydrogen plant in Porsgrunn. China's Da'an project will integrate renewable energy sources and advanced technology to produce a predicted 180,000 tonnes of green ammonia a year once fully commissioned in 2025.

> Green ammonia is predicted to see significant growth over the next 5 years, with an annual CAGR of 72%

Industry challenges and fuelling growth

In order for industries to make the adoption of green ammonia viable, significant investments and development of regulations are required. Renewable energy sources are essential to the gas production meaning further investments in renewable energy systems are required to support the growing demand for ammonia. This will involve a large-scale development of infrastructure such as solar and wind farms. The number of green ammonia plants, such as the ones in Australia and China, will need to increase, with large scale electrolysers needed to perform required splitting of water into hydrogen. Significant investment is required to be able to reach a scale that can support the growth of the green ammonia industry. Challenges also arise from factors such as transport and storage. Modifying existing ammonia pipelines and storage facilities to make them compatible with green ammonia's highly corrosive nature, whilst handling larger quantities, poses financial and safety challenges.

Rigorous government and industry regulations are therefore required to ensure an effective and safe integration of green ammonia production into wider energy transition efforts. Government investment into research and development through loans or subsidiaries will massively aid green ammonia's growth. Setting out clear guidelines and targets on the use of green ammonia across industries will not only facilitate growth, but will also ensure this is done with the utmost safety. The US Environmental Protection Agency, for example, has issued Acute Exposure Guideline Levels (AEGLs), which provide essential regulations on ammonia exposure to protect human health. These guidelines help inform safety measures and emergency response protocols, ensuring that the production and transport of ammonia are conducted with the highest safety standards to prevent harmful exposure and environmental contamination.

Green ammonia production

The cost of producing green ammonia, in comparison to standard ammonia, is another significant challenge. Producing green ammonia is currently a far more expensive task than brown ammonia thus presenting the challenge of getting the former to be broadly accepted within the market. Despite this, increasing investments and regulations into green ammonia will reduce costs, and can thus make the gas a more commercially viable option than biofuels, for example.

In the marine industry, the search for effective decarbonisation strategies has yet to determine which alternative fuel will take precedence, with options like dual-fuel systems, using LPG, LNG, ammonia, or methanol all under consideration. Additionally, the industry currently lacks certified engines that run purely on ammonia, complicating its integration into existing maritime operations and potentially slowing market growth.

With these factors in mind, STS transfers can still help facilitate growth through the physical movement of cargo. As the infrastructure and supply chain develops, STS can help ensure that the existing supply chain keeps moving.

> "Significant investment is required to be able to reach a scale that can support the growth of the ammonia industry"

The challenges facing ship-to-ship transfers of ammonia

The use of ship-to-ship transfers for ammonia cargo remains in its infancy, facing several key challenges and uncertainties. A major hurdle is the essential development of a definitive ammonia supply chain. This is currently prohibited by the above points on a need for further investment into infrastructure, production and policy. As infrastructure is scaled up and definitive policies developed, a clearer supply chain will evolve. This will also rely on effective coordination between key industry players and policy makers.

Despite its significant promise as a solution to a greener future, ammonia is a volatile cargo that possesses unique challenges and safety concerns to those handling and transporting it, as well as environmental risks.

Unlike LPG, which is neither toxic or corrosive, ammonia poses a higher risk in the event of an incident, although due to comprehensive due diligence such incidents are rare.

Proper training is required in order to ensure crews are operating at the highest level of safety when performing transfers and have an understanding of ammonia and consequences of exposure. This training is time consuming yet crucial to ensure crews are certified to work with ammonia and aware of what to do in the unlikely event of an emergency. The development of industry standard risk assessments, HAZOPs and exercises are still ongoing for ammonia STS transfers.

How ship-to-ship transfers can support the growth of the ammonia supply chain

As a result of the challenges posed by ammonia, ensuring STS transfers take place with the utmost understanding and safety is vital. The current STS guidelines for the transfer of other cargo, such as crude oil or LNG, need further development to meet the growing demand of ammonia. The industry is therefore undertaking studies and posing further advancements to the equipment used when conducting an STS transfer, to ensure they're performed with the utmost safety and efficiency.

Operational requirements under review include:

- **High quality marine hoses that can withstand the corrosive nature of ammonia.** Avoiding spills is paramount to the safety of our oceans and people and can be achieved through advancements in the lining of the hoses and the reinforcement wire used to support them.
- **Emergency release couplings (ERCs) as standard.** ERCs ensure a quick disconnect without human interaction with the flange thus enhancing safety in the event of an emergency.
- **Exclusion zones at the hose's manifold.** STS vessels are divided into 15 metre space zones, with Zone 0 being at the hoses manifold where exposure is most likely to occur in the unlikely event of a leak. This ensures that any unnecessary risks of exposure are avoided.
- **Full hazmat suits and breathing apparatus'.** As an essential requirement for STS superintendents operating in Zone 0 to prevent direct exposure to ammonia in the event of a leak.
- **Hot-gas and nitrogen purging.** An essential procedure to ensure removal of any harmful residual ammonia in the transfer systems.

Benefits of STS transfers to the ammonia market

STS transfers offer significant economic and logistical advantages for the ammonia market. Most importantly, STS transfers will aid trade flow through the physical trading and shipping of ammonia in a volatile and rapidly changing market and will enable companies to maximise their shipping and cargo potential on short notice, aligning with the short-term trading dynamics prevalent in the industry. These benefits collectively support the growth and flexibility of the ammonia market.

By reducing the costs associated with docking, such as berthing charges and fuel consumption during wait times, STS transfers also enhance cost-efficiency. Additionally, STS transfers increase market accessibility, promoting the wider adoption of green ammonia and allow providers to generate new market relationships. As industries across the globe develop the necessary technological advancements needed to develop the supply chain of green ammonia, STS transfers can play an essential role in maintaining and supporting the movement of cargo.

> "STS transfers offer significant economic and logistical advantages to support the trade flow as the market and supply chain develops"

Image courtesy of the Global Centre for Maritime Decarbonisation'

Conclusion

Upon analysis of current market dynamics and challenges surrounding the growth of ammonia as a sustainable fuel source, it's clear that industries around the world have a long way to go with regards to developing the production and trade of ammonia, including green ammonia. Significant growth in infrastructure and regulations are needed before industries can meet growing demand. In the marine industry, ambiguity remains over which clean fuel is the most appropriate to drive shipping into a greener future. Ammonia's growth rate in the industry will be affected as a result.

Despite these challenges, there is no doubt surrounding the huge potential of ammonia as an energy carrier and zero-carbon fuel.

Developing the production and trade of green ammonia as a fuel can have a massive impact on reducing greenhouse gas emissions and drive net-zero targets across the globe.

Incorporating STS transfers into the development of the ammonia supply chain in a rapidly changing market, where costs are constantly subject to change, could offer effective trading dynamics and cost effectiveness, for example a reduction on aspects such as docking charges. More importantly, as the ammonia market grows, the option of STS can ensure a continuation in the movement of ammonia, allowing companies to maximise their cargo potential.

James Fisher
Fendercare

James Fisher Fendercare

T: +44 (0) 1508 482 691
E: STSBD@fendercare.com