

AMMONIA ENERGY
ASSOCIATION

FREQUENTLY AND RARELY ASKED QUESTIONS TO ENABLE MARITIME AMMONIA — PROJECT DEFINITION

Summary

The AEA intends to publish a whitepaper that addresses frequently and rarely asked questions from a set of stakeholder perspectives across the maritime ammonia value-chain. The answers to these questions will assist with the removal of barriers for the uptake of ammonia as fuel for the maritime sector.

The whitepaper will present answers to “frequently asked questions” but it will also seek to identify critical questions that may be as-yet unanswered. It will contain a stakeholder perspective including, but not limited to, the public, shipowners and operators, equipment makers, banks and insurers, policy makers and regulators, class societies, shipyards, fuel producers and bunkering providers, ports and cargo owners. It will help to identify barriers to the use of ammonia as a maritime fuel which are yet to be widely understood. Where available the status of progress to overcome these barriers will be detailed. The whitepaper will be illustrated with relevant overviews of industry development, such as technology adoption, rules and regulations, standards etc.

Strategic objectives

This whitepaper fits into the Knowledge Stewardship and Advocacy pillars of the AEA’s strategy, as it fills a knowledge gap regarding the maturity of ammonia as a maritime fuel and provides a foundation for focus areas moving forward. It serves to assist strategic planning for the AEA, as to how and where the Association and its members can contribute to the progress of ammonia as a maritime fuel.

Furthermore, this whitepaper supports the AEA’s Collaboration pillar, as it will be a member-led process drawing input from AEA members via a dedicated working group, strengthening member networks and cooperation. The publication also allows the AEA to showcase the technologies and projects of its members.



Working Group establishment

To pursue this initiative the AEA is establishing a Maritime Ammonia Enabling Questions Working Group (MAQ), which will be responsible for directing the AEA staff who will write this report. The Working Group will define the structure and content of the report, participate in workshops as needed, oversee the development of the report, and provide final approval for the conclusions and positions it contains. Working Group participants may also wish to contribute text, images, and data, and may want to have a role in disseminating the finished report in public.

All AEA Members are entitled to participate in this working group and external experts will be invited to contribute as appropriate. The Working Group will disband upon completion of the report, estimated to be before the end of December 2022. The AEA may wish to review and reissue future editions of this work and would relaunch the Working Group to oversee that project.

Working Group schedule

Most Working Group input can be provided through e-mail or via direct engagement with AEA staff, but the workplan is structured around four Working Group meetings, with the following proposed schedule:

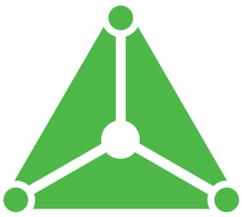
(Note: depending upon the Working Group composition, meetings may be repeated on a given day to cover diverse time zones. The AEA staff will then consolidate members input)

- **Meeting 1: Kick-off and Project Definition.** Mid-August.
 - Before attending the meeting, members are requested to fill in a questionnaire to:
 - state any content or stakeholder perspectives that they want to see included or emphasized
 - indicate their relevant specific knowledge
 - propose case studies.
 - During the meeting, we aim to:
 - amend / approve this Project Definition
 - identify missing people/organizations who should be invited to participate
 - identify data requirements and sources
 - agree methodology for delivering the project



AMMONIA ENERGY ASSOCIATION

- assign any specific tasks to working group participants.
- After the first meeting, AEA staff will:
 - reach out to missing people/organizations
 - compile data and undertake initial analysis
 - draft an outline of conclusions supported by any available data
 - develop a marketing and communication plan for the report launch
 - distribute these items to participants for written feedback.
- **Meeting 2: Workshop: 360° Maritime Ammonia Enabling Questions.** September.
 - During the workshop, we aim to:
 - Present comprehensive overview of prioritized questions across wide stakeholder segments
 - identify any missing data
 - achieve consensus on the best presentation of data
 - achieve consensus on the outline of conclusions.
 - The workshop format will involve the repeated splitting of attendees into smaller work groups for guided discussion, with looped feedback to plenary.
- **Meeting 3: First Draft.** October.
 - Before the meeting, AEA staff will:
 - draft a first version of the whitepaper
 - distribute the manuscript to participants for written feedback.
 - During the meeting, we aim to:
 - discuss significant feedback
 - work to achieve consensus or identify issues requiring attention
 - identify any missing content (text, data, imagery).
- **Meeting 4: Final draft and launch plan.** November.
 - Before the meeting, AEA staff will:
 - draft a finished version of the whitepaper, including all data and images
 - distribute the manuscript to participants for written feedback.
 - During the meeting, we aim to:
 - discuss significant feedback
 - work to achieve consensus or identify issues requiring attention
 - approve release of the report, following final revisions, to the graphic designer
 - approve final details for marketing and communications activities.



Project description

As the maritime industry searches for decarbonization solutions, ammonia fuel continues a rise to prominence. To complement this development, ammonia producers have an opportunity to respond to the need for supply. In this setting, with ammonia 2-stroke engines expected to be available by 2024, and with ammonia-fueled vessels on order, it is now relevant to take stock and identify – across a wide stakeholder landscape – what important questions are still left unanswered. The purpose is to confidently identify and unpack the major potential barriers for effectively progressing ammonia as a maritime fuel, and to provide a meaningful route to removing those barriers.

The questions this report aims to answer are suggested to include, but not limited to:

Readily defined questions-

Technology

- What is the status of ICE development?
 - 4 stroke and/or 2 stroke?
 - Power ratings
 - Pilot fuels?
 - Dual fuels?
 - Engine conversions?
 - Vessel retrofits?
 - Costs?
 - Timeline?
 - Impact on cargo capacity?
 - Other limitations?
 - Segment applicability?

- What is the status of fuel cell development?
 - Power ratings?
 - Cracking or direct ammonia?
 - Maximum range considerations /restrictions?
 - Vessel retrofits?
 - Costs?
 - Timeline?
 - Impact on cargo capacity?
 - Segment applicability?



AMMONIA ENERGY ASSOCIATION

- What is the status of on-board fuel storage and delivery systems?
 - Costs
 - Impact on cargo capacity?
 - Cold/ambient advantages/disadvantages?
 - Present state of technology?
 - LNG NH₃ versatile tanks?
 - Typical fuel train system designs and limitations?
- What is the status of bunkering solutions?
 - Types of terminals being developed?
 - Bunker barge development?
 - Specification of bunker fuel?
 - Trading and certification of bunker fuel?
 - Carbon content reduction development?
 - Timelines to availability?

Operational and Corporate

- Status of crew training and competency?
 - Sweet spot segments?
 - Training establishments?
 - Approved training and past experience (LNG)?
 - STCW
- Vessel and terminal management capacity?
 - Availability of superintendence competency?
 - Differences with financially managing an ammonia fueled vessel?
 - Procurement and OEM support with ammonia fueled vessels?
 - Relationship with Flag and Class?
 - How to engage and with which yards for construction and drydocking?

Safety

- Characteristics of maritime ammonia fuel?
 - Boiling point, flashpoint, flammable limits, density, phase curve, energy properties?
 - Chemical properties?
- Containment failure?
 - Liquid spill characteristic and handling, use of water and disposal?



AMMONIA ENERGY ASSOCIATION

- Vapour development and propagation characteristics?
- Toxicity profile, personal protection, first aid and critical care?
- Detection, containment, and isolation?
- Key differences between handling containment failure with ammonia compared to relevant hydrocarbons and chemical gasses?

- Design safety?
 - Incompatibility with certain materials (e.g. copper)?
 - Detection and installed containment failure control systems?

- Fire safety?
 - Fixed fire fighting systems?
 - Portable fire fighting systems?
 - Types of fires and fighting techniques?
 - Fire detection special provisions?

- Non shipboard safety aspects?
 - Terminal and storage location?
 - Regulatory interface?

Regulatory (To be further developed)

- IMO?
- EU?
- Other regional jurisdictions (China, U.S.A.)?
- LCA, Verification and Certification?
- Flag role?
- Classification role?
- Ammonia fuel and carbon accounting

Environmental (To be further developed)

- Environmental impacts?
 - Sea emission?
 - Air emission?
 - Fresh water environments (rivers, lakes and intertidal) emission?
- Mitigation and control?
- Existing regulatory frameworks?
- Expected regulatory frameworks?

Business models (To be further developed)?

- Techno-economic modelling?



AMMONIA ENERGY ASSOCIATION

- Financing routes being explored?
- Public – Private partnerships?
- Enablers such as long terms COAs?
- Green corridors?
- Sector coupling?
- Consolidation, partnership and collaboration?
- Further business model innovation for first movers and scaling.
- Application of cargo accounting and MBMs.

Stakeholder defined questions -

Public

- What happens if there is a leakage or fire (ammonia) in the port?
- How can I be sure there hasn't been a leak?

Shipowners and Operators

- What kind of ammonia projects attract public funding?
- How will we ensure that staff onboard are safe?
- Safe distances from bunkering, how will it affect port operations?
- When can I order and NH₃ fuelled ship?
- How will the CO₂ saved be accounted for?
- How can I find out where NH₃ bunkering will be available?
- How is NH₃ compatible as dual fuel?

Maritime insurers

- How are classification societies engaging with this new toxic fuel option?
- P+I, What are the major pollution risks and other public liability issues associated with NH₃ over and above other maritime fuels?
- What Class notations should we consider for evaluating premiums for NH₃ fuelled ships?

Finance and investment

- In appraising ROI we need some idea of employment forecast. How is fuel supply and cost developing? What about carbon levies?
- How should we appraise stranded asset risk? Can methanol or another alternative fuel supply NH₃ for example?
- How does the NH₃ future sit with the Poseidon Principles?
- Where can I find market intelligence on maritime NH₃ fuel development?

Ports



AMMONIA ENERGY ASSOCIATION

- How must we prepare for enabling NH₃ bunkering in our facilities?
- How can we become part of an ammonia fuel green corridor?
- What capacities of storage and transfer should we plan for?
- What is needed to meet safety standards for NH₃ storage and bunkering?

Cargo Owners

- Where does NH₃ fuel sit vis a vis the sea cargo charter?
- How can we get some security on the price development of NH₃ maritime fuel?
- Where and when will NH₃ bunkers become available?
- As a commodity, how is low carb NH₃ bunkers to be certified?
- Will this allow us to offset carbon in other areas of our value chain?

OEMs

- What are the statutory requirements for NH₃ combustion (emissions and other)?
- What are the spec requirements for NH₃ as a maritime fuel?
- How is the industry evolving? Is there a fleet segment that we can target to scale with?
- How is the transfer and quantity verification of NH₃ fuel to be handled?

Flag States

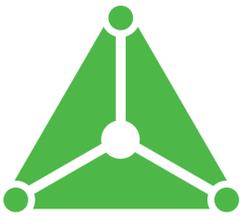
- How do we account for the life cycle carbon impact and create a level playing field?
- Which Class Societies are publishing guidelines/papers/advice on NH₃ fuel?
- Which companies using our flag are working on NH₃ fuelled ships?
- What are the regional differences ref. suggested standards and certification criteria?

Digital Maritime

- Which monitoring and efficiency pain points does NH₃ maritime fuel have?
- Can the maritime ammonia fuel industry, being still emergent, benefit from early introduction of digitised solutions to improve its efficiency along various points of the value chain?

Classification Societies

- Which Flag States are interested in NH₃ fuel?
- What are the safety issues we need to ensure that we manage?
- How can we ensure that NH₃ is catered for properly within our fuel agnostic policy?



AMMONIA ENERGY ASSOCIATION

- Which shipowners are working for NH₃ fuel?

NGOs / NFPs

- How can NH₃ maritime fuel be integrated in the economies of SIDS and LDCs?
- How can/ should my maritime members association get up to speed with NH₃ maritime fuel and its future?
- What is the status of environmental research regarding spillage of ammonia (fuel) into the sea and inland waterways/lakes? What are the current regulations and what is being done about potential increased risk from maritime fuel usage of ammonia?

Maritime Innovators

- How can we monitor NH₃ carbon content through digital chain of custody?
- I have a new techno/commercial idea for maritime NH₃, where can I make entry to the industry? Through academia, industry groups or other?
- Are there any incubators for ammonia fuel innovation?

Ammonia Producers

- Which ports/countries/ regions look like future NH₃ maritime fuel suppliers?
- Who will help me get my product to the ships? Which traders, logistics, storage and bunker companies?
- How will shipping certify and verify low carbon ammonia fuel? Will this be different from shore side consumers?

Academia

- How can I get involved with NH₃ maritime fuel research?
- What about the training of crew for NH₃ fuel handling?
- How do we ensure limited loss of biodiversity when scaling ammonia production, trade and bunkering?

Proposed Charts and illustrations

- **Introduction:** Maritime Ammonia Stakeholder landscape
- **Infrastructure:** Overview of ports currently exploring bunkering of ammonia as fuel
- **Safety:** Class Society overview of ship design guidelines and criteria
- **Regulatory:** Overview of regulatory status for inclusion of maritime ammonia e.g., IGC/IGF Code



- Technology: tbd
- Technology: tbd
- Economics: tbd
- Economics: tbd

Proposed outline of the whitepaper

1. Executive summary

2. Background

- Ammonia as maritime fuel getting great traction
- With many uncertainties still prevailing, what are the major barriers across the value chain to progress ammonia as a maritime fuel?
- How can these questions find answers?

3. Maritime ammonia stakeholder landscape and readily defined questions

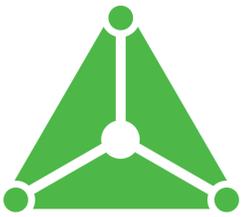
- Who are the stakeholders and what is their individual degree of relevance to enablement?
- How are the readily defined questions structured and rolled out along the next section?

4. Rollout of the key questions and answers with curated stakeholder detail.

This is the main question and answer area, following the predefined structure and accompanied as appropriate with stakeholder specific questions as callouts and margin columns.

Case Studies

Integrated throughout the whitepaper, a series of case studies can help to illustrate the points being made. Ideally, these would focus on AEA member projects and technologies, or significant announcements.



AMMONIA ENERGY

ASSOCIATION

5. Conclusion, outlook, and recommendations

Conclude with main messages of the report:

- What aspects of the maritime ammonia journey are developing particularly well?
- What aspects of this journey are developing poorly or seemingly neglected to date(insurance)?
- Where are the main business case gaps?
- Where should the R&D effort focus?
- What actions can industry take?
- What are the AEA's policy recommendations?
- Fictional (or real) case study which illustrates so many as possible of the forementioned conclusions.

6. Further reading / References

A further reading section will be added, with extensive references including:

(To be developed)