

Fuel Pathway Maturity Map (Source: MMMCZCS)

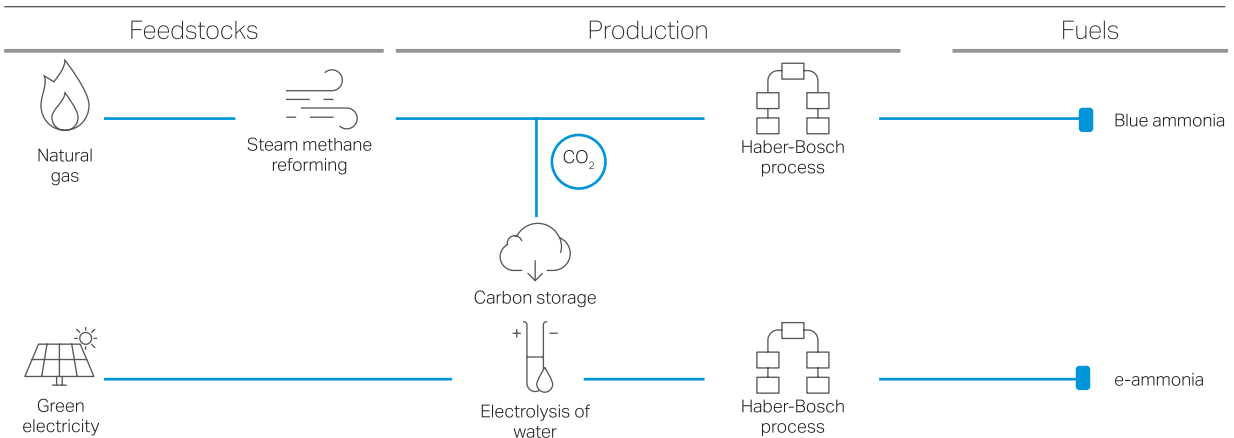
	Feedstock availability	Fuel production	Fuel storage, logistics & bunkering	Onboard energy storage & fuel conversion	Onboard safety & fuel management	Vessel emissions	Regulation & certification
e-ammonia	◆	◆	◆	◆	◆	◆	◆
Blue ammonia	◆	◆	◆	◆	◆	◆	◆
e-methanol	◆	◆	◆	◆	◆	◆	◆
Bio-methanol	◆	◆	◆	◆	◆	◆	◆
e-methane	◆	◆	◆	◆	◆	◆	◆
Bio-methane	◆	◆	◆	◆	◆	◆	◆
e-diesel	◆	◆	◆	◆	◆	◆	◆
Bio-oils	◆	◆	◆	◆	◆	◆	◆

◆ **Mature**
 Solutions are available, none or marginal barriers identified

◆ **Solutions identified**
 Solutions exist, but some challenges on e.g., maturity and availability

◆ **Major challenges**
 Solutions are not developed or lack specification

Ammonia fuel pathways



Ammonia limits (in ppm) from Class guidelines

Classification Society	ppm limits for release, alarm, and safety systems activation	Source
ABS	10 ppm as release/exhaust limit, gas alarms at 25 ppm and safety systems activated at 150 ppm	ABS, "Guide for Ammonia Fueled Vessels", September 2021
BV	30 ppm exposure limit, triggering shut down and other safety measures	Bureau Veritas, "AMMONIA-FUELED SHIPS TENTATIVE RULES - NR671 - JULY 2022", 2022
Class NK	25 ppm as release/exhaust limit, same safety and alarm provisions as Korean Registry	ClassNK, "Guidelines for Ships Using Alternative Fuels (Edition 2.0) - Methy/Ethyl Alcohol/LPG/Ammonia, June 2022
DNV	30 ppm as release/exhaust limit, gas alarms at 150 ppm and safety systems activated at 350 ppm	DNV, RULES FOR CLASSIFICATION, Ships, "Part 6 Additional class notations, Chapter 2 Propulsion, power generation and auxiliary systems", July 2022
Korean Register	Safety systems activated at 300 ppm. Alarm sounds at 25 ppm	Korean Register, "Guidelines for ships using Ammonia as fuels (2021.26)", 2021
Lloyd's Register	Prevent venting in normal and abnormal conditions. Safety systems activated at 220 ppm and alarm sounds at 25 ppm.	Lloyd's Register, Notice No. 1, Rules and Regulations for the Classification of ships using Gases or other Low-flashpoint Fuels, December 2022