

Ammonia engine technology
development for martime transport

Kaj Portin, Wärtsilä

20.10.2026

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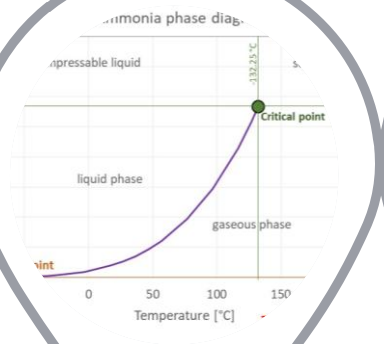
Content



Wärtsiläs role in the journey towards a sustainable future



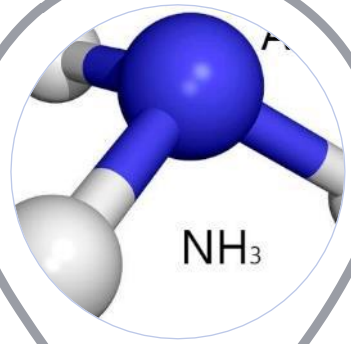
Ammonia basics



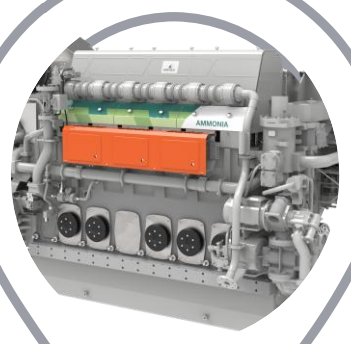
Ammonia safety



Ammonia system development



Ammonia regulation



The ammonia engine concept

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Set for 30 – our decarbonisation targets for 2030

Product portfolio ready for zero-carbon fuels

- Our engines can run on low- and zero-carbon fuels
- Hydrogen, ammonia, and methanol technologies progressed significantly in 2025

Carbon neutral in our own operations

- Greenhouse gas emissions down 53% by end of 2025

25% reduction of direct suppliers' greenhouse gas emissions

- In 2025, target baseline was set based on suppliers' GHG emissions data



Håkan Agnevall,
President & CEO

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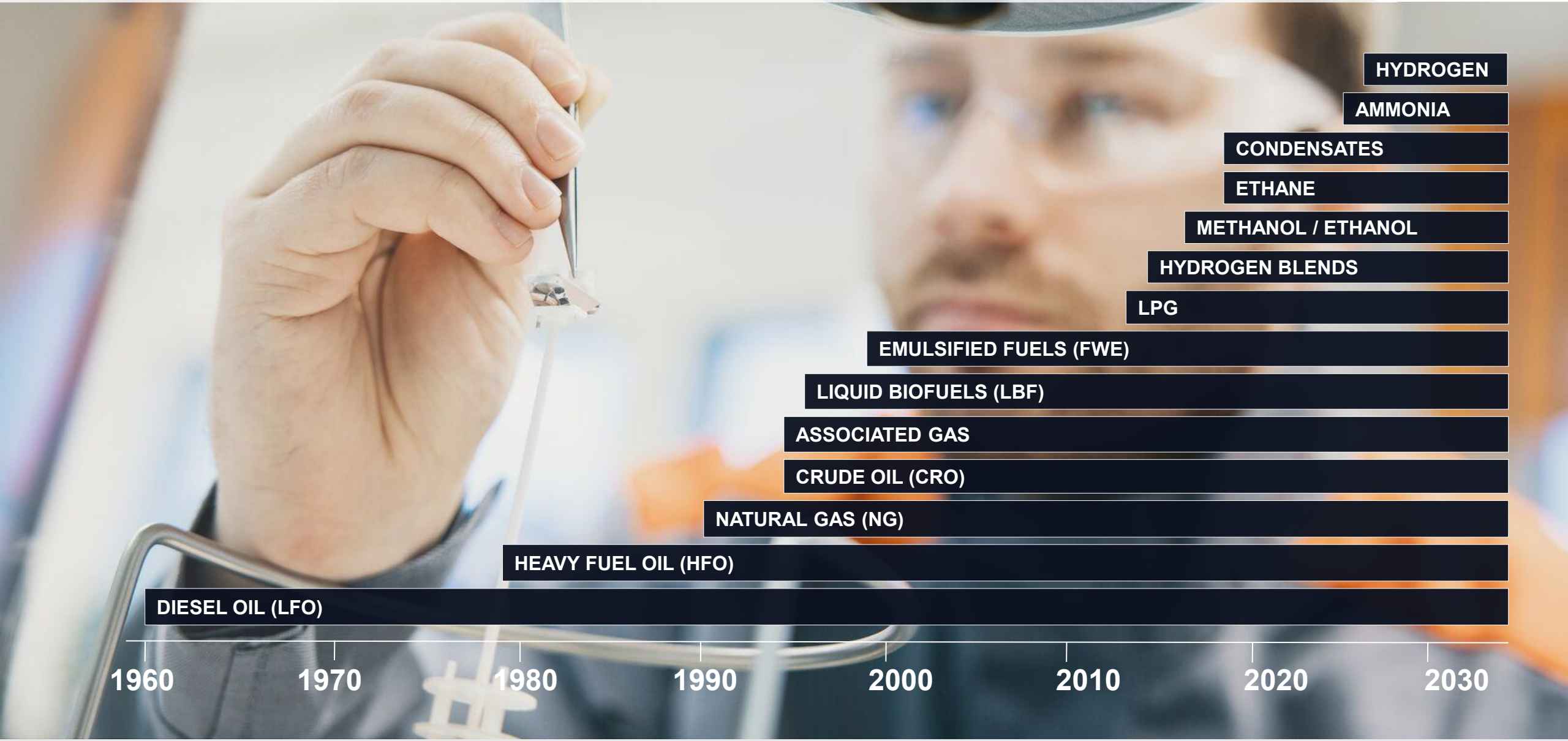
Wärtsilä has a long history of introducing new fuels



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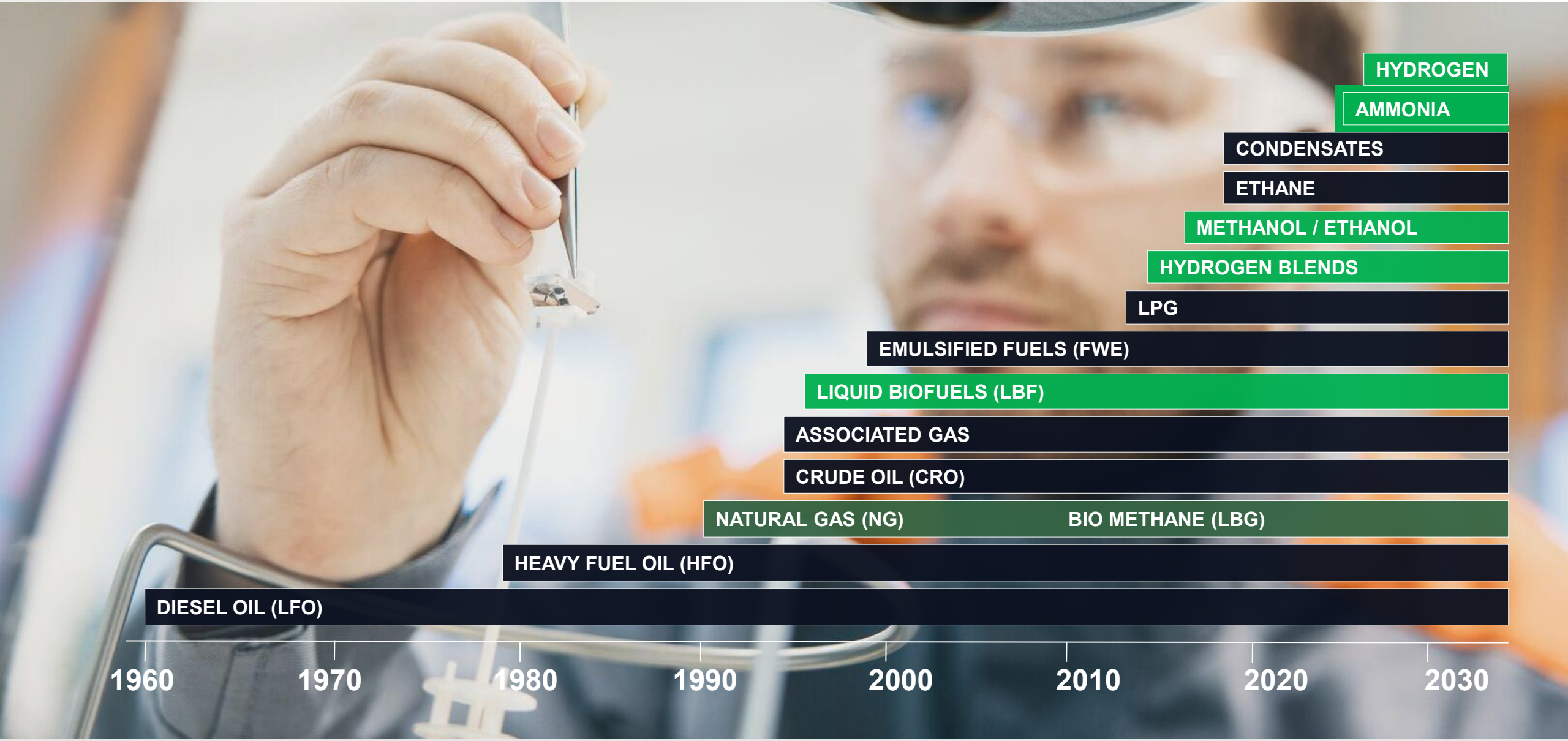
Wärtsilä has a long history of introducing new fuels



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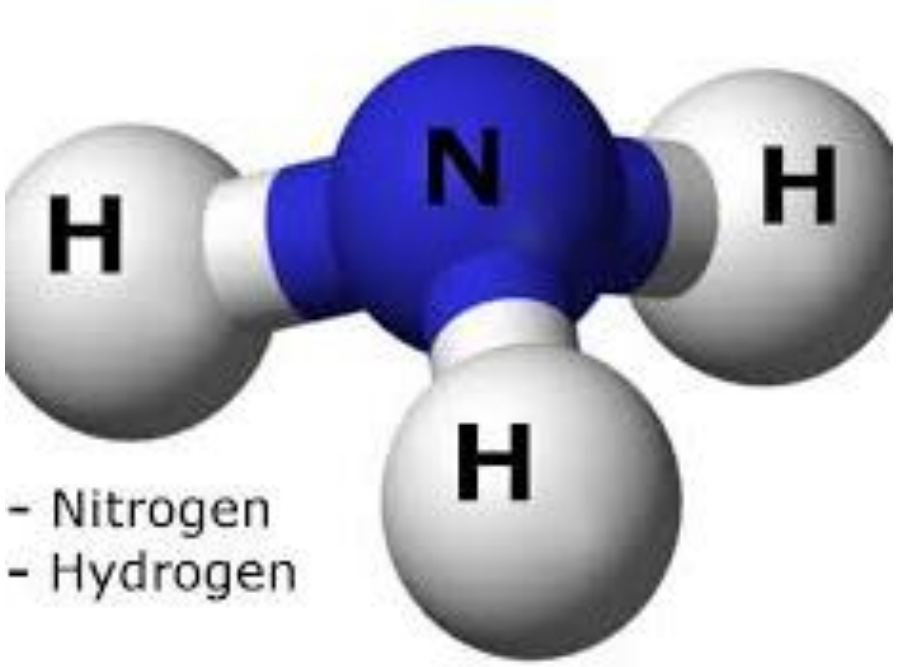
Key Ammonia Characteristics



Toxicity Risks

Ammonia is highly toxic, requiring strict safety measures to protect personnel from exposure.

Flammability Range

Ammonia has a flammability range of 15–28% by volume, making it potentially explosive under certain conditions.

Corrosive Nature

Ammonia’s corrosive properties necessitate special materials to prevent system degradation and leaks.

Safety Systems Importance

Continuous monitoring and rapid response are essential to manage ammonia leaks and ensure operational safety.

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Colours of Ammonia

Brown Ammonia	Produced from lignite (brown) coal
Black Ammonia	Produced by black coal
Grey Ammonia	Produced from fossil fuels (methane)
Blue Ammonia	Produced from fossil fuels with CO2 captured (CCS)
Green Ammonia	Produced from carbon-free and renewable energy sources such as wind, solar or hydro, using water electrolysis and nitrogen from air separation.
Pink Ammonia	Produced from nuclear energy
Yellow Ammonia	Produced from hydrogen electrolysis of electricity from solar power
Turquoise Ammonia	Produced using thermal splitting of methane (Hycamite)
White Ammonia	Produced as a by-product of industrial process

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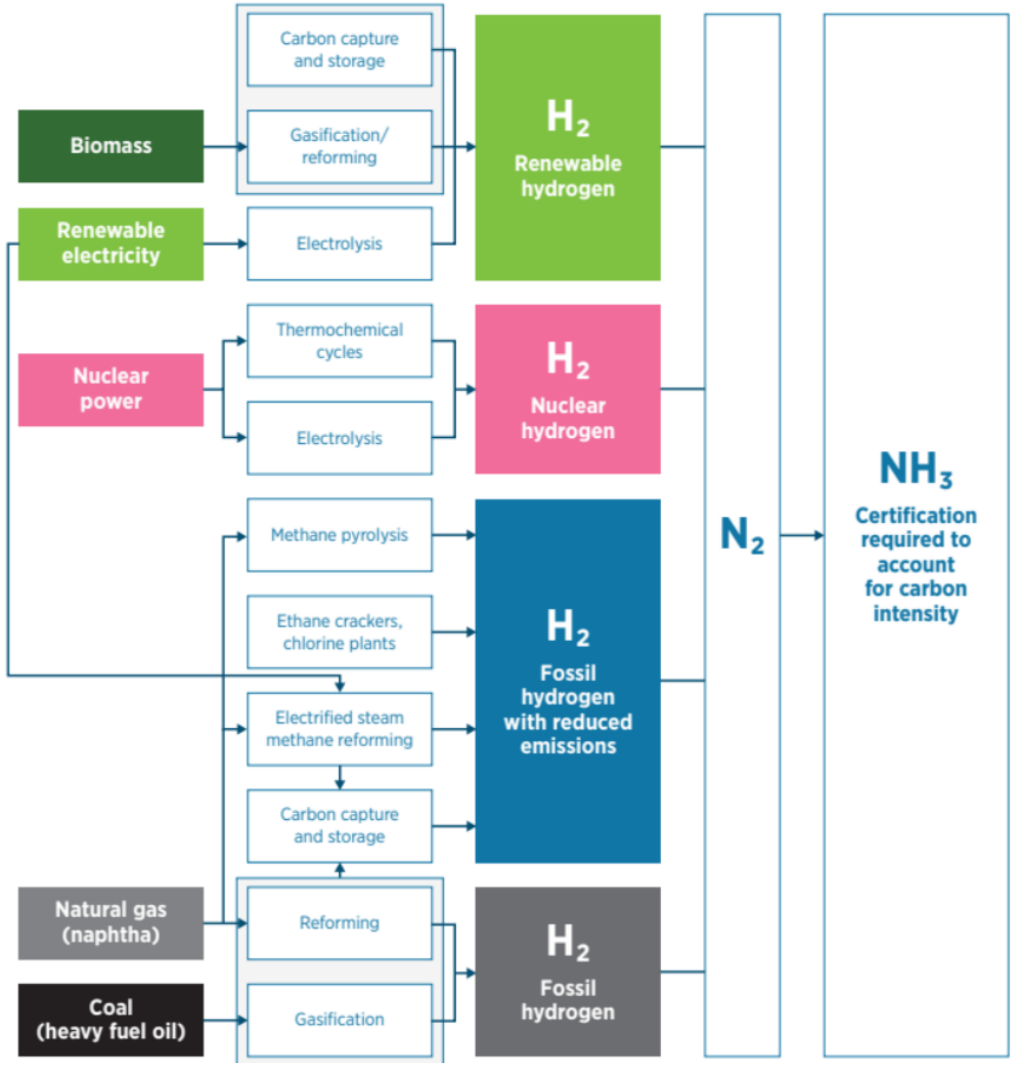
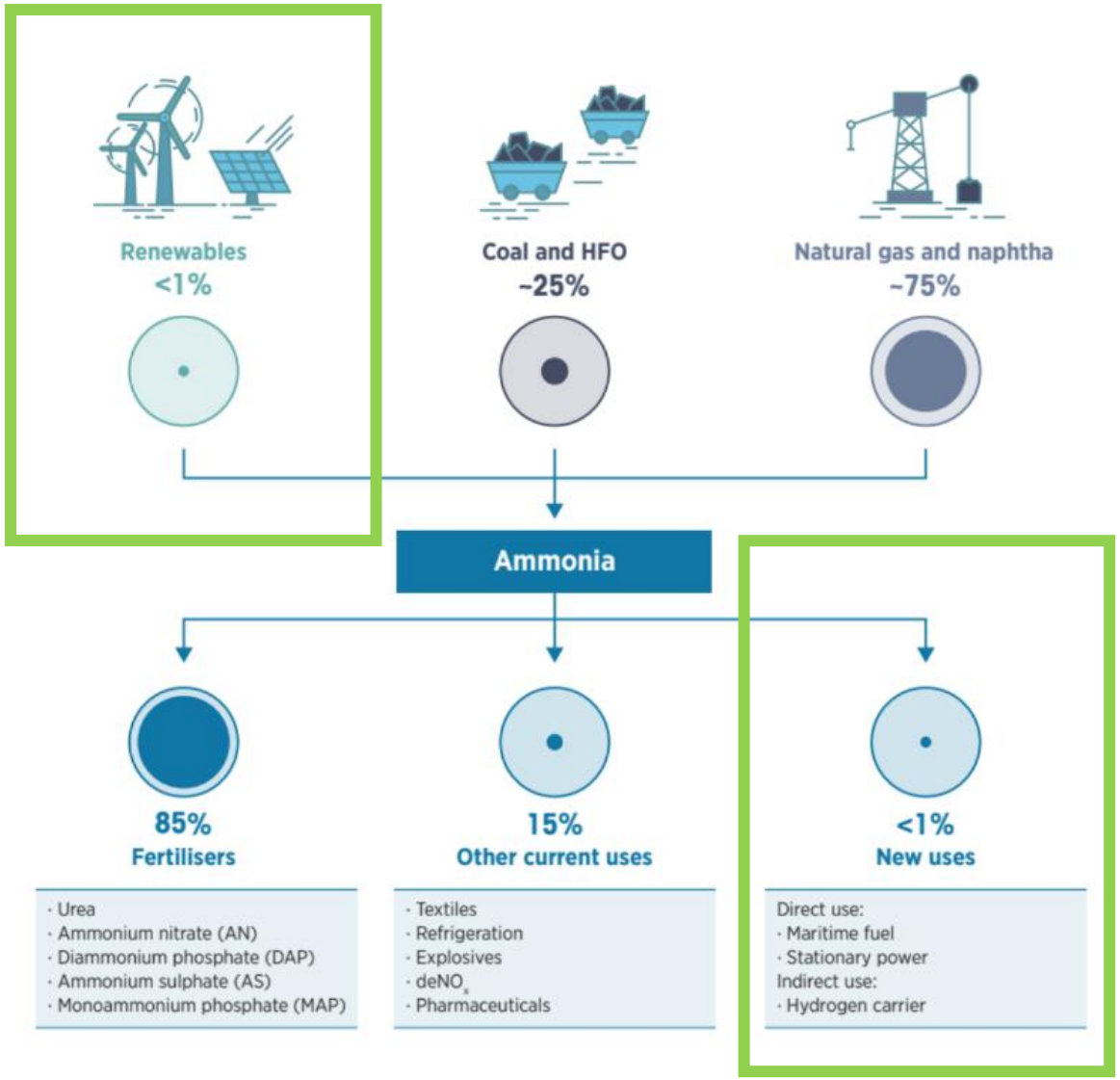
Ammonia annual production ~200 million tonnes





Source: Irena Innovation Outlook 2022

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Ammonia safety: advancing from industrial chemical to zero-carbon ship fuel through R&D and collaboration



2019-

Training: Internal & External



2020-

Material and combustion testing



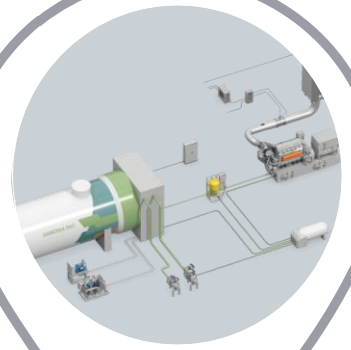
2020-

Hazids and Hazops



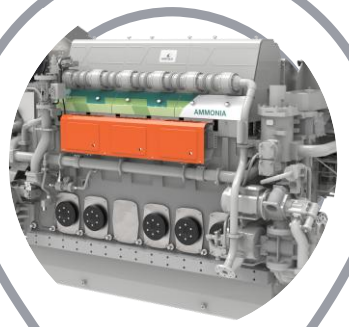
2020-

Safety systems



2020-

System design



2021-

Engine operation

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Ammonia: properties

Table 1. Key properties of ammonia in comparison to MGO

Item	Ammonia	MGO
Energy density (MJ/L)	12.9	35.95
Latent heat of vapourisation (LHV) (MJ/kg)	18.8	42.8
Heat of vapourisation (kJ/kg)	1371	250-450
Autoignition temperature (ºC)	651	250
Liquid density (kg/m3)	696 (at -33 ºC)	840 (at 15 ºC)
Adiabatic flame temperature at 1 bar (ºC)	1800	2000
Molecular weight (g/mol)	17.031	54
Melting point (ºC)	-77.7	-26
Boiling point (ºC)	-33	154
Flash point (ºC)	132	60
Critical temperature (ºC)	132.25	654.85
Critical pressure (bar)	113	30
Flammable range in dry air (%)	15.15 to 27.35	0.7 - 5
Minimum ignition energy (mJ)	8	0.23
Cetane number	0	40
Octane number	~130	15-25

Source: EMSA 2022: Potential of Ammonia as fuel in shipping by ABS, CE-Delft & Arcsilea

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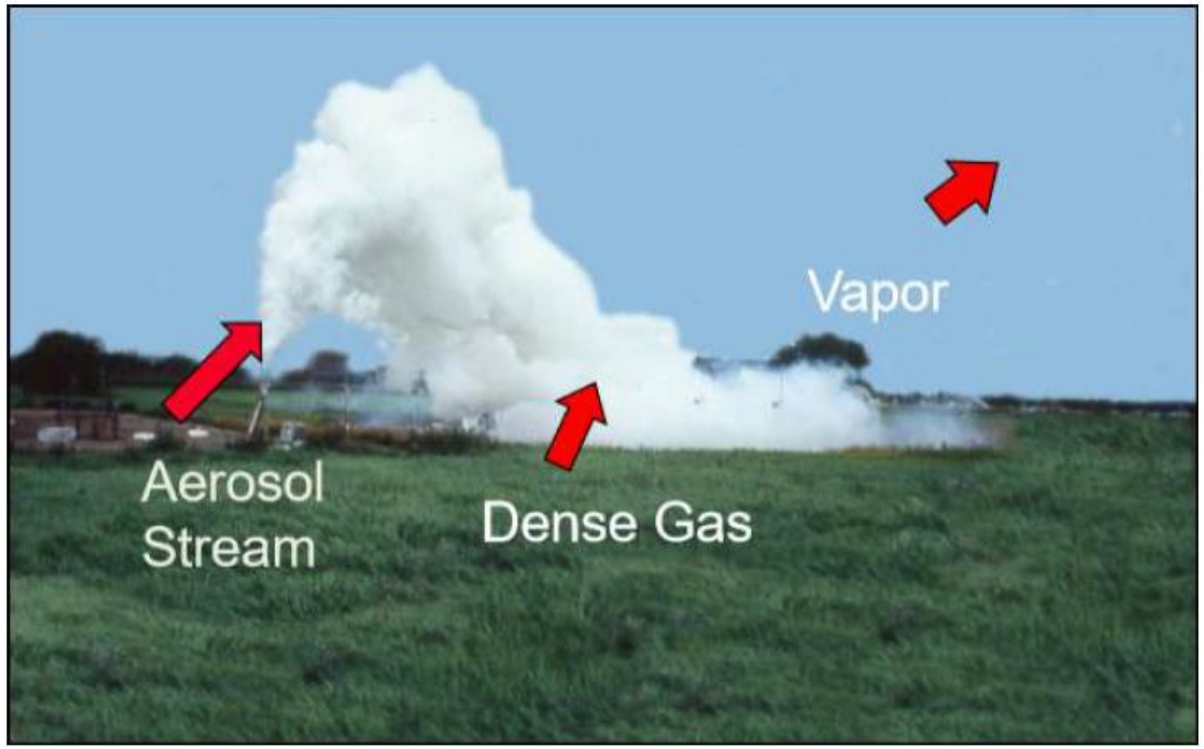
Ammonia safety

Ammonia as a molecule
Colourless & lighter than air, but…



Yara Clean Ammonia

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Ammonia: properties

Appendix II– Acute Ammonia Exposure Limits

Reference	10 min	30 min	1 hour	4 hour	8 hour
AEGL-1[a,b]	30 ppm	30 ppm	30 ppm	30 ppm	30 ppm
AEGL-2[c]	220 ppm	220 ppm	160 ppm	110 ppm	110 ppm
AEGL-3[d]	2,700 ppm	1,600 ppm	1,100 ppm	550 ppm	390 ppm

AEGL-1 is the airborne concentration (expressed as parts per million [ppm] or milligrams per cubic metre [mg/m^3]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Source: EMSA 2022: Potential of Ammonia as fuel in shipping by ABS, CE-Delft & Arcsilea

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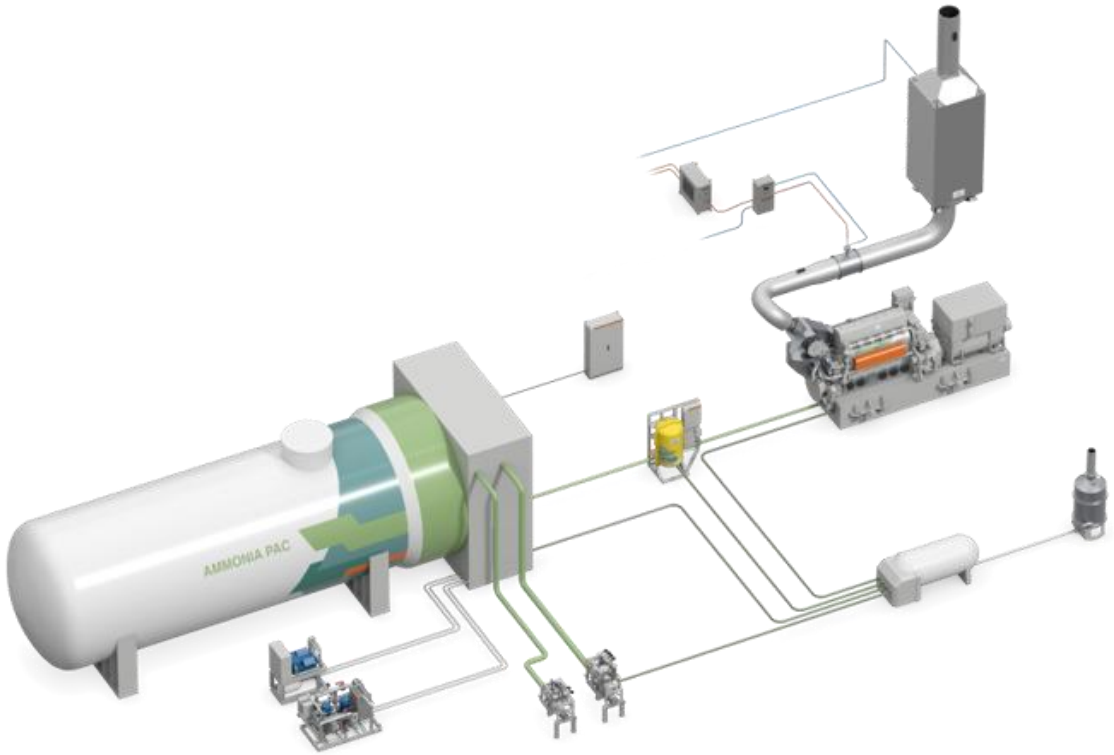
Ammonia engine and fuel system





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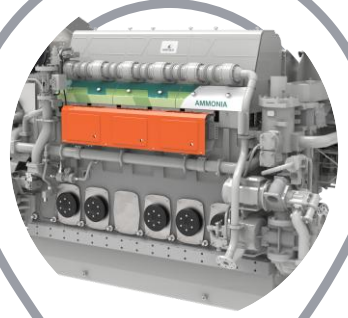
Ammonia: advancing from industrial chemical to zero-carbon ship fuel through R&D and collaboration



2019

Innovation initiative and ZEEDS launch



2021

Technology development started



2022

Industry collaboration for solution validation



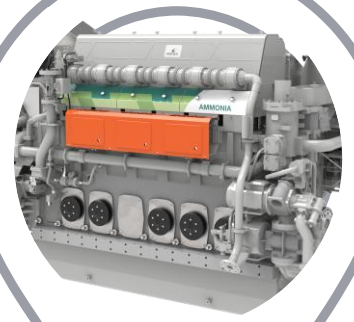
2023

Technical concept ready



2024

First ammonia engine orders



2025

First ammonia engine deliveries

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W25DF NH_3 DEVELOPMENT TIMELINE



1L**25**DF NH_3 (lab)



6L**25**DF NH_3 (lab)

2020 2021 2022 2023 2024 2025 2026

NH_3 combustion
(Wärtsilä fuel lab)



6L32 NH3
research engine





6L34DF NH_3
research engine
(Katapult center, Stord)



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Ammonia engine experience at Wärtsilä October 2026



Small bore SCE
1200 operating hours



Wärtsilä 32/34 DF
1000 operating hours



Wärtsilä 25 DF Ammonia
2300 operating hours

Status:

90% + Ammonia share

Natural Gas mixing possibility

>90% GHG reduction potential

N_2O < 20 ppm

NOx = Tier III

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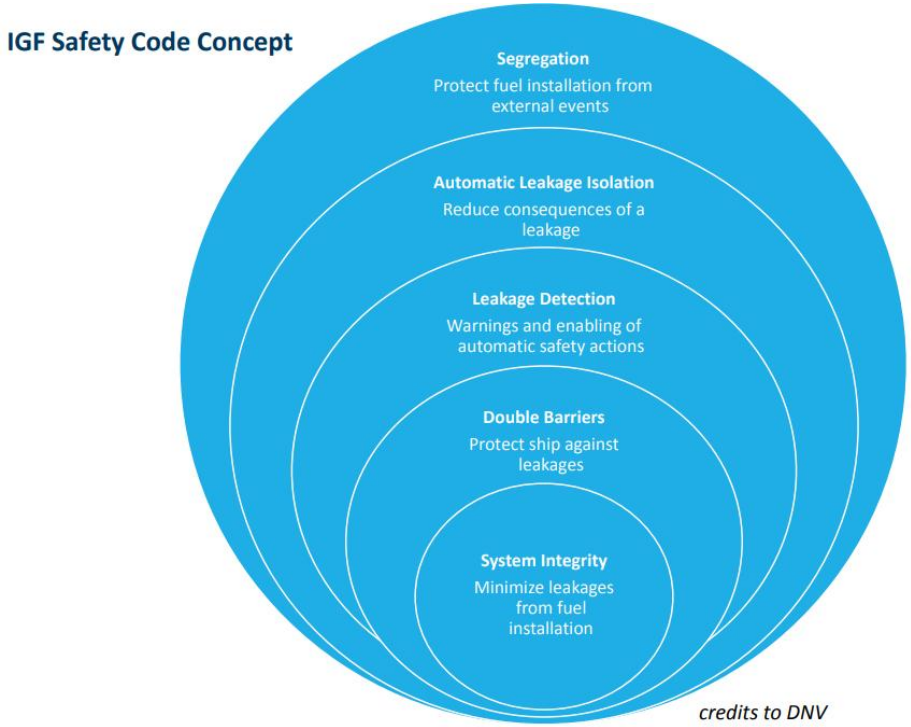
Ammonia interim guideline MSC.1-Circ.1687

- **Released:** 26 February 2025
- **Applies to ships using Ammonia as fuel, not addressing ships using Ammonia as cargo**
- **Structure:**



credits to DNV

- **Highlights:**
  - Direct release of ammonia into the atmosphere during normal operation and during any foreseeable and controllable abnormal scenario should be avoided.
  - Fixed fuel vapour and/or leakage detection suitable for all spaces and areas concerned should be arranged.
  - A single failure in a technical system or component should not lead to an unsafe or unreliable situation.

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Approval in principle by Classification Societies

DNV

APPROVAL IN PRINCIPLE

Particulars of Product

Designer:	**Wärtsilä Finland Oy**
Product:	**Wärtsilä 25DF Ammonia**

This is to verify:

That the plan for development and principle of engine design has been assessed by DNV and found to comply with current Rules of the Society, as specified below.

- DNV Rules for classification, Ship, DNV-RU-SHIP-Pt.6 Ch.2 Sec.8 – FUEL READY Ammonia (MEc/AEc), July 2023

中国船级社

CHINA CLASSIFICATION SOCIETY

证书编号/Certificate No.
JS23PPR00003_05

船用产品原理认可证书

APPROVAL IN PRINCIPLE FOR MARINE PRODUCT

概念认可证书

CERTIFICATE OF CONCEPT APPROVAL

兹证明本证书所述设计方设计的下列产品的技术原理具有可行性，能够原则上满足列明标准的要求。
This is to certify that the innovative design principles in the following products designed by the designer stated in the certificate are feasible, and can meet the requirements of the standards listed below in principle.

设计方/ Designed by

Wärtsilä Finland Oy

认可产品/ Product Approved

氨/燃油双燃料发动机

Ammonia/Fuel Oil Dual Fuel Engine

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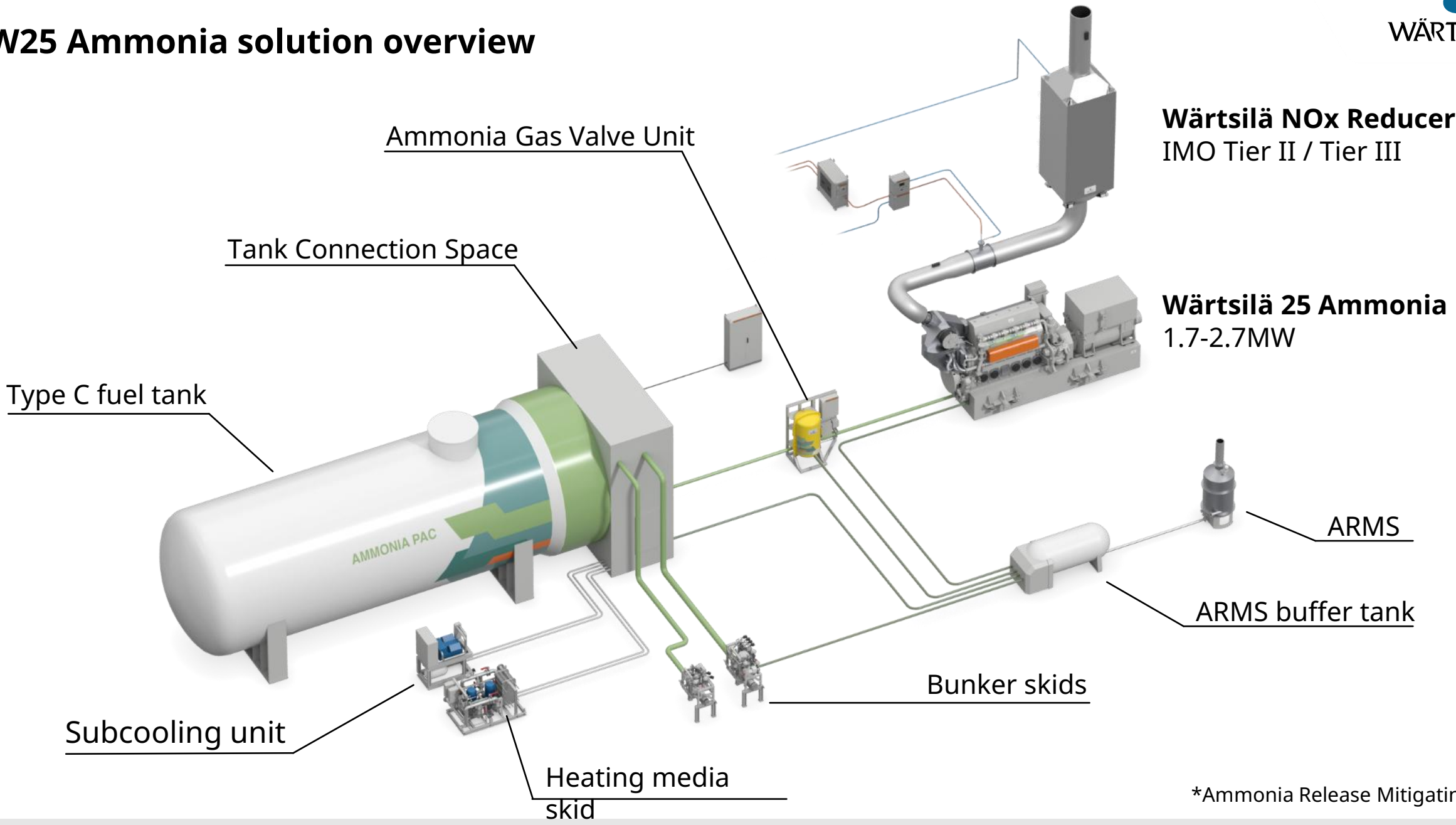
W25 Ammonia solution overview



*Ammonia Release Mitigating System

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From concept to hardware



Wärtsilä 25 Ammonia engine underwent finishing work at WaskiCenter, Vaasa.



AmmoniaPac fuel tank at the factory

Gas valve unit (GVU)



ARMS buffer tank



The AmmoniaPac fuel tank, gas valve unit (GVU) and ammonia release mitigation system's (ARMS) buffer tank are essential parts of the Wärtsilä 25 Ammonia solution.

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First ammonia vessel conversion with Wärtsilä 25 Ammonia solution

Partnership with Norwegian shipowner Eidesvik to convert the platform supply vessel (PSV) Viking Energy for ammonia operation; the contract was signed in June 2024.

The vessel will be converted from LNG to ammonia operation.

The conversion will reduce GHG emissions by at least 90% compared to previous emission level of the ship.

Customer operation will begin in 2026.

Safety and reliability have been the primary drivers behind all technology decisions for the ammonia solution.

Scope of supply

- 1 × Wärtsilä 9L25 Ammonia engine
- AmmoniaPac fuel gas supply system
- Ammonia Release Mitigation System
- Wärtsilä NOx Reducer



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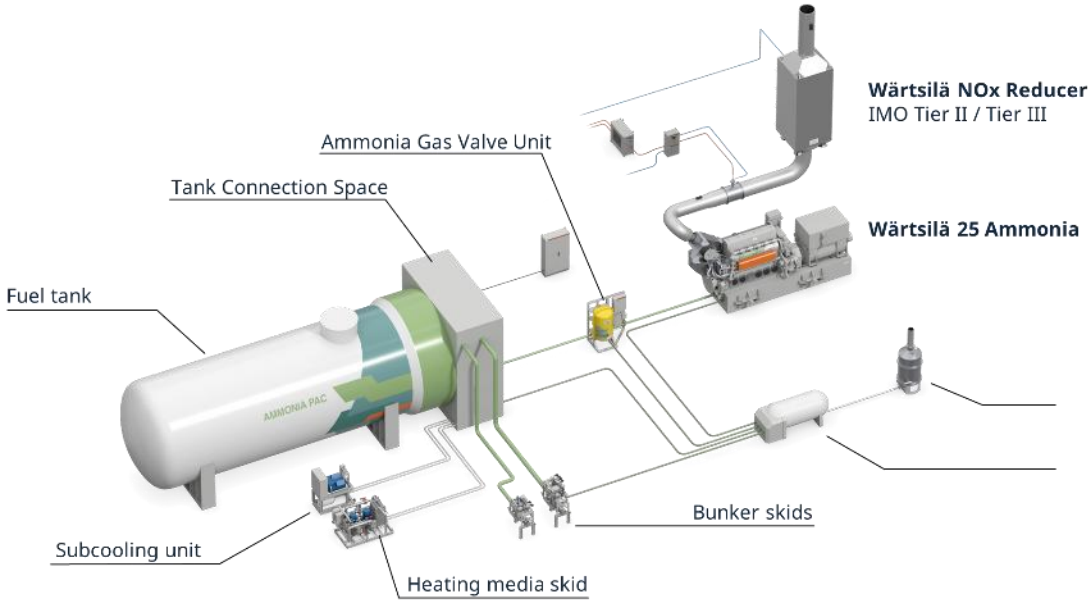
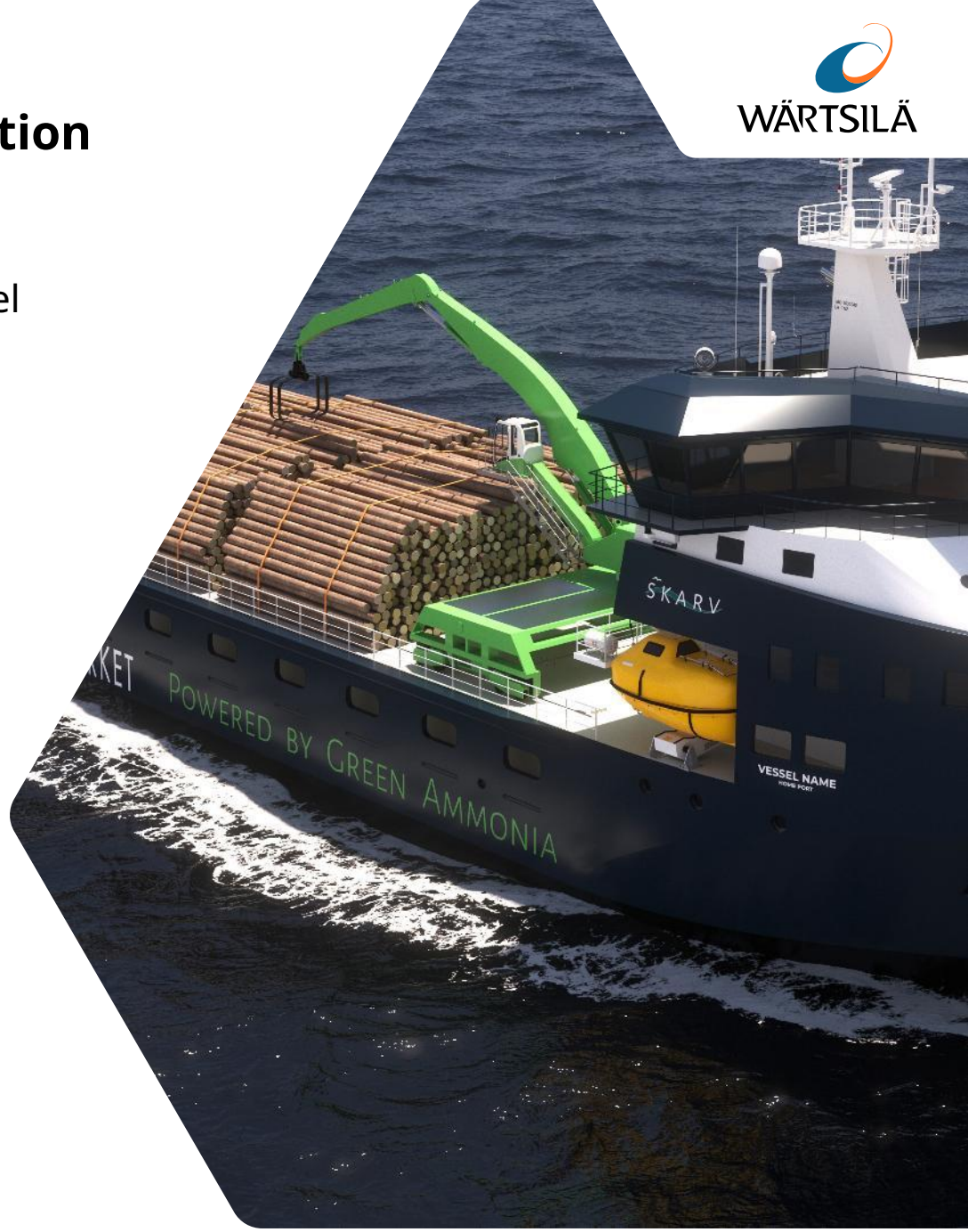
First newbuild vessel with Wärtsilä 25 Ammonia solution

Contract signed Q4 2025 for Skarv Shipping Solutions' new cargo vessel

Up to 90% GHG reduction compared to a similar vessel running on a diesel engine

Wärtsilä 6L25 Ammonia engine will be delivered together with a large Wärtsilä scope of supply





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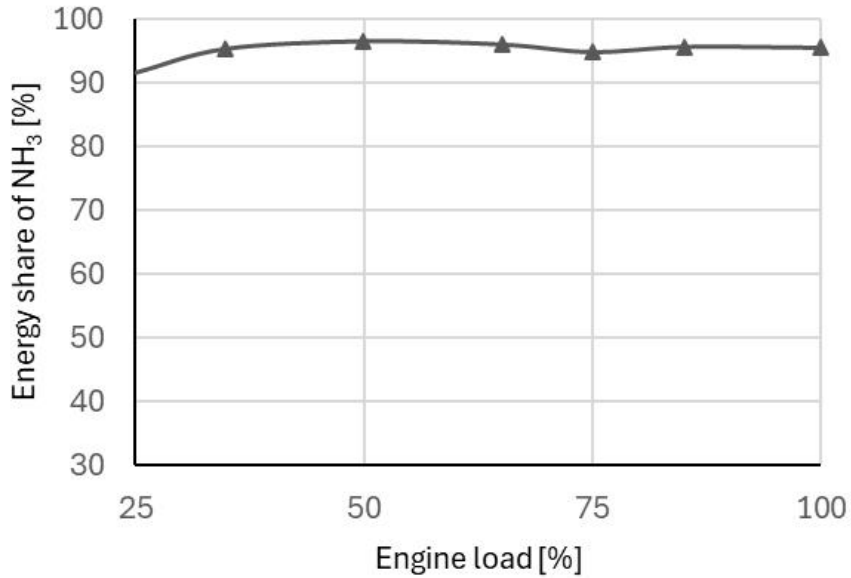
Ammonia share during laboratory tests

6L25DF laboratory engine results

- Ammonia is ignited by a small amount of pilot fuel.
- The energy share of ammonia is ~95% across a wide load range.
- Thanks to the built-in flexibility of the Wärtsilä 25DF engine the inherent slow combustion of ammonia can be mitigated.
- Fuel efficiency of the low-pressure Otto concept has been consistent with and equal to that of dual fuel LNG engines.
- In the tests Ammonia has proven to be a good fuel for the low-pressure Otto concept.



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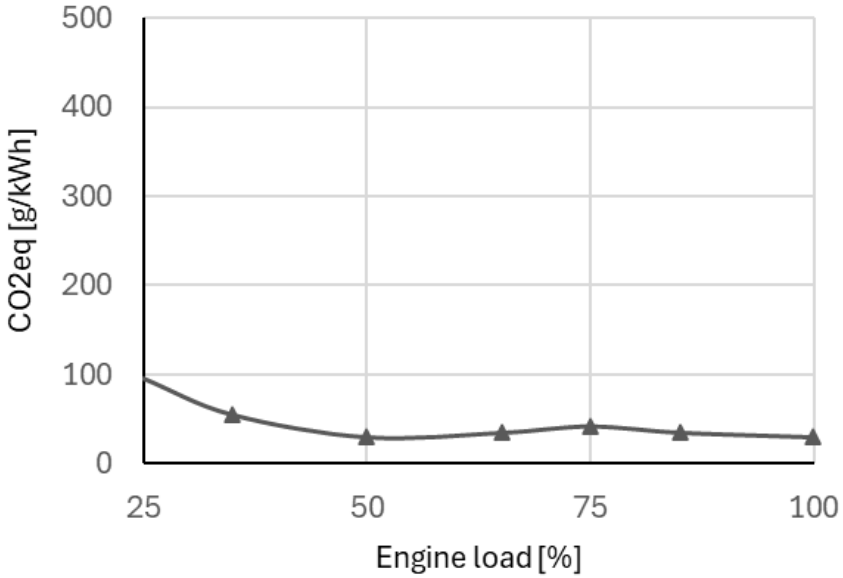
GHG reduction during laboratory tests

6L25DF laboratory engine results

- CO_2 equivalent emissions are reduced by ~90% (TtW) compared to a diesel engine using LFO.
- The CO_2 equivalent emissions originate from the pilot fuel used and the N_2O formed during combustion.
- Emissions from engine are already low, testing shows that a N_2O catalyst can give further improvements but is not a must to reach good levels.
- The aftertreatment for NOx reduction is based on the proven Wärtsilä NOR system, Consistent Tier III compliance has been shown.



Summary

- Ammonia as a marine fuel offers up to ~90% GHG reduction (TtW)
- Wärtsilä 25 Ammonia builds on proven DF and LNG technology
- Safety is the primary design driver,
- Alignment with the regulatory demands in early stage
- Technology maturity demonstrated through laboratory testing, first vessel conversion (Viking Energy), and first newbuild contracts, with entry into service from 2026.

Conclusion:

- Wärtsilä’s ammonia solution is a safe, scalable, and future-proof pathway enabling zero-carbon shipping while maintaining reliability and fuel flexibility.



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