

유럽조선해양전문가협회

Europe-Korea Marine and Ocean Engineers Association (EKMOA)

2026년 협회 소개

협회 소개 (회칙)

❖ 협회 목적 (3장 목적)

- 일반 대중을 위한 정보 및 기술 교류를 증대한다.
- 기술자, 과학자 및 학생들에게 교육 및 전문성 개발 기회를 제공한다.
- 논문 출판을 통해 연구 결과를 전달한다.

❖ 기술 영역

- Offshore & marine technology
- Green shipping
- Subsea engineering and installation
- Offshore renewable energy
- Marine environment
- Geo-technology
- Safety and reliability
- Naval defense

협회 소개 (회칙)

주요 활동:

- EKC학술대회 기간 중 EKMOA 세션 준비/진행 (매년, 정기)
- Workshop on Ships and Offshore Structures 개최 (매년, 정기)
- 한-영 해양플랜트 공동학위프로그램지원
- 국내외 유관기관/전문가간 기술정보 교류, 관련 기술 개발사업 참여
- 국내외 유관기관과의 협력네트워크 구축 및 협력 활동 등 수행
- 대한조선학회, 한국조선해양플랜트협회 등과 MoU 체결 등을 통해서 관련 학술회의 공동개최, 연구자 교류 등을 수행하고 있음

❖ 회원구분 및 자격 (8장 1조)

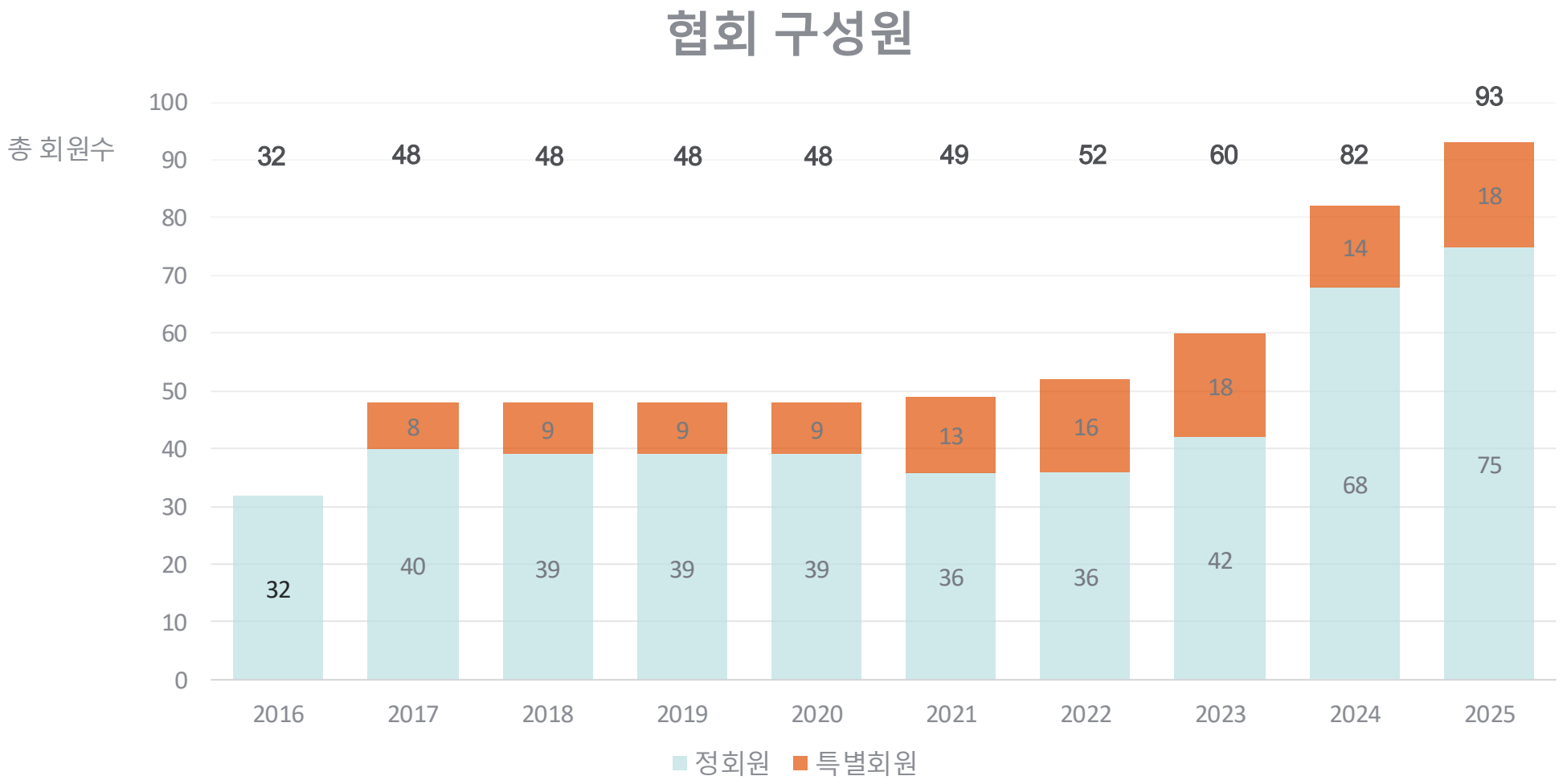
- ✓ 가. **정회원**: 유럽에 거주하며 일정 수준 이상의 전문성을 갖춘 자로,석사학위소지자이상(박사학위과정 포함)의 학문적 전문성을 갖추었거나, 조선해양 분야에서 오랜 실무경력 보유한 자로서 운영위원의 동의를 얻은 자.
- ✓ 나. **준회원**: 조선해양 분야 또는 이와 관련된 학문에 관심을 갖고 있는 자로, 운영위원의 동의를 얻은자.
- ✓ 다. **특별회원**: 운영위원의 추천을 받아 운영위원회에서 동의를 얻은 자, 기업 또는 기관

2026 Committees

- **President:** Dr Baejun Kwon, (DNV, Norway)
- **Vice President:** Dr Koosup Yum, (HD Hyundai, Germany)
  Prof Hyungju Kim, (NTUA, Norway)
  Dr Injun Yang, (University of Strathclyde, UK)
- **Director of General Affairs:** Hayoung Jang, (University of Strathclyde, UK)
- **Marketing Assistant:** Solji Yun, (Korea Institute of Oriental Medicine, South Korea)
- **Secretary:** Eunseok Kwon, (United Kingdom Carrer Pathway (UKCP), UK)
- **Representative:** (UK) Mr Joongwon Kim, (University of Strathclyde, UK)
- (Scandinavia), TBD
- Chybyung Park (South Korea), (KMOU, South Korea)
- **Audit:** Dr Changkyo Choi, (INN, Norway)
- **Advisory Committee:** Dr Yongwon Lee, (Lloyd's Register, UK)
  Dr Dohan Oh, (Hongik University, South Korea)
  Dr Dong Nam, (Gunsan Regional of Oceans and Fisheries, South Korea)
  Dr Keunjae Kim, (SSPA, Sweden)
  Dr Seungdeog Yoo, (Microvortex, Germany)
  Dr Mingyu Kim, (KMC, South Korea)

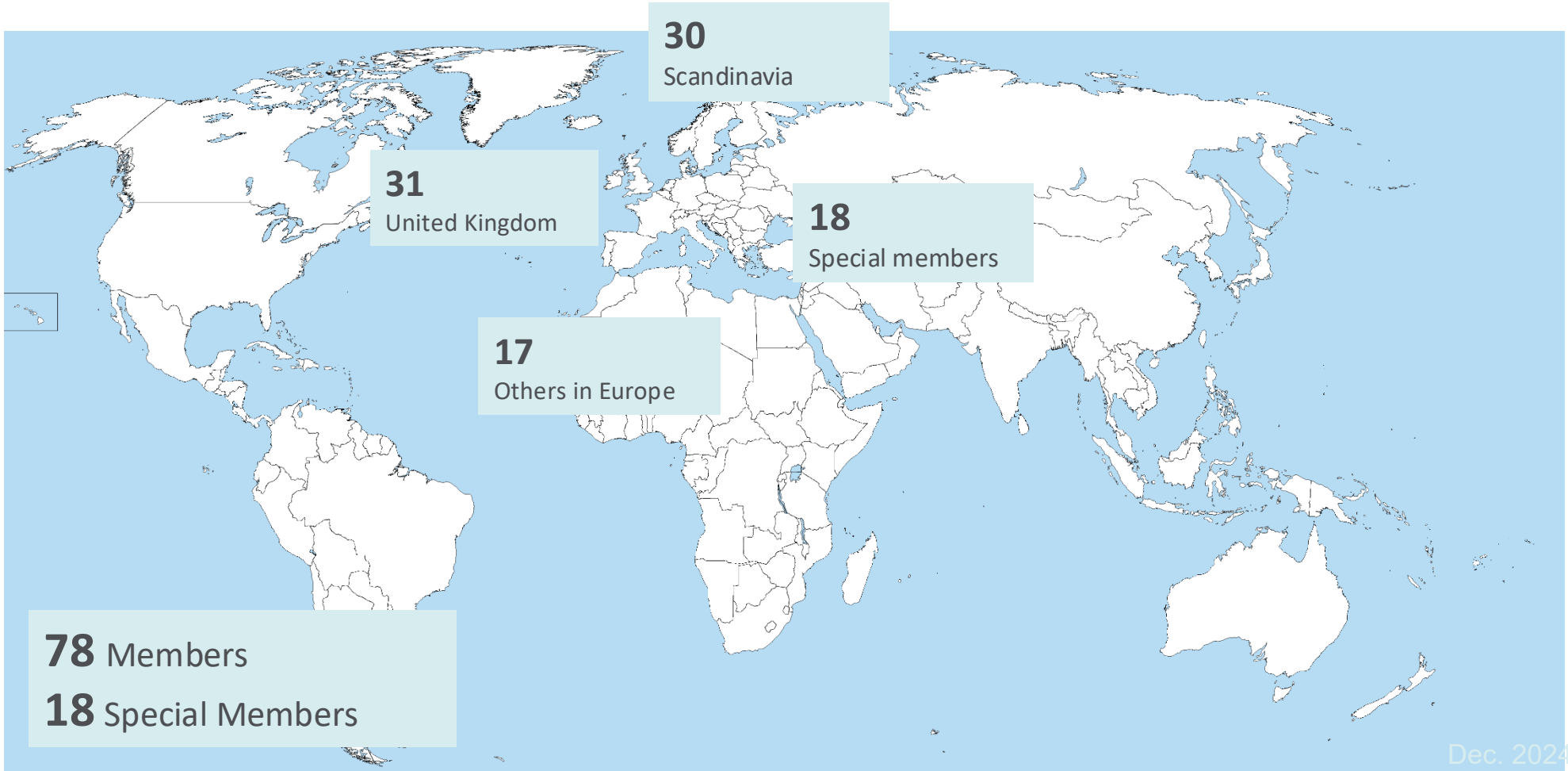


2026년 1월 현재 협회 맴버수



EKMOA Europe-Korea Marine and Ocean Engineers Association

2026년 1월 현재 협회 맴버수



2026년 협회 멤버 기관 맵핑



Communication Channels

- Website : https://www.ekmoa.org
- LinkedIn: https://www.linkedin.com/company/europe-korea-marine-and-ocean-engineers-association-ekmoa/
- KakaoTalk Open Chat: https://open.kakao.com/o/gYthz5Sh

2025년 협회 주요 활동

WSOS 2025 (30th May – 2nd June)



EKMOA Europe-Korea Marine and Ocean Engineers Association

DNV

HD한국조선해양

KEIT 한국산업기술기획평가원 Korea Planning & Evaluation Institute of Industrial Technology

KRISO

KORIES

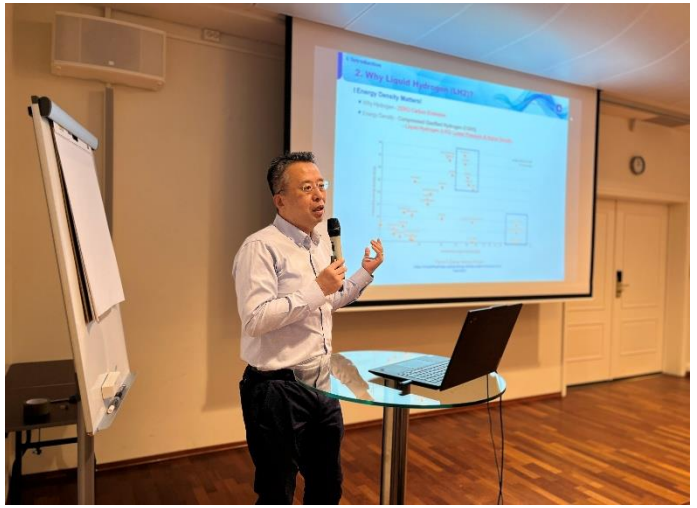
WSOS 2025 (30th May – 2nd June)













EKMOA Europe-Korea Marine and Ocean Engineers Association

HD

Keit 한국산업기술평가관리원

EKMOA General Assembly 2025





KIRD 멘토링 견학 Mid-Career Training Program









EKC 2025



EKMOA Europe-Korea Marine and Ocean Engineers Association

EKC 2025 Marine & Ocean 세션

학술 위원:
정병욱 회장 (재영과협)
권배준 부회장 (재독과협)

- EKMOA – HD현대 유럽
- EKMOA – KMC
- EKMOA – 대한조선학회
- EKMOA – KRISO
- EKMOA – KOMERI
- EKMOA – LR

PROGRAMME COMMITTEE



DR. JEONG, Byongug (정병욱)
University of Strathclyde
byongug.jeong@strath.ac.uk
Show Profile



MR. KWON, Bae Jun (권배준)
DNV AS
bae.jun.kwon@dnv.com
Show Profile

[MO1] KRISO-EKMOA Joint Session: Advanced Future Marine Mobility

[MO2] Innovative Cryogenic and Computational Solutions for Decarbonized Maritime and Offshore Systems

[MO3] Innovations in Electric (Hybrid) Propulsion Systems for Sustainable Maritime Applications

[MO4] HDERC-EKMOA Joint Session: Technologies and Strategies for Decarbonizing Global Shipping

[MO5] LR-EKMOA Joint Session: Maritime Safety – Current Challenges and Future Pathways

[MO6] KMC-EKMOA Joint Sessions

EKC 2025



EKC 2025




Methanol Propulsion System
EKC 2025


Korea-Europe
Maritime Mobility
Sustainable Development Forum
EKMOA
KRISO
Korea-Europe Maritime Mobility Sustainable Development Forum
August 26, 2025 Vienna, Austria


Introduction of KIMST
Introduction of Ship-related R&D by the Ministry of Oceans and Fisheries, Korea
Proposal of New R&D Needs


Coupled Operation and Emission Analysis of a Natural Gas-fueled SOFC-Battery Hybrid Demonstrator for Maritime Application
DLR


Introduction of Ship-related R&D by the Ministry of Oceans and Fisheries, Korea, and Proposal of New R&D Needs
Dr. LEE SUNG MI

MOU (EKMOA & KMOU)

MOU with KMOU



▪ MOU with KMOU



2025 KOMERI 프로젝트

보고서 작성 기간: Oct. 01, 2025 – Dec. 19, 2025

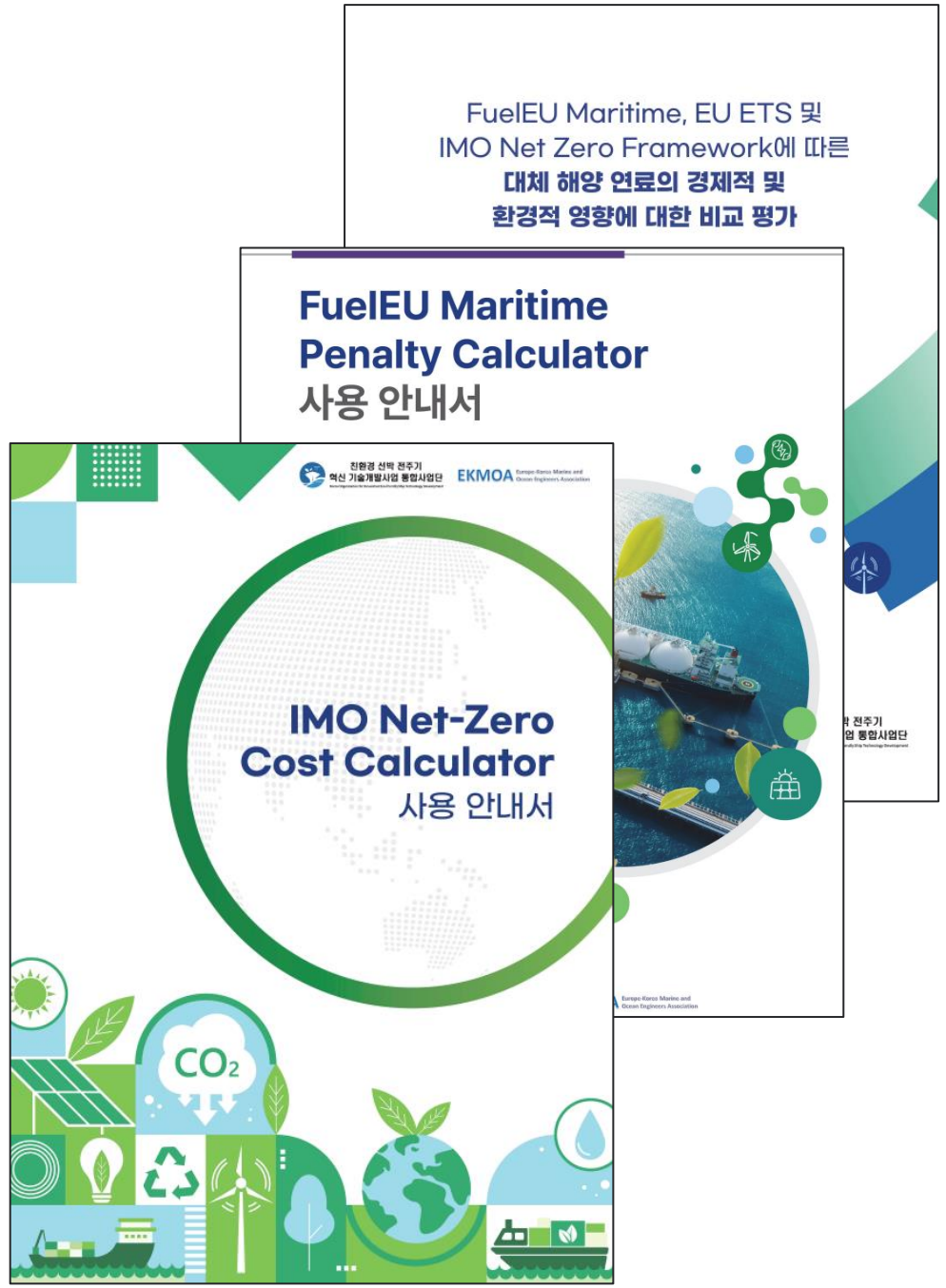
보고서 참여 연구원

정병욱　조수아　최윤
장하영　양인준

보고서 수행 범위 및 내용

❍ 선박 CO2 배출량과 해당 배출량에 대한 IMO GFI, FuelEU Maritime 계산을 통한 penalty를 확인할 수 있는 Excel 계산서 작성 및 제공

❍ 계산서 사용법 및 계산서를 활용한 예시등을 포함하는 보고서 작성 후 제시
- (필요시) 화상회의 등을 통한 활용법 설명



EKMOA Europe-Korea Marine and Ocean Engineers Association

KRISO Europe Center Magazine “See Frontier”

정보지 작성 기간: Jan. 01, 2025 – Dec. 31, 2025

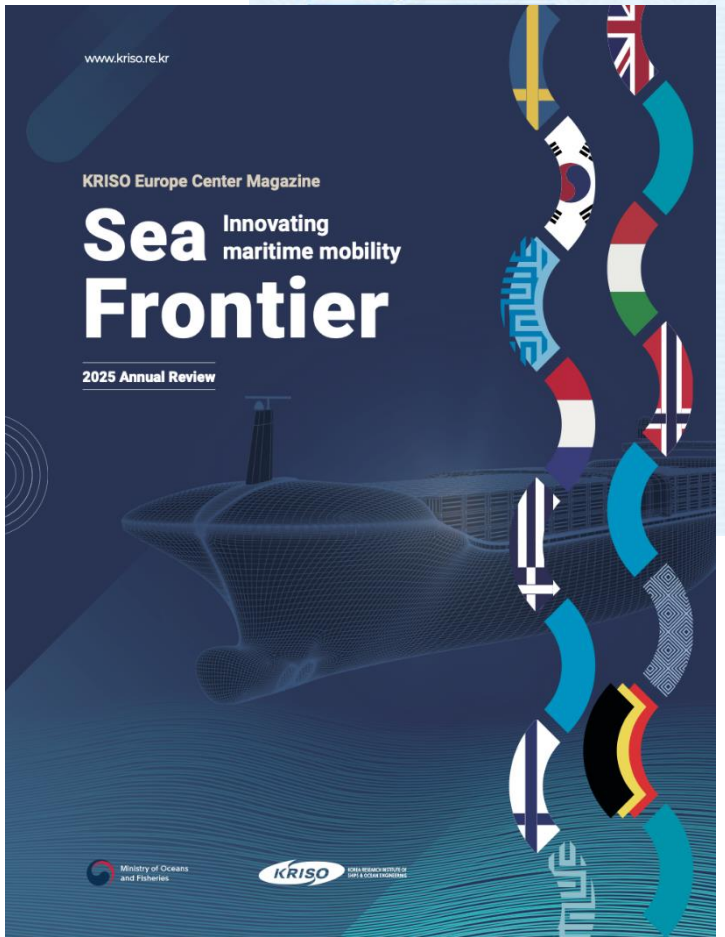
참여 연구원

정병욱	김형주
장하영	권은석

정보지 수행 범위 및 내용

❍ 해양 탈탄소화, 친환경 연료, 규제 동향, 디지털 기술 적용 사례 등 최신 이슈를 반영한 전문 기술 기사 작성 및 제공

❍ 현장 사례, 연구 결과, 정책 및 산업 동향을 기본으로 한 기고문 작성 후 제공



EKMOA Europe-Korea Marine and Ocean Engineers Association

Research Output

- “A PIDA-PDA integrated parametric approach for establishing safety zone for hydrogen, ammonia and LNG bunkering operations (December 2025)” (정병욱 회장, 황인식)

International Journal of Hydrogen Energy 206 (2026) 153212

Contents lists available at ScienceDirect

International Journal of Hydrogen Energy

journal homepage: www.elsevier.com/locate/he

A PIDA-PDA integrated parametric approach for establishing safety zone for hydrogen, ammonia and LNG bunkering operations

Insik Hwang [a,b], Byongug Jeong [a,b,c,*], Peilin Zhou [a,d], Haibin Wang [a], Ana Mesbahi [a], Hayoung Jang [a,b], M.P. Mujeeb-Ahmed [a], Injun Yang [a,b]

[a] Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow, G41 4PP, UK
[b] Europe-Korea Marine and Ocean Engineers Association (EKMOA), Southampton, SO16 9WX, UK
[c] Marine Advanced Research Centre (MARC) Ltd., Glasgow, G11 6BT, UK
[d] Faculty of Marine Science and Technology, Harbin Institute of Technology, Weihai, 264209, China

ARTICLE INFO

Keywords:
Hydrogen bunkering
Safety zone
Risk assessment
Marine alternative fuel

ABSTRACT

This paper proposes a comprehensive methodology that systematically integrates Population-Independent Analysis (PIDA) and Population-Dependent Analysis (PDA), providing both spatial hazard delineation and human risk quantification. By utilizing scenario-based simulations with varying leak diameters (5 mm, 10 mm, and 100 mm) and distinct bunkering methods (ship-to-ship, truck-to-ship, and facility-to-ship), the research elucidates fuel-specific risk profiles under diverse operating conditions. Key findings indicate that ammonia's high toxicity can produce a toxic exclusion zone extending beyond 600 m in worst-case scenarios, while compressed hydrogen often yields a similarly large hazard radius—exceeding 200 m—primarily driven by its propensity to form flammable and explosive vapour clouds. In contrast, liquefied hydrogen exhibits a more constrained dispersal pattern, with average outer-zone radii near 25 m, albeit still presenting significant explosion hazards in enclosed spaces. These quantitative results underscore the importance of robust leak detection and rapid emergency shutdowns, which effectively reduce total leak volumes and resultant hazard footprints. The integrated PIDA-PDA framework offers distinct benefits over conventional single-method approaches. PIDA quantifies worst-case hazard boundaries for each scenario, ensuring stringent protective measures within clear safety zones. PDA then refines these zones by incorporating actual population densities and exposure rates, enabling stakeholders to prioritize areas of high casualty potential for intensified safety measures. This complementary approach avoids overly conservative restrictions while preserving critical safety margins. Ultimately, the results advance more resilient strategies for adopting LNG, ammonia, and hydrogen as viable pathways to decarbonized maritime transport.

1. Introduction

1.1. Background

The pursuit of net-zero emissions has become a fundamental objective across industries, with the maritime sector being no exception. The International Maritime Organization (IMO) has set more practical targets aimed at reducing emissions from shipping during MEPC 80 [1]. These targets include a 20 % of emission reduction by 2030, 70 % reduction by 2040 compared to 2008 levels, and ultimately achieving net-zero emissions by or around 2050. However, unlike land-based transportation, where electrification has become the dominant solution, the maritime industry faces distinctive challenges. Ocean-going vessels demand substantial energy, and their operational environments are constrained by the absence of charging infrastructure [2]. These realities necessitate innovative approaches, positioning alternative fuels like ammonia and hydrogen as pivotal pathways to achieve sustainable maritime operations [3].

Ammonia and hydrogen, in particular, have gained prominence due to their ability to achieve zero emissions, aligning well with the overarching goals of decarbonization [4]. In contrast, methanol serves as a transitional fuel on the path toward fully sustainable marine energy systems, attributed to its liquid state at ambient conditions and its potential to be produced from renewable sources such as biomass [5].

* Corresponding author. Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow, G41 4PP, UK.
E-mail address: Byongug.jeong@strath.ac.uk (B. Jeong).

https://doi.org/10.1016/j.ijhydene.2025.153212
Received 12 March 2025; Received in revised form 20 December 2025; Accepted 23 December 2025
Available online 8 January 2026
0360-3199/Crown Copyright © 2026 Published by Elsevier Ltd on behalf of Hydrogen Energy Publications LLC. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Table 3
Leakage frequency.

	Component	Size and Number	Frequency (per year)		
			5 mm	10 mm	100 mm
Shore side	Buffer tank	150A × 1 EA	2.22E-05	2.27E-05	8.80E-06
	LP Pump	150A × 1 EA	8.52E-05	2.17E-05	5.76E-06
	HP Pump	150A × 1 EA	8.52E-05	2.17E-05	5.76E-06
	Pipe	150A × 200 m	1.81E-05	6.71E-05	1.22E-05
	Manual Valve	150A × 7 EA	1.21E-05	5.79E-06	1.29E-06
	Actuated Valve	150A × 8 EA	7.82E-05	2.41E-05	2.48E-06
	Flange	150A × 30 EA	4.06E-05	1.47E-05	2.59E-06
Ship side	Manual Valve	150A × 10 EA	1.72E-05	8.27E-06	1.96E-06
	Manual Valve	100A × 4 EA	5.78E-06	2.77E-06	1.62E-06
	Actuated Valve	150A × 20 EA	2.92E-04	9.02E-05	1.21E-05
	Pipe	150A × 150 m	1.36E-04	5.02E-05	9.16E-06
	Pipe	100A × 60 m	6.52E-05	2.42E-05	2.15E-06
	Flange	150A × 80 EA	1.03E-04	2.91E-05	6.91E-06
	Flange	100A × 8 EA	9.12E-06	2.30E-06	2.49E-06

A: Pipe nominal diameter (mm) EA: each.

documented at 2455 [68]. Fuel leakage incidents during bunkering have ramifications that extend beyond the vessel itself, encompassing its immediate surroundings. The extent of damage ensuing from such accidents correlates directly with the number of individuals present within the affected vicinity, rendering the population density of the accident area an influential determinant of the accident's outcome. It can be asserted that if a fuel spill transpires in the absence of individuals in the vicinity, potential consequences like fire, explosions, or adverse health effects due to toxicity are mitigated.

The predominant annual wind trajectory in Hamburg aligns with the west-south-west direction, characterized by notable occurrences of winds veering toward W, WSW, and SW azimuths, encompassing a substantial portion, around 30 percentage of the 16 distinct directions of wind rose [69]. The prevailing wind velocities predominantly adhere to a 6.48 m/s range, with subsequent levels following at 4.25 m/s and 9.16 m/s as shown in Fig. 7.

The weighting of the population is assumed by researchers, the average population density (100 %) is assumed for residential and working areas, while the city centre, anticipated to accommodate a higher transient population than the norm, is categorized as a denser 120 %. Conversely, the harbour area, characterized by a mix of transitory populations, was designated at 50 %, reflecting half of the average density. This adjustment takes into account the dispersion of workers engaged in ship operations, cargo handling, and port management, as well as passengers traversing passenger ships, spanning diverse areas due to the general port's characteristics. For areas such as Car parking and bulk storage, which are expected to host minimal transient populations in sprawling areas, a 10 % assumption was assigned to each. The assignment of population is displayed in Fig. 8.

The DNV Safety software was employed to model and calculate the range of influence, generating comprehensive results displayed on a geographical map with the combined frequency analysis and consequence analysis. The consequence analysis presents the border on the map to show the boundary of an accident It is considered that the fatality occurred within the boundaries of toxicity, fire and explosions caused by fuel leaks. The accident frequencies are displayed in the period of each accident, where the different colours of border lines show each accidental case.

The purpose of establishing a safety zone for bunkering is to restrict access to the danger zone for all individuals except essential personnel, thereby minimizing potential human casualties from accidents that may occur during ammonia bunkering. Additionally, it aims to strengthen safety equipment within the danger zone to prevent possible accidents.

The critical distance for each scenario was combined with its occurrence frequency, and the combined scenario results were reordered from the lowest to the highest risk range. The critical distance closest to the acceptable accident frequency was then established as the bunkering safety zone for the vessel. The safety zone from these results is displayed on the bunkering GIS map.

ISO/TS 19683:2021 recommends establishing safety zones around LNG bunkering stations to minimize ignition risks and threats to human life during bunkering [12]. It suggests restricting access to all personnel, except for essential workers, within the safety zone to minimize potential casualties in case of an actual accident. This ISO standard advises setting the safety zone range using either deterministic or probabilistic risk assessment methods based on the worst-case scenario.

However, when applying a deterministic method, the risk from low flash fuel leakage is evaluated based on the worst-case scenario without considering the likelihood of occurrence. As a result, the accident impact area may be significantly large and impractical. Therefore, in this project, a quantitative risk assessment using a probabilistic approach was applied to establish a more reliable safety zone for low flash fuel bunkering for the vessel. The criteria for defining the safety (or danger) zone are described in Chapter 2.3.

Building on the considerations outlined above, the default figure simulations are performed for four different types of fuels. These default values serve as the baseline for the subsequent parametric analysis, allowing for a systematic assessment of how variations in each

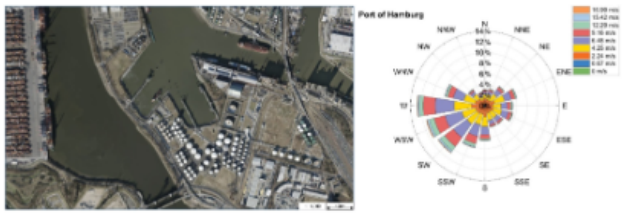


Fig. 7. Port of Hamburg [66].

EKMOA Europe-Korea Marine and Ocean Engineers Association

Research Output

- "Data-driven and scenario-based risk and reliability assessment framework: a case study for hydrogen bunkering (October 2025)" (정병욱 회장, 최윤)

Ocean Engineering 343 (2026) 123303

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

Research paper

Data-driven and scenario-based risk and reliability assessment framework: a case study for hydrogen bunkering

Yoon Choi [a,b], Byongug Jeong [a,b,c,*]

[a] Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow, G4 0LN, UK
[b] Europe-Korea Marine and Ocean Engineers Association (EKMOA), Southampton, SO16 9WE, UK
[c] Marine Advanced Research Centre (MARC) Ltd., Glasgow, G11 6BT, UK

ARTICLE INFO

Keywords:
D-FTA
D-FMEA
Reliability analysis
H2 bunkering safety
Montecarlo simulation

ABSTRACT

This paper introduces a Data-driven and Scenario-based Risk and Reliability Assessment Framework (DS-RAF) for enhancing the safety of maritime alternative fuels and technologies. The framework combines qualitative and quantitative methods and is demonstrated through a case study on a hydrogen bunkering system across its operational lifespan. An in-house system failure database was developed to support comprehensive risk and reliability assessments. To overcome the limitations of static Failure Modes and Effects Analysis (FMEA), a dynamic FMEA (D-FMEA) was applied, incorporating time-dependent component reliability. This enabled the identification of critical components, P&ID-based design improvements, and optimized replacement intervals. Dynamic Fault Tree Analysis (D-FTA) was further employed to capture sequential and functional dependencies among failures, providing system-level reliability insights. Additionally, scenario-based reliability analysis (S-BRA) using Monte Carlo Simulation (MCS) evaluated the impact of varying failure rates under different operating conditions. Results showed that the original design of the bunkering system degraded to around 50 % reliability after 1000 h. With optimized replacement strategies identified through D-FMEA and D-FTA, the improved configuration maintained around 70 % reliability over 10,000 h. The proposed framework offers a robust, multi-layered, and data-driven approach that enhances accuracy, reduces uncertainty, and supports proactive design and maintenance strategies, advancing the safe adoption of maritime decarbonization initiatives, including hydrogen solutions.

1. Introduction

1.1. Background

The global maritime industry is undergoing a transformative shift, driven by the urgent need to reduce greenhouse gas (GHG) emissions and comply with increasingly stringent environmental regulations, such as the FuelEU Maritime initiative (Ning et al., 2023) and the IMO's greenhouse gas fuel intensity (GFI) measures (Dominioni, 2025). This regulatory pressure underscores the critical need to adopt alternative fuels, including hydrogen and ammonia, to enable the sector's decarbonization.

On the other hand, alternative fuel technologies remain relatively new and are supported by limited safety records, which introduces significant challenges for their safe adoption. Ensuring their viability requires rigorous risk assessment processes, not only at the project level but also across the wider maritime decarbonization domain.

Current international safety regulations for alternative fuels are still at an early stage and lack explicit requirements. Consequently, development cannot rely solely on prescriptive, rule-based approaches but instead demands risk-based methodologies (Garbatov and Georgiev, 2021). Although the IMO and classification societies have issued guidance encouraging risk-based design (Hamann and Peschmann, 2013), these do not specify which assessment methods should be applied or under what scope. As a result, ship designers and relevant stakeholders adopt divergent approaches, leading to inconsistency and limited confidence in outcomes. To address this gap, a comprehensive and standardized risk and reliability assessment framework is not only timely but essential for ensuring the safe and reliable integration of alternative fuels into maritime practice.

* Corresponding author. Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow, G4 0LN, UK.
E-mail address: byongug.jeong@strath.ac.uk (B. Jeong).

https://doi.org/10.1016/j.oceaneng.2025.123303
Received 1 July 2025; Received in revised form 7 October 2025; Accepted 24 October 2025
0029-8018/Crown Copyright © 2025 Published by Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

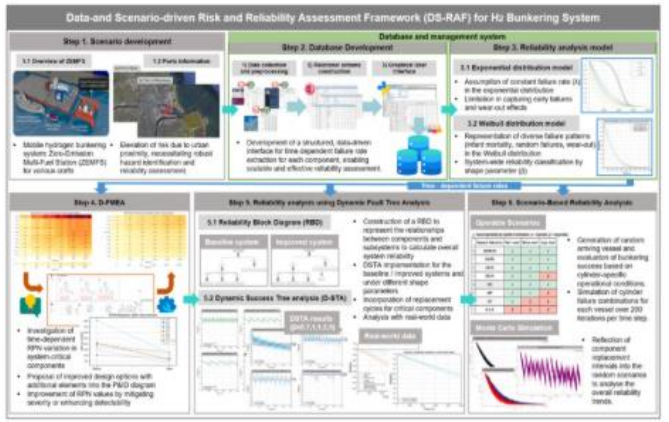


Fig. 1. Outline of data- and scenario-driven risk and reliability framework (DS-RAF).

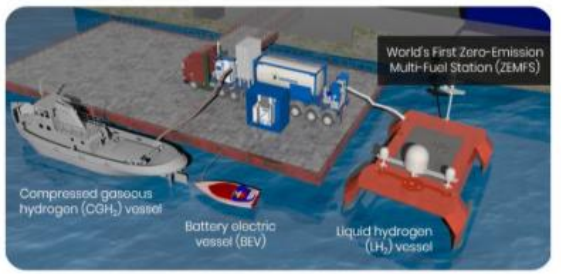


Fig. 2. Overview of Zero-Emission Multi-Fuel Station (ZEMFS) for Hydrogen and Electric Craft (*by cartesy of* Unirow).

research highlights the value of scenario-based analytical approaches to accident risk modeling, particularly when data for evaluating safety factors is limited or unavailable.

Collectively, the literature highlights a clear trajectory: from static, expert-driven analyses toward integrated, dynamic, and data-driven frameworks. These advances are essential for addressing the complexity and uncertainty of modern maritime systems, especially with the introduction of alternative fuels and novel technologies. Table 13 in the Appendix summarizes past research on applied risk and reliability assessment methods, highlighting their inherent limitations when applied to novel, high-risk systems such as hydrogen bunkering.

To address these gaps, the proposed hybrid approach combines the systematic failure mode identification of FMEA with the dynamic, time-dependent analysis capabilities of D-FTA, while grounding the assessment in empirical failure data. These findings provide the foundation for the proposed framework introduced in Section 2.

2. Methodology

In response to the limitations of existing methods, this paper was designed to introduce an enhanced safety and reliability framework, named Data- and Scenario-driven Risk and Reliability Assessment

EKMOA Europe-Korea Marine and Ocean Engineers Association

Research Output

- “Strategic forecasting of GHG intensity: Econometrically enhanced LCA for the Singapore-Rotterdam containership green corridor (September 2025)” (정병욱 회장, Ioannis Chalaris)

Results in Engineering 28 (2025) 107437

Contents lists available at ScienceDirect

Results in Engineering

journal homepage: www.sciencedirect.com/journal/results-in-engineering

Research paper

Strategic forecasting of GHG intensity: Econometrically enhanced LCA for the Singapore-Rotterdam containership green corridor

Ioannis Chalaris [a,1,*], Byongug Jeong [a,b,2], Jaehoon Jee [c,3]

[a] Department of Naval Architecture, Ocean, and Marine Engineering, University of Strathclyde, 100 Montrose Street, Glasgow G4 0LZ, United Kingdom
[b] Europe-Korea Marine and Ocean Engineers Association (EKMOA), Southampton SO16 9WE, United Kingdom
[c] Division of Coast Guard & Marine Engineering, Mokpo National Maritime University, 58628 Mokpo, Republic of Korea

ARTICLE INFO

Keywords:
Green corridor
Bio-methanol
E-methanol
Life cycle assessment
Forecast
Fuel EU maritime
EU ETS

ABSTRACT

Green shipping corridors are networks of ports and shipping lanes designated exclusively for low and zero-carbon alternative fuels. By sharing the expenses and benefits of using these fuels, participants in these corridors are incentivized to do so. The Port of Rotterdam and the Maritime and Port Authority of Singapore (MPA) have signed a Memorandum of Understanding (MoU) to establish the world's longest green and digital corridor, facilitating low- and zero-carbon shipping. Currently, there is a lack of studies and research determining the actual green character of this specific green corridor. Here is a forecast based on econometric parameters (GDP, population, TEU demand) and the integration between LCA and the Holt-Winters additive method, evaluating the GHG intensity of bio-methanol, e-methanol, and MDO utilized by an 8000 TEU containership in this green corridor until 2050. It is reported that e-methanol produced by solar power has the lowest WTW emissions with -24,49 g CO_2 Eq./ MJ, a value that aligns with the Fuel EU targets until 2045. Starting with Fuel EU, the total amount of penalties for that specific fuel choice is 80.673.138,5 €, and according to the EU ETS, the highest amount needed to be paid for allowances is 4.352.943,4 € in 2045. This study demonstrates the critical importance of the source of electricity during production and the need for additional investments in renewables in Rotterdam and Singapore, as only e-methanol, as opposed to bio-methanol and MDO, can be considered a promising net-zero pathway for shipping and a cost-effective option in the coming years until 2050.

Abbreviations

ABS	American Bureau of Shipping
EU	European Union
EU ETS	European Union Emission Trading Scheme
EU MRV	European Union Monitoring, Reporting, and Verification
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWP	Global Warming Potential
IAM	Integrated Assessment Models
IMO	International Maritime Organization
LCIA	Life Cycle Impact Assessment
LCA	Life Cycle Assessment
LEAP	Low Emissions Analysis Platform
MDO	Marine Diesel Oil
MoU	Memorandum of Understanding
MPA	Maritime and Port Authority of Singapore
MSW	Municipal Solid Waste
NLD	The Netherlands
OPS	Onshore Power Supply
pLCA	Prospective Life Cycle Assessment
pLCI	Prospective Life Cycle Inventory
SFOC	Specific Fuel Oil Consumption
SGP	Singapore
TEU	Twenty-Foot Equivalent Unit
TTW	Tank-to-Wake
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change

* Corresponding author.
E-mail addresses: ioannis.chalaris.2020@uni.strath.ac.uk (I. Chalaris), byongug.jeong@strath.ac.uk (B. Jeong), jhjee@mmu.ac.kr (J. Jee).
[1] Ioannis Chalaris: Ph.D. Candidate, University of Strathclyde (https://www.strath.ac.uk/).
[2] Byongug Jeong: Associate Professor, University of Strathclyde and President, EKMOA (www.ekmoa.org).
[3] Jaehoon Jee: Associate Professor, Mokpo National Maritime University (https://www.mmu.ac.kr/eng).

https://doi.org/10.1016/j.rineng.2025.107437
Received 11 June 2025; Received in revised form 7 September 2025; Accepted 23 September 2025
Available online 23 September 2025
2590-1230/© 2025 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

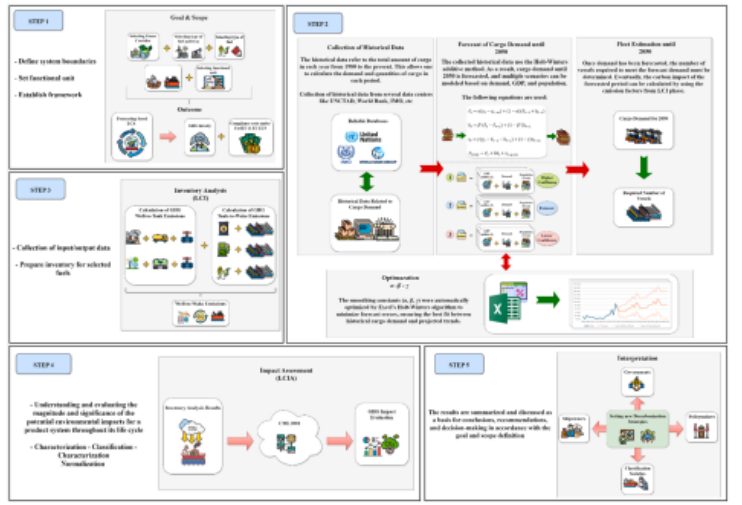


Fig. 2. Layout of the Holt-Winters integrated LCA forecast methodology (HILF).

WTT GWP, which measures the global warming impact (expressed in CO_2 Eq.), and the aggregate WTW GHG emissions are divided by the energy expended by the vessel (MJ). GHG intensity links these emissions to the fuel's energy content (gr CO_2 Eq./MJ), enabling substantial comparisons of environmental impacts among different fuels.

At this stage, data sources and assumptions are crucial for evaluating the carbon intensity of the fuels utilized by the case vessel along this green corridor. Certain assumptions are outlined, with further information available in the Appendix. This study utilizes investment reports, emissions databases, manufacturer specifications, and regulatory frameworks as primary and secondary data sources. The bunkering emissions are omitted as methanol may utilize the existing MDO bunkering system, diminishing additional fuel logistics emissions. Regional energy systems dictate the composition of electricity utilized for bio-methanol and e-methanol production, with natural gas and wind prevailing in Rotterdam and solar power in Singapore. Data from specific production facilities in Rotterdam and Singapore are utilized to estimate the bio-methanol and e-methanol production pathways, whereas MDO emissions variables are derived from the Fuel EU Maritime regulations.

Following the assessment of the vessel's energy consumption, the yearly operational profile was extracted from the UNCTAD database [64] for port days in Rotterdam and Singapore, supplemented with assumptions from the Fourth IMO GHG Study [16] for auxiliary engines and boilers. The emission factors for MDO and methanol are presented in Table 4. Various formulae have been employed to compute the emissions for each life cycle stage of this case study.

2.3.1. Tank-to-Wake

The emissions produced from fuel combustion during vessel operation are termed the TTW phase. The fuel consumption and emissions of the main engine, auxiliary engines, and boilers under different operational conditions (sailing, maneuvering, and berthing) are all encompassed. TTW alone evaluates onboard fuel use and its GHG intensity (Tables 5, 6 and 7).

$$\text{Main Engine}: FC_f = \sum_{op}^{n} \left(\frac{P_{op,i} \times Sfoc_f \times t_{op,i}}{10^6} \right) \quad (5)$$

Where FC_f is the total fuel consumption in tons across all operational profiles, op is the operational profile (sailing, maneuvering, berth), P_{op} is the propulsion power in kW used in each operational profile, $SFOC$ in g/kWh is the specific fuel oil consumption of the fuel, t_{op} is the time spent in each operational profile in hours and the conversion factor 10^6 converts grams to tons. In methanol engines, an additional parameter is necessary to characterize the pilot fuel required for combustion, influencing overall fuel consumption and emissions. The combustion of methanol generally produces lower CO_2 emissions per unit of energy in comparison to traditional fuels; however, the possibility of methanol slip (unburned methanol) and other secondary emissions warrants consideration. The final TTW emissions for methanol-fueled vessels are influenced by engine efficiency, fuel injection strategies, and emission control technologies.

EKMOA Europe-Korea Marine and Ocean Engineers Association

Research Output

- “Effectiveness of mechanical ventilation in mitigating ammonia leaks: A safety assessment for ammonia-fuelled ships (September 2025)” (정병욱 회장, 양인준 재무이사)

International Journal of Hydrogen Energy 178 (2025) 151568

Contents lists available at ScienceDirect

International Journal of Hydrogen Energy

journal homepage: www.elsevier.com/locate/he

Effectiveness of mechanical ventilation in mitigating ammonia leaks: A safety assessment for ammonia-fuelled ships

Lin Yang [a,1], Binteng Gu [a,*,1], M.P. Mujeeb-Ahmed [a,*], Peilin Zhou [a,b], Byongug Jeong [a,c], Haibin Wang [a], Ana Mesbahi [a], Injun Yang [a]

[a] Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow, G41 4PP, UK
[b] College of Power and Energy Engineering, Harbin Engineering University, Harbin, 150001, China
[c] Europe-Korea Marine and Ocean Engineers Association (EKMOA), Southampton, SO16 9WE, UK

ARTICLE INFO

Handling editor: B Shabani

Keywords:
Ammonia as a marine fuel
Ammonia toxicity
Mechanical ventilation
Safety assessment
Sustainable shipping

ABSTRACT

This study assesses the effectiveness of mechanical ventilation systems in mitigating ammonia leaks onboard ships, with a focus on crew safety. Numerical simulations are conducted for two case vessels – a container ship and a RoPax ship – under various leak scenarios in storage spaces. The analysis evaluates ammonia concentration levels against the occupational safety threshold of 30 ppm and the lower flammability limit. Sensitivity analysis considers vent position, number of vents, ventilation rate, and ambient temperature. Results show that optimal vent configurations and higher air-change rates (ACH) significantly reduce ammonia concentrations and decay times, thereby enhancing ventilation efficiency. The minimum ventilation durations for safe crew access to the storage areas following a leak were determined as 20 min for the Container ship and 15 min for the RoPax ship. These findings provide practical guidance for ship designers and operators, supporting the safe adoption of ammonia as a marine fuel while addressing the risk associated with its toxicity and handling.

Nomenclature

ABS	American Bureau of Shipping
ACH	Air Changes per Hour
AEGL	Acute Exposure Level Guideline
BV	Bureau Veritas
CAD	Computer-Aided Design
CCC	IMO Sub-Committee on Carriage of Cargoes and Containers
CCS	China Classification Society
CFD	Computational Fluid Dynamics
CFLC	Courant-Friedrichs-Lewy number based on sound velocity
CFLV	Courant-Friedrichs-Lewy value based on fluid flow velocity
ClassNK	Nippon Kaiji Kyokai
DNV	Det Norske Veritas
EEA	European Environment Agency
eMARS	Major Accident Reporting System
EPA	Environmental Protection Agency
FLACS	Flame Accelerator Simulator
FVM	Finite Volume Method
GHG	Greenhouse Gas
HAZID	Hazard Identification
HSE	Health and Safety Executive

(continued on next column)

(continued)

IBC	The International Bulk Chemical Code
IDLH	Immediately Dangerous to Life or Health
IGC	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
IGF	International Code of Safety for Ships using Gases or Other Low-flashpoint Fuels
IMO	International Maritime Organization
IR	India Register of Shipping
KR	Korean Register
LFL	Lower Flammability Limit
LR	Lloyd's Register
MARPOL	The International Convention for the Prevention of Pollution from Ships
MP	Monitoring Point
MSC	Maritime Safety Committee
NH_3	Ammonia
NIOSH	National Institute for Occupational Safety and Health
NOx	Nitrogen Oxides
OSHA	Occupational Safety and Health Administration
ppm	Parts Per Million
PRV	Pressure Reducing Valve
RANS	Reynolds-Averaged Navier-Stokes

(continued on next page)

* Corresponding author.
E-mail address: mujeeb.mughadar-palliparambil@strath.ac.uk (M.P. Mujeeb-Ahmed).
[1] These authors contributed equally.

https://doi.org/10.1016/j.ijhydene.2025.151568
Received 4 June 2025; Received in revised form 11 September 2025; Accepted 14 September 2025
Available online 24 September 2025
0360-3199/© 2025 The Author(s). Published by Elsevier Ltd on behalf of Hydrogen Energy Publications LLC. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

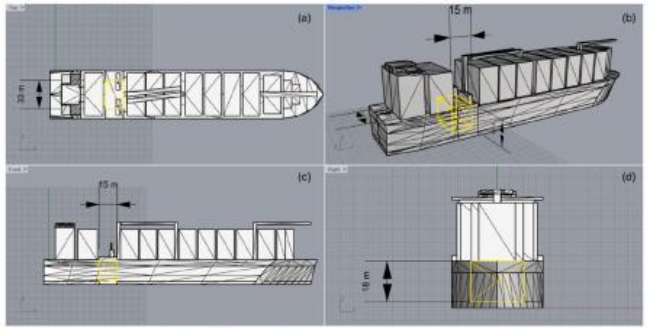


Fig. 8. Geometric CAD model of a 2700 TEU container ship: (a) top view; (b) perspective view; (c) front view; and (d) right view.

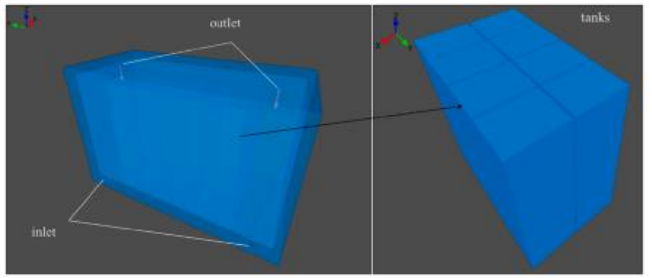


Fig. 9. 3D model of the cargo hold space and ventilation ducts (left), and the arrangement of TEUs (right).

of the cargo hold space.

The cargo hold space measures 33 m in length, 15 m in width, and 18 m in height, with a wall thickness of 2 m. It contains eight sets of columnar tanks, evenly distributed, accommodating a maximum of 96 TEUs. Each TEU measures 6 m in length, 4.9 m in width, and 15.5 m in height. To ensure proper ventilation, two extraction points, each measuring 1.2 m, are arranged on the top surface for mechanical ventilation. Additionally, two circular air inlet holes, each with a diameter of 1 m, are located at the bottom of one side wall to facilitate natural airflow.

Fig. 9 shows a detailed view of the cargo hold space, ducts, and tank arrangements. Given the modularity and scalability of ammonia storage, multiple tanks are housed within containerized units (96 TEUs) in the No. 5 cargo hold. However, the presence of a large number of ammonia tanks within containerized units raises significant concerns about potential ammonia leaks leading to toxic exposure, explosions, and fire hazards. To mitigate these risks, an effective mechanical ventilation system is essential.

For cargo hold space, based on the measured volume of ammonia, which is calculated to be 2771.5 m^3 and using the density of air, the required flow rate capacity of the fan is found to be 27.8 kg/s. The ventilation arrangement details for this scenario are summarised in Table 3.

Table 3
Parameters of the ventilation system for cargo hold space

Parameter	Value	Unit
Fan type	suction	–
Duct size	1.2 m (fan), 1 m (natural vent)	m
Fan position	Position 1: (6, 2.2, 15.8); (6, 28.2, 15.8) Position 2: (5, 2.2, 15.8); (7, 28.2, 15.8) Position 3: (3, 2.2, 15.8); (9, 28.2, 15.8)	m
Number of mechanical vents	2	–
Number of natural vents	2	–
Position of natural vent	Bottom of cargo hold space	–
Position of fans	Top of cargo hold space	–
Mass flow rate	13.9	kg/s
Flow velocity	8.16	m/s

EKMOA Europe-Korea Marine and Ocean Engineers Association

Research Output

- “A prospective life cycle assessment framework for sustainable renewable fuels in international shipping: Hydrogen based e fuels (August 2025)” (하승만 전 재무이사, 장하영 총무이사)

Renewable and Sustainable Energy Reviews 226 (2026) 116219

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A prospective life cycle assessment framework for sustainable renewable fuels in international shipping: Hydrogen based e fuels

Seungman Ha [a,d], Hayoung Jang [b,d,*], Chybyung Park [c,d], Byongug Jeong [b,d]

[a] Korean Register, 36 Myeongji Ocean City 9-ro, Gangseo-gu, Busan, South Korea
[b] Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, 100 Montrose Street, Glasgow, G4 0LZ, UK
[c] Division of Marine System Engineering, Korea Maritime & Ocean University, Busan, 49112, South Korea
[d] Europe-Korea Marine and Ocean Engineers Association (EKMOA), 90 Cowley Close, Hants, Southampton, SO16 9WE, UK

ARTICLE INFO

Keywords:
Prospective LCA
GHG emissions
Hydrogen based e fuels
Marine fuels

ABSTRACT

This paper presents a prospective life cycle assessment (pLCA) framework to evaluate the greenhouse gas (GHG) reduction potential of hydrogen-based e-fuels in international shipping. Maritime transport currently contributes approximately 2.89 % of global anthropogenic GHG emissions, with projections indicating a possible increase to 130 % of 2008 levels by 2050. In response, the International Maritime Organization (IMO) aims for net-zero emissions around 2050, necessitating a shift from fossil-based fuels to renewable alternatives. However, concerns persist regarding the life-cycle GHG emissions of such fuels, especially during the well-to-tank stage.

This study develops a pLCA framework that goes beyond conventional attributional or consequential LCA approaches by incorporating future-oriented parameters such as projected transport demand, vessel scrapping rates, and the impact of evolving international regulations (e.g., CII and EEXI). Using a dynamic fleet modeling approach applied to 2062 bulk carriers over 50,000 GT, the study simulates multiple decarbonization pathways and fuel uptake scenarios through 2030, 2040, and 2050. It integrates upstream fuel production emissions—linked to electricity source carbon intensity and technology readiness—with downstream fleet emissions, reflecting regulatory and operational constraints.

The results reveal that while renewable e-fuels such as e-ammonia and e-hydrogen show promising GHG reductions, their effectiveness is highly dependent on the carbon intensity of electricity used in fuel synthesis and on policy-driven adoption rates. The proposed framework offers a reproducible tool for policymakers and shipowners to assess the effectiveness of decarbonization strategies in meeting IMO targets, particularly for import-reliant countries like South Korea.

Abbreviations and Terms

AWE	Alkaline Water Electrolysis
CII	Carbon Intensity Indicator
COP	Coefficient of Performance
DAC	Direct Air Capture
DWT	Dead Weight Tonnage
EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency Existing Ship Index
GFS	GHG Fuel Standard
GHG	Greenhouse gas
HFO	Heavy fuel oil
IEA	International Energy Agency
IMO	International Maritime Organization
LCA	Life Cycle Assessment
NEM	National Electricity Market
PEM	Proton Exchange Membrane Electrolysis
PM	Particulate Matter
PSA	Pressure Swing Adsorption
PV	photovoltaic
SCR	Selective Catalytic Reduction
SEEMP	Ship Energy Efficiency Management Plan
SMR	Steam Methane Reforming
SOEC	Solid Oxide Electrolysis Cells
TRL	Technology Readiness Levels
TtW	Tank-to-Wake
WtW	Well-to-Wake

* Corresponding author. Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, 100 Montrose Street, Glasgow, G4 0LZ, UK.
E-mail address: hayoung.jang@strath.ac.uk (H. Jang).

https://doi.org/10.1016/j.rser.2025.116219
Received 9 October 2024; Received in revised form 6 August 2025; Accepted 14 August 2025
Available online 21 August 2025
1364-0321/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

case region for the reason that it has great low primary energy production and heavily relies on energy imports from other countries. Fig. 1 shows the methodology applied in this study.

2.2. Step 1 fuel production pathway and emission modeling (WtT part)

2.2.1. Marine fuels selected

HFO was chosen as a baseline for assessing the lifecycle GHG emissions linked to conventional fossil fuels. Additionally, four hydrogen-based e-fuels-hydrogen, ammonia, methanol, and LNG-were selected. This study delved into their production pathways, considering both fossil and renewable sources, to evaluate their potential for reducing life cycle GHG emissions.

Hydrogen is generated from a primary energy source and subsequently utilized to produce energy through internal combustion engines or fuel cells. Hydrogen serves as a clean energy source, generating only water as a by-product [44]. Hydrogen has a very high calorific value compared to conventional fossil fuels. Hydrogen combines with other atoms to form the products such as water, ammonia, and methane. More notably, hydrogen can store intermittent renewable energy sources

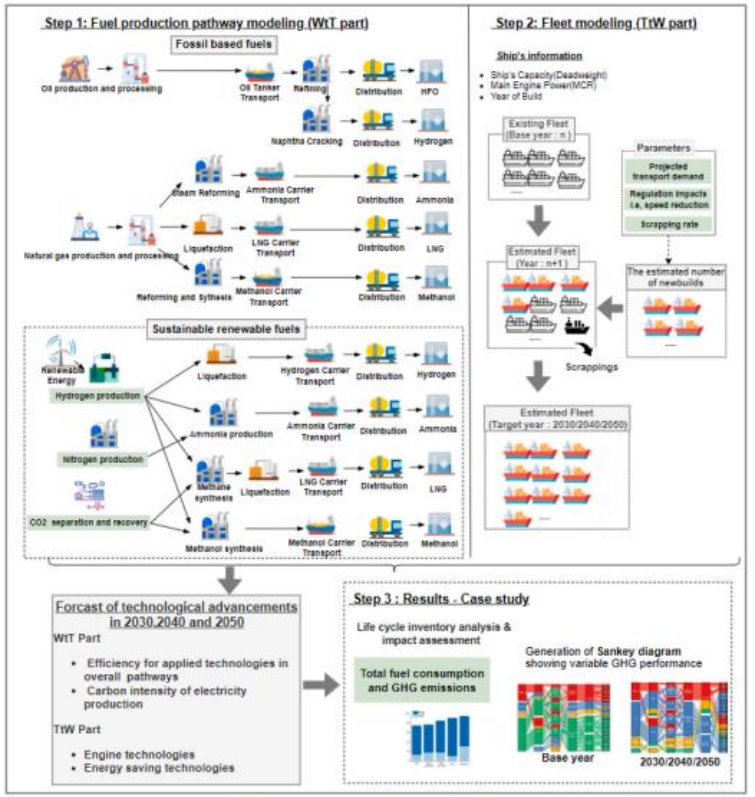


Fig. 1. Life cycle assessment framework applied in this study.

EKMOA Europe-Korea Marine and Ocean Engineers Association

Research Output

- “An integrated qualitative–quantitative risk assessment for defining toxic and hazardous zones on hydrogen-fuelled ships with ammonia cracking systems (August 2025)” (정병욱 회장, 황인식)

Ocean Engineering 341 (2025) 122475

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

Research paper

An integrated qualitative–quantitative risk assessment for defining toxic and hazardous zones on hydrogen-fuelled ships with ammonia cracking systems

Insik Hwang [a,b], Byongug Jeong [a,b], Hayoung Jang [a,b], Daejeong Kim [b,c,*], Jaehoon Jee [d]

[a] Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, 100 Montrose Street, Glasgow, G4 0LZ, UK
[b] Europe-Korea Marine and Ocean Engineers Association (EKMOA), 90 Cowley Close, Hants Southampton, SO16 9WE, UK
[c] Division of Navigation Convergence Studies, Korea Maritime & Ocean University, 727, Taejong-ro, Yeongdo-gu, Busan, Republic of Korea
[d] Division of Coast Guard & Marine Engineering, Mokpo National Maritime University, 58628, Mokpo, Republic of Korea

ARTICLE INFO

Keywords:
Ammonia-fuelled ships
Toxic zone
Hazardous zones
Gas dispersion
Probabilistic risk assessment

ABSTRACT

This paper proposes a novel quantitative risk assessment model aimed at determining toxic zones in response to a critical design challenge in ammonia-powered vessels. The developed model was applied to a hydrogen-fuelled ship equipped with an ammonia cracking system. This vessel is currently under design and construction and is scheduled to be dispatched to service in 2025 in the coastal area of Busan, South Korea. A qualitative risk assessment, HAZID, identified five high-potential gas leak points across the entire system. These points include critical areas where gas leaks could occur, posing severe risks to the crew and environment. The analysis results suggest the following toxic zones: bunkering connection (less than 1m radius), ammonia storage tank connection (7m radius), ammonia cracking system (5m radius), ammonia tank vent master (less than 1m radius), and fuel cell room ventilation (less than 1m radius). The model effectively determines practical toxic and safety zones for the utilization of hydrogen and ammonia as marine fuels, demonstrating that the proposed risk assessment model can serve as a new solution or standard to address one of the most challenging design issues in using ammonia as marine fuel. This research finally underscores the importance of integrating advanced risk assessment methodologies into the design and operational planning of maritime vessels.

1. Introduction

1.1. Background

Ammonia and hydrogen are increasingly gaining attention in the marine industry as potential carbon-neutral fuels, aligning with the growing decarbonization demands. However, ammonia's toxicity, corrosiveness, and fire and explosion hazards, along with hydrogen's high flammability, pose significant safety concerns when these fuels are used for ships (Hu et al., 2024).

Since 2017, ships with a gross tonnage of 500 and above using low flashpoint fuels are subject to the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) and class regulations (IMO, 2017). The IGF Code was initially designed for LNG as a marine fuel, resulting in notable safety discrepancies when applied to other low flashpoint fuels, particularly hydrogen and ammonia (Jang et al., 2023a). Consequently, the International Maritime Organization (IMO) is developing additional safety guidelines for hydrogen and ammonia, with interim guidelines expected by 2025. Local governments and classification societies are making similar efforts.

Despite significant regulatory advancements, certain aspects of current regulations still fall short of providing practical guidelines for ensuring the safe use of ammonia and hydrogen as marine fuels. The existing regulations outline the hazardous zones for potential leak points in ammonia and hydrogen systems onboard. However, these guidelines present two critical design issues. Firstly, the specified extents of hazardous zones are impractical for small vessels, being too extensive for application. Secondly, the guidelines do not comprehensively suggest all potential leak points, leaving designers facing considerable design challenges and confusion.

* Corresponding author. Europe-Korea Marine and Ocean Engineers Association (EKMOA), 90 Cowley Close, Hants Southampton, SO16 9WE, UK.
E-mail address: kdj4907@kmou.ac.kr (D. Kim).

https://doi.org/10.1016/j.oceaneng.2025.122475
Received 30 April 2025; Received in revised form 18 July 2025; Accepted 10 August 2025
Available online 18 August 2025
0029-8018/© 2025 Elsevier Ltd. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

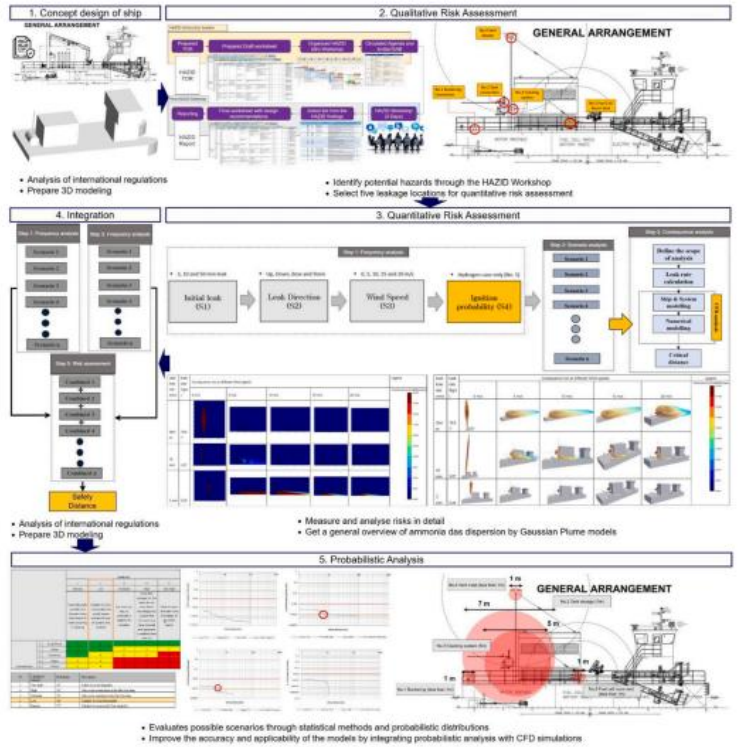


Fig. 1. Outline of the quantitative risk assessment for establishing safety zone.

Table 1
Ship specifications.

Main particulars	Symbols	Full scale
Length overall	L_{OA} (m)	18.5
Length between the perpendiculars	L_{BP} (m)	18.0
Breadth (MDL.)	B (m)	7.00
Depth (MDL.)	D (m)	1.80
Draft	T (m)	1.00

The limited safety records and lack of comprehensive standards further complicate the safe integration of these fuels into marine applications. Therefore, ensuring safety through comprehensive risk management practices becomes paramount.

1.2. Remarkable past research

Consequently, it is imperative to identify potential areas with a high likelihood of ammonia or hydrogen leakage through comprehensive risk assessments and to propose practical design recommendations. Numerous studies have investigated the effects of ammonia gas dispersion using various methodological approaches. This paper will discuss key past research to provide a foundation for developing safe and practical designs for using ammonia/hydrogen as marine fuels.

2025 Annual Report

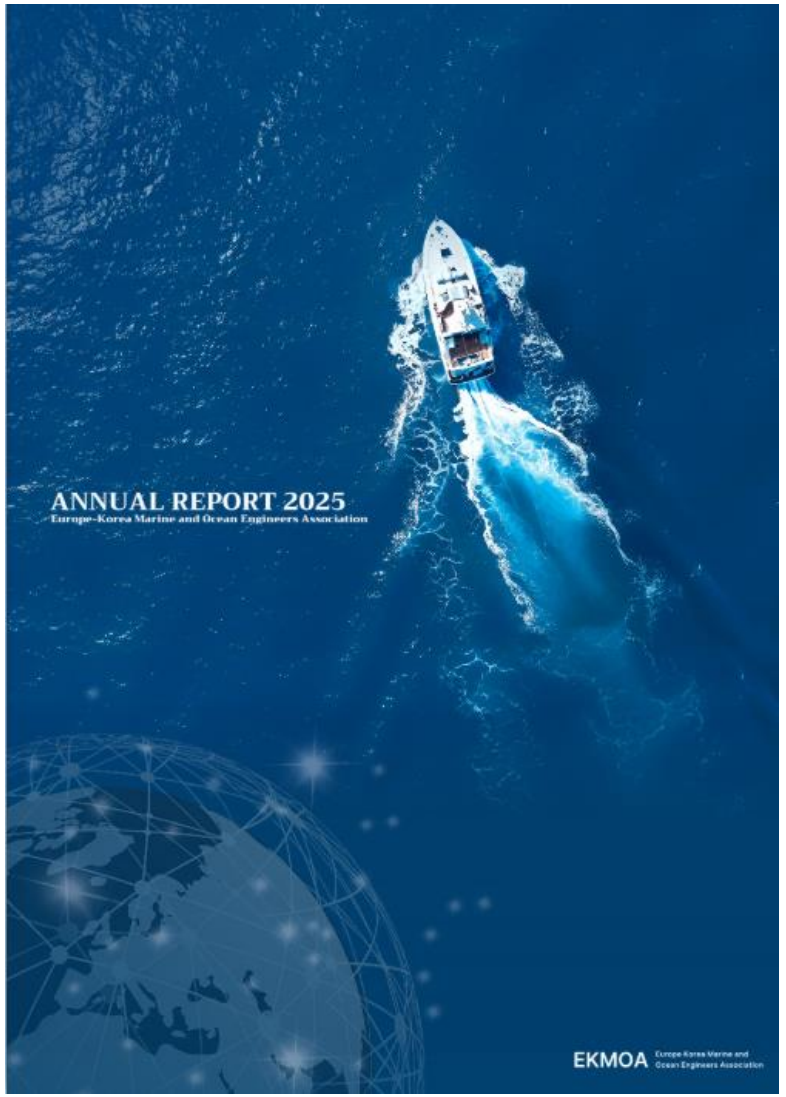




Table of Contents

I. Association Overview

1. President's Foreword 4

II. Major Achievements in 2025

1. Academic Exchange and Research Collaboration 6

01. KRISO Europe Centre Magazine - "Sea Frontier" 6
02. EKMOA & KORIES Joint Research 7
03. Research Output 8

2. Major Events and Participation 9

01. Workshop on Ships and Offshore Structure (WSOS 2025) 9
02. European-Korean Conference (EKC) 2025 10
03. KIRD Mid-Career Training Program 11

3. Global Partnership and Collaboration 12

01. Overview of MOUs and Partnerships 12
02. MOU Signed with Korea Maritime & Ocean University 13

4. EKMOA Member Highlights 14

01. Member Achievements and Awards 14
02. EKMOA Committee Activities Summary 15

III. Appendix

01. Steering Committee & Communication Channels 16
02. 2026 Plan & Outlook 16

2026년
협회 주요 활동 내용 및 계획

WSOS 2026 Gothenburg, Sweden

부제: "한-유럽 조선해양 분야 기술협력 포럼"



- THE 9th WORKSHOP ON KOREA AND EUROPE'S SHIP & OCEAN RESEARCH AND PARTNERSHIP STRENGTH (WSOS), "한-유럽 조선해양 분야 기술 협력 포럼"
- Theme: Collaboration and exchange between Europe, the UK, and Korea.
- Dates: 28 May to 29 May 2026
- Organise by: Europe-Korea Marine and Ocean Engineers Association

EKMOA Europe-Korea Marine and Ocean Engineers Association DNV HD한국조선해양 KEIT 한국산업기술기획평가원 Korea Planning & Evaluation Institute of Industrial Technology KRISO KORIES Korea Organization for Innovative Eco-friendly Ship Technology Development KIAT

EKC 2026 (20th – 23rd July, 2026)



EKMOA Europe-Korea Marine and Ocean Engineers Association

G-NAOE 2026



EKMOA Europe-Korea Marine and Ocean Engineers Association

Contact



CONTACT US

EKMOA (Europe-Korea Marine and Ocean Engineers Association)

- Email: service@ekmoa.org
- Website: https://www.ekmoa.org
- LinkedIn: https://www.linkedin.com/company/europe-korea-marine-and-ocean-engineers-association-ekmoa/
- KakaoTalk Open Chat: https://open.kakao.com/o/gYthz5Sh

EKMOA Europe-Korea Marine and Ocean Engineers Association