

## **Integrating Decarbonization and Green Shipping Knowledge into Maritime Curriculum: Stakeholder Perspectives from Cadets and Industry Veterans**

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### ***Abstract***

*The International Maritime Organization's 2050 net-zero emissions target has fundamentally reshaped the competency requirements for maritime professionals worldwide. This study examines stakeholder perceptions of decarbonization and green shipping knowledge integration within the maritime curriculum at Sekolah Tinggi Ilmu Pelayaran (STIP) Jakarta, in North Jakarta, Indonesia. Using a qualitative multi-stakeholder methodology, data were gathered from 71 respondents including cadets across three academic majors, former seafarer-lecturers, veteran officers, management lecturers, industry practitioners, and former senior transportation officials. Thematic analysis, cross-group comparisons, and narrative synthesis were applied. Overall curriculum integration scored a mean of 3.20 on a five-point scale, with IMO 2050 awareness relatively established but sustainability pedagogy and alternative fuel knowledge critically underdeveloped. A pronounced industry-curriculum gap was identified, with cadets scoring significantly lower than industry practitioners. The study proposes a structured green curriculum framework aligned with IMO standards and STCW conventions, with implications for curriculum developers, institutional policymakers, and national maritime education governance.*

**Keywords:** Decarbonization, Green Shipping, Maritime Curriculum, IMO 2050, Indonesia.

### **INTRODUCTION**

The decarbonization of global shipping stands as one of the most transformative institutional and educational imperatives of the contemporary era. In April 2023, the International Maritime Organization (IMO) revised its greenhouse gas strategy, committing the global shipping industry to achieving net-zero emissions by or around 2050 — a target that requires not only technological innovation but a profound transformation of the maritime professional competency landscape (Sheikh et al., 2025). This mandate presents maritime educational institutions across the world with an urgent and complex challenge: how to reformulate curricula, pedagogical methods, and institutional cultures to equip future seafarers with the technical knowledge, regulatory literacy, and environmental values necessary to operate within a decarbonized global shipping economy. In Indonesia, where maritime trade underpins the national economy and the Ministry of Transportation oversees a network of maritime academies tasked with producing internationally certified officers, this educational transformation is at once a professional obligation and a national development imperative.

Yet despite the clarity and urgency of the IMO's mandate, maritime curricula in many institutions — particularly those operating in developing economies — continue to be structured around conventional propulsion technologies, traditional regulatory frameworks, and operational competencies that do not adequately address the realities of green shipping (Simanjuntak et al., 2025; Wulandari et al., 2025). Khabir et al. (2025) argue in their systematic review of green digital shipping that the transition to sustainable maritime operations requires a comprehensive workforce transformation beginning in maritime education, yet find that most maritime education and training (MET) institutions globally lag significantly behind industry expectations in integrating decarbonization content into their programs. This gap between what

the industry demands and what educational institutions deliver constitutes the central problem motivating the present research.

The growing body of literature on sustainability integration in maritime education underscores the breadth and depth of this challenge. Garay-Rondero and Issa Zadeh (2025) identify sustainability thinking as a core professional competency that must be systematically embedded across all dimensions of maritime training programs, yet document that few institutions have developed coherent pedagogical frameworks for achieving this. Karahalios (2025) highlights how rapidly evolving technological demands — including autonomous shipping, alternative fuels, and emissions monitoring systems — require correspondingly rapid educational adaptation, arguing that the digital and environmental sustainability competencies of future seafarers must be treated as non-negotiable baseline requirements rather than elective additions. In the Indonesian context, Wulandari et al. (2025) document a pronounced misalignment between vocational maritime training and the operational realities of green technology in the national shipping fleet, while Malau et al. (2025) advocate for competency-based educational frameworks capable of simultaneously meeting STCW standards and emerging IMO environmental mandates.

The research questions this study addresses are: To what extent is decarbonization and green shipping knowledge currently integrated into the maritime curriculum at STIP Jakarta? What are the perceptions of cadets, lecturers, veteran officers, and industry practitioners regarding the adequacy of this integration? And what competency gaps and curricular enhancements are most urgently needed? Specific objectives are: to assess current curriculum coverage of green shipping themes across five knowledge domains; to compare perceptions of curriculum adequacy across six stakeholder groups; and to develop an evidence-based framework for strengthened decarbonization curriculum integration.

The rationale for this study is compelling at multiple levels. At the policy level, Indonesia's national maritime strategy — enshrined in Presidential Regulation No. 16/2017 on Indonesian Maritime Policy — explicitly links maritime human resource development to the country's blue economy and sustainability aspirations, making green curriculum reform a governmental priority as well as an institutional one (Putri, 2024). At the institutional level, Hebala et al. (2025) demonstrate that maritime education institutions themselves carry a direct responsibility for carbon footprint reduction through their operational and training practices, making sustainability curriculum integration both symbolically and practically significant. At the human resource level, the presence of veteran officers and former seafarers as lecturers at STIP Jakarta represents an invaluable resource for contextualizing green shipping education through operational experience — yet this resource remains systematically underutilized in current curriculum design (Yu et al., 2025). These experienced professionals have navigated the practical complexities of MARPOL compliance, energy efficiency management, and ballast water treatment at sea, and their contextual knowledge, if properly integrated into pedagogy, could substantially enrich the curriculum's real-world relevance.

The significance of this research is further underscored by the growing recognition within the maritime education community that competency reform for green shipping cannot proceed without deep stakeholder engagement. Karahalil et al. (2025), in their analysis of the IMO STCW comprehensive review process, demonstrate that the alignment of MET standards with emerging regulatory and technological demands requires active, participatory involvement from institutional stakeholders at every level. Kim et al. (2023) similarly show that the most effective sustainable MET approaches are those that integrate multiple pedagogical modalities — including simulation, industry partnership, and experiential learning — all of which require institutional commitment and stakeholder buy-in. By centering the voices of cadets, practitioners, veteran officers, and lecturers in an empirical assessment of curriculum adequacy, this study advances a participatory approach to green curriculum development that is both democratically grounded and contextually appropriate for the Indonesian maritime education sector.

## RESEARCH METHOD

This study adopts a qualitative research methodology grounded in the interpretive paradigm, selected for its appropriateness in exploring stakeholder perceptions of curriculum adequacy — phenomena that are inherently subjective, institutionally embedded, and not reducible to numerical measurement alone (Simanjuntak et al., 2025; Garay-Rondero & Issa Zadeh, 2025). The research was conducted at Sekolah Tinggi Ilmu Pelayaran (STIP) Jakarta, purposively selected as the primary site due to its institutional responsibility for producing internationally certified officers and its direct relevance to national maritime decarbonization objectives under the Ministry of Transportation.

The sample of 71 respondents was drawn purposively to represent the full institutional stakeholder ecosystem with respect to maritime curriculum development and green shipping competency. The sample comprises 20 cadets from the Nautical Science major, 20 from Marine Engineering, and 20 from Port and Shipping Management; 10 former seafarers serving as deck and engine lecturers; 5 veteran officers; 8 management and shipping lecturers; 3 former senior transportation officials; and 5 maritime industry practitioners. This multi-stakeholder configuration reflects Khabir et al.'s (2025) recommendation that workforce transformation for green shipping requires simultaneous engagement of education providers, active learners, and industry partners — a configuration that single-group studies cannot achieve. The inclusion of veteran officers and seafarer-lecturers as distinct respondent categories addresses the specific research interest in experiential knowledge transfer as a green curriculum resource, an approach validated by Yu et al. (2025).

The research instrument consists of a semi-structured interview guide organized around six independent variable clusters aligned with green curriculum integration domains: awareness of IMO 2050 decarbonization targets and regulatory frameworks; familiarity with alternative fuel technologies including LNG, ammonia, and hydrogen; knowledge of energy efficiency management systems (EEXI/CII); understanding of emissions monitoring and MRV reporting frameworks; competency in green port operations and environmental compliance; and engagement with sustainability-focused pedagogical approaches. The dependent variable is the perceived adequacy of green curriculum integration. Indicators include depth and breadth of green content coverage in current courses, teaching methodology and pedagogical delivery, assessment alignment with green competency objectives, availability of relevant learning materials, and perceived industry relevance of curriculum content. Documentary analysis of course syllabi, institutional policy documents, and IMO curriculum alignment reports provided supporting evidentiary data. Field observations of classroom and simulator sessions were recorded as additional contextual instruments.

Data collection proceeded through individual semi-structured interviews of 45 to 75 minutes each, conducted on-site at STIP Jakarta over a six-week period. All interviews were audio-recorded with consent and transcribed verbatim. Data analysis followed a three-stage thematic process. First, thematic analysis was applied to categorize transcripts into competency development and sustainability themes using open, axial, and selective coding procedures. Second, cross-group comparisons were conducted systematically across the six respondent categories to identify convergences and divergences in perceptions of curriculum adequacy. Third, narrative synthesis was employed to develop a cohesive explanatory account of the findings, integrating emergent themes into an evidence-based framework for green curriculum reform (Cahyadi et al., 2025; Wulandari et al., 2025).

RESULTS and DISCUSSION

Results

Table 1 presents mean scores for each green curriculum integration indicator across all respondent groups, rated on a five-point scale (1 = Very Inadequate; 5 = Fully Adequate).

Table 1. Green Curriculum Integration Scores by Indicator and Respondent Group (Mean, 5-Point Scale)

| Indicator                                  | Cadets<br>(n=60) | Seafarer-<br>Lecturers<br>(n=10) | Veteran<br>Officers<br>(n=5) | Mgmt.<br>Lecturers<br>(n=8) | Industry<br>(n=5) | Officials<br>(n=3) | Overall |
|--------------------------------------------|------------------|----------------------------------|------------------------------|-----------------------------|-------------------|--------------------|---------|
| IMO 2050<br>Awareness                      | 3.5              | 3.8                              | 4.1                          | 3.6                         | 4.2               | 4.3                | 3.75    |
| Alternative Fuel<br>Knowledge              | 2.8              | 3.2                              | 3.5                          | 2.9                         | 3.7               | 3.4                | 3.08    |
| Energy Efficiency<br>Systems<br>(EEXI/CII) | 3.1              | 3.4                              | 3.6                          | 3.2                         | 3.8               | 3.6                | 3.28    |
| Emissions<br>Monitoring &<br>MRV           | 2.9              | 3.1                              | 3.4                          | 3.0                         | 3.9               | 3.7                | 3.17    |
| Green Port<br>Operations                   | 3.0              | 2.9                              | 3.1                          | 3.4                         | 3.6               | 3.5                | 3.08    |

|                                |      |      |      |      |      |      |      |
|--------------------------------|------|------|------|------|------|------|------|
| <b>Sustainability Pedagogy</b> | 2.7  | 2.8  | 2.9  | 3.1  | 3.4  | 3.3  | 2.87 |
| <b>Overall Mean</b>            | 3.00 | 3.20 | 3.43 | 3.20 | 3.77 | 3.63 | 3.20 |

The overall mean of 3.20 indicates moderate green curriculum integration at STIP Jakarta. IMO 2050 awareness scores highest (3.75), suggesting general institutional familiarity with the decarbonization mandate. Sustainability pedagogy scores lowest (2.87), indicating that even where green content is nominally present, its pedagogical delivery is widely perceived as inadequate.

| <b>Table 2.</b> Thematic Analysis — Competency Gaps and Priority Curriculum Enhancement Needs |                         |                                                                                    |
|-----------------------------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------------------|
| <b>Theme</b>                                                                                  | <b>% of Respondents</b> | <b>Representative Concern</b>                                                      |
| <b>Career relevance of green skills</b>                                                       | 82%                     | Green competencies seen as essential for employment but underdeveloped in training |
| <b>Alternative fuels and propulsion</b>                                                       | 76%                     | Insufficient practical content on LNG, hydrogen, ammonia, and methanol             |
| <b>Sustainability pedagogy adequacy</b>                                                       | 71%                     | Over-reliance on theoretical lecture delivery without simulation or case studies   |
| <b>Regulatory knowledge (IMO/MARPOL 2023)</b>                                                 | 68%                     | Curriculum content does not reflect most recent IMO regulatory amendments          |
| <b>Industry-curriculum gap</b>                                                                | 65%                     | Training perceived as disconnected from current fleet decarbonization realities    |
| <b>Green port operations content</b>                                                          | 58%                     | Port Shipping Management cadets lack dedicated green port competency training      |



**Figure 1.** Perceived Priority Areas for Curriculum Enhancement (n=71)

**Discussion**

The overall curriculum integration score of 3.20 for STIP Jakarta, a maritime academy in Indonesia, confirms that the institution has established a baseline awareness of the International Maritime Organization (IMO) decarbonization mandates, a necessary first step toward aligning its training programs with contemporary environmental and sustainability standards. However, the data reveal critical gaps that must be urgently addressed, both in the pedagogical delivery of green shipping topics and the substantive coverage of the relevant content. These gaps suggest that while awareness of sustainability in maritime education is present, there is still much work to be done in terms of ensuring that the curriculum provides the full spectrum of operational competencies needed for a greener shipping industry. This finding is consistent with similar research by Simanjuntak et al. (2025), who document comparable curriculum-

industry misalignments across Indonesian maritime institutions. Their work highlights the challenges of integrating green shipping education effectively into maritime programs. Similarly, Khabir et al. (2025) have identified sustainability pedagogy as one of the most systematically underdeveloped aspects of global green shipping education. These studies point to the need for a comprehensive approach to embedding sustainability into maritime training programs, rather than focusing on a fragmented or superficial understanding of the concept.

Despite the moderate overall curriculum integration score, the data show that three of the six indicators — alternative fuel knowledge, emissions monitoring, and green port operations — score below 3.20. These results suggest that the curriculum's green dimensions are concentrated more in raising awareness rather than building out the full operational competencies needed to prepare students for real-world challenges in green shipping. The lower scores in these critical areas indicate that while students may be aware of sustainability concepts, they are not being adequately equipped with the specific technical skills and practical knowledge required to navigate the rapidly evolving green shipping industry. This gap is concerning, as it implies that the education provided at STIP Jakarta may not fully meet the emerging demands of the maritime sector, particularly in the context of decarbonization efforts and the adoption of alternative fuels.

One of the most striking findings from this study is that 82% of respondents identify green skills as essential for their future careers, yet they feel they are receiving inadequate training in these areas. This gap between learner expectations and curriculum delivery signals a productive tension within the institution. Cadets clearly recognize the urgency of acquiring green competencies in order to remain competitive in the job market, but the curriculum seems to fall short in meeting these expectations. This discrepancy directly aligns with Karahalios' (2025) argument that digital and environmental sustainability competencies are no longer optional additions to maritime education. Instead, they have become baseline requirements for employability in the contemporary shipping market. The fact that cadets themselves recognize this urgency — despite scoring curriculum integration at only 3.00 — suggests a high level of motivational readiness among students to embrace and engage with an enhanced green curriculum. This readiness provides a valuable opportunity for institutional leadership to capitalize on and implement the necessary changes. By doing so, STIP Jakarta could foster a more environmentally conscious and operationally capable cohort of future maritime professionals.

The pronounced gap between the scores of industry practitioners (3.77) and cadets (3.00) is also highly instructive. It mirrors the curriculum-industry misalignment that Jeevan et al. (2022) documented in their study of maritime education. The structural dynamic in which industry partners perceive greater institutional progress than learners actually experience can have serious practical consequences. Industry practitioners may assume that graduates are adequately prepared with the green competencies they need, only to find upon hiring that the graduates lack the necessary skills. This misalignment between industry expectations and student capabilities could lead to safety risks, onboarding inefficiencies, and reputational damage for Indonesian maritime education institutions on the international labor market. Caesar (2024) emphasizes that such mismatches can undermine the competitiveness of Indonesian maritime institutions in global hiring processes, further intensifying the pressure to reform the curriculum to meet both industry standards and environmental goals.

The study also reveals that the lowest-scoring indicator is sustainability pedagogy (2.87), which represents a critical area for improvement. Sustainability thinking, as shown by Garay-Rondero and Issa Zadeh (2025), cannot be effectively transmitted through traditional lecture-based, didactic instruction alone. Instead, it requires more innovative, experiential, and simulation-based pedagogical approaches. Kim et al. (2023) provide empirical evidence that simulation-based and blended Maritime Education and Training (MET) methods significantly enhance competency outcomes, particularly in sustainability-related content. These methods enable students to better grasp the complexities of green shipping, offering hands-on experience in a controlled environment. Furthermore, Bolmsten and Manuel (2020) show that participatory, technology-supported pedagogies are vital for delivering sustainable MET in the digital age, emphasizing the need for modernized teaching approaches that integrate technology and real-world scenarios. STIP Jakarta's current reliance on lecture-based delivery for green shipping topics, which typically focuses on passive learning, represents a pedagogical gap that is just as significant as the content deficiencies revealed by the curriculum integration scores. Reforming this aspect of the curriculum to include more interactive and experiential learning opportunities should therefore be a top priority for the institution.

This study contributes to the Indonesian maritime education literature by providing the first multi-stakeholder, indicator-based assessment of green curriculum integration at a government maritime academy. The strengths of the study lie in its robust respondent sample, the triangulation of interview and documentary data, and its grounding in both the national policy context and international MET standards. By synthesizing these various data sources, the study offers valuable insights into the current state of green curriculum integration at STIP Jakarta, highlighting both strengths and areas for improvement. Moreover, the study provides practical recommendations for addressing the gaps identified. These include three priority interventions: first, systematically updating the syllabus to reflect the IMO's 2023 regulatory amendments and the latest developments in alternative fuel technologies; second, introducing simulation-based and case-based learning modules that focus on sustainability and green shipping practices; and third, formalizing industry partnerships to bring operational green shipping expertise into the classroom and training environments.

The implementation of these interventions would align STIP Jakarta's curriculum with both international standards and the expectations of the maritime industry. By ensuring that students are equipped with the latest knowledge and practical skills in alternative fuels, emissions monitoring, and green port operations, the institution would significantly enhance the employability of its graduates while contributing to the global effort to decarbonize the shipping sector. Future research should evaluate the impact of these interventions through longitudinal competency assessments, allowing for a comprehensive understanding of how curricular reforms affect student outcomes and industry readiness. Additionally, further studies could extend the inquiry to other Indonesian maritime institutions, enabling comparative analysis across the sector and providing a more comprehensive picture of the state of green shipping education in the country. This will be critical for understanding whether the findings from STIP Jakarta are indicative of broader trends in Indonesian maritime education or whether they are specific to the institution in question.

The study highlights the urgent need for curriculum reform at STIP Jakarta to better align with both IMO decarbonization mandates and the expectations of the maritime industry. While the institution has made some progress in integrating sustainability concepts into its curriculum, significant gaps remain, particularly in the areas of content coverage, pedagogical approach, and industry integration. Addressing these gaps through systematic syllabus updates, innovative teaching methods, and stronger industry partnerships will be key to ensuring that future maritime professionals are adequately prepared to meet the challenges of a greener, more sustainable shipping industry.

## CONCLUSION

This study assessed the integration of decarbonization and green shipping knowledge into the maritime curriculum at STIP Jakarta through multi-stakeholder qualitative inquiry involving 71 respondents. The overall curriculum integration mean of 3.20 indicates moderate but uneven progress, with IMO 2050 awareness relatively well-established and sustainability pedagogy critically underdeveloped. A pronounced industry-curriculum gap exists, with cadet scores substantially lower than industry practitioner perceptions. The study identifies alternative fuel knowledge, emissions monitoring literacy, and green port operations as the most urgent content gaps, and sustainability pedagogy as the most critical delivery weakness. The proposed evidence-based green curriculum framework provides an actionable roadmap for institutional leadership, curriculum developers, and national maritime education policymakers in Indonesia and comparable developing maritime economies seeking to meet IMO 2050 obligations through educational transformation.

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