FINAL REPORT

Rev.2.0

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About this study:

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Document History

Version	Date	Changes	Prepared	Approved
1.0	03/12/2024	First issue – Final Report	ASAHOE	PHOWEL
2.0	12/12/2024	Final Report updated after comments from EMSA	ASAHOE	PHOWEL

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Executive summary

Introduction

The European Maritime Safety Agency (EMSA) has contracted DNV to carry out a study on the safe bunkering of biofuels, particularly focusing on the following pre-selected biofuels: bio-methanol, bio-Fischer-Tropsch (FT) diesel, bio- Dimethyl Ether (DME), Hydrotreated Vegetable Oil (HVO), and Fatty Acid Methyl Ester (FAME). The goal of the study was to draw up a goal-based technical guidance document with checklists, based on findings from:

- A preliminary safety assessment considering their characteristics (Task 1)
- A regulatory review and best practices from other industries (Task 1)
- The results from a risk assessment (Task 2)

This ensured that all relevant hazardous properties and different bunkering configurations (shore-to-ship, truck-to-ship, and ship-to-ship) were considered.

As part of the proposal development, DNV gathered letters of intent from a wide range of stakeholders. These contributed to the study by participating in HAZID workshop and reviewing the risk assessment (from Task 2), providing feedback and participating in the stakeholder consultation (in Task 3).

The study consisted of three main tasks:

- **Task 1 – Characterisation and Regulatory Review:** Safety analysis of the preselected biofuels and their characteristics, reviewing the current regulations and standards, examining land-based industry incidents and accidents reports, and definition of preliminary safety goals and requirements.
- **Task 2 – HAZID and Risk Assessment:** Conduct a qualitative risk analysis of bunkering operations for various configurations, using a HAZID workshop with stakeholders to identify potential safety risks.
- **Task 3 – Developing a Guidance Document with checklists:** Draft based on the findings in Task 1 and 2, review (by arranging a stakeholder consultation and incorporating feedback from stakeholders), and finalise guidance documents including checklists, for safe bunkering of biofuels.
- **Task 4 – Final Report:** Prepare a report summarising the activities, findings, conclusions, and recommendations, including the finalised guidance.

The study resulted in three main deliverables:

Deliverable 1	*Bunkering of biofuels in maritime: Characteristics, regulatory landscape, and safety assessment*
Deliverables 2 & 3	*HAZID and Risk assessment report*
Deliverable 4	*Guidance for safe bunkering of Biofuel (with Checklists)*

This final report - Deliverable 5 - aims to summarise the activities carried out throughout the study and provide references to the results and findings of each of the tasks listed above. The scope of and the interconnections between the tasks are illustrated in Figure 1 below.

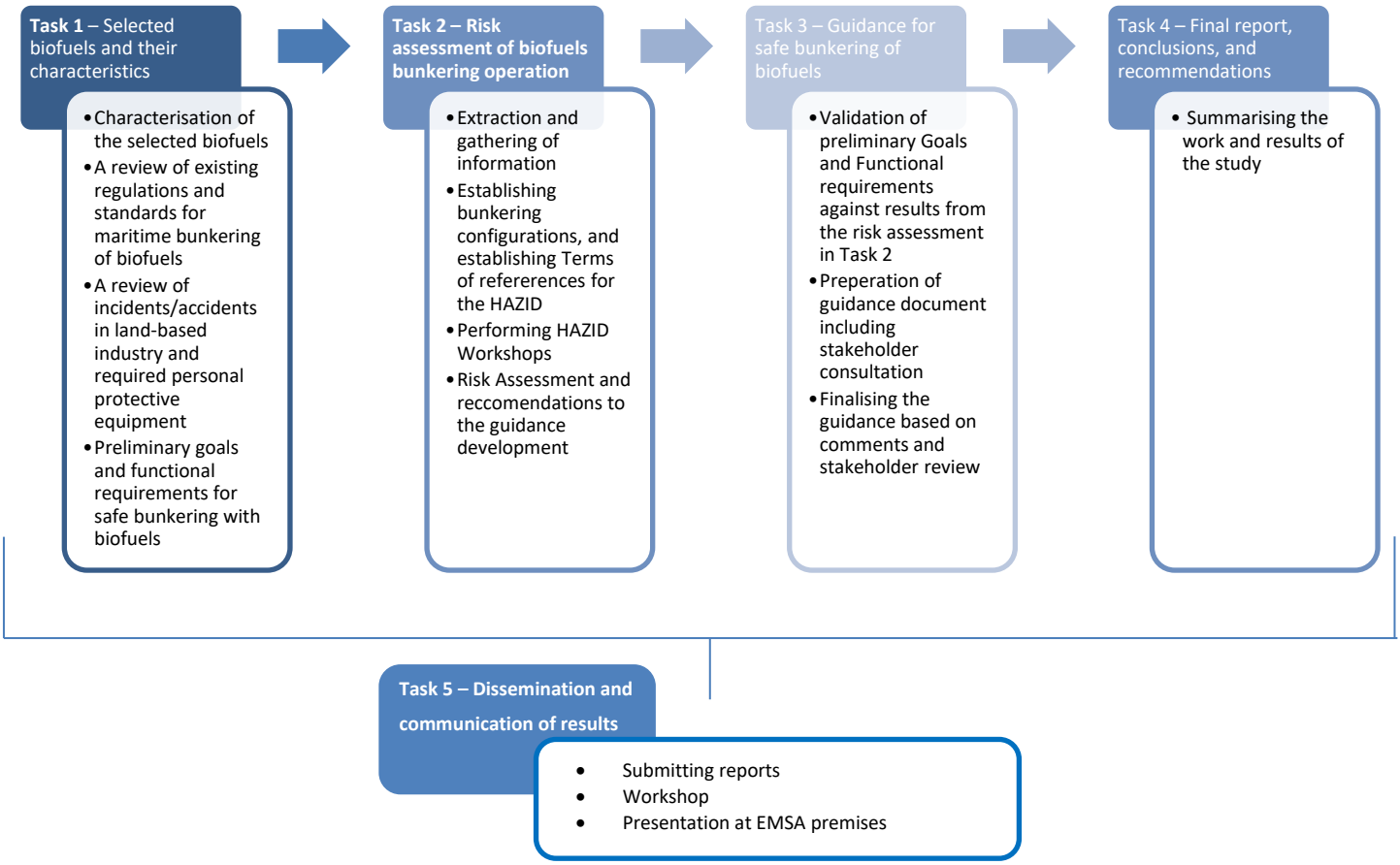

Figure 1 The task, activities and interconnections in the study on safe bunkering of biofuels

1. Task 1 Selected Biofuels and their characteristics

1.1 Approach for Task 1

Task 1 focused on determining the biofuel characteristics and reviews of best practise and regulation of the selected biofuels (bio-methanol, bio-DME, bio-FT-diesel, FAME and HVO). Key activities included:

- Characterisation of selected biofuels as chemicals and fuels, describing their hazardous properties
- Review of applicable rules and regulations, and description of existing standards and guidelines for bunkering of biofuels
- Review of best practices from other industries for possible transfer into maritime use
- Gathering statistics of incidents and accidents from land-based chemical and processing industries
- Review the need for PPE and safety measures
- Suggesting a preliminary structure for the guidance report.

The scope was limited to assessing safety for individuals on board, third parties, and the ship, excluding environmental damage related to bunker spills.

1.2 Results from Task 1

The results of task 1 are presented in the report published as the first deliverable (D1). Chapter 1 detailed the definition and characteristics of these biofuels, covering aspects such as storage and handling. Chapters 3 and 5 provided an extensive review of regulatory frameworks, including conventional bunkering practises at international and EU level, while Chapter 5 also assessed suitable use of Personal Protective Equipment (PPE). Chapter 4 summarised the insights from incidents and accidents in land-based chemical and processing industries dealing with selected fuels. As an input to drafting a goal-based guidance framework for safe bunkering of biofuels, a preliminary table of contents was established in Chapter 6.

1.2.1 Main findings in the D.1 report:

Bio-FT-diesel, HVO, and FAME share similarities with conventional marine diesels in bunkering hazards, while bio-methanol, chemically identical to fossil methanol, benefits from existing maritime practises and regulations. Bio-DME, resembling LPG, could utilise LPG infrastructure and regulations. Among these, bio-methanol is relatively mature, with best practises such as the methanol bunker operating regulations from the Port of Gothenburg. In contrast, FT-diesel having the least regulatory coverage, although general bunkering guidance is available. Ports like Singapore are developing frameworks, demonstrating the importance of local administrations in interpreting regulations. A risk-based approach to bunkering remains essential until these biofuels achieve wider industry maturity.

The report also highlights incidents from land-based industries involving fuel ignition due to hot work, equipment failure, or inadequate maintenance. It underscores the need for robust maintenance and the use of appropriate personal protective equipment (PPE) tailored to fuel-specific risks, as detailed in Safety Data Sheets.

For in-depth findings, refer to the report “Bunkering of biofuels in maritime: Characteristics, regulatory landscape, and safety assessment”.

2. Task 2 Risk assessment of biofuel bunkering operation

2.1 Approach to Task 2 – Process of planning and performing HAZID workshop

A preliminary hazard identification (HAZID) was conducted in task 1, listing their hazardous properties. In task 2, DNV expertise and stakeholders were gathered in HAZID workshops to perform a more detailed hazard identification of the bunkering operations for three bunkering configurations and considering all selected biofuels. In short, task 2 involved the following activities:

- Information gathering, bunkering configurations and preliminary qualitative risk assessment as input to the Terms of References (ToR) for the HAZID.
- Preparation meeting
- A three-day HAZID workshop to identify hazardous situations during bunkering and recommend additional measures or safeguards that could help reduce the risk involved with the bunker operation
- After the workshop, a qualitative risk ranking of each identified hazard was set based on a review of similar studies carried out in the past
- Summarising recommendations and drafting a report for task 2

The study had the following limitations:

- Findings from task 1 formed the basis of the study, including
  - Properties of each biofuel (including physical properties and critical conditions)
  - Toxicity effects on humans
  - Regulatory framework for each biofuel
- The following three bunkering configurations were considered:
  - Ship-to-ship (StS)
  - Port(shore)-to-ship (PtS)
  - Truck-to-ship (TtS)
- The risk ranking was set based on and drawing on experience from past similar studies and subsequently reviewed by the HAZID team.

Prior to the workshop it was decided to group the liquids, HVO, FT-diesel, and FAME together for assessment based on their characteristics. The two other, Bio-methanol and DME, were assessed individually due to significant differences in their properties.

2.2 Results from Task 2

A three-day HAZID workshop was conducted from March 11th to 13th, 2024 with participants from the following stakeholders BP, GoodFuel (now part of Finco Energies), BunkerOne, Cepsa, Exolum, Port of Huelva, Hapag Lloyd, NMA, together with subject matter experts from DNV and observers from EMSA.

The results of the task are presented in the HAZID and Risk Assessment report. The composition and expertise of the HAZID team is presented in Chapter 3, while the analysis basis and methodology are covered in Chapter 4 and 5. It provides a detailed overview of activities, including conducting the HAZID workshops (with dates and participants), collecting essential information, analysing various bunkering configurations, and carrying out a preliminary qualitative risk assessment.

2.2.1 Main findings from the Task 2 report (D2&3)

Main findings are detailed in the HAZID and Risk Assessment report, in chapter 6 under Results, which identify hazards, present findings from the risk evaluation for all biofuels, and provide recommendations for future risk mitigation.

The HAZID workshop identified hazards primarily during the fuel transfer phase, emphasizing two key safeguards for safe bunkering: thorough compatibility assessments and adherence to sound bunkering procedures. The risks associated with bio-methanol and DME were deemed higher than those of drop-in biofuels like HVO, FT-diesel, and FAME, particularly in terms of the potential severity of accidental events. Handling bio-methanol and DME requires stricter regulatory compliance, including adherence to the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code) and interim guidelines such as MSC/Circ. 1621 (bio) methanol.

The IGF Code mandates a separate risk assessment for vessels using gases or low-flashpoint fuels, incorporating bunkering scenarios to address potential onboard hazards effectively.

DME bunkering poses specific challenges, such as accounting for thermal expansion during filling, maintaining tank loading limits to avoid overfilling, and ensuring that receiving ships' refrigeration systems can handle fuel delivery at varying temperatures. Fuel supplied at ambient temperatures may exceed the reliquefication capacity of refrigerated systems, while low-temperature deliveries could cause overflow due to liquid expansion. In contrast, no additional safety risks were identified for HVO, FT-diesel, and FAME, though operational risks related to shorter longevity and potential contamination highlight the importance of proper storage practises. The workshop generated 59 recommendations across the assessed biofuels, many of which align with existing best practises but were documented to address specific scenarios raised during the HAZID.

3. Task 3 Developing Guidance for safe bunkering of biofuels

3.1 Approach to Task 3: the process for drawing up the goal-based Guidance

Task 3 builds on the previous two reports and aims to guide mariners on safely conducting bunkering operations with the five specific biofuels. The document is designed for a wide range of stakeholders, including ship operators, bunker suppliers, and regulators, addressing various topics to meet their diverse needs. The appendices include bunkering checklists, which users can adapt to their specific operations and requirements.

The guidance drew on existing best practises and guidance to tailor a comprehensive guidance document, encompassing topics relevant for the bunkering of biofuels. Such as:

- Bunkering supply modes
- Ship design
- Operations
- Stakeholders
- Training
- Emergency preparedness

3.1.1 Stakeholder consultation

An important aspect of Task 3 was utilising a dialogue with industry to ensure the guidance document reflects industry experience and needs. A broad range of stakeholders were involved in reviewing and providing input to the guidance document. Drawing from the following stakeholder groups:

- Class societies
- Interest groups
- Flag administrations
- Ports
- Vessel owners

3.2 Results from Task 3 (D.4)

The guidance document is extensive, the intention is not for readers to read the whole guidance, but rather use the sections most relevant to their needs.

The most key sections for operators are Chapter 6 (Operations) and the Appendices which contain the checklists. The checklists provide concrete, procedural guidance for operators bunkering with the various biofuels and distil the essence for the entire biofuel bunkering process.

For more information on Task 3, refer to the guidance document “Guidance for Safe Bunkering of Biofuel”.

3.3 Limitations for the goal-based Guidance

As commented by some stakeholders in the consultation process in Task 3, the guidance document is limited to the five biofuels scoped. The guidance can still be used for other, similar biofuels, but consideration should be taken regarding their different characteristics and properties.

4. Part 4 and 5

4.1 Task 4 –Final report, conclusions, and recommendations

The current document is considered the final report of the study. Outlining the general approach and key findings per Task.

4.2 Task 5 – Dissemination and communication of results

The project was disseminated through developing the reports.The first report was published on EMSAs webpage in January 2024.

The Draft guidance document was sent out to a wide range of stakeholders in October and November 2024 for feedback.

The study was presented during the EMSA's 3rd Workshop on Alternative Fuels and Power Solutions for Shipping and Ports on November 26th, 2024. The workshop was streamed live and is available on EMSA's Youtube channel.

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