



FUNDACIÓN  
VALENCIAPORT

# PORTS PERSPECTIVE: AVAILABILITY AND DELIVERY

**Mercedes de Juan**  
Innovation & Port Cluster Development

Lisbon, 18 Oct 2022





**Port-maritime  
market**



**Port planning  
and  
management**



**Port  
logistics**



**Digital  
transformation**



**Sustainability  
and energy  
transition**



**Security and  
protection**



**Integration  
between the  
port and the city**

# INDEX

---

## **1. Introduction**

## **2. Opportunities**

## **3. Challenges**

A. Legislation framework

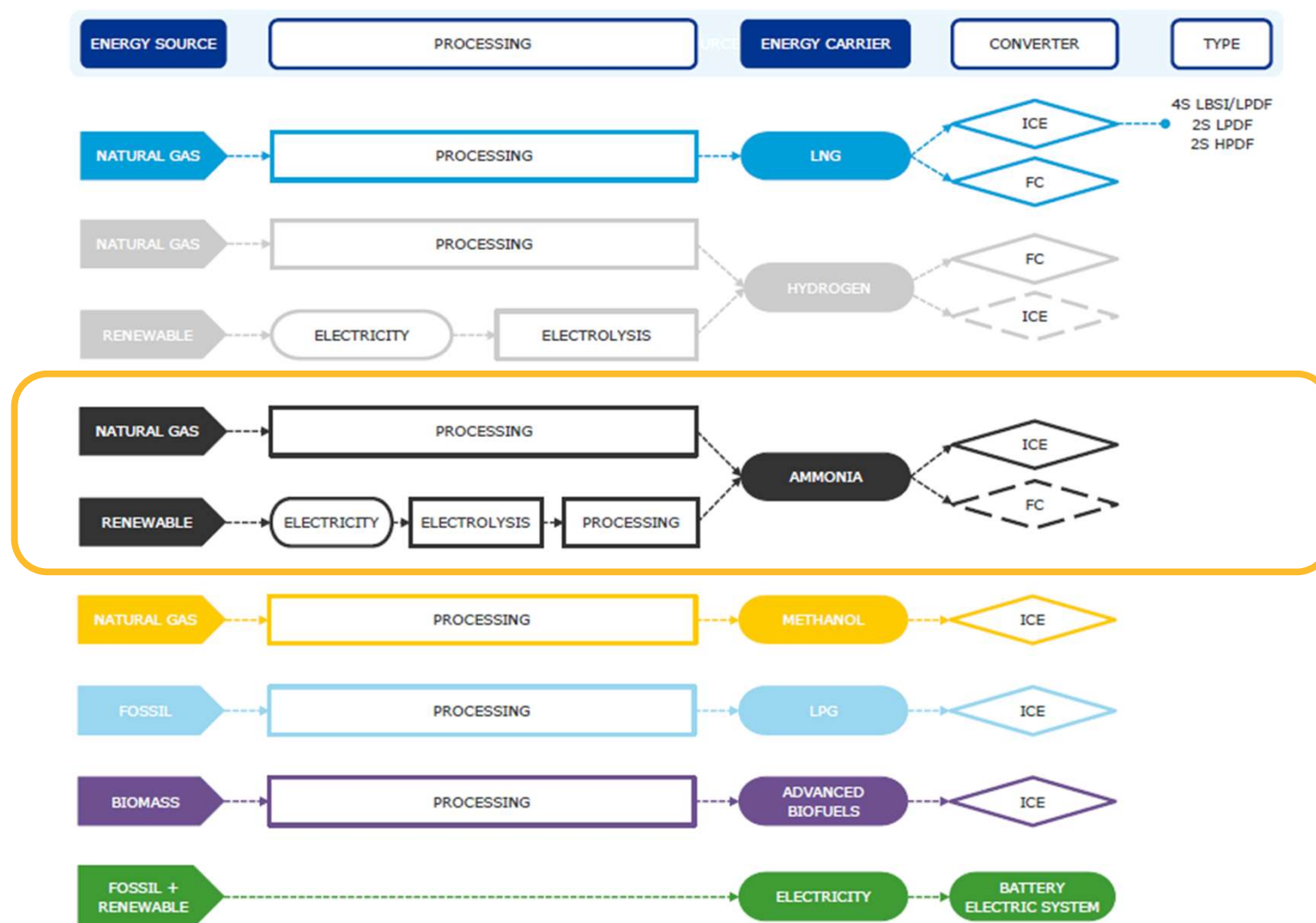
B. Safety (perception) at first

## **4. Bunkering key factors**

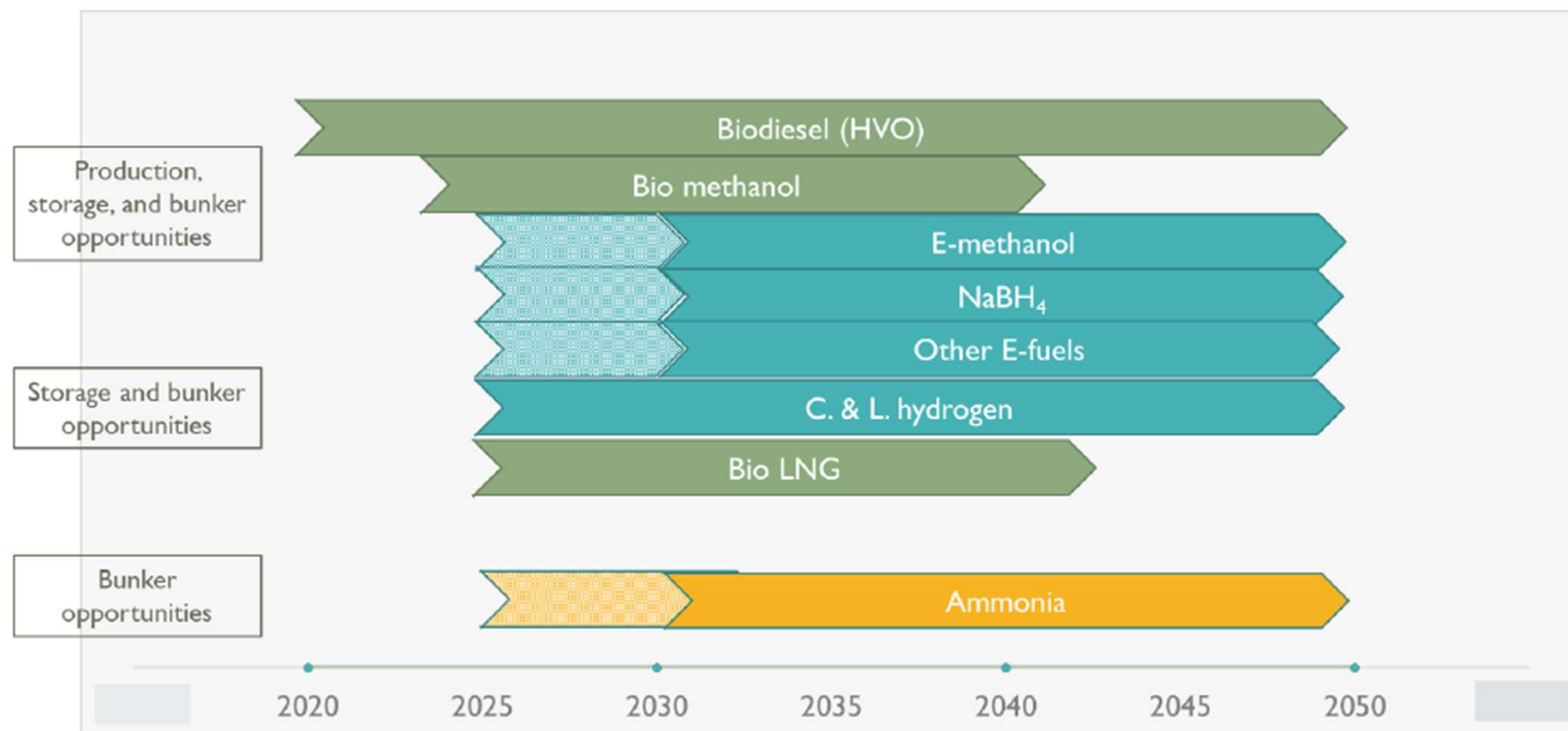
A. Bunkering safety measures

B. HAZID - Safety areas

# INTRODUCTION



# INTRODUCTION



Source: Interreg North West Europe H2Ship project



# INTRODUCTION

Energy source		Fossil (without CCS)					Bio	Renewable <sup>(3)</sup>		
Fuel		HFO + scrubber	Low sulphur fuels	LNG	Methanol	LPG	HVO [Advanced biodiesel]	Ammonia	Hydrogen	Fully-electric
<b>High priority parameters</b>										
• Energy density		●	●	●	●	●	●	●	●	●
• Technological maturity		●	●	●	●	●	●	●	●	●
• Local emissions		●	●	●	●	●	●	●	●	●
• GHG emissions		●	●	● <sup>(2)</sup>	●	●	●	●	●	●
• Energy cost		●	●	●	●	●	●	●	●	● <sup>(4)</sup>
• Capital cost	Converter	●	●	●	●	●	●	●	●	●
	Storage	●	●	●	●	●	●	●	●	●
• Bunkering availability		●	●	●	●	●	●	●	●	●
<i>Commercial readiness<sup>(1)</sup></i>		●	●	●	●	●	●	●	●	● <sup>(5)</sup>
<b>Other key parameters</b>										
• Flammability		●	●	●	●	●	●	●	●	●
• Toxicity		●	●	●	●	●	●	●	●	●
• Regulations and guidelines		●	●	●	●	●	●	●	●	●
• Global production capacity and locations		●	●	●	●	●	●	●	●	●

<sup>(1)</sup> Taking into account maturity and availability of technology and fuel.

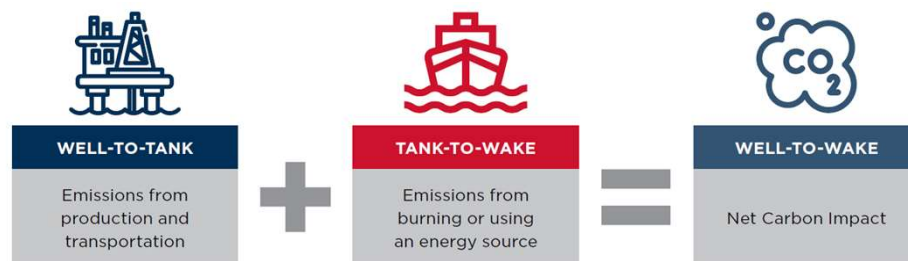
<sup>(2)</sup> GHG benefits for LNG, methanol and LPG will increase proportionally with the fraction of corresponding bio- or synthetic energy carrier used as a drop-in fuel.

<sup>(3)</sup> Results for ammonia, hydrogen and fully-electric shown only from renewable energy sources since this represents long term solutions with potential for decarbonizing shipping. Production from fossil energy sources without CCS (mainly the case today) will have a significant adverse effect on the results.

<sup>(4)</sup> Large regional variations.

<sup>(5)</sup> Needs to be evaluated case-by-case. Not applicable for deep-sea shipping.

# INTRODUCTION



Fuel type	Well-to Wake CO2 (g CO2e/MJ)
Diesel	87,95
LNG	66,94
Ammonia from urban waste	18,73
Ammonia from nuclear power	45,65
Ammonia from biomass	46,19

Source: Own elaboration

- **Low flammability risk** – 15.15% to 27.35% in air
- Can be produced from electrical energy – **renewable**
- **Easily reformed to hydrogen and nitrogen**
- Can be **stored and transported** as a liquid at a practical pressure and temperature (8,6 bar/20°C)
- Less tank volume than Hydrogen
- Established **commercial product/worldwide logistic chain**

# INTRODUCTION



- Toxicity.
- High explosive in combination with some halogens, interhalogens and oxidizers
- Fuel infrastructure/ LPG carriers as Bunkering vessels
- Lack of regulations
- Engine development at design stage
- Cost
- Corrosiveness to certain materials
- Poor combustion characteristics for IC engine application
- Possible need for high percentage of pilot fuel
- Possible increased NOx emission
- Possible ammonia slip



# PORT PERSPECTIVE: OPPORTUNITIES



Ammonia is **an alternative fuel** on which the shipping industry relies on as a realistic option to **replace fossil fuels** for contributing to achieving the IMO's GHG reduction targets from shipping.



The design of the first vessels powered by ammonia is at early stage, aimed to make the **ships as efficient and safe as possible**.

**Ports** are a key partner in the implementation of Ammonia as a marine fuel, where **ammonia bunkering** is expected to become widespread in the medium to long term.



Ports should inform the shipping industry (shipyards, shipping companies, etc.) about their vision related to conduct **safe ammonia bunkering operations in their ports**.

This will allow the design of vessels powered by ammonia and bunkering vessels adapted to the port needs, **and not backwards**.

# CHALLENGES



According to IMO rules, ammonia is not allowed to be used as marine fuel, as it is a toxic gas. Not covered by IGF/IGC Codes ➡ **ALTERNATIVE DESIGN PROVISION**

**IMO regulations need to be updated.** Moreover, it is expected that some countries will issue local legislation covering ammonia bunkering operations in ports.



In order maintain the same autonomy as oil-fueled ships, the capacity of ammonia tanks is 2,4 times, which will reduce cargo space.

Consequently, ships will **spend more time bunkering**, or increase the hoses diameter, with the consequent **greater risk of leakage** in the event of damage or rupture.



The safety criteria applied in industry must be adapted to the reality of ports.

**Safety standards must be developed for ports.** The economic cost criteria must not prevail over the safety of both port staff and crew.

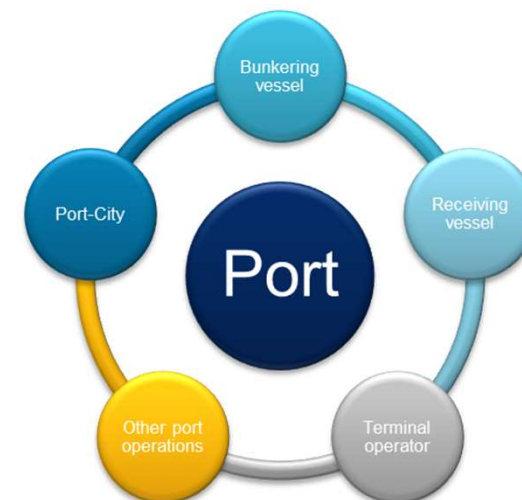
# CHALLENGES

## How should ammonia bunkering be done in a port?

The current relationship between the port and the surrounding cities is based on the confidence that the **port operations are intrinsically safe** and do not pose **any danger to the population**.

However, the smell of NH<sub>3</sub> is one of those that **cause the most public alarm**, since it can be noticed with concentrations from 1 to 20 ppm.

Ammonia smell will definitely cause problems during bunkering operations in the port with stevedore workers and population in the nearby areas (complaints, protests, strikes, etc.).



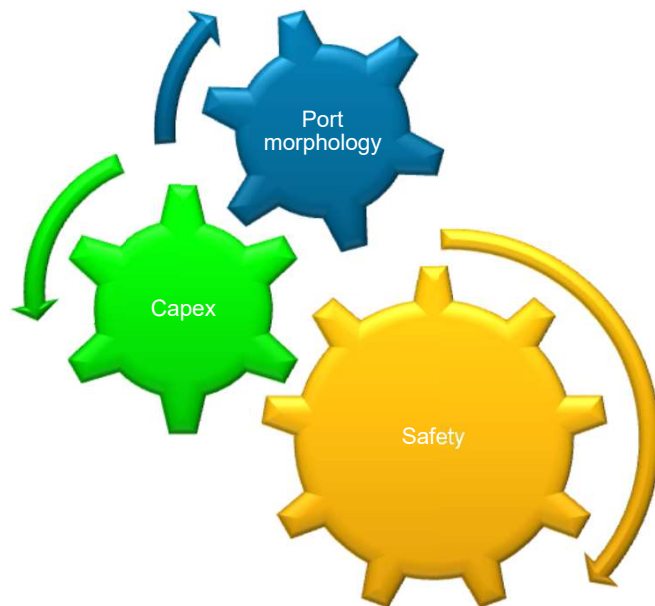
### SAFETY PRINCIPLES FOR NH<sub>3</sub> BUNKERING IN A PORT

- 👍 **Population should not perceive that one or more bunkering operations are taking place in the port.**
- 👍 **Except emergency/accident, no emission of ammonia into the atmosphere or harbor waters will be allowed under any circumstances**
- 👍 **Even in the case of an accident, the vessels involved must have safety devices that eliminate or mitigate the consequences to a level that the people's health does not be affected.**



# BUNKERING KEY FACTOR

## ALTERNATIVE DESIGN PROVISION


























































The objective of the risk assessment as required by the IGF code is to help **eliminate/mitigate** any adverse effect to the person on board, the environment or the ship. Its scope in general covers:

- Equipment installed on board to **receive, store, condition as necessary and transfer ammonia** to engines or other fuel consumers
- Equipment to **control the operation**
- Equipment to **detect, alarm and initiate safety actions**
- Equipment to **vent**, contain or handle operations outside of process norms
- Fire-fighting appliances and arrangements to protect surfaces from fire, fuel contact and escalation of fire
- Equipment to **purge and inert fuel lines**
- Structures to **house equipment**

# BUNKERING KEY FACTOR

## Involvement Map

-  **Production Map**  
Who is likely to participate in production of the documents
-  **Process Map**  
Who needs to process the produced documentation for approval
-  **Retention Map**  
Who retains the information after commissioning
-  **Control Map**  
Who may require access to the documentation during operation

	Design and Construction Phase							Operation	
	Concept design description, drawings and documents	HAZID, Hazard investigation	Preliminary approval statement by the administration	Risk assessment, analysis and detailed documentation	Approval of the design by the administration	Certificates	Ship construction file	Summary of the design details/Port State Control file	Safety management system
Designer									
Shipyard/Subcontractor									
Design Team									
Consultants/External Experts									
Administration									
Supervisors/Surveyors									
Port State Control Officers									
Crew									

# FINDINGS

Key Factors	Findings
<u>1. Gas Detection System</u> <ul style="list-style-type: none"> <li>■ whether automatic activation of water spray against NH<sub>3</sub> leakage during NH<sub>3</sub> bunkering should be required or not.</li> <li>■ If it is so, what would be condition for automatic activation.</li> </ul>	<ul style="list-style-type: none"> <li>■ Proper system of “First Reaction” against leakage is important</li> <li>■ Automatic Activation seems to be preferred option if it is effective</li> </ul>
<u>2. Water Spray against NH<sub>3</sub> leakage</u> <ul style="list-style-type: none"> <li>■ How much capacity for storage of drain tank for NH<sub>3</sub> contaminated water for NH<sub>3</sub> Fuel Ship and/or NH<sub>3</sub> Bunkering Ship.</li> <li>■ What is requirement for treatment of NH<sub>3</sub> contaminated water such as (i) discharge such water to on-shore for treatment by 3<sup>rd</sup> party or (ii) dilution with sea water for disposal to sea or (iii) disposal to sea without any treatment but outside of port.</li> </ul>	<ul style="list-style-type: none"> <li>■ Drain Tank if required to be designed based on worst scenario but with consideration of effectiveness of ESD</li> <li>■ Safety is more important than environment in case of emergency</li> </ul>
<u>3. Handling of Vent Gas</u> <ul style="list-style-type: none"> <li>■ Weather limited discharge into air shall be permitted or not.</li> <li>■ If it is so, what would be threshold</li> </ul>	<ul style="list-style-type: none"> <li>■ Zero release as target to be investigated with proper equipment and operation</li> </ul>
<u>4. Safety Zone</u> <ul style="list-style-type: none"> <li>■ Whether PPE for all of crew / stevedore on deck during NH<sub>3</sub> bunkering should be required or not.</li> <li>■ Whether restriction of cargo operation during bunkering is requested or not.</li> <li>■ If it is so, what is purpose of restriction, if limited crew / stevedore are protected by PPE.</li> </ul>	<ul style="list-style-type: none"> <li>■ PPE for crew for bunkering but not for stevedore, which should be trained related to NH<sub>3</sub> bunkering safety</li> <li>■ Restriction of cargo operation for mitigation risk of damages</li> <li>■ Restriction of SIMOPs for all ships in port to be investigated</li> </ul>
<u>5. Bunkering Station</u> <ul style="list-style-type: none"> <li>■ whether enclose “Bunkering Station” is required or not</li> </ul>	<ul style="list-style-type: none"> <li>■ Effectiveness of enclose or semi-close type with ventilation system to be investigated with ship design</li> </ul>

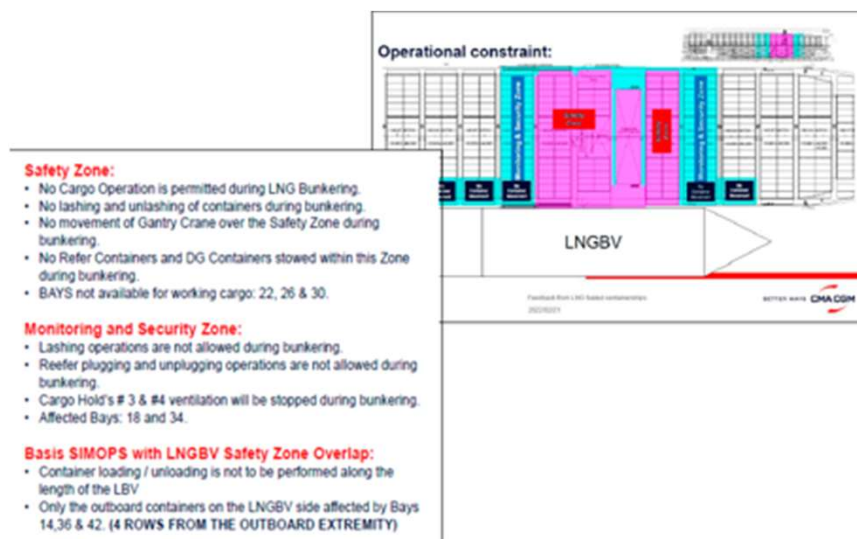


# HANDLING OF VENT GAS



- NH3 release will rapidly absorb moisture from the air and will form a dense and heavy whitish cloud in the atmosphere, which will therefore not reach much height above land/sea level. The NH3 cloud will move more or less rapidly depending on the weather conditions, especially as a function of wind speed and direction.
- Allowing vents during bunkering operations in ports can cause problems with stevedore workers and population in the nearby areas
- In the event that it is impossible to achieve "No NH3 Release" on disconnection after purging, the vent must be treated as a gas leak, activating the Water Spray System on both the fueled vessel and the bunkering vessel

# SAFETY ZONE



Source: CMA-CGM

- For container shipping companies, SIMOP's are essential to avoid **unnecessary delays at berth or shifting to other berth made exclusively for NH3 bunkering.**
- To avoid the risk of a container falling into the NH3 bunkering ship, Port of Valencia agrees that restrictions similar to those referred to LNG fuelled vessels must be adopted.
- The audible alarm emitted by the gas detection system (installed on both the NH3 bunkering ship and the NH3 fueled vessel) must be the signal for the evacuation or confinement of all stevedores on board the NH3 fueled ship and crew not required to respond to the possible leak.

# SAFETY ZONE

## AEGL (Acute Exposure Guideline Level) by EPA-USA

Ammonia					
ppm					
	10 min	30 min	60 min	4 hr	8 hr
<b>AEGL 1</b>	30	30	30	30	30
<b>AEGL 2</b>	220	220	160	110	110
<b>AEGL 3</b>	2.700	1.600	1.100	550	390

AEGLs represent threshold exposure limits (exposure levels below which adverse health effects are not likely to occur) for the general public and are applicable to emergency exposures ranging from 10 minutes (min) to 8 h. Three levels—AEGL-1, AEGL-2, and AEGL-3—are developed for each of five exposure periods (10 min, 30 min, 1 h, 4 h, and 8 h) and are distinguished by varying degrees of severity of toxic effects. The three AEGLs are defined as follows:

**AEGL-1** is the airborne concentration (expressed as parts per million [ppm] or milligrams per cubic meter [mg/m<sup>3</sup>]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic no sensory effects. However, **the effects are not disabling and are transient and reversible upon cessation of exposure.**

**AEGL-2** is the airborne concentration (expressed as ppm or mg/m<sup>3</sup>) of a substance above which it is predicted that the general population, including susceptible individuals, **could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.**

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



# SAFETY ZONE



## European Union (EU) INDICATIVE OCCUPATIONAL EXPOSURE LIMIT VALUES

Einecs <sup>(1)</sup>	CAS <sup>(2)</sup>	Name of agent	Limit values				Notation <sup>(3)</sup>
			Eight hours <sup>(4)</sup>		Short-term <sup>(5)</sup>		
			mg/m <sup>3</sup> <sup>(6)</sup>	ppm <sup>(7)</sup>	mg/m <sup>3</sup> <sup>(6)</sup>	ppm <sup>(7)</sup>	
231-635-3	7664-41-7	Ammonia, anhydrous	14	20	36	50	—

( Short-term) A limit value above which exposure should not occur and is related to a **15-minute period**, unless otherwise specified.



## The American Conference of Governmental Industrial Hygienists

### AMMONIA

**TLV-TWA, 25 ppm (17 mg/m<sup>3</sup>)**

**TLV-STEL, 35 ppm (24 mg/m<sup>3</sup>)**

**TLV-TWA** (Threshold Limit Value - Time Weighted Average)

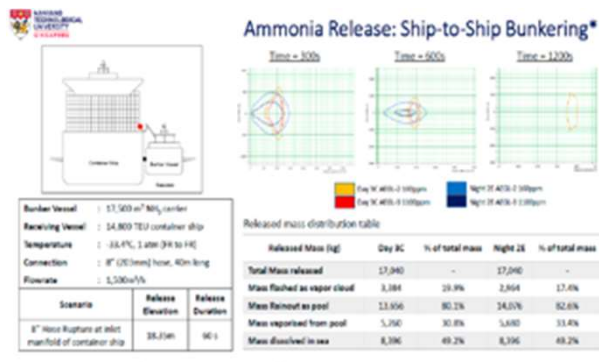
The time-weighted average concentration limit for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. Developed by the ACGIH

**TLV-STEL** (Threshold Limit Value - Short term exposure limit)

Refers to a 15 minute time-weighted average exposure which should not be exceeded at any time during a workday even if the time-weighted average is within the TLV. It supplements the 8 hour TLV-TWA for certain substances that produce acute effects on high, short term exposure

# SAFETY ZONE

As a conclusion, the safety zone during an NH<sub>3</sub> bunkering operation is difficult to determine in advance, since it will be defined by the amount released into the atmosphere, and the meteorological conditions existing at the time (temperature, humidity, wind direction and speed, etc.), as well as the physical conditions of the environment (facilities, obstacles, etc.). The “reasonably foreseeable” worst leakage scenario during NH<sub>3</sub> bunkering must be calculated



Two possibilities of dispersion of NH<sub>3</sub> toxic clouds in the atmosphere



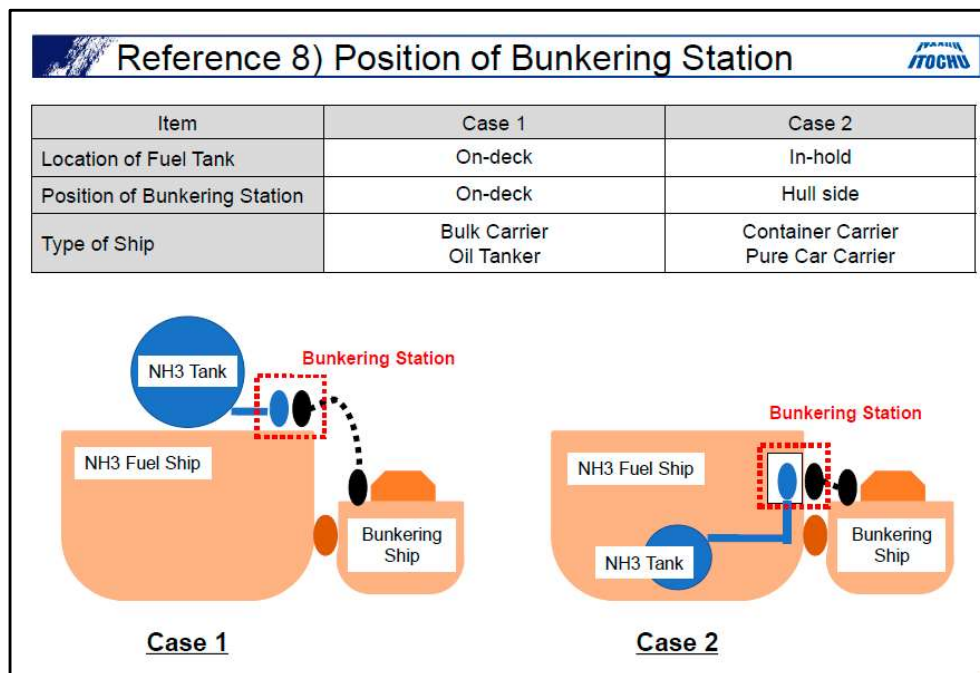
gaussian  
dispersion



dense cloud  
dispersion

In order to reduce the safety zone as much as possible, the ship's safety systems must prevent any emission of NH<sub>3</sub> into the atmosphere.

# BUNKERING STATION



- Bunkering stations must be “closed” type.
- They must have a water spray system and a gas detection system.
- After preparing the hose connections the station should be operated remotely, without the presence of the crew.



# CONSIDERATIONS

In addition to the risks arising from NH<sub>3</sub> bunkering operations, ports must also take into account the permanent risks of major accidents caused by massive leaks of NH<sub>3</sub> stored both in the tanks of the fueled vessels and in the tanks of the bunkering vessels.



## Anhydrous ammonia leak from LPG tanker Sombeke, Houston

Posted in [Accidentes](#) by Mikhail Voytenko on Jul 26, 2014 at 08:25.

USCG reported anhydrous ammonia leak from an LPG tanker **SOMBEKE** during cargo operation at the Houston Ammonia Terminal in Houston Ship Channel on July 25. "It was reported that the **SOMBEKE** was in the initial cool down phase, preparing to transfer, at the Houston Ammonia Terminal, when a gasket blew and an unknown amount of the anhydrous ammonia was released." – said officials. Tug Trigger was engaged in **SOMBEKE** bunkering at a time of an accident, four crewmembers were exposed to the chemical, and have been hospitalized. Anhydrous ammonia is a colorless, highly irritating gas with a sharp, suffocating odor.







**Fernando Gimeno Cervera (Mr.)**  
Head of Safety  
**PORT AUTHORITY OF VALENCIA**  
[fernandogimeno@valenciaport.com](mailto:fernandogimeno@valenciaport.com)

**Mercedes De Juan Muñoyerro (Ms)**  
Innovation & Port Cluster Development  
**FUNDACIÓN VALENCIAPORT**  
[mdejuan@fundacion.valenciaport.com](mailto:mdejuan@fundacion.valenciaport.com)

**[www.fundacion.valenciaport.com](http://www.fundacion.valenciaport.com)**

