

# LNG as Fuel- safe bunkering procedures

## Background and Scope

# AGENDA

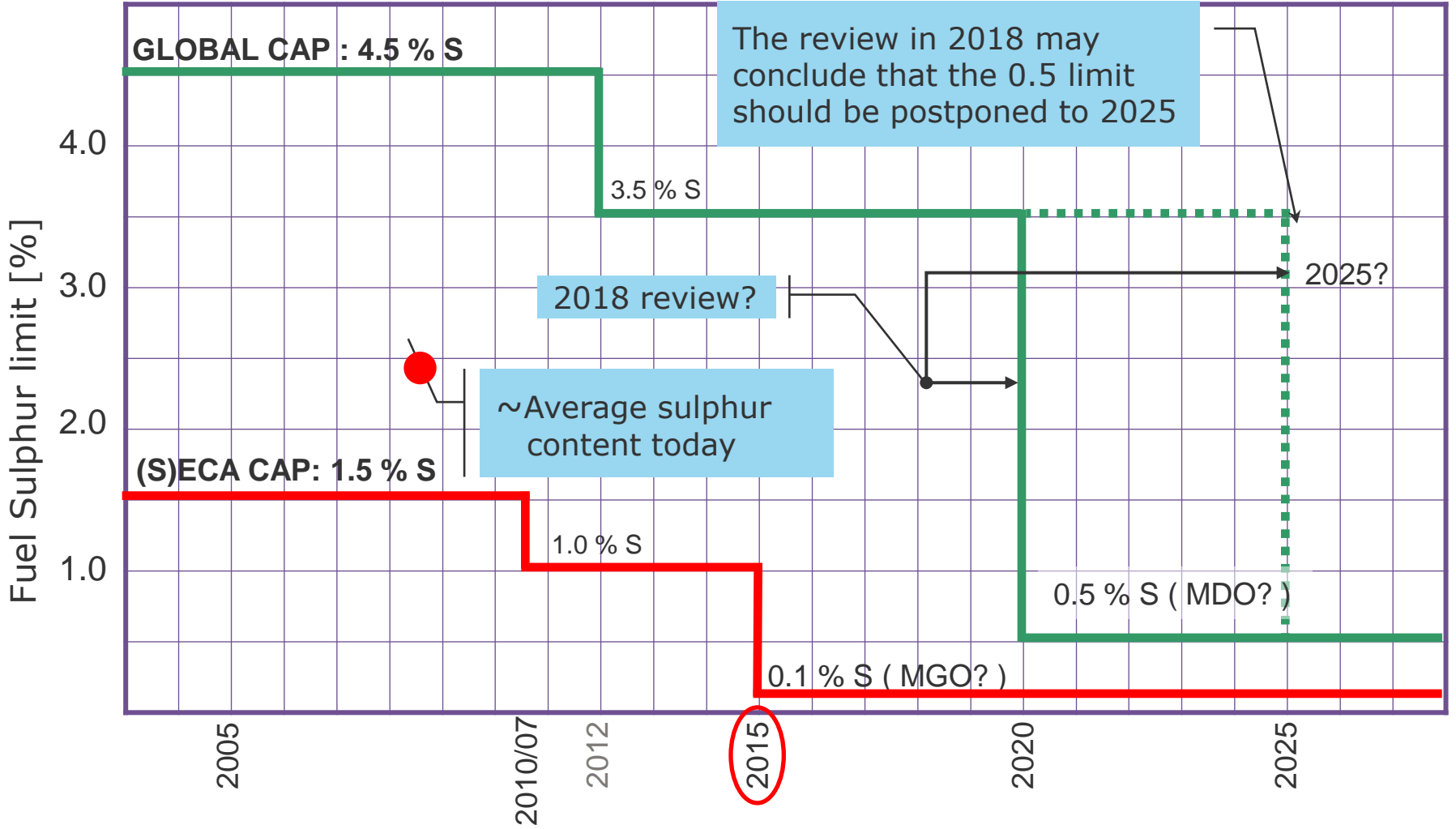
1. Background
2. LNG Basics
3. Shipping & ports
4. Status of LNG fuelled ships
5. ECA options
6. Regulatory



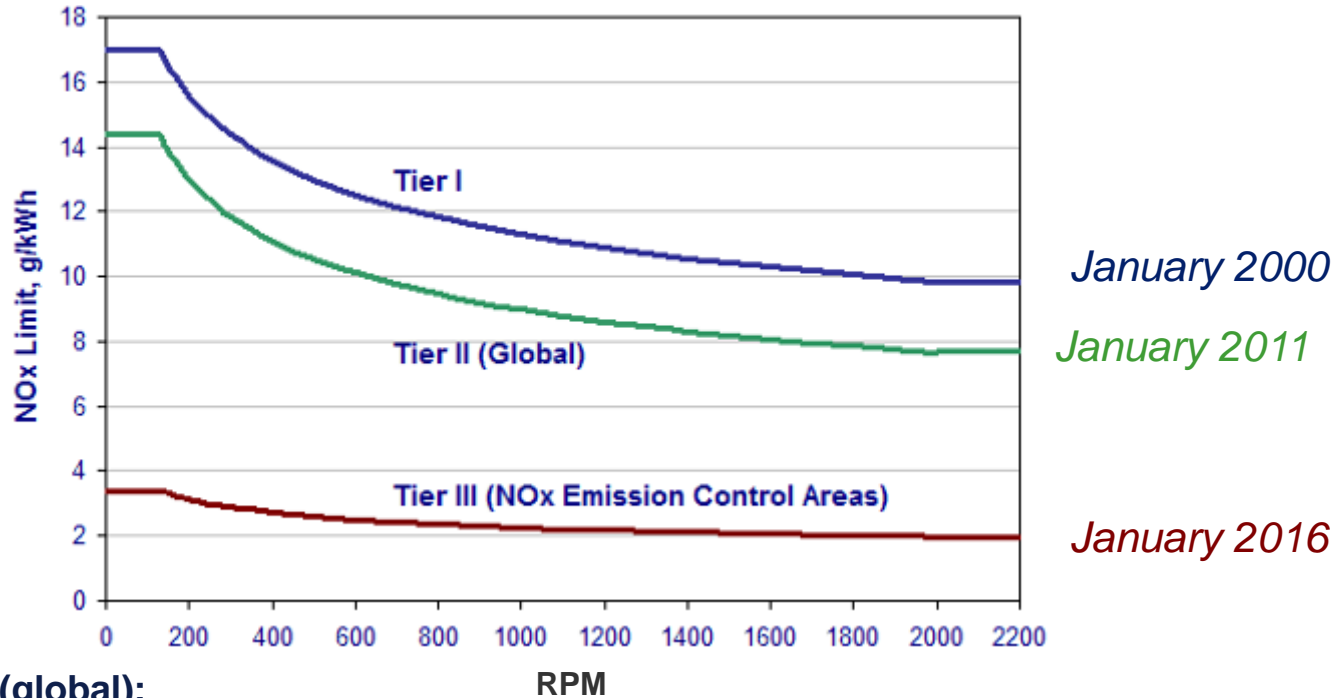
# Current & Future ECAs



# MARPOL Annex VI SOx



## ....Not only SOx; NOx-in ECAs by 2016!



### Tier I (global):

engines in new ships with keel laid between 01.01.2000 – 01.01.2011

### Tier II (global):

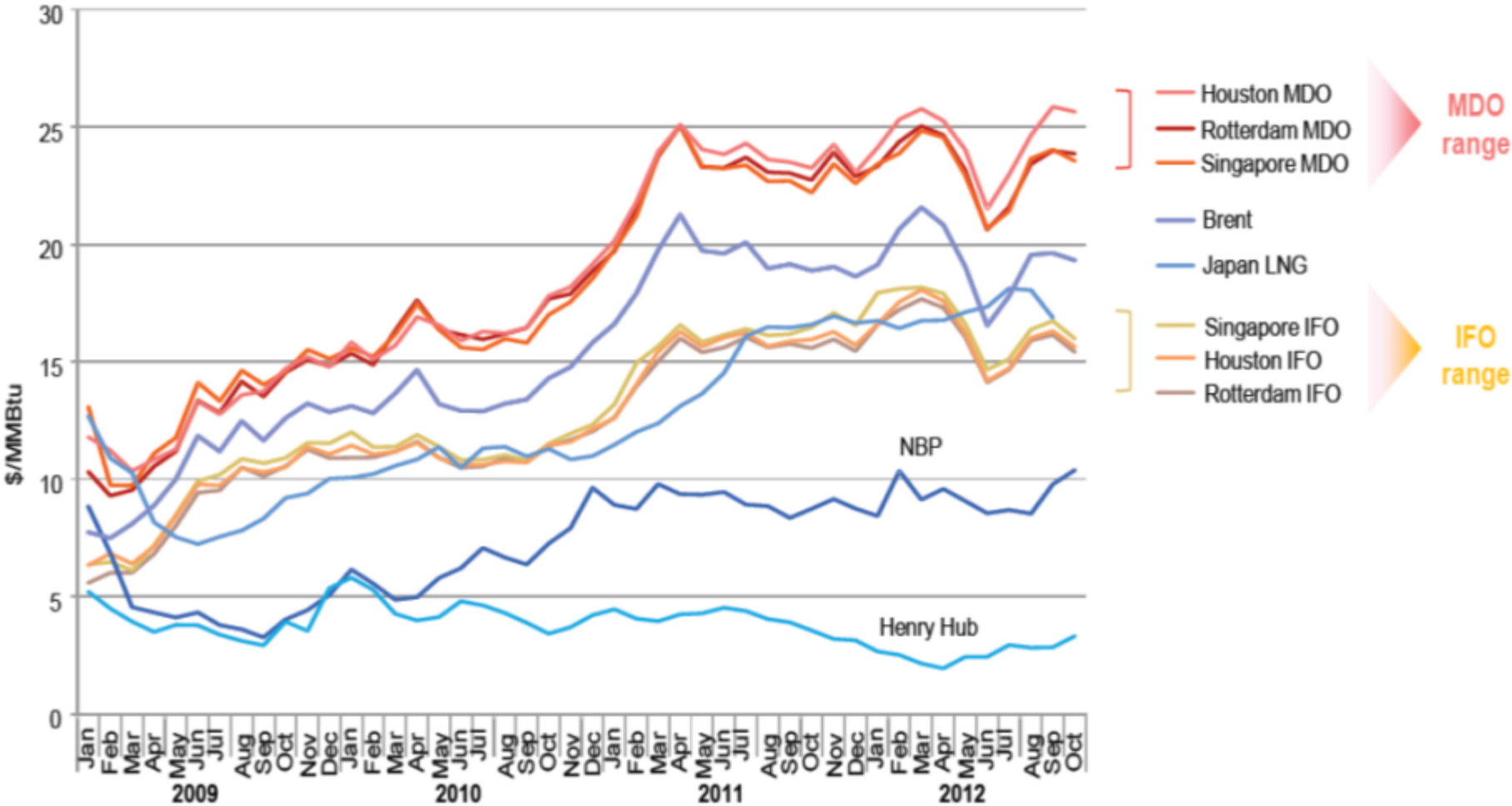
engines in new ships with keel laid after 01.01.2011

### Tier III (in NOx ECAs):

Applicable for engines in new ships with keel laid after 01.01.2016. No current engine on conventional fuel meets Tier III, hence need additional post treatment (e.g. SCR).

LNG fuelled engines will likely be approved as Tier-III equivalent measure

# NG Cost vs Marine diesel



# What to do?

1 LNG as fuel



2 Scrubbers for exhaust gas cleaning



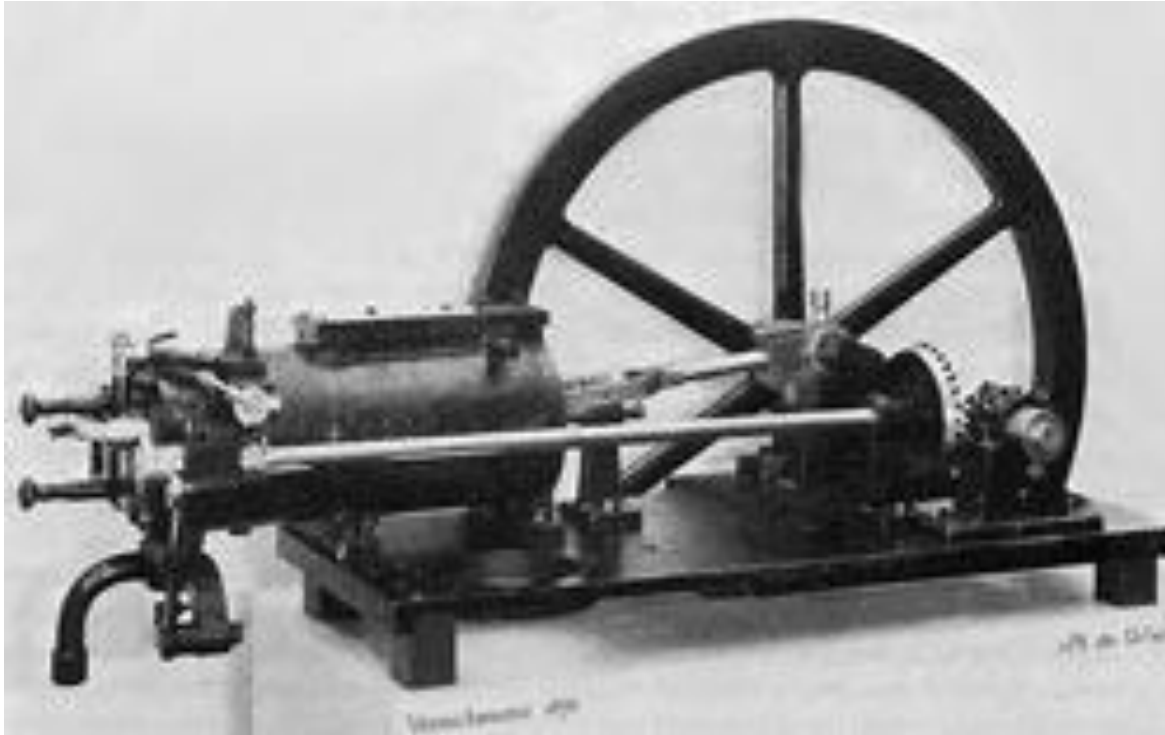
3 Low sulphur fuel



*...or fleet redeployment, i.e. give up trading in ECAs...*

## LNG Basics and Risk

**Gas is not new as fuel for the Internal Combustion Engine !!**



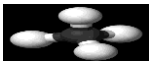
Nikolaus Otto's engine from 1876



# LNG Basics and Risk

## Why is natural gas better?

- Sulphur free
  - SO<sub>x</sub> emissions 100 % reduction
- Burned in lean mixture in combustion engine
  - Low temperature → NO<sub>x</sub> emissions substantially reduced (~ 90% reduction)
  - Lean burn engine- efficient engine without “engine knocking” (uncontrolled self-ignition)
  - Gas diesel: Also some reduction in NO<sub>x</sub>
- Clean combustion – particles almost eliminated
- Methane, CH<sub>4</sub> , has less carbon to hydrogen than oils
  - CO<sub>2</sub> emissions reduced compared to oil combustion (~ 20% reduction)



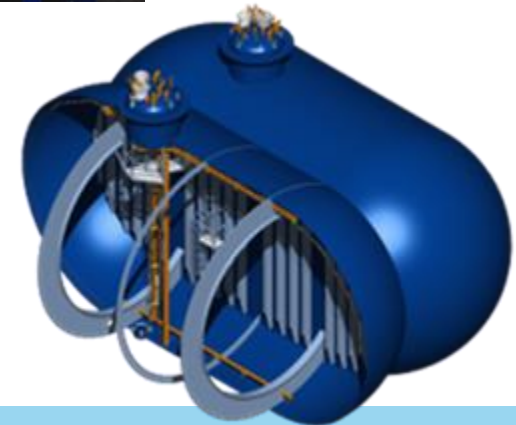
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# LNG Basics and Risk

## Main safety challenges using natural gas as fuel

- Fire/ explosion risk
- Low temperature
- Tank high energy content



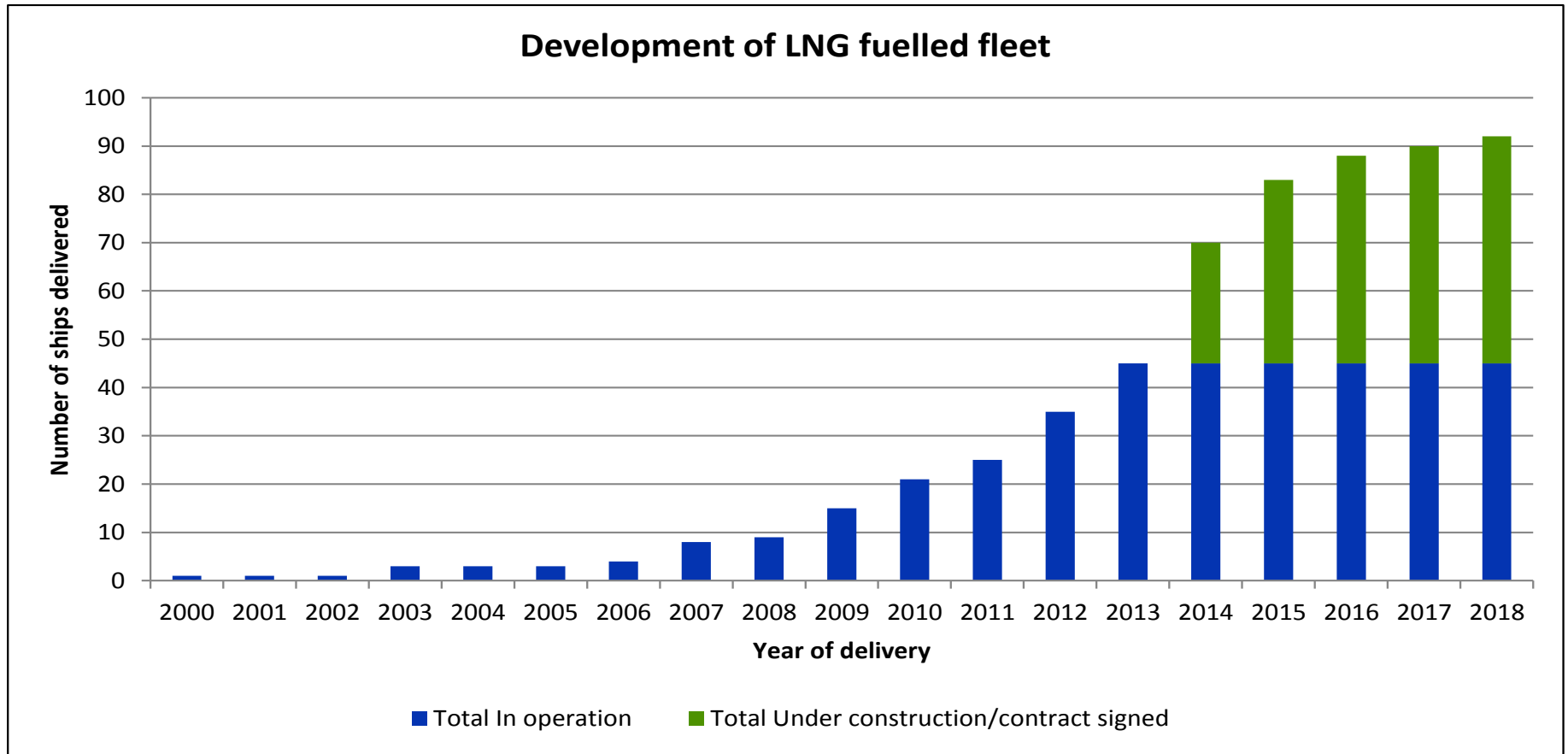
## LNG Basics and Risk

### Main safety challenges using natural gas as fuel

- Low temperature of liquid gas / cold jets from compressed natural gas
  - LNG at  $-163^{\circ}\text{C}$
  - Normal steel will become brittle



## There are currently 92 confirmed LNG fuelled ship projects



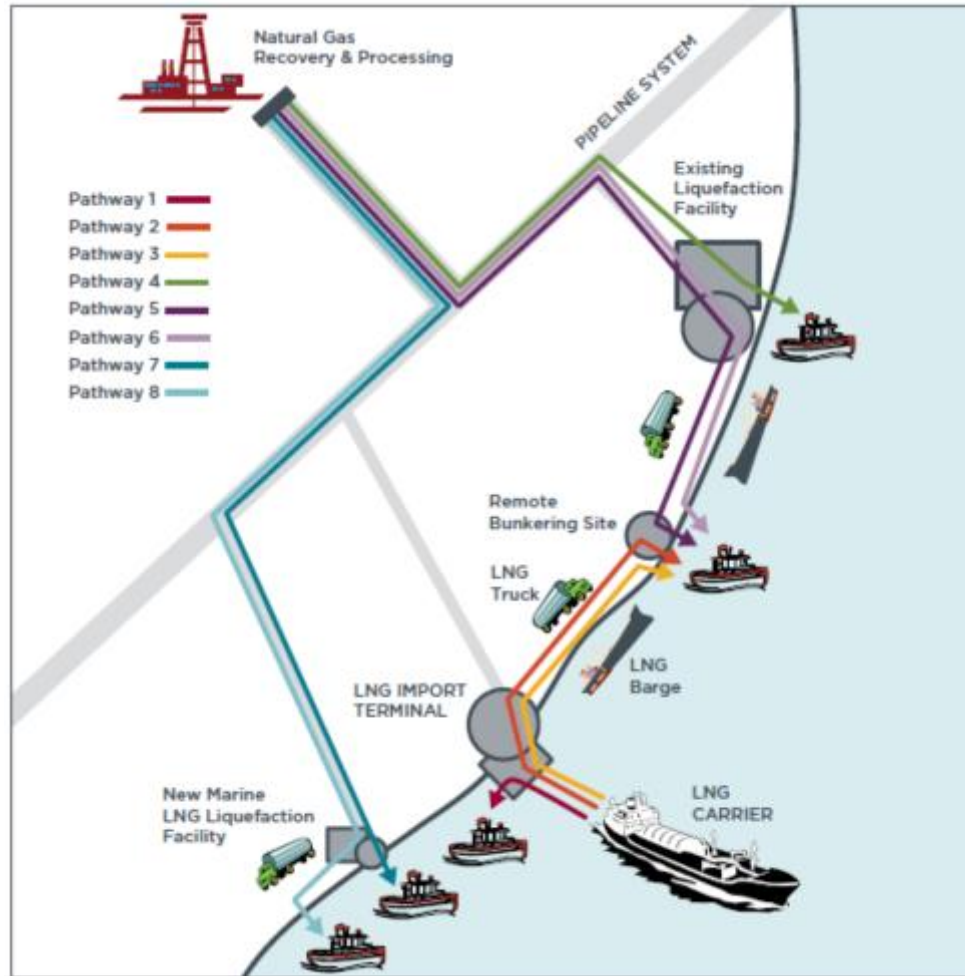
As of January 1 the order book is 47, with 22 to DNV/GL class  
In NA order book is 15 NBs with 4 DNV /GL

## Profile of an LNG fuelled vessel

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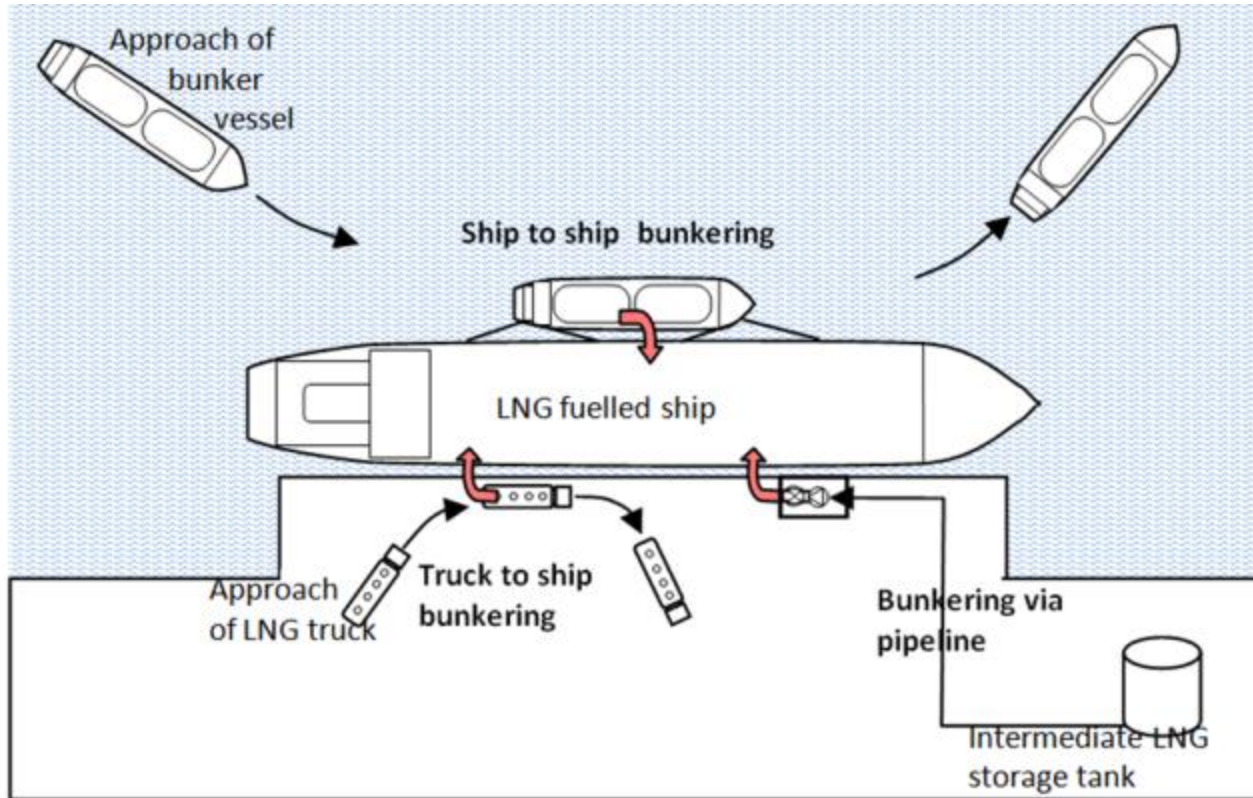
- Vessels that operate inside mostly inside the ECA, e.g short sea shipping
- Coastwise and regionally bound vessels, e.g. ferries, tugs, offshore vessel
- Fuel cost sensitivity
- Sufficient size and onboard space to accommodate the installation
- LNG bunker availability and cost
- Possibilities for conversion
- Fleet renewal demand
- Liner service, vessel on fixed routes
- Environmental profile is beneficial

# LNG Infrastructure and Supply Chain



# LNG Infrastructure and Supply Chain

## LNG Bunkering Options



# LNG Infrastructure and Supply Chain

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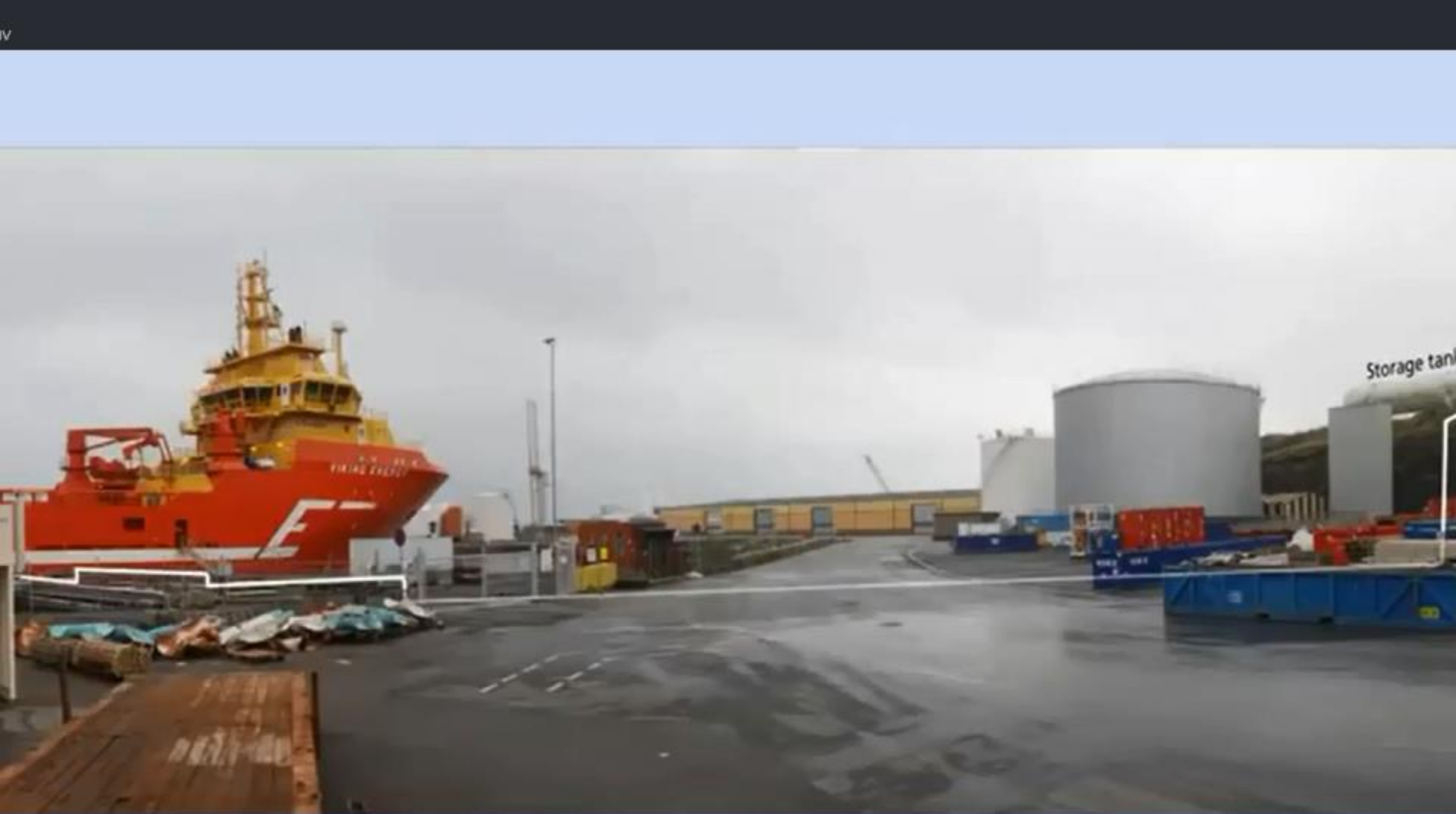
Use of ISO standards containers..





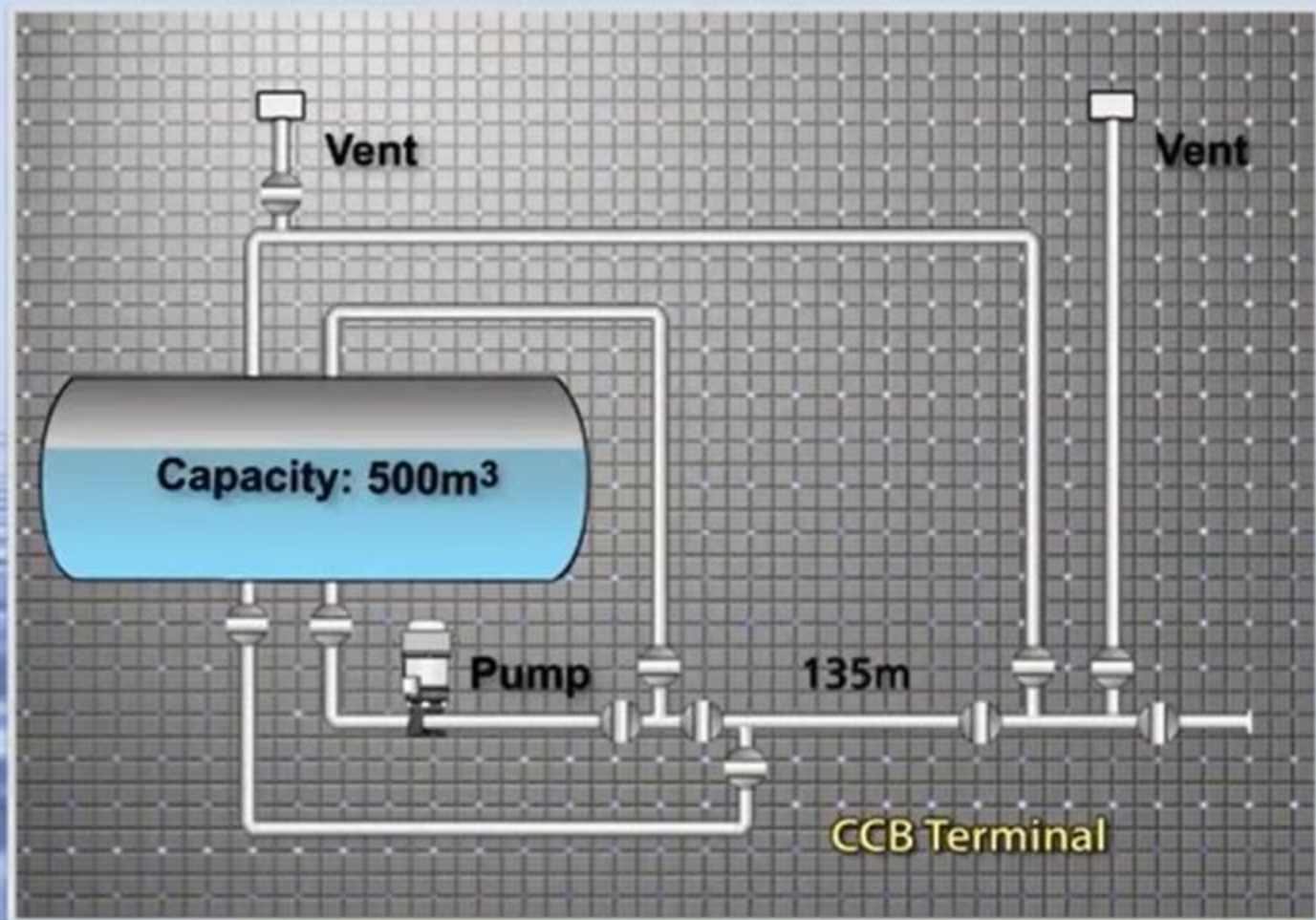
<https://www.youtube.com/watch?v=oZWuTWtp5Rs>



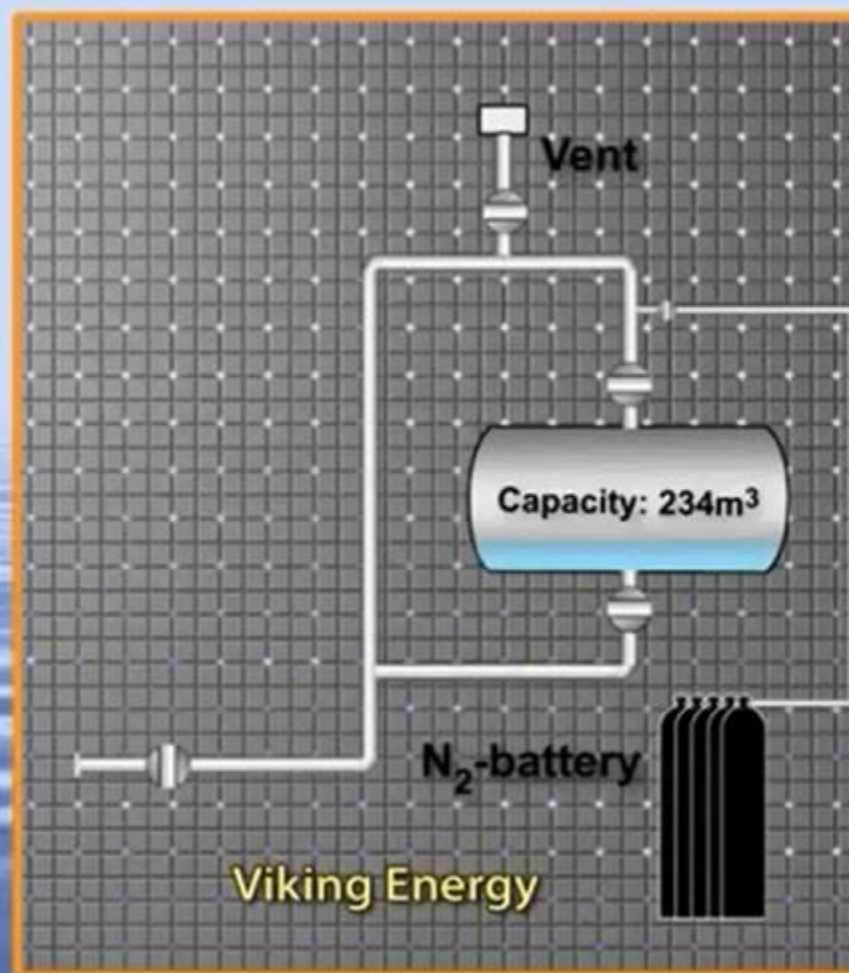


Distance to the connection point: 135m

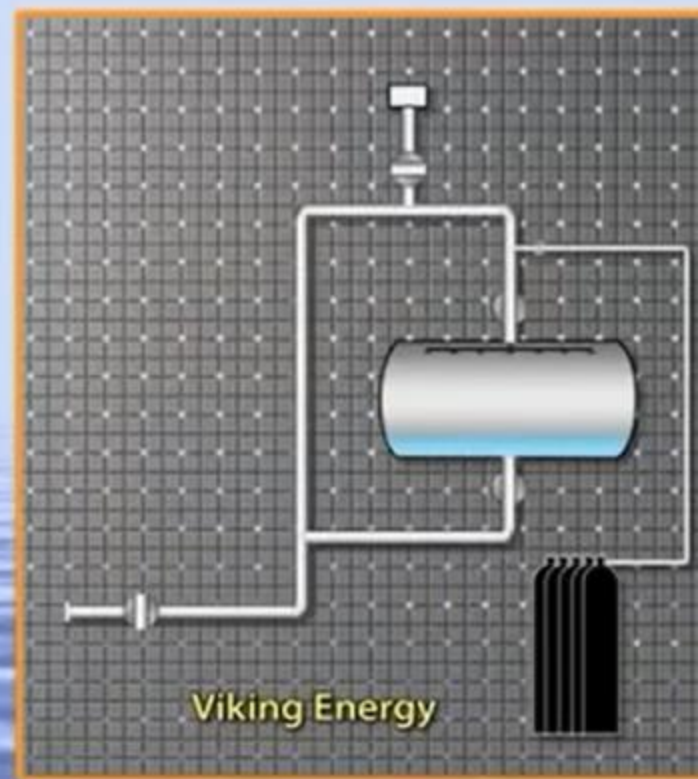
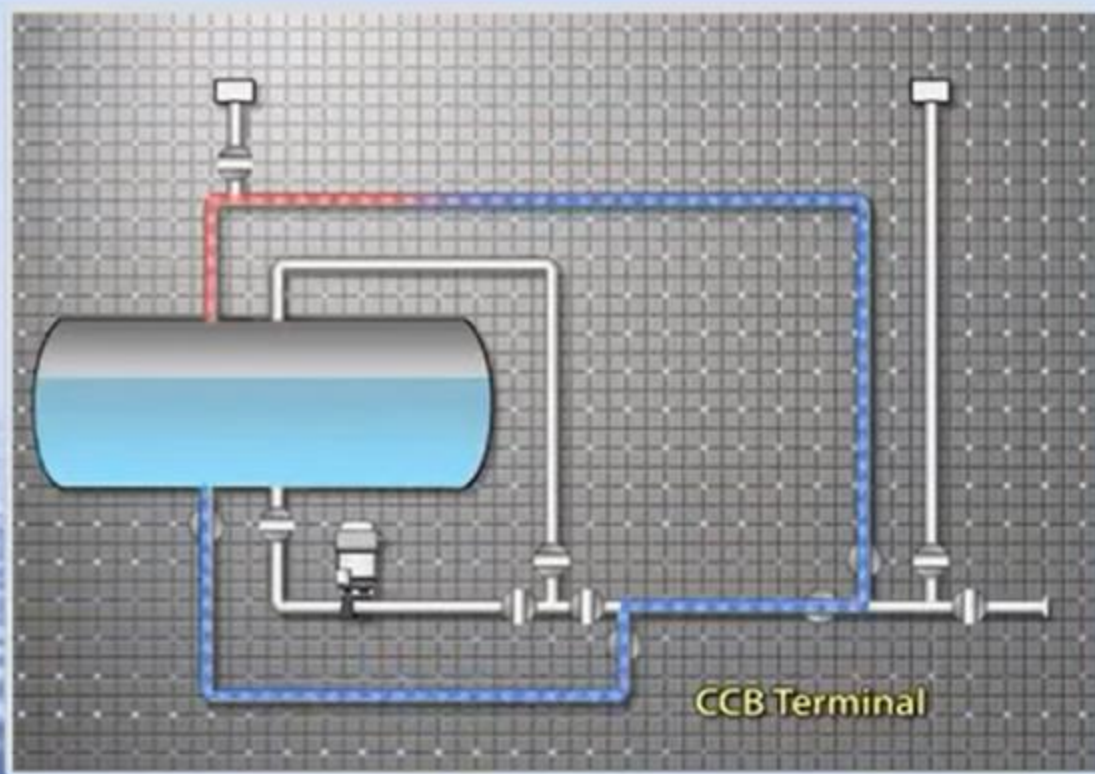
## Basic Landside Layout



## Basic Vessel Layout

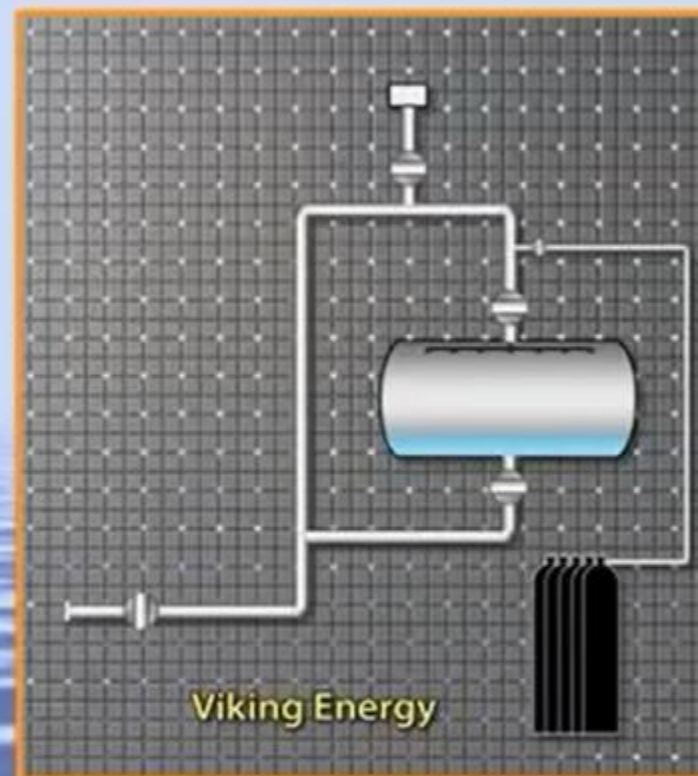
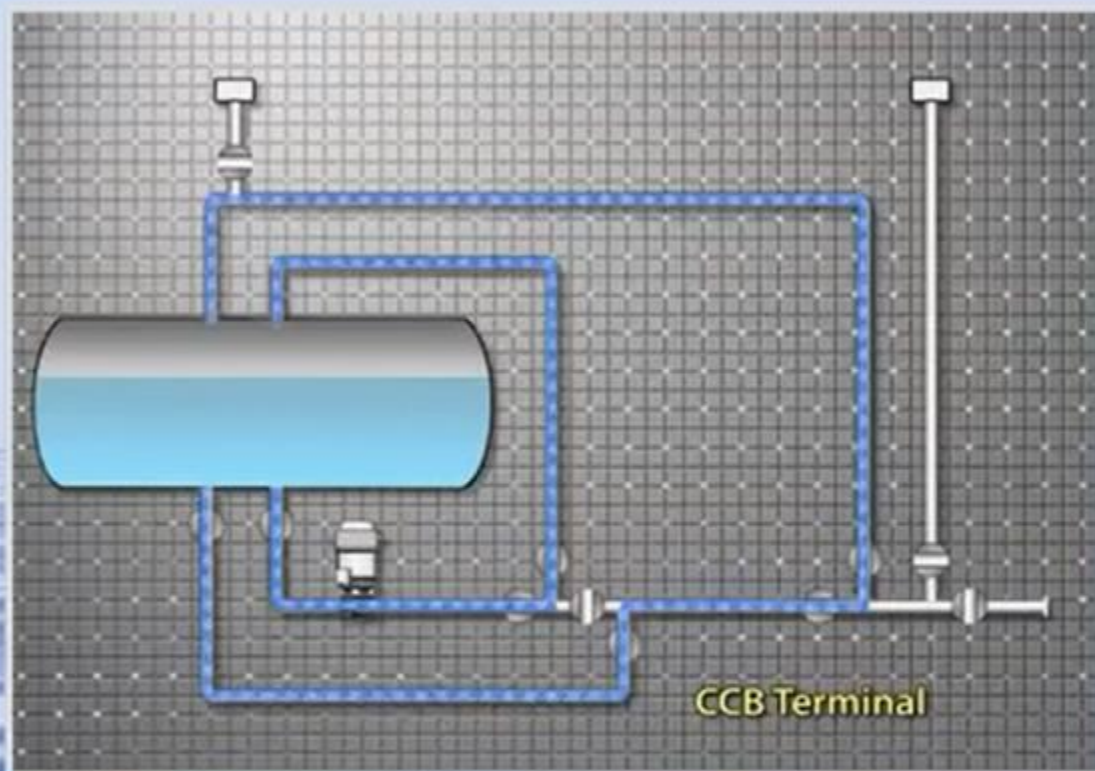


## Step 1 - Initial Precooling



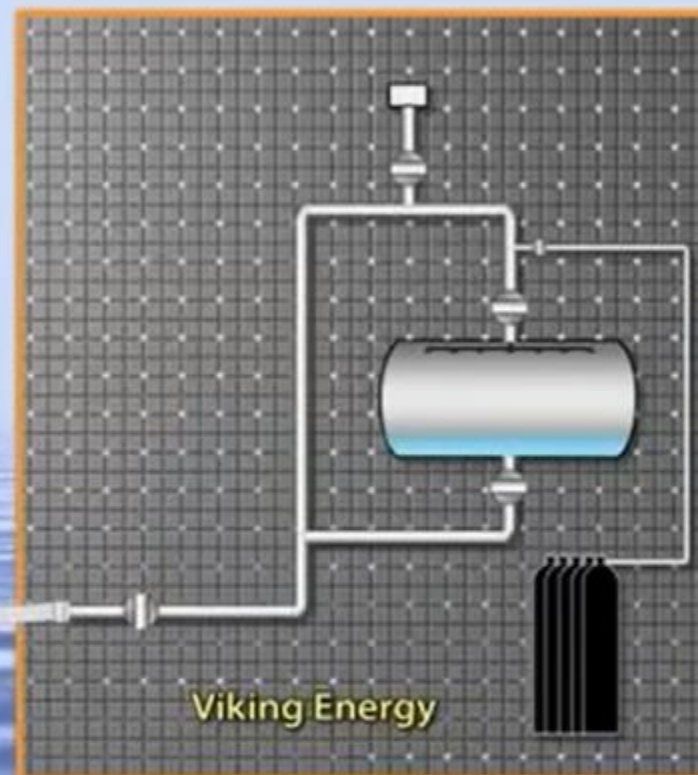
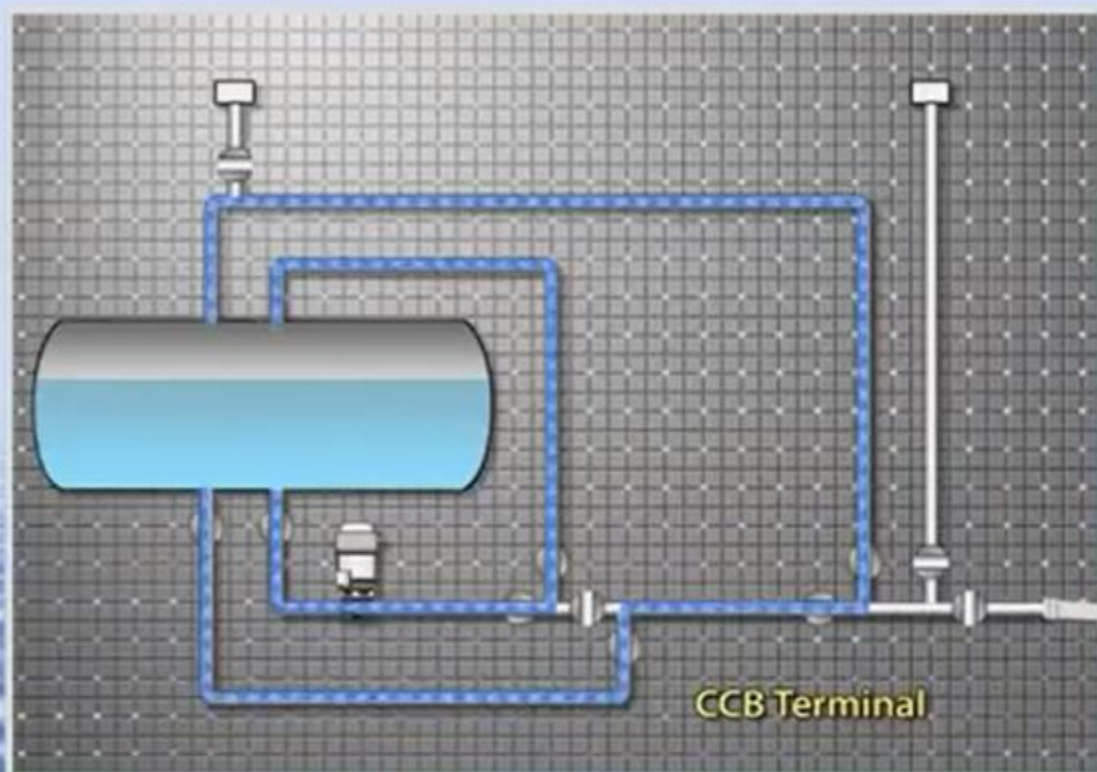
- Precooling of filling lines during vessel berthing and mooring
- The precooling sequence depends on cargo pump, terminal design and size of installation

## Step 2 - Initial precooling of the cargo pump



- At terminals where the pressure difference between the shore and the ship tank is  $> 2$  bars the pressure is utilized as a driving force. This makes the cargo pump redundant

## Step 3 - Connection of bunker hose



- Measures are taken to avoid groundfault arcing (e.g. isolated flanges)

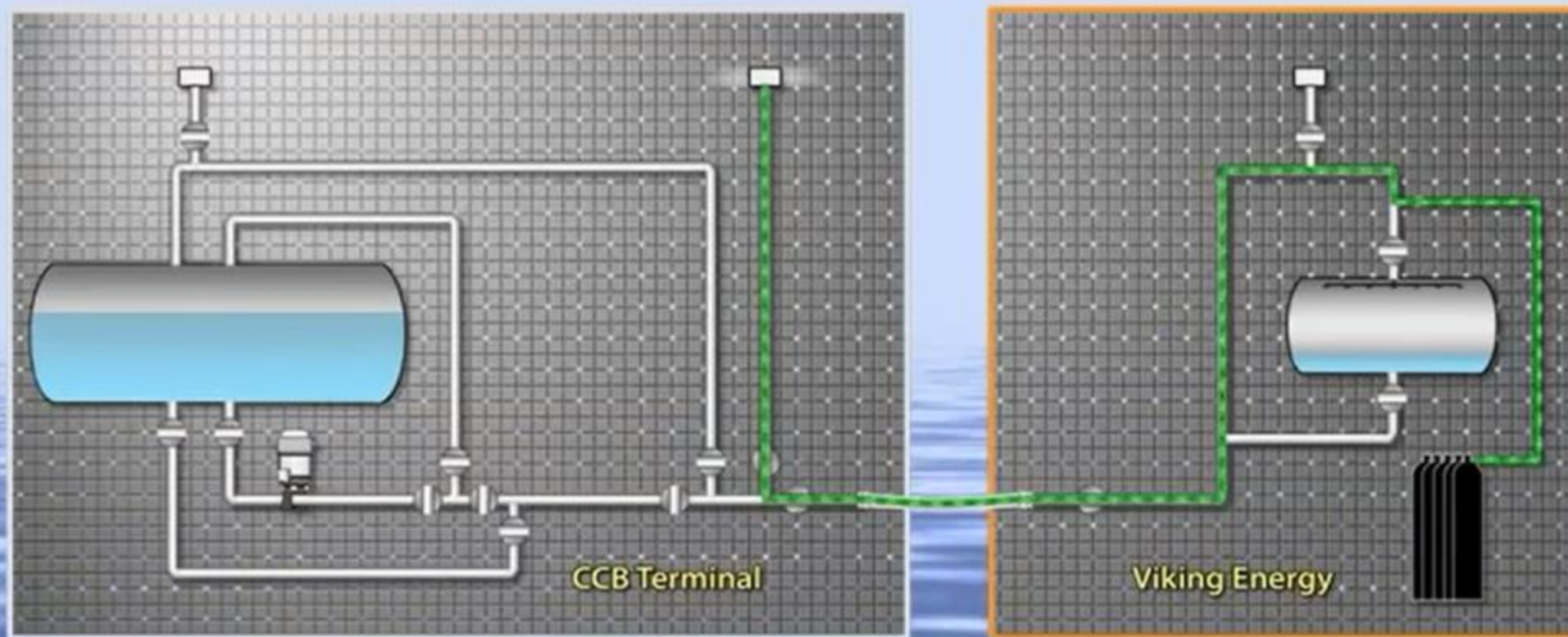
## Step 3 - Connection of bunker hose



- Loading arms are available for bunker hose connection

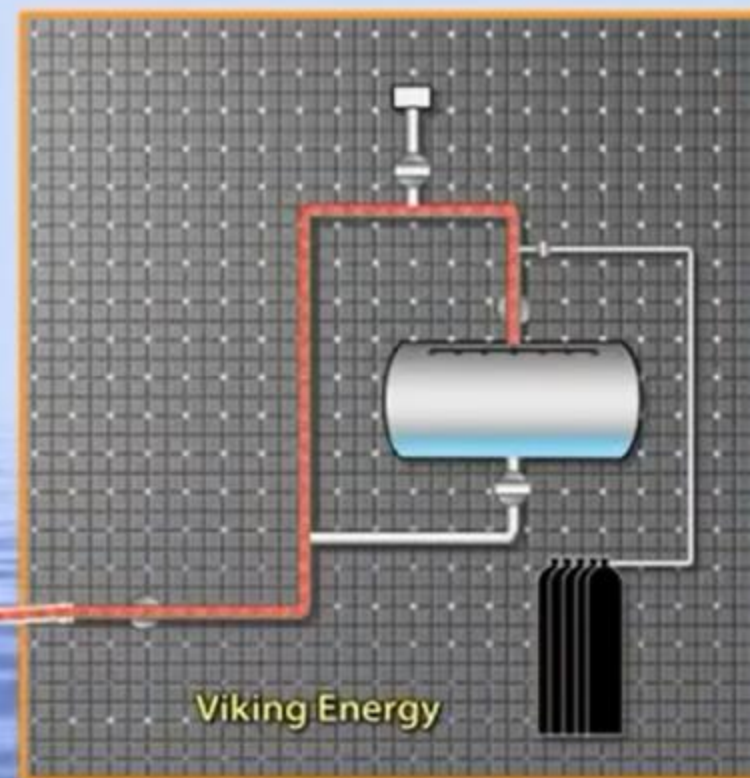
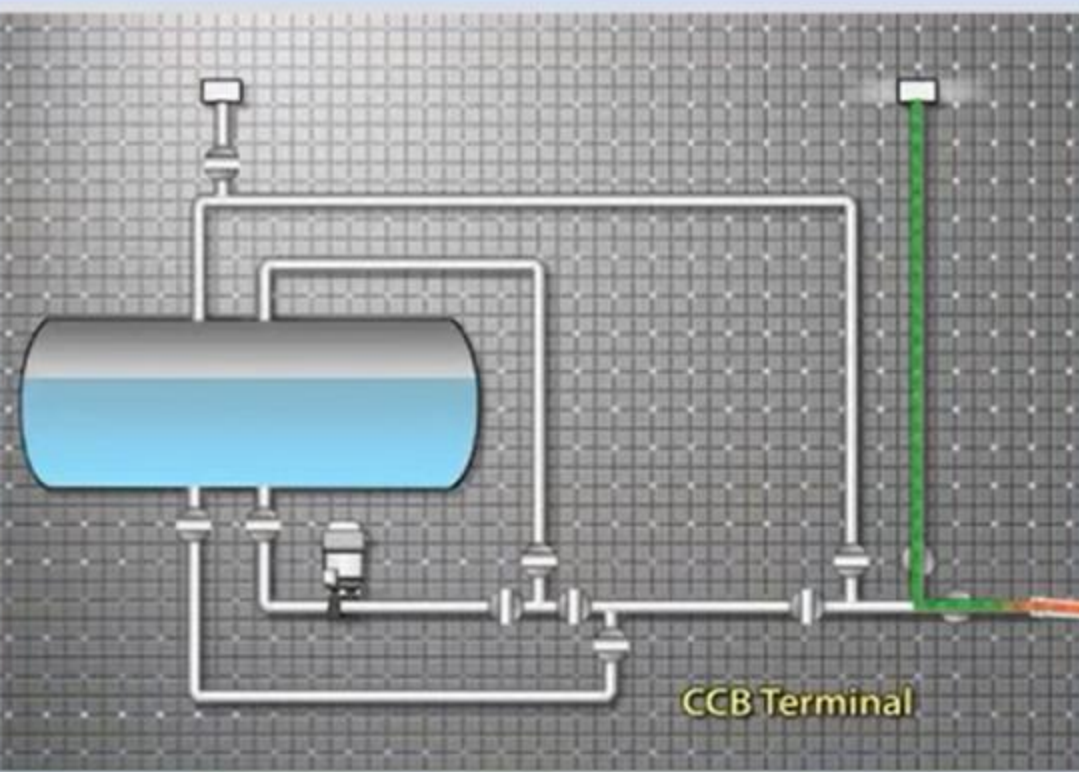


## Step 4 - Inerting the connected system



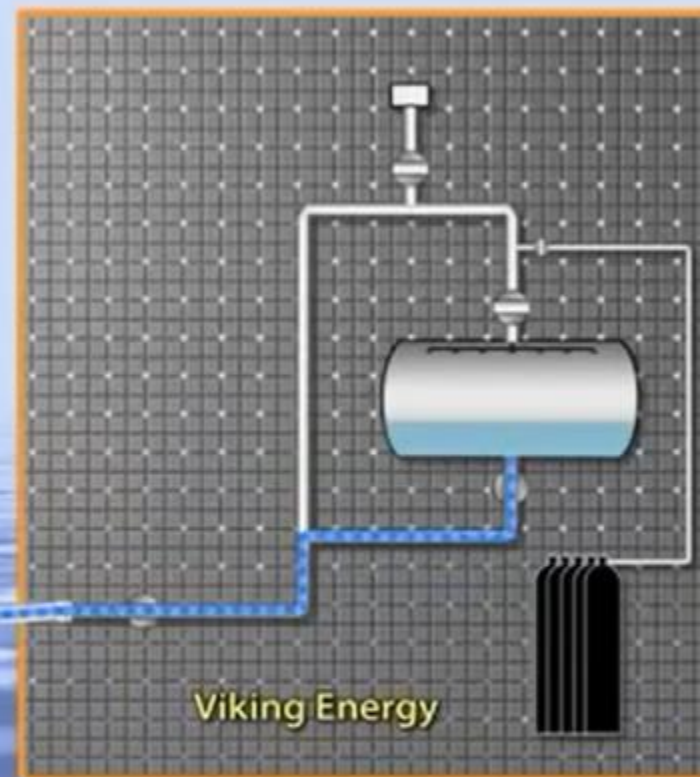
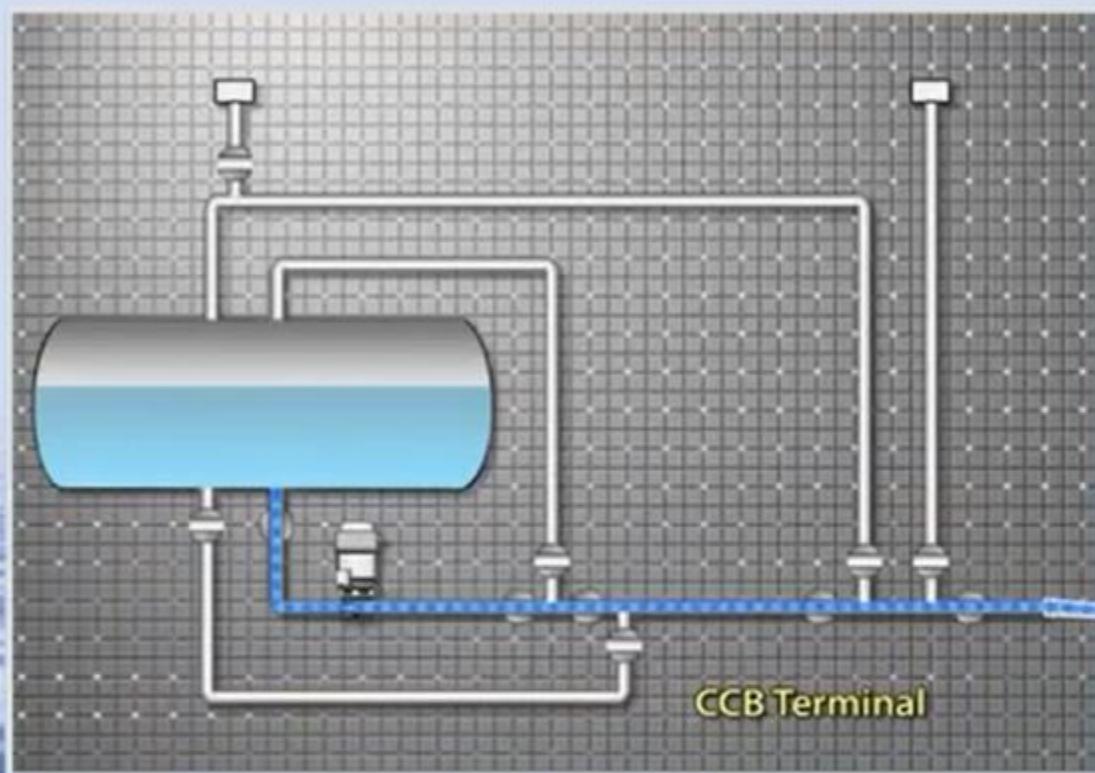
- Inert gas is used to remove moisture and oxygen from the connected system
- Sequence duration: 5mins

## Step 5 - Purging the connected system



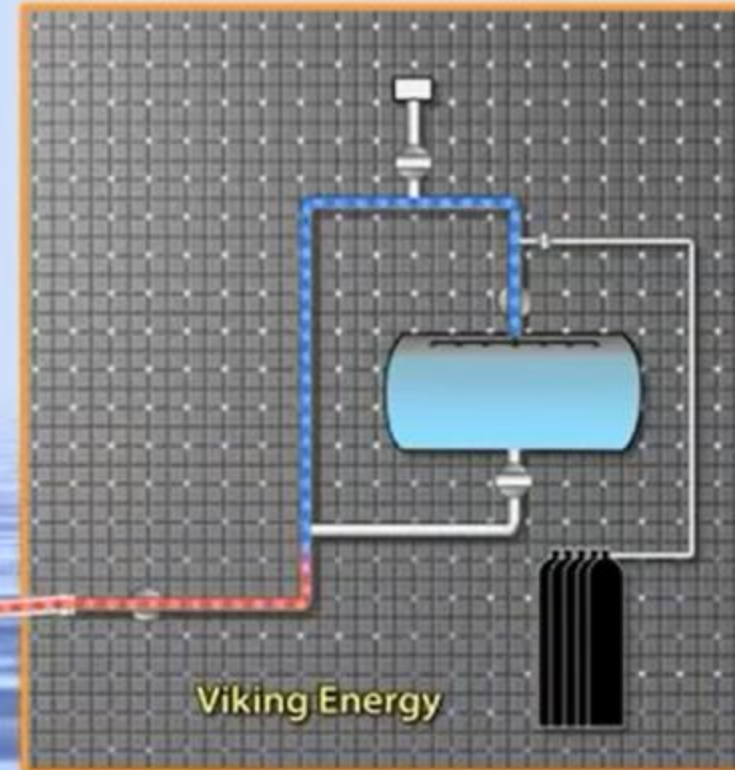
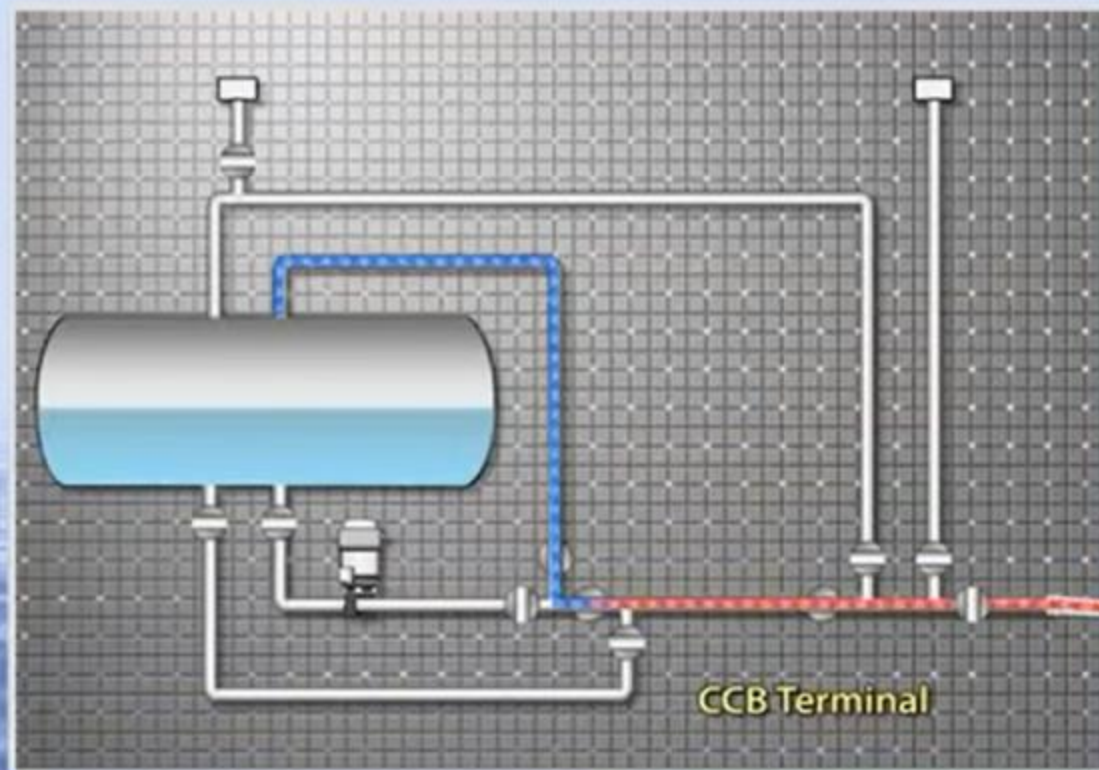
- Venting trace amounts of methane is current practice. The industry is now now looking for zero emission solutions

## Step 6 - Filling sequence



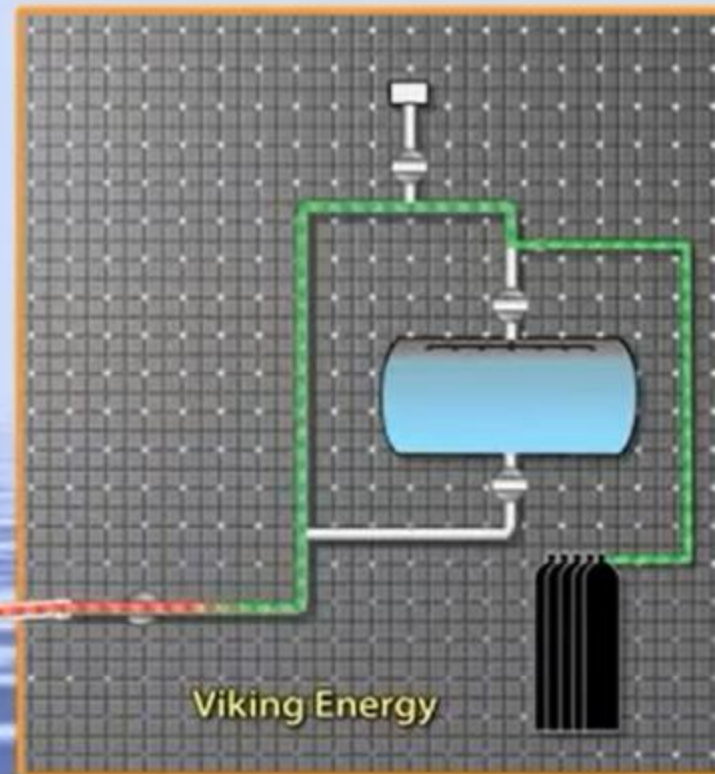
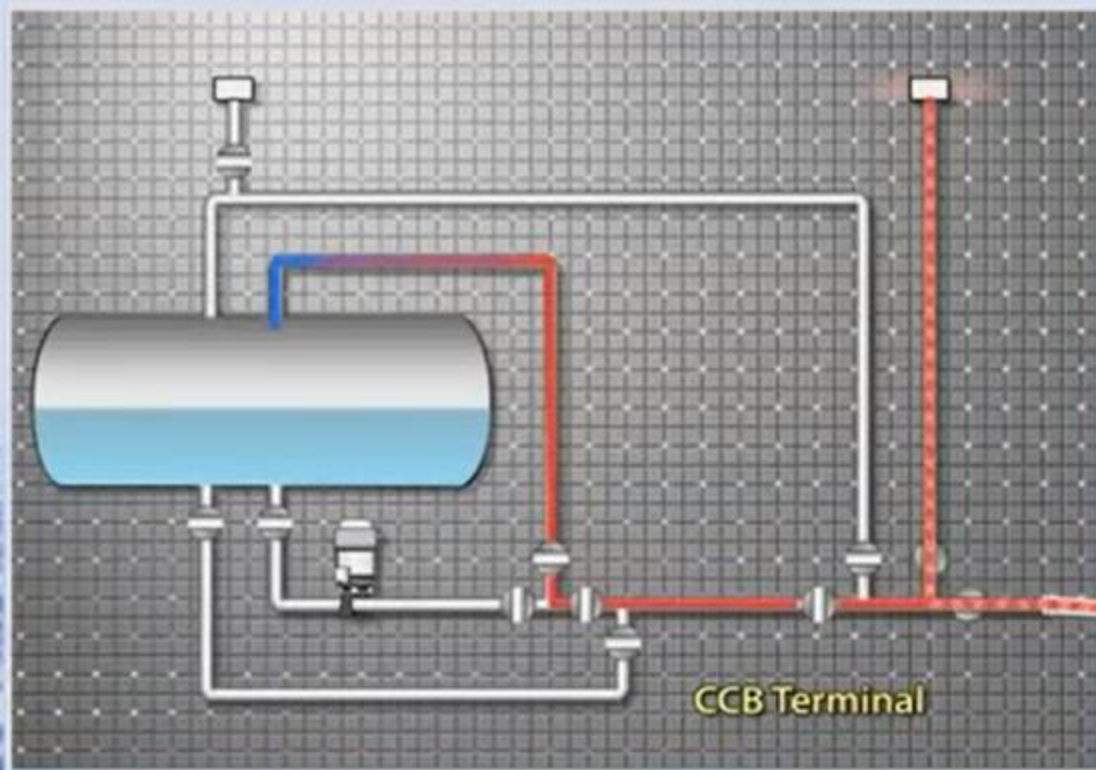
- Transfer speed range 100 - 1,000 m<sup>3</sup>/h depending on tanks and equipment

## Step 7 - Liquid line stripping




- Closing of shore-side valve. NG pressure build-up due to temperature rise. LNG residuals are forced into both tanks

## Step 8 - Liquid line inerting



- Remaining NG in liquid line is removed by inert gas for safety reasons



## Existing LNG Bunkering Solutions

- Transfer from onshore facility to ship
- Truck to ship transfer
- Ship-to-ship bunkering and LNG barges



## Integrating LNG Bunkering Solutions

Transfer from onshore facility to ship  
Truck to ship transfer

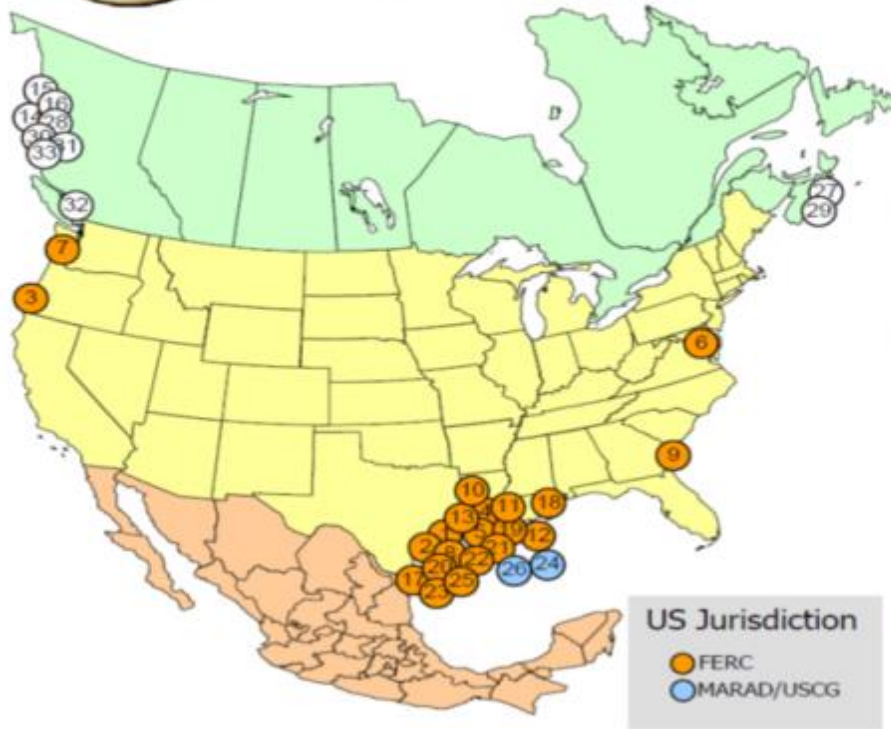
Ship-to-ship bunkering and LNG barges

# LNG Availability – North America

- But there many projects in the “pipeline”



## North American LNG Export Terminals *Proposed/Potential*



As of November 12, 2013

\* Filed Certificate Application

### Export Terminal PROPOSED TO FERC

1. **Freeport, TX:** 1.8 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction)\*
2. **Corpus Christi, TX:** 2.1 Bcfd (Cheniere – Corpus Christi LNG)\*
3. **Coos Bay, OR:** 0.9 Bcfd (Jordan Cove Energy Project)\*
4. **Lake Charles, LA:** 2.4 Bcfd (Southern Union - Trunkline LNG)
5. **Hackberry, LA:** 1.7 Bcfd (Sempra – Cameron LNG)\*
6. **Cove Point, MD:** 0.82 Bcfd (Dominion – Cove Point LNG)\*
7. **Astoria, OR:** 1.25 Bcfd (Oregon LNG)\*
8. **Lavaca Bay, TX:** 1.38 Bcfd (Exceleerate Liquefaction)
9. **Elba Island, GA:** 0.35 Bcfd (Southern LNG Company)
10. **Sabine Pass, LA:** 1.96 Bcfd (Sabine Pass Liquefaction)\*
11. **Lake Charles, LA:** 1.07 Bcfd (Magnolia LNG)
12. **Plaquemines Parish, LA:** 1.07 Bcfd (CE FLNG)
13. **Sabine Pass, TX:** 2.1 Bcfd (ExxonMobil – Golden Pass)

### PROPOSED CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

14. **Kitimat, BC:** 0.7 Bcfd (Apache Canada Ltd.)
15. **Douglas Island, BC:** 0.25 Bcfd (BC LNG Export Cooperative)
16. **Kitimat, BC:** 3.23 Bcfd (LNG Canada)

### POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS

17. **Brownsville, TX:** 2.8 Bcfd (Gulf Coast LNG Export)
18. **Pascagoula, MS:** 1.5 Bcfd (Gulf LNG Liquefaction)
19. **Cameron Parish, LA:** 0.16 Bcfd (Waller LNG Services)
20. **Ingleside, TX:** 1.09 Bcfd (Pangea LNG (North America))
21. **Cameron Parish, LA:** 0.20 Bcfd (Gasfin Development)
22. **Cameron Parish, LA:** 0.67 Bcfd (Venture Global)
23. **Brownsville, TX:** 3.2 Bcfd (Eos LNG & Barca LNG)
24. **Gulf of Mexico:** 3.22 Bcfd (Main Pass - Freeport-McMoRan)
25. **Brownsville, TX:** 0.3 Bcfd (Annova LNG)
26. **Gulf of Mexico:** 1.8 Bcfd (Delfin LNG)

### POTENTIAL CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

27. **Goldboro, NS:** 0.67 Bcfd (Pieridae Energy Canada)
28. **Prince Rupert Island, BC:** 4.2 Bcfd (BG Group)
29. **Melford, NS:** 1.8 Bcfd (H-Energy)
30. **Prince Rupert Island, BC:** 2.5 Bcfd (Pacific Northwest LNG)
31. **Prince Rupert Island, BC:** 3.8 Bcfd (ExxonMobil – Imperial)
32. **Squamish, BC:** 0.27 Bcfd (Woodfibre LNG Export)
33. **Kitimat/Prince Rupert, BC:** 0.3 Bcfd (Triton LNG)

*Office of Energy Projects*



## Regulatory Regime

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The use of gas as fuel in ships other than LNG carriers is not covered by international conventions and such installations will need ***additional acceptance by flag***

## Regulatory Regime – IMO Interim Guidelines

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IMO Resolution **MSC.285(86)**

### ***'Interim Guidelines on Safety for Gas Fuelled Engine Installations in Ships'***

- Finalized by IMO in 2009
- Only for natural gas and internal combustion engines
- Same technical content as the DNV Rules, in addition a risk analysis is required for new designs and concepts
- Not mandatory

### **Next step is the mandatory IMO "IGF code"**

- To include other gases than methane/ natural gas, also low flashpoint liquids
- To include other machinery types like fuel cells, gas turbines, boilers
- Expected to enter into force in 2017

## Regulatory Regime – USA & Canada

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USCG has issued a Policy Letter to accept LNG fuelled ship based on IMO Interim guide lines, with some changes;

- use of US standards for type approved products
- fire protection, including monitoring systems
- electrical systems, in particular the designation of hazardous areas.

Special considerations for LNG tanks below accommodations, and the use of ESD concept.

- Transport Canada do not permit the use of LNG as fuel for ships
- IMO Interim Guidelines are not referenced in any Canadian regulation.
- WIP to develop regulations for the use of LNG as fuel for Canadian vessels

- 
- - USCG Draft PL No. 01-13 "Guidelines for Liquefied Gas Fuel Transfer Operations and Training of Personnel of Vessels using Natural Gas as Fuel
  - - USCG Draft PL No. 02-13 "Guidance Related to Vessels and Waterfront facilities Conducting Liquefied Natural gas (LNG) Marine Fuel Transfer (Bunkering) Operations
  - **Code Description**
  - NFPA59A            Standard for the Production, Storage, and handling of LNG
  - USCG 33CFR Part 127    Waterfront facilities handling LNG and Liquefied Hazardous Gas
  - USCG 49CFR Part 193    LNG facilities: Federal Safety Standard
  - 18 CFR Part 153            Applications for authorization to construct, operate, or modify facilities used for the export or import of natural gas

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- Finalized by IMO in 2009
- Only for natural gas and internal combustion engines
- Same technical content as the DNV Rules, in addition a risk analysis is required for new designs and concepts
- Not mandatory
  
- Class- DNV GL is developing a Recommended Practice (RP) for LNG bunkering. A draft was issued in October 2013, and following an external comment period, the document will be formally published.

# Thank you for your attention!

**Geoff Ashton**  
**2014-05-14**

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