

FRD - Floating Regas Dock

The next generation FSRU solution

...offering superior regas regularity and cost benefits...

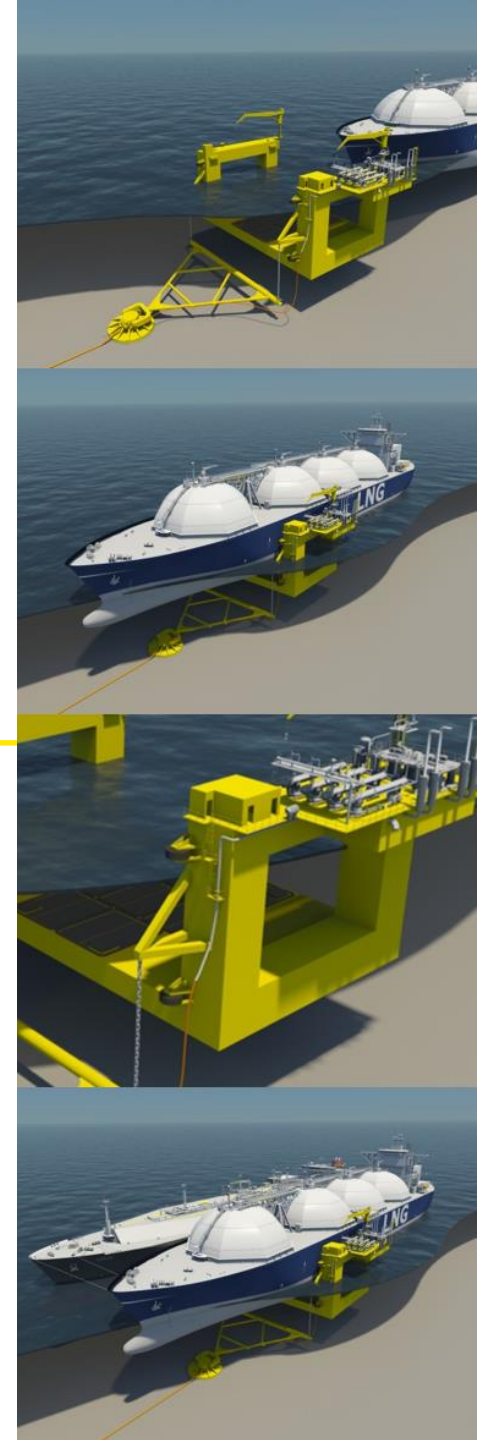
Presentation by
Mr Knut Bredahl



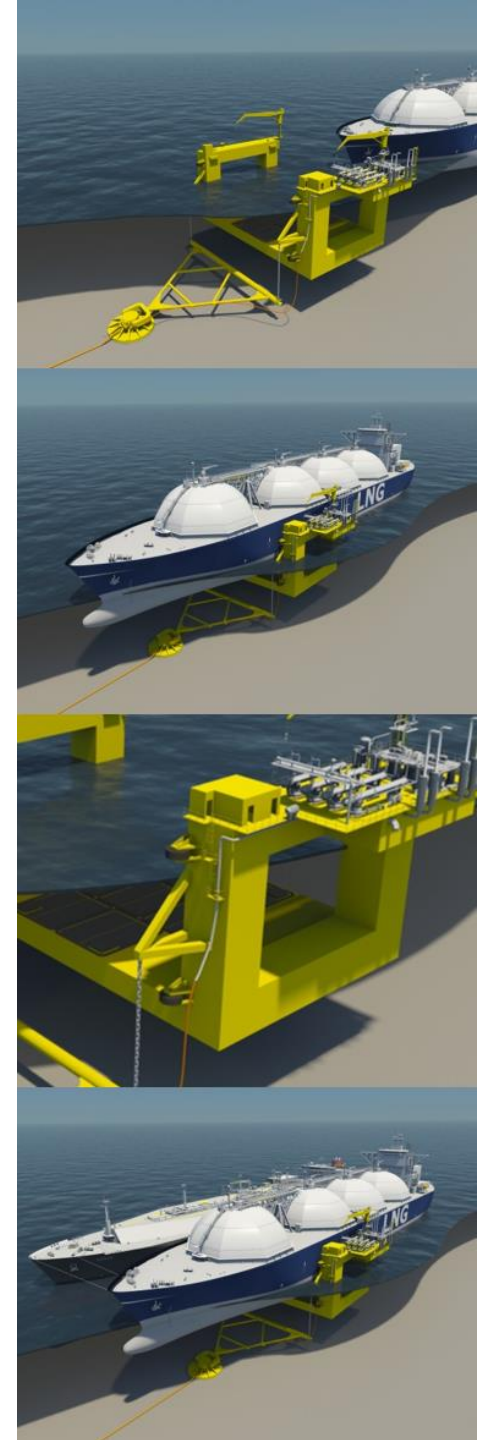
**FLNG
Global**

8 - 9 May 2017

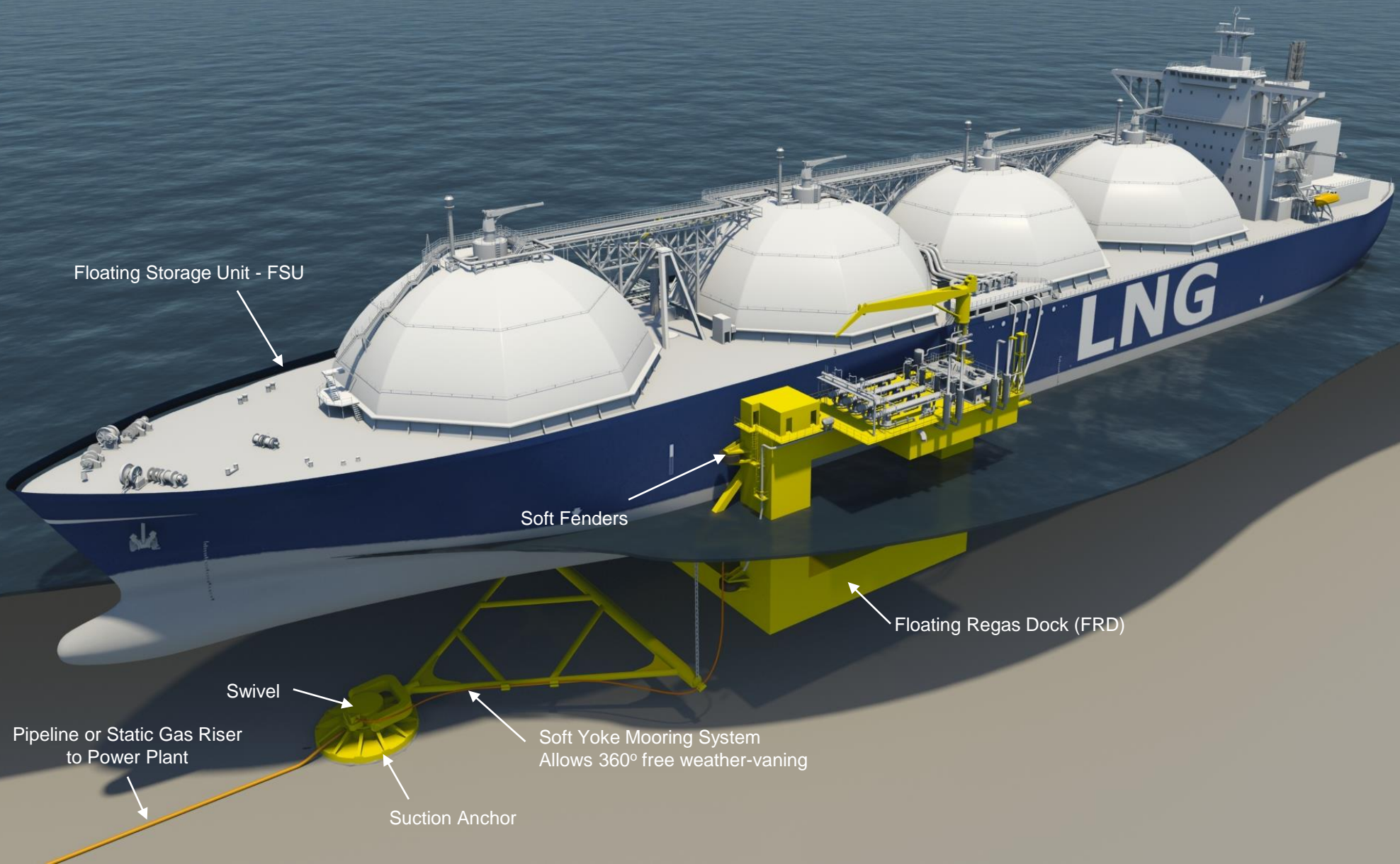
Hotel Okura,
Amsterdam



Floating Regas Dock - FRD System Overview



FRD - Main Systems and Components



FRD and Power Plant - Overview

- 360° Weather-vaning = High availability
- Flexible regas configuration. (typ. 4 x 50 MMSCFD)
- Tsunami and Earthquake Resistant
- 100% Boil-off conservation
- Min Waterdept: Min 25 m
- FSU may be replaced



Typical Power Plant

(onshore or floating)

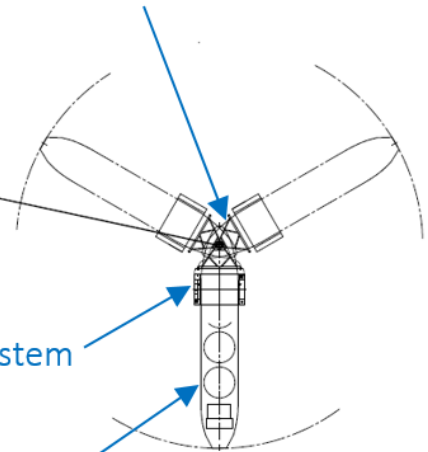
Image: Courtesy of Wärtsilä

Gas Pipeline to Power Plant
(Optional: Static Riser to save installation cost)

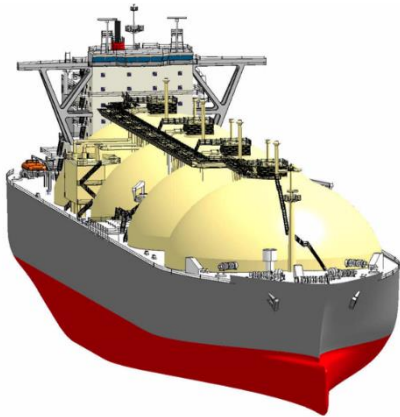
Turret Mooring of LNGC by FRD
360° weather-vaning

FRD w/LNG Regasification System

Conventional LNGC, 125-170,000 m³



FRD – The next generation FSRU...



1 x old LNGC

Minor modifications required

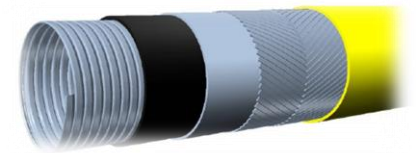
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FRD

Floating Regas Dock w/Turret Mooring

+



Gas Flowline

Flexible Riser to save installation cost
(for short flowlines)

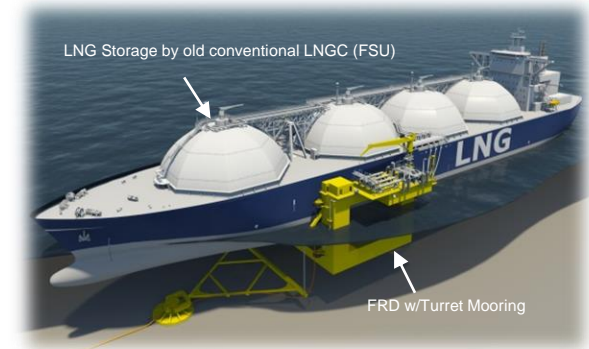
= The Complete LNG Logistics Solution

Storage | Regas | Distribution

FRD – Replacing Costly Infrastructure

A typical complete FRD solution consists of:

- 1 x FRD w/Turret Mooring and STS Transfer System
- 1 x old Moss LNGC for storage (FSU) (minor modification required)
- Gas flowline to shore



The FRD provides superior cost advantages over:

Onshore Terminal w/Jetty



- Jetty w/LNG pipeline to shore
- Mooring Berth for LNG Carrier w/LNG Loading Arms
- Onshore LNG Storage
- Onshore LNG Regas System
- Breakwater structure (if required)
- Dredging

FSRU at Offshore Berth



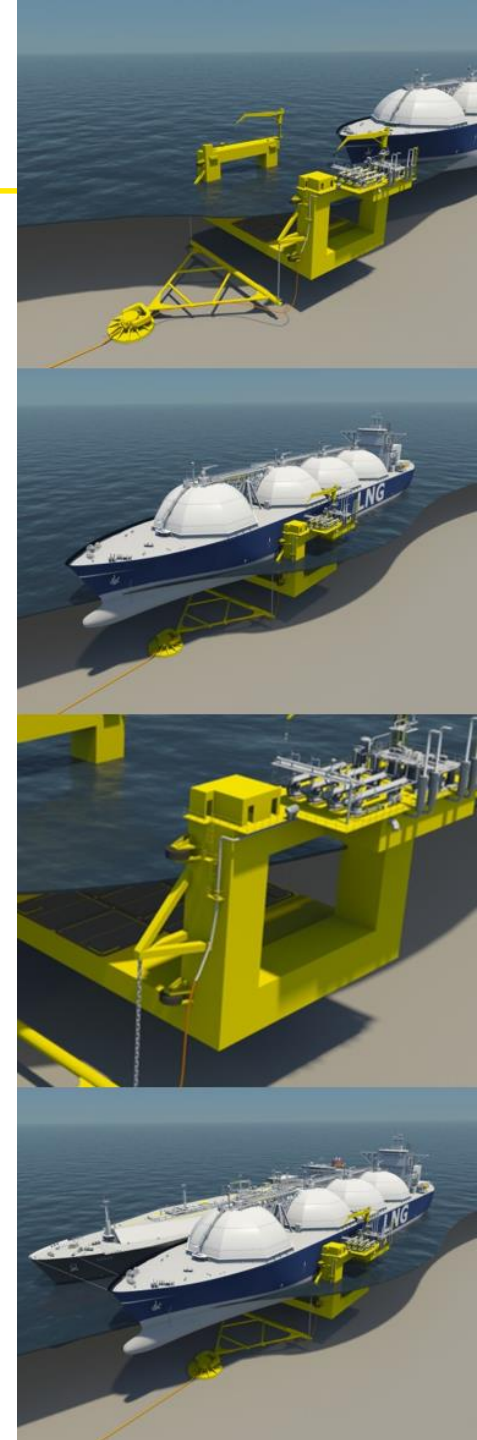
- FSRU w/LNG Regas System
- Offshore Mooring Berth for FSRU
- Offshore Mooring Berth for visiting LNGC
- Breakwater structure (if required)
- Gas flowline to shore
- Dredging

Turret Moored FSRU



- FSRU w/LNG Regas System
- Turret Mooring System
- Side by side LNG transfer system from LNGC to FSRU
- Gas flowline to shore

Technology Development History and Highlights



Technology Ownership



The ownership of the FRD/HiLoad Technology is split between two companies:

HiLoad LNG AS

Arendal – Norway

LNG and GAS



Shareholders:  **SEVAN** marine (95%)  (5%)


Note: Sevan owned 43% by 

Remora AS

Stavanger – Norway

OIL

REMORA

- Major shareholder: Teekay (90%) 
- Field operation performed for HiLoad DP No.1 in Brazil. Vessel owned and operated by Teekay



Extensive Technology Development Program

17 YEARS

17-years extensive technology development project and qualification.

150,000 man-hours
(combined by HiLoad LNG AS and Remora)

Full scale testing

7 MODEL TESTS

7 Model Test carried out:

- Docking
- DP Station Keeping
- 100-year survival
- Towing

FIELD OPERATION OF FIRST VESSEL

Field operation performed in Brazil.

Vessel owned and Operated by Teekay



First idea – year 2000...

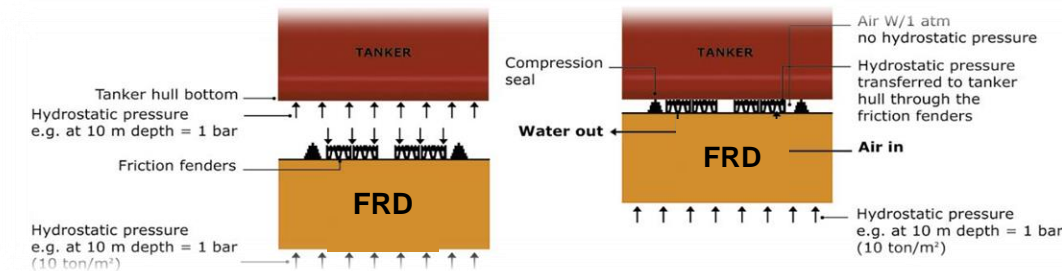
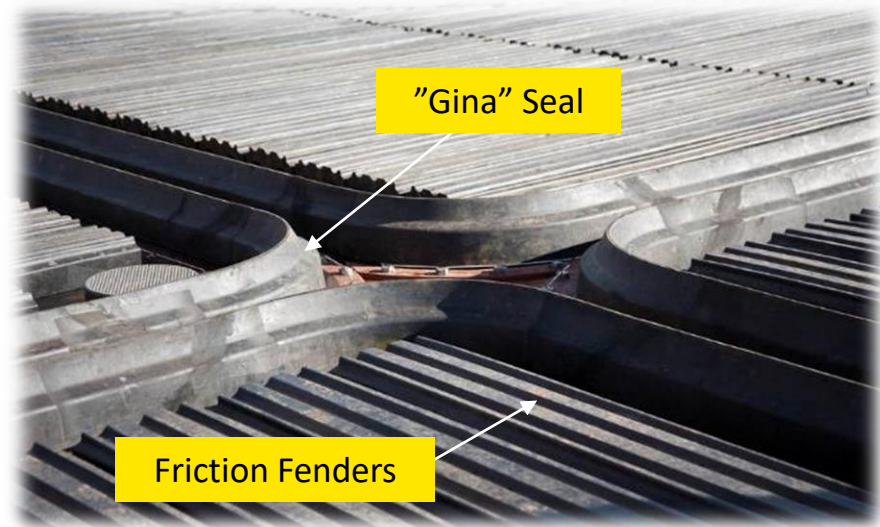
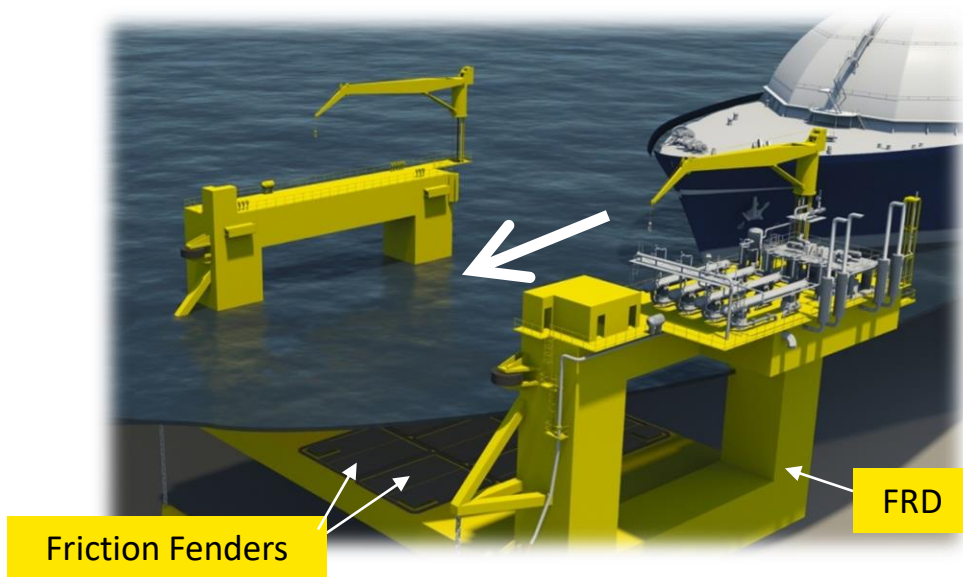


Model Tests



Field Operation of first vessel (crude oil)

Friction Attachment System – LNG Carrier Interface

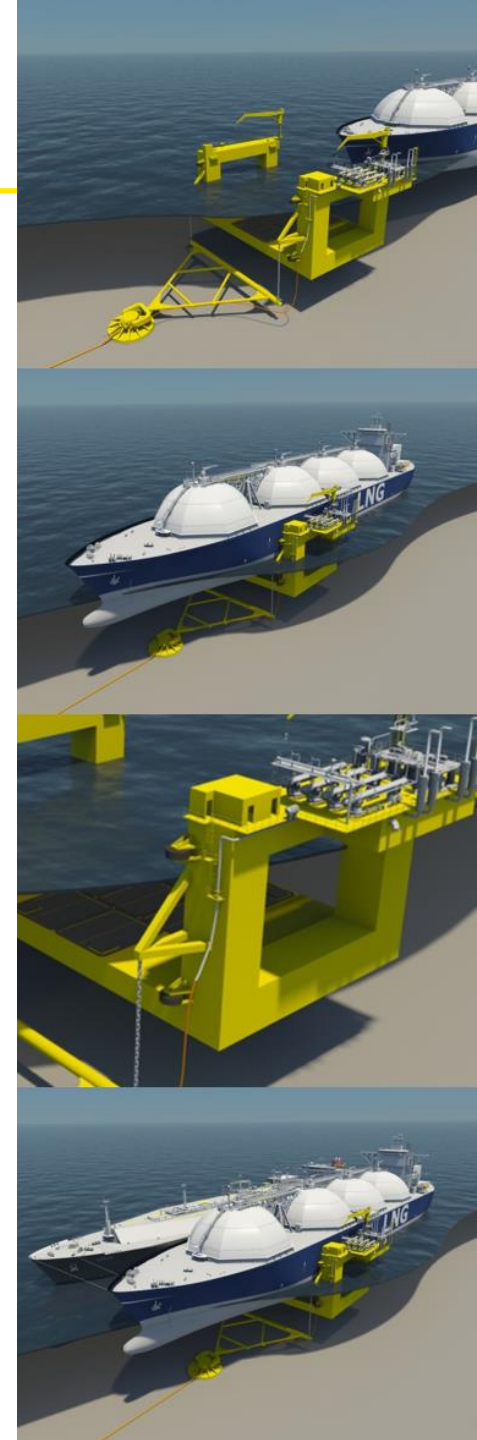


High Safety Factor at Max Mooring Loads | Robust and Redundant System
100+ Successfully Operations Completed (by Remora/Teekay)

FRD – Floating Regas Dock



Technical &
Operational



FSU Approach to FRD

Change out of FSU only if drydocking is needed.

Floating Storage Unit (FSU)

Conventional LNGC

125,000 – 170,000 m³

Minor modifications required

Free width inside FRD: 50 m

Waterdepth shown: 25 m

LNGC assisted by two tugs (FWD and AFT)
during docking and undocking operations
(LNGC mooring winches may be used for final positioning)

Soft Fenders

Docking Clearance = 5 m

Friction Attachment System

Soft Landing Fenders

Clump Weight for Soft Yoke

10" Gas Swivel
No electrical, control or
hydraulic swivel required

Pipeline or Static Gas
Riser to Power Plant

Suction Anchor

Soft Yoke Mooring System
Allows 360° free weather-vaning of LNGC

Power Generators

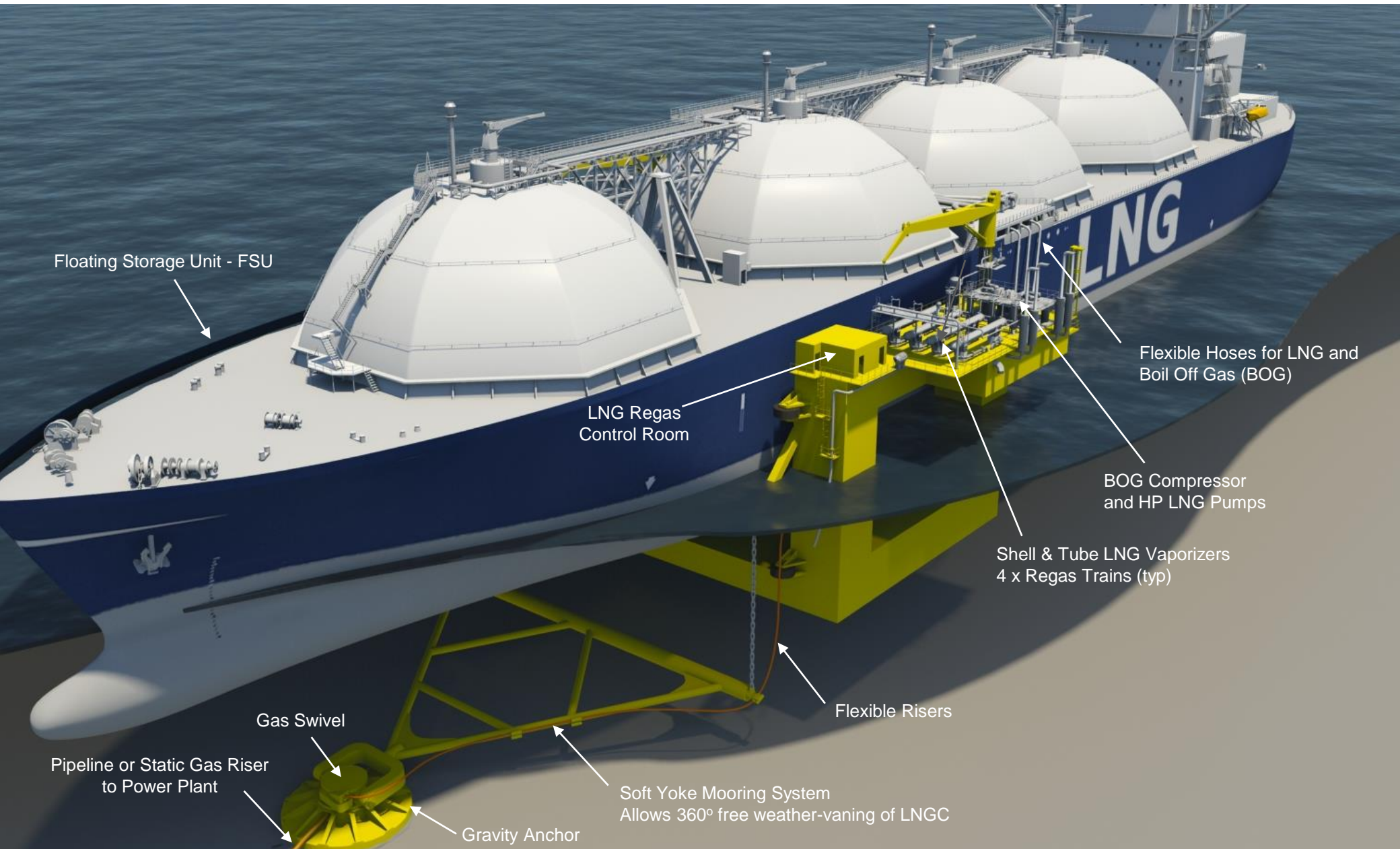
BOG Compressor
and HP LNG Pumps

Shell & Tube LNG Vaporizers
4 x 50 mmscfd Regas Trains

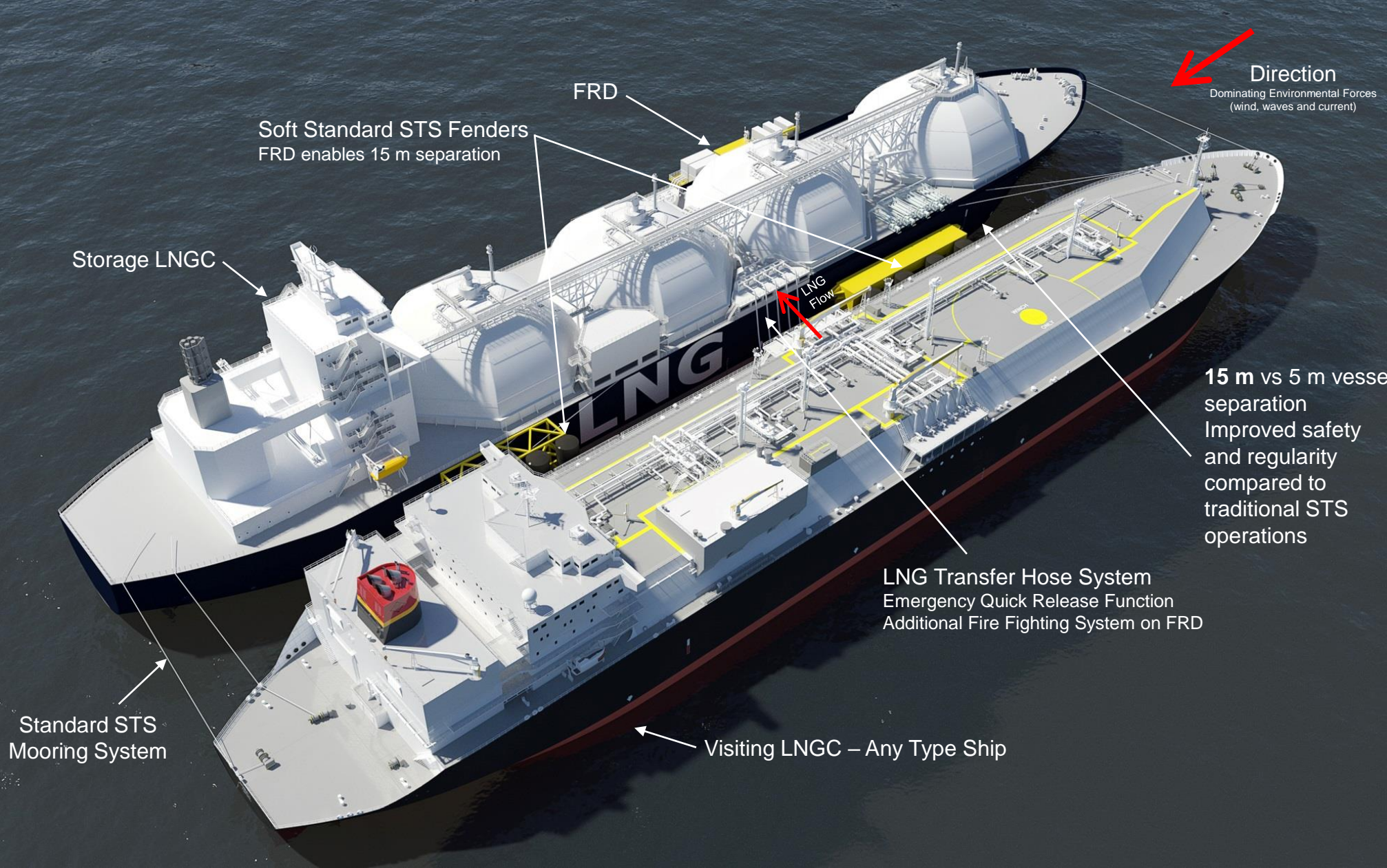
Floating Regas Dock (FRD)

Flexible Gas Risers

Floating Regas Dock in operation



Ship-To-Ship Transfer (STS) from any size LNGC



Soft Standard STS Fenders
FRD enables 15 m separation

FRD

Storage LNGC

Direction

Dominating Environmental Forces
(wind, waves and current)

LNG
Flow

15 m vs 5 m vessel
separation
Improved safety
and regularity
compared to
traditional STS
operations

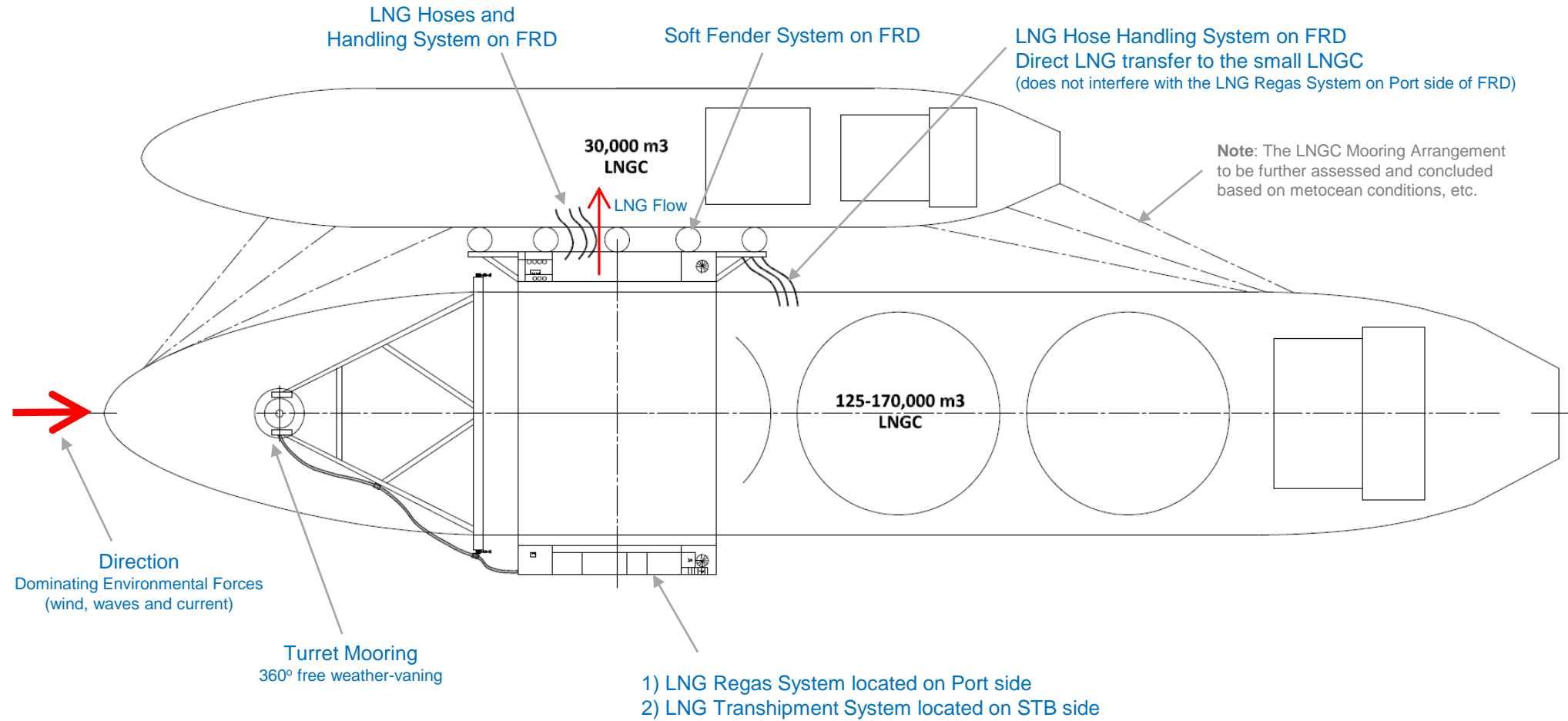
LNG Transfer Hose System
Emergency Quick Release Function
Additional Fire Fighting System on FRD

Standard STS
Mooring System

Visiting LNGC – Any Type Ship

LNG Distribution to Smaller LNG Carriers

The FRD may also be equipped to facilitate distribution of LNG to smaller LNGC's

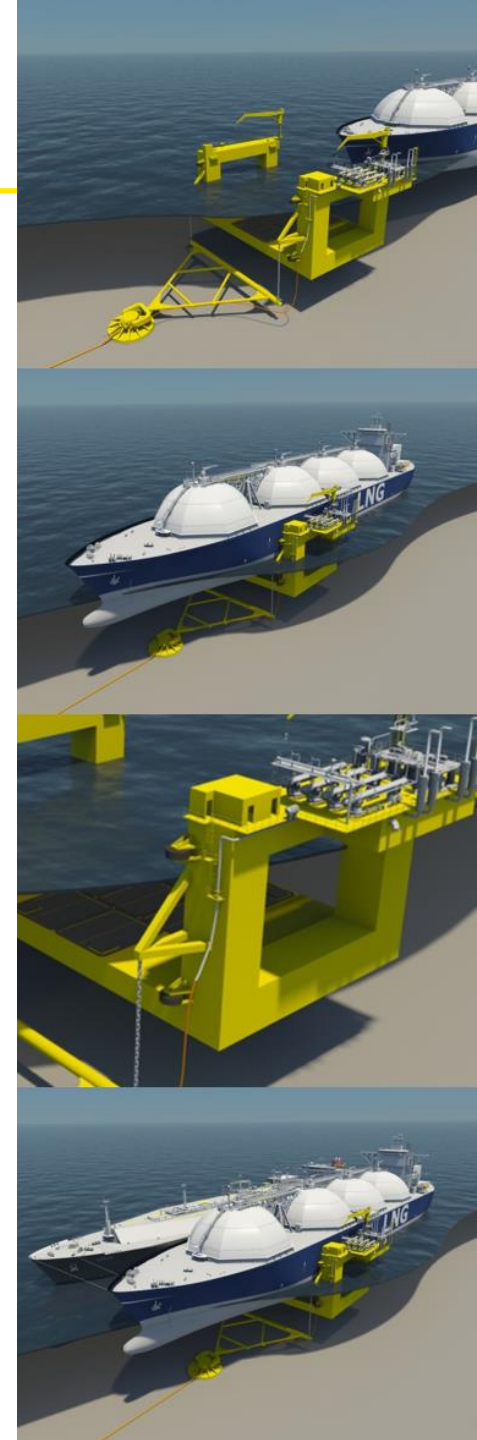


Boil-off gas: FRD will handle all boil-off gas from both Large and Small LNGC = No energy lost

FRD – Floating Regas Dock



Comparison to Jetty
Moored FSU/FSRU?



Why FRD? | Technical and Operational

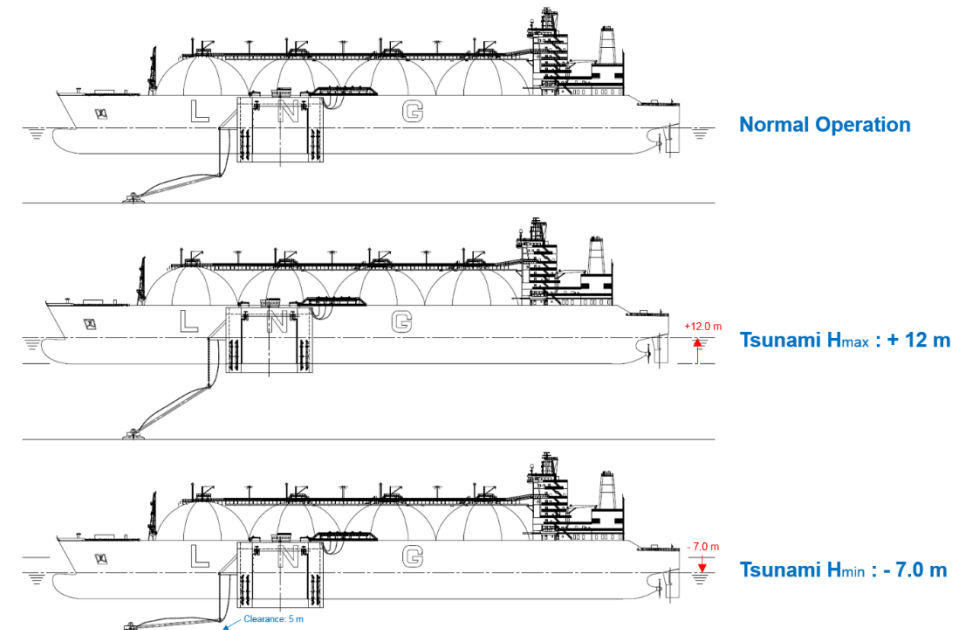
Swivel mooring - 360° weather-vaning

- Designed to stay connected in typ. 100-yr conditions ($H_s = 6.0$ m, Wind 35 m/sec)
- Not sensitive to swell – improved STS regularity
- **Result:** Provides superior uptime and regas regularity compared to any fixed moored FSRU/FSU solutions



Tsunami and Earthquake Resistant

- The Soft Yoke Mooring System enables vertical flexibility to withstand a significant Tsunami
- Gravity Anchor resistant to Earthquake
- **Result:** A Tsunami and Earthquake Resistant solution is obtained without costly structures



Typical extreme Tsunami condition for one specific location

Why FRD? | Philosophy and Business Idea



FRD and FSU – Philosophy and Business Idea

- FSU permanently moored in FRD during all weather conditions – gives high regularity
- FSU to be flagged and classed, and hence follow normal 5-year classing regime / inspection. Hence, the FSU remains a 'LNG Carrier'.
- Low-cost / minimum upgrade of FSU to comply with class requirement for permanent stay in FRD.
- Class has confirmed that re-classing of FSU after 5-years operation can be done at site with FSU connected to the FRD. Hence, new dry-docking not required.
- FRD sized for all FSU sizes, from small 125,000 m³ to 175,000 m³ storage capacity
- CAPEX investments in the FRD, not the FSU. Tying CAPEX to the longer design life.

FRD Regas Capacity

- FRD Pre-FEED study performed for 4x50 mmscfd regasification train.
- FRD can be upgraded for higher regasification capacity without adjusting main FRD design

High level comparison FRD vs Jetty Moored FSRU's

Jetty Moored FSRU Terminal

– typical figures

- **FSRU CAPEX** ~ **\$250 mill**
- **Port facilities**
 - jetty head, moorings and pipeline to shore:
~ **\$50 – 400 mill**
 - breakwater, dredging (if required)
~ **\$100 - 300 mill**

Total typical CAPEX

(unprotected location, incl. FSRU: > **\$400 mill**)



FRD based FSRU terminal

FRD Cost **\$ 100 mill**

- Engineering, design package, model test, Class approvals
- Long Lead Items/Equipment (Power / Regasification / BOG / LNG transfer system / STS)
- FRD Hull structure, complete with utility and control system / engineering & management)
- Soft Yoke systems, subsea equipment / management & engineering / FRD equipment for mooring / riser hook-up)

Installation, pipeline and hook-up **\$ 35 mill**

- Installation pipeline, Soft Yoke, FRD, transport and hook-up

FSU Cost (optional) **\$ 55 mill**

- Purchase old FSU (assume 15 – 20 year old, 138,000 m³ Moss FSU LNGC)
- 5 year dry-docking and modification to preparation for FSU operation

TOTAL Installed Cost
(excluding pipeline):

\$ 190 mill

Why FRD? | Operation & Maintenance Cost

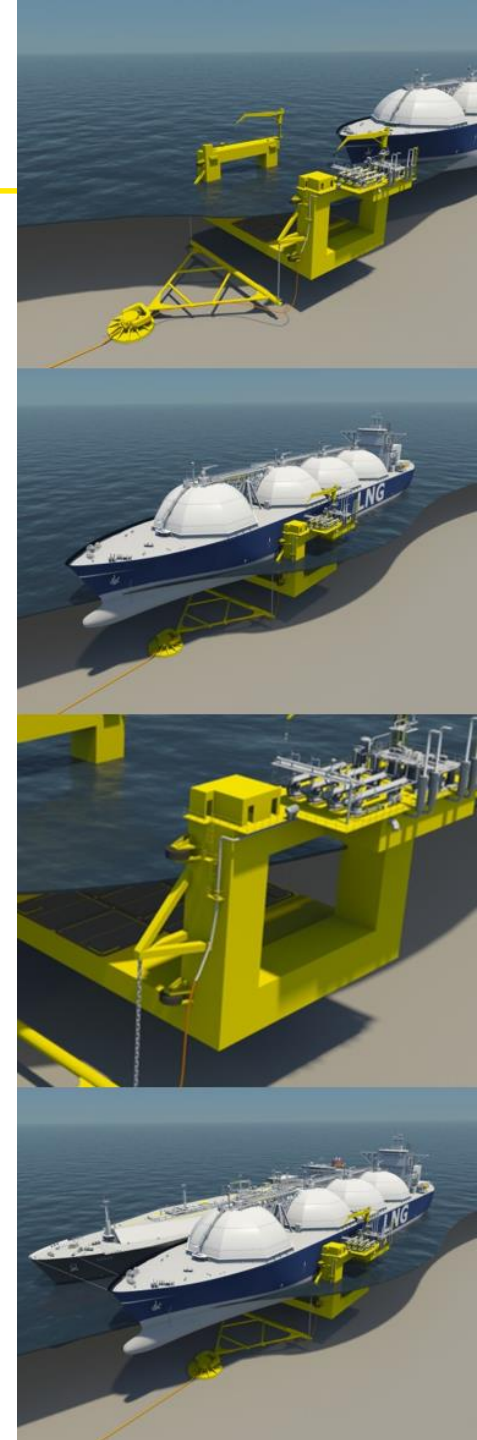


FRD Operation & Maintenance Cost

- With a Permanently Moored FSU in the FRD, the FSU can be operated in 'Cold Standby' (not required to keep boiler or propulsion system operational)
- Class has confirmed that the FSU can operate below 'Minimum Safe Manning' when permanently moored in the FRD
- 'Cold Standby' operation will significantly reduce required crew from 35 - 40 (typ for a Jetty Moored FSRU) to typically 15 -18 for the FSU including FRD (ref below)
- Normal FRD maintenance to be handled by maintenance crew already on the FSU
- FRD may supply FSU with power – Power system on FSU could be closed down = Less manning

FRD - Summary

- Provides a low cost LNG Receiving and Regasification solution for the World market, typically 50-400 mmscfd
- Proven and proprietary technology – Standard systems
- Cost competitive - utilizes elder and inexpensive LNG Carriers for storage
- Tsunami and Earthquake resistant
- Enables STS operation with increased distance - 15 m vs 5 m
- Boil-off gas conservation - excess gas compressed and sent to Power Plant
- 360° weather vaning – provides superior operational uptime
- LNG distribution to smaller LNGCs if required
- Suitable for feeding 100 – 1000+ MW Power Plants
- Generic Design - Short construction time
- Flexible design, turns LNGC's into FSU's with a minimum of investment. FSU can be returned to LNGC operation.



Thank you!

