LNG Shipping and Latest Trends

PETRONET LNG LIMITED

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- ➢ Truck loading
- ➢ Small scale LNG trade

LNG
A Unique Product
A Unique Business

LNG A Unique Product – A unique Business

- LNG Is Natural Gas Liquefied at –16O ^{o}C
- During the Liquefaction process NG is purified to very high level, which enhances its combustion properties.
- LNG is therefore environmentally friendly and efficient fuel
- NG Is liquefied to make it suitable for transportation in LNG ships through sea routes where transportation of NG by pipeline route is not feasible / economical
- LNG Volume is 1/600 OF NG (1 ton of LNG is 1315 Sm3)

LNG A Unique Product – A unique Business

- LNG is subsequently regasified at receiving terminal for use by the End users.
- Natural Gas can offer an opportunity to reduce air pollution
- The green house emission of NG is much lower (40% less than hard coal) due to its chemical structure that has a lower C/H ratio
- Even new coal based plants with the best available technology emit:
  - 0.07 kg NOx / GJ (energy)
  - 0.15 kg SO2 / GJ (energy)

SPECIFICS OF LNG TRADE

- Being capital intensive LNG is mostly traded as dedicated Chains.
- LNG contracts are long term (typically 20 years +), on take or pay basis; although recently market is slowly opening to spot purchases.
- Any LNG Project, thus begins only when the complete chain is tied up.
- LNG trade in India essentially means import of Gas. The elements involved are:
  - Shipping
  - Un-loading, Storage & Re-gasification facilities
  - Transportation / Distribution net work
  - End users (e.g. power plants)

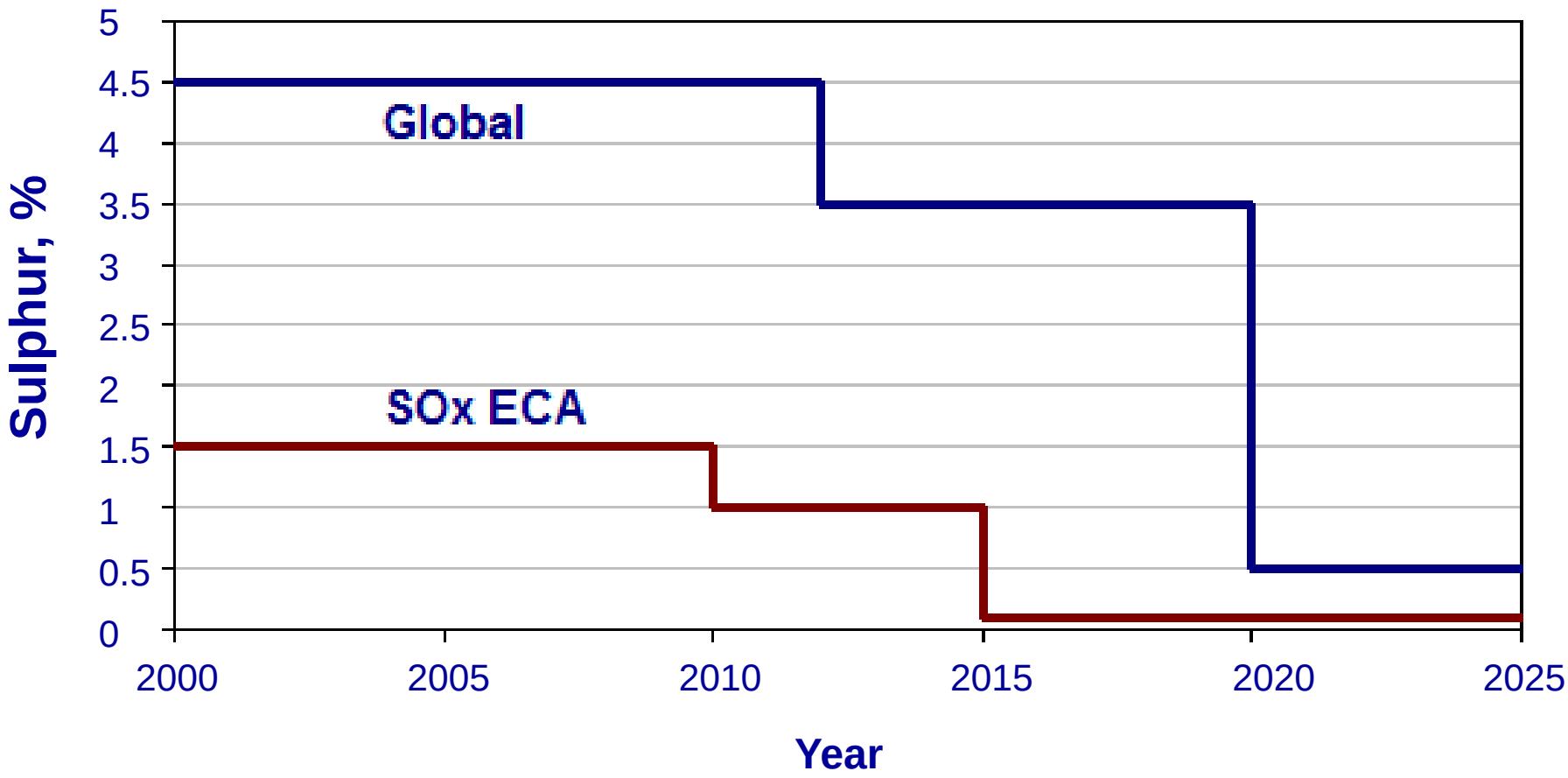
LNG Properties – A comparison with other fuels

	LNG	Naphtha	LPG
Composition	Methane, Ethane, Propane, Butanes	C5-140C Cut	Propane
Boiling Point	-161.5 C	24-140C	>-40.0C
Flash Point	-187.8 C	< 21.0 C	-
Specific gravity	0.6	3	1.8
Physical State	Gas at 15 C @ 1 Atm	Liquid	Gas at 15 C & 1 Atm
Explosion Limits	5.3 % to 15%	0.6 % to 8.0 %	1.9 % to 9.5 %
Effects On Exposure	Simple asphyxiant	Headache, Dizziness, Nausia & Drousiness on inhalation and abdominal pains, vomiting, breathing difficulties on ingestion	Concentration in air greater that 10% causes dizziness in few munutes. 1 % Concen, Gives the same effect in 10 minutes

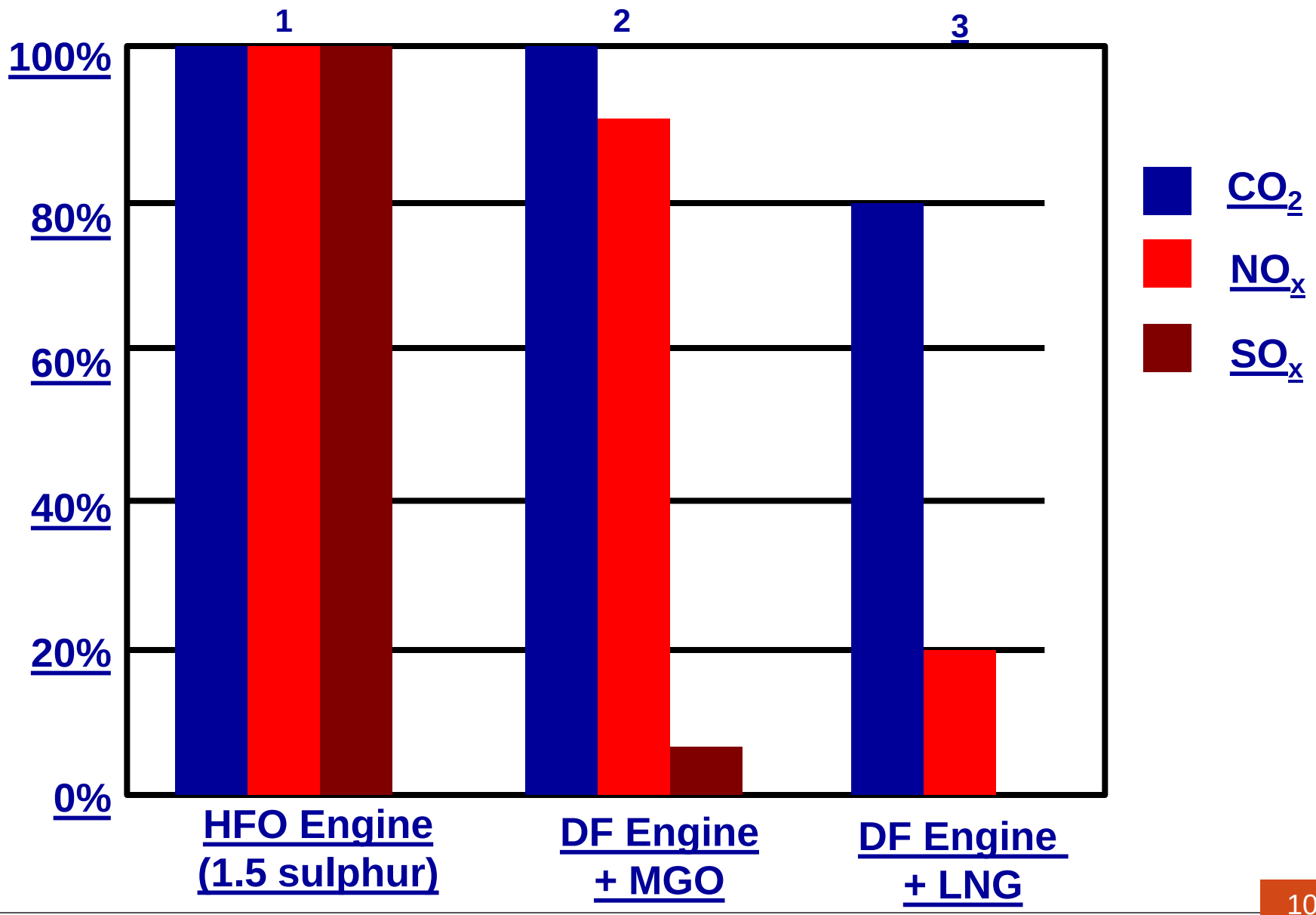
PROPERTIES OF LNG – REACTION ON WATER

Un like other liquid petroleum products LNG reacts vigorously with water and vapourizes very fast (leaving nothing behind) posing minimum risk for the marine life

IMO Regulations for SOx



Emission Reduction



LNG – Safety Requirements

Properties of LNG – Safety considerations

- Properties of LNG that have safety implications include auto-ignition temperature, Low temperature, heat of vaporization, flammability limits, heat transfer rate of boiling liquid and specific gravity

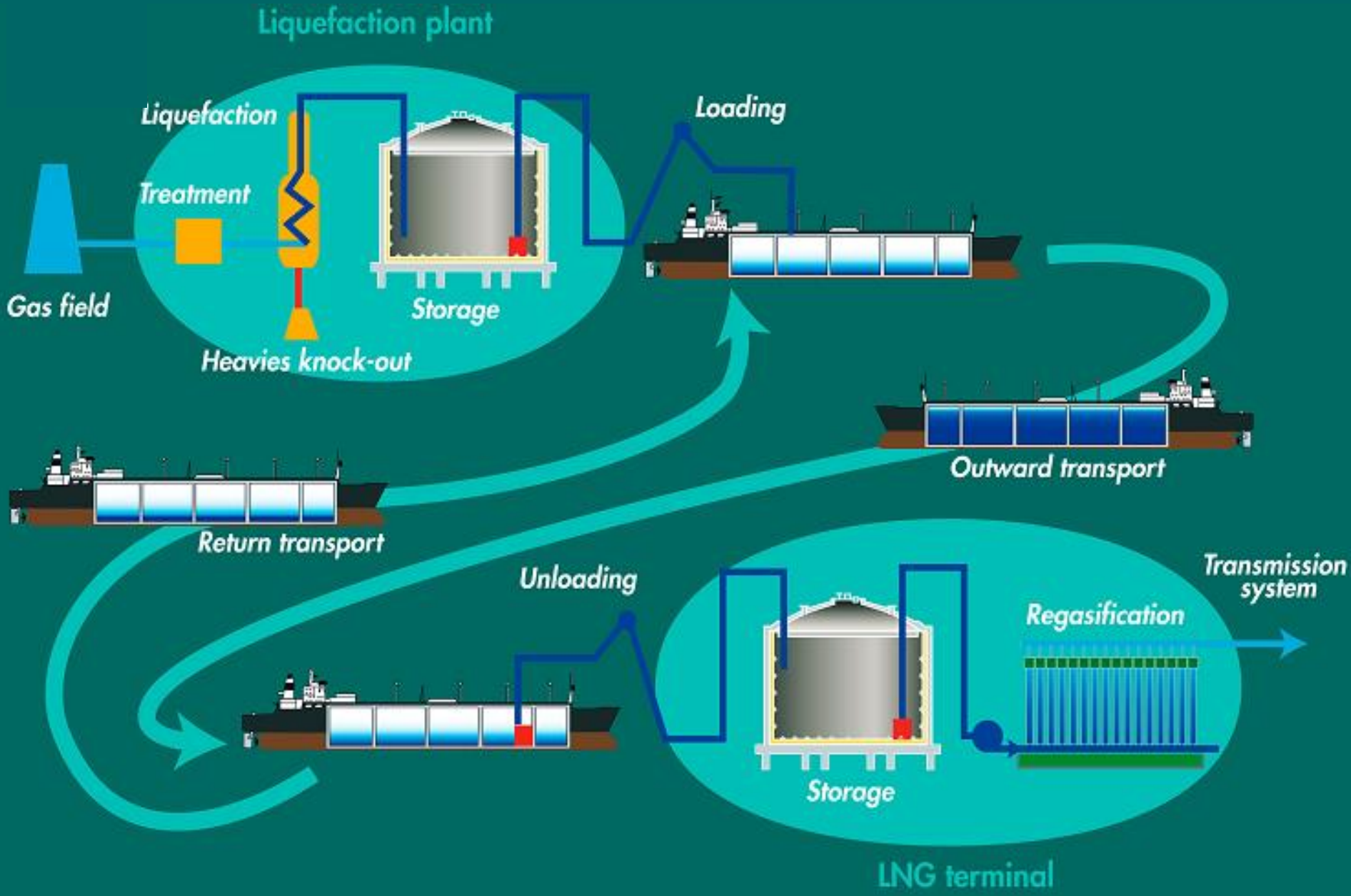
- The average auto-ignition temperature for pure methane at atmospheric pressure is 537 deg C, which is quite high

- The lower and upper flammability limit of methane in air is 5% & 15% by volume respectively.

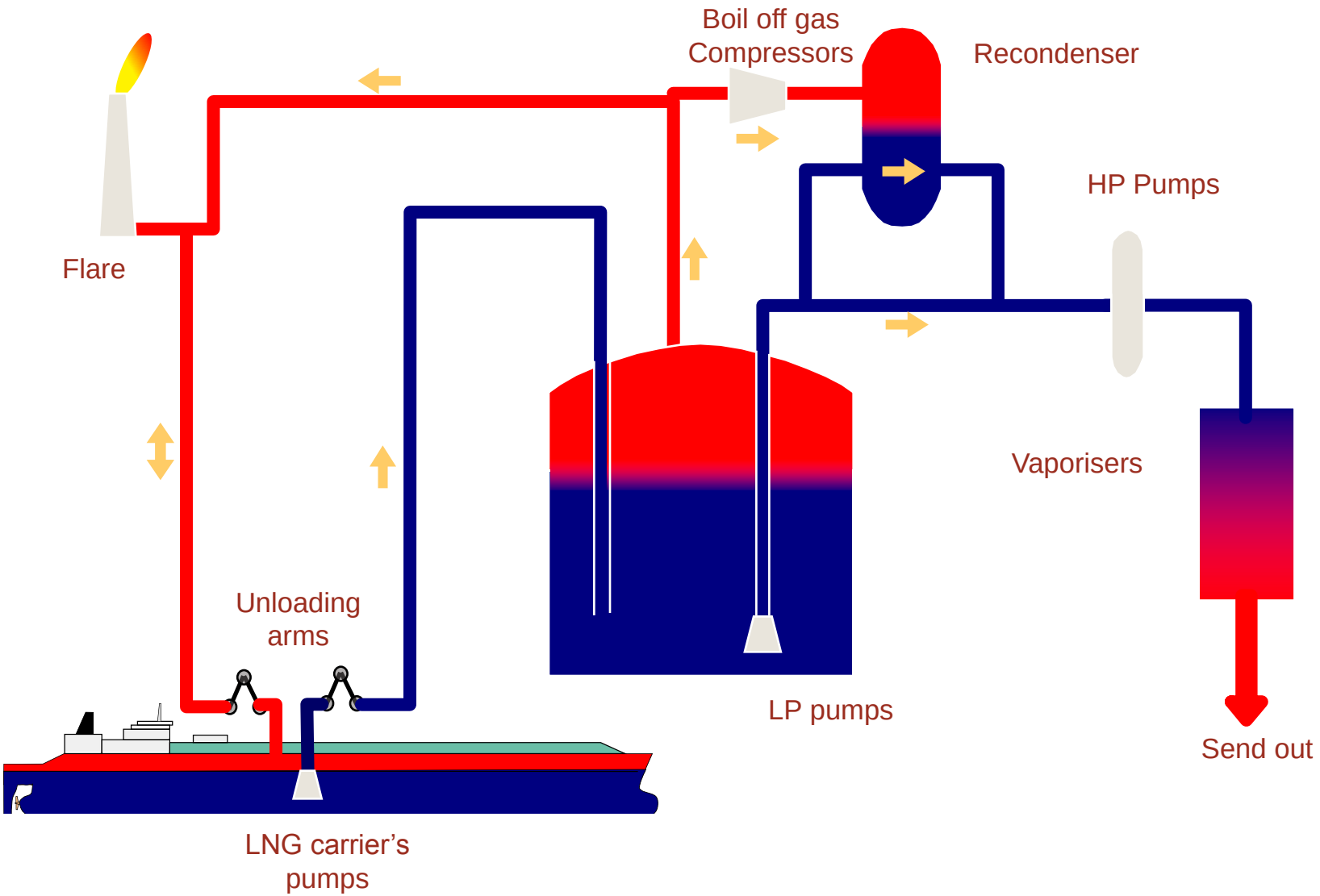
- In a closed tank, the percentage of methane is 100%, thus it cannot ignite.
- Methane leaking from a tank in a well – ventilated area is likely to rapidly dissipate to less than 5% , thus it is relatively safer as compared to other fuels
- The most of Hazardous properties of LNG are due to extreme low temperatures.
- The only danger from skin contact with LNG is freezing; there are no poisonous or toxic effects.

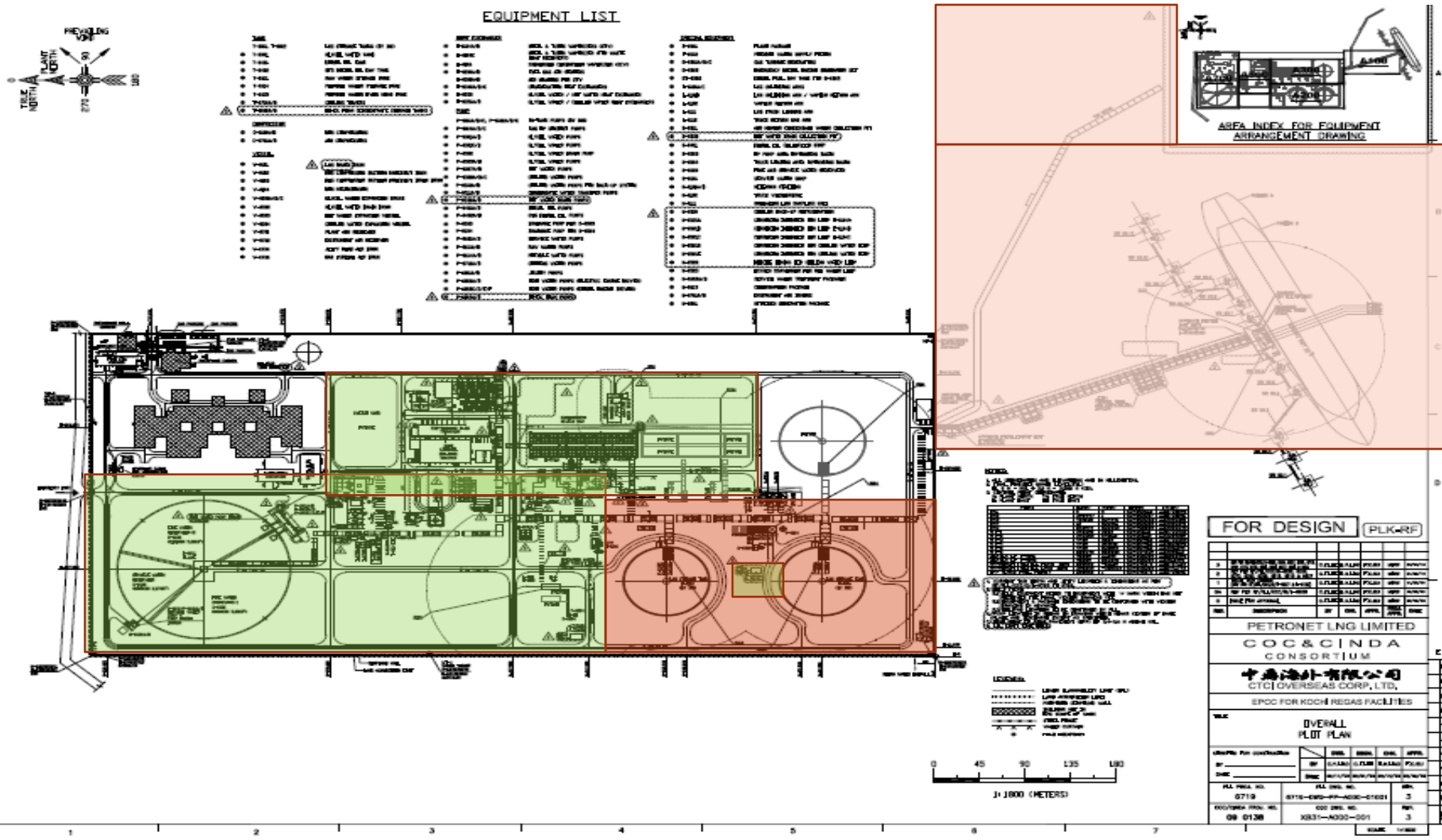
LNG Chain

LNG CHAIN


Liquefaction plant
Liquefaction
Treatment
Gas field
Heavies knock-out
Storage
Loading
Outward transport
Return transport
Unloading
Transmission system
Regasification
Storage
LNG terminal

LNG Terminal Main Features




EQUIPMENT LIST
PREVAILING WIND
PLANT NORTH
TRUE NORTH
AREA INDEX FOR EQUIPMENT ARRANGEMENT DRAWING
FOR DESIGN
PLK-RF
PETRONET LNG LIMITED
COC&CINDA
CONSORTIUM
CTCI OVERSEAS CORP, LTD.
EPCC FOR KOCHI REGAS FACILITIES
OVERALL PLOT PLAN
0 45 90 135 180
1:1800 (METERS)

Latest trends in LNG shipping

LNG is supplied to such engines from the onboard cryogenic tanks, where it is stored in liquefied form.

The tank arrangement for storing LNG requires 3-4 times space when compared with the space required for a conventional MDO/HFO tank.

Hence, size of the ship fuelled with LNG may be increased suitably.

Engine Manufacturer's are offering multi fuel (HFO/ MDO/LNG) engines.

Container feeder ships, coastal ferries, coast guard vessels, Ro Ro ships, small bulk and tanker vessels, passenger boats etc are suitable for using LNG as fuel.

LNG may be fuelled into ships through trucks, fixed pipelines or barges. This is already being done in Norway.

Norwegian shipping companies, with focus on reducing exhaust gas emissions from short sea and coastal vessels, have turned to using LNG as fuel in few of its Ro Ro ships under construction. The intended traffic for these ships is between Norway, UK and the European continent.

For LNG Bunker trade to gain momentum globally, LNG has to be competitive in fueling capacity, speed and flexibility when compared with bunkering with conventional fuel.

Shore storage

LNG Truck loading Shore tank

Ferry at Norway

Ferry taking LNG bunkers

Small Regassification Terminal

Ship Unloading Terminal

- Global use of LNG as bunker fuel for all ships

  Main challenge is lack of LNG bunkering infrastructure. Heavy investment is required in transportation and handling of the gas or LNG.

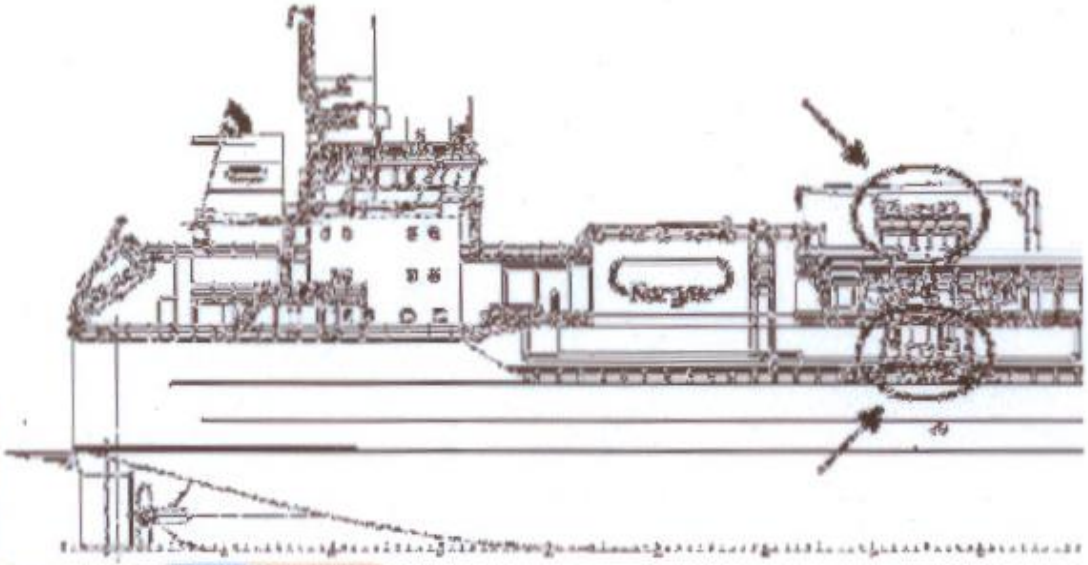
  Dedicated LNG bunkering terminals may be built for LNG bunkering along the major maritime routes involving heavy national and international traffic.

  These bunkering terminals may be fed through small scale LNG ships which are currently available in the market.

  These small LNG ships are designed to load LNG in large LNG terminals.

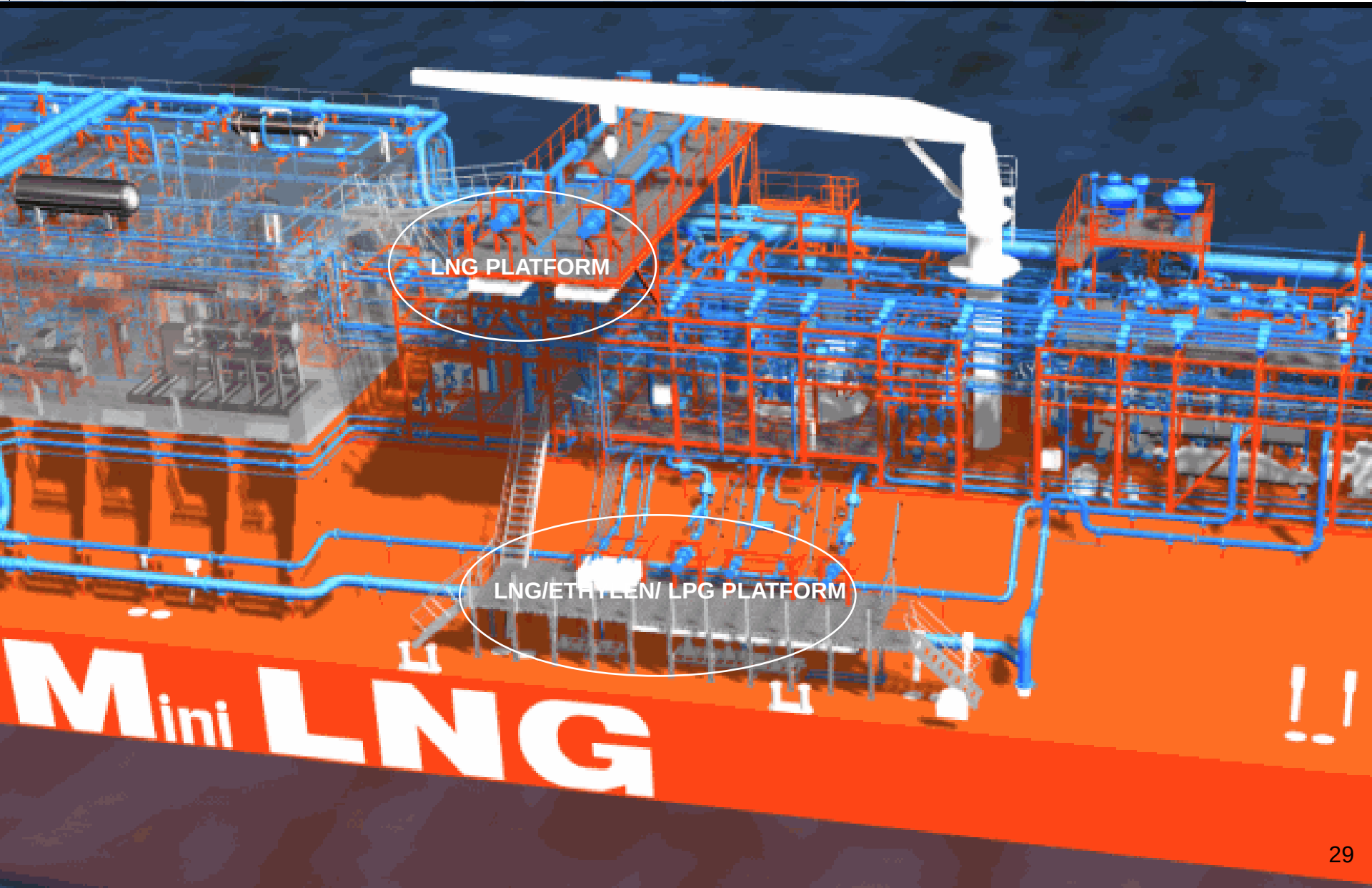
10.000 m3 Multigas LNG carrier– Can load at large terminals

- The vessels are equipped with dual manifolds making it possible to fit the operating envelope of loading arms at both large traditional LNG terminals as well as terminals made for the Small Scale LNG trade.

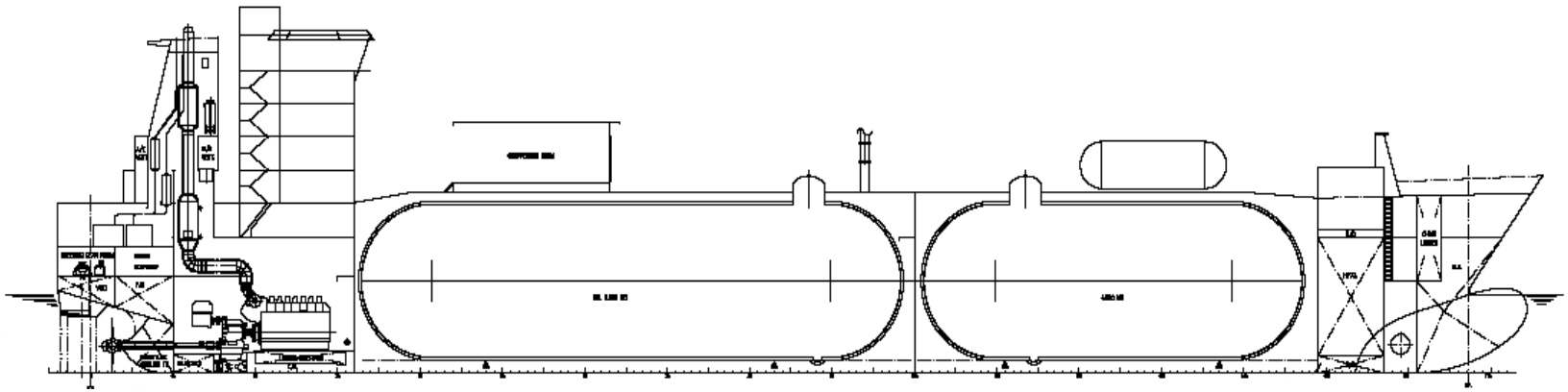


Source: I.M.Skaugen ASA

Multigas – Cargo manifold



10,000 m3 Multigas – Main Data



Loa:	137,1 m	DWT:	10,600	Cargo tank no.1:	6,000 m3
Lpp:	127,2 m	GT:	10,060	Cargo tank no.2:	4,000 m3
B:	19,8 m	NRT:	3,020	Max pressure:	5.2/3.8 bar g
D:	11,5 m	Main engine:	7,000 kW	Max density:	0.97 ton/m3
T_D:	6,7 m	Shaft generator:	1,900 kW	Min temp.:	- 163°C
T_S:	8,3 m	Aux. engines:	3 x 920 kWe	Pump capacity:	640/380 m3/h
T_{LNG}:	6,3 m	Service speed:	16,5 knots	Pump head:	120/220 mlc

Germanischer Lloyd * ; ✠ 100 A5, E, Liquefied Gas Tanker Type-2G, IW, BWM
✠ MC AUT, RI, INERT

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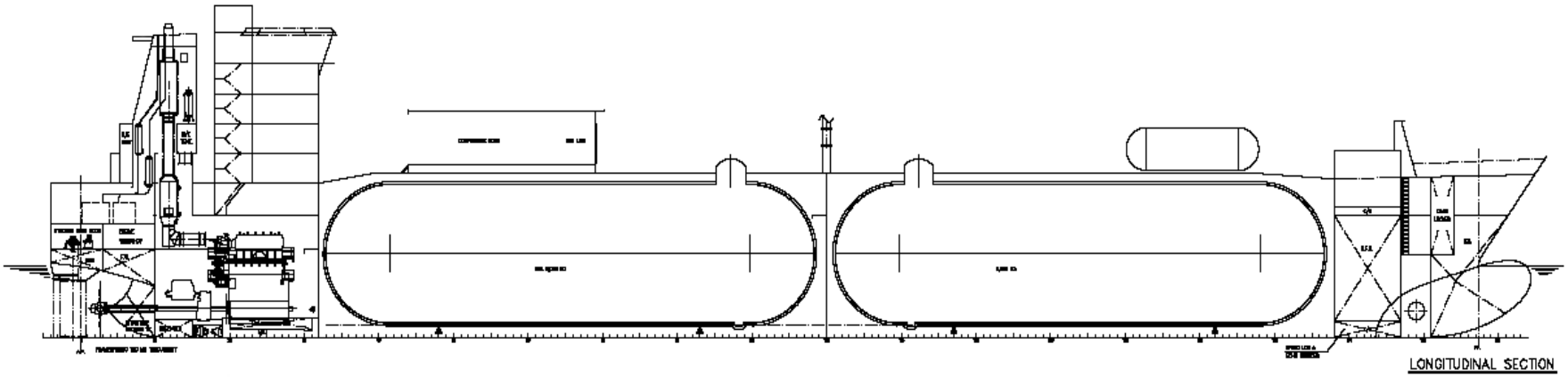
12,000 m3 Multigas – Main Data



Loa:	152,3 m	DWT:	12,570	Cargo tank no.1:	6,000 m3
Lpp:	142,4 m	GT:	11,320	Cargo tank no.2:	6,000 m3
B:	19,8 m	NRT:	3,395	Max pressure:	5.2/3.8 bar g
D:	11,5 m	Main engine:	8,200 kW	Max density:	0.97 ton/m3
T_D:	6,7 m	Shaft generator:	1,900 kW	Min temp.:	- 163°C
T_S:	8,3 m	Aux. engines:	3 x 920 kWe	Pump capacity:	640/640 m3/h
T_{LNG}:	6,3 m	Service speed:	17,0 knots	Pump head:	120/220 mlc

Germanischer Lloyd * ; ✠ 100 A5, E, Liquefied Gas Tanker Type-2G, IW, BWM

✠ MC AUT, RI, INERT

MultiGas carrier

- Cargo Volume -10,000 cbm
- Dual manifolds- Upper and Lower
- LOA -137.1m
- LBP - 127.2m
- Beam - 19.8m
- Depth - 11.5m
- Draft - 6.7m
- Speed - 16.5 knots, Consumption - 27 tpd IFO 380
- Cargo tanks - 2
- Max density - 970 kg/m3
- Re-liquefaction plant and GCU installed
- Tanker design can be modified to carry only LNG with maximum density of 500kg/m3 and utilize boil off gas in main engines.

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Gdansk (Poland) Shipyard Gas Tanker Coral Methane

Specifications:

- Capacity 7500 cbm,
- LOA 117.8m,
- Beam 18.6m,
- Speed 15.5 kts,
- Draft-6.3m,
- Duel fuel electric propulsion technology.

Tanker is fitted with re-liquefaction plant and GCU

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Courtesy of Wikimedia

Conclusion

- LNG in future may well be a financially preferable fuel type for shipping especially with emission taxes present and increasing oil prices.
- Apex maritime bodies like IMO shall play a major role.
- Further cost reductions for LNG technology as well as the fuel itself are two things that could make a LNG fuel solution more attractive. Such cost reductions are likely to occur due to increased competition and economies of scale among the suppliers.
- States need to devise policies in which coastal ships are offered LNG as fuel at competitive rates when compared to conventional fuels.

Thank You

Latest Trends - FSRU and FSU

BY CAPT. SANJAY GUPTA

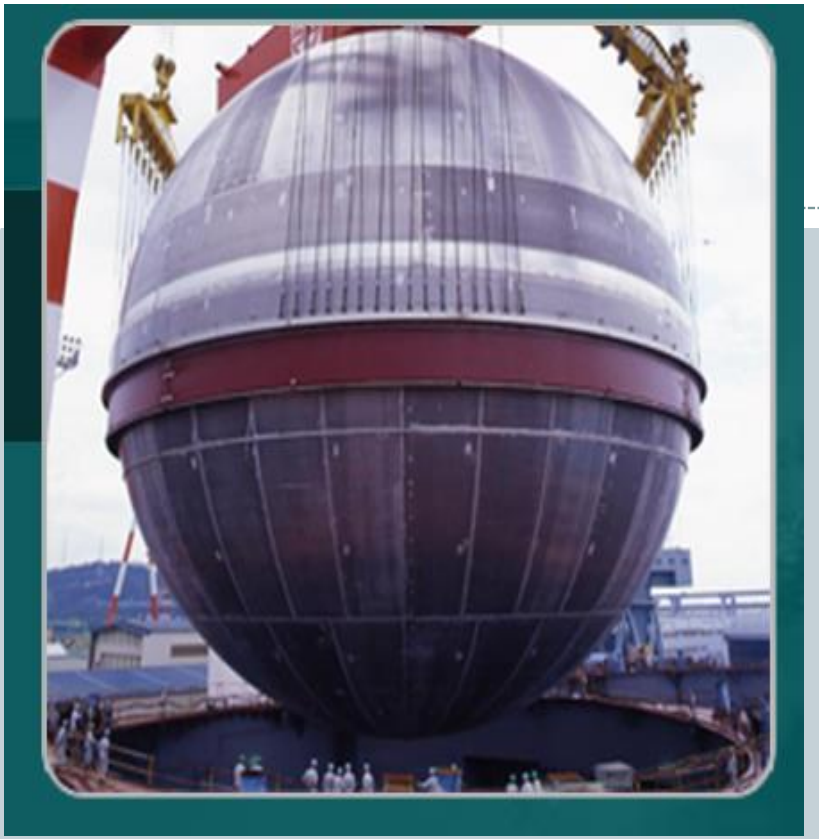
OVERVIEW

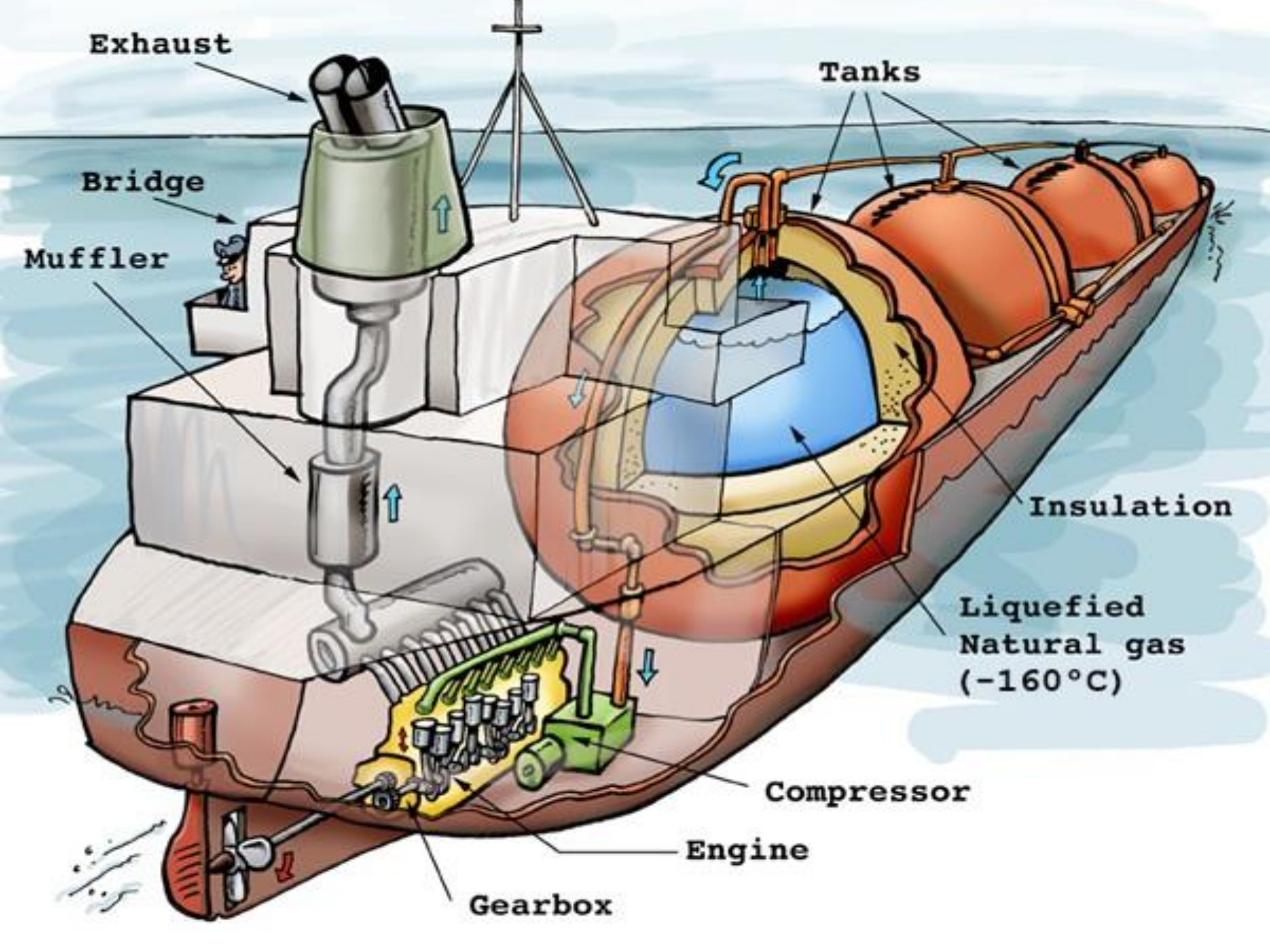
- Floating Storage Unit
- Types of LNG carrier
- Floating Storage regasification unit
- Business case for FSRU's
- Land based LNG Terminal vs FSRU
- Conversion of LNG carriers into FSRU
- Mooring , loading arm regasification system and gas transfer
- Complexities
- FSRU feed requirement

Floating Storage Unit (FSU)

- LNG Floating Storage Units are used for temporary storage of LNG before being transferred to the regasification system.
- FSU concept is typically based on chartering a conventional LNG carrier
- LNG is loaded into the FSU by Ship to Ship Transfer operation.

Moss type LNG Carrier




Exhaust
Tanks
Bridge
Muffler
Insulation
Liquefied
Natural gas
(-160°C)
Compressor
Engine
Gearbox

Moss

- Moss is owned by Norwegian Company Moss Maritime.
- Outside of tank thick layer of foam insulation.
- Over this insulation thin layer of tin foil
- Normal operating pressure 22kPa.

Membrane type LNG carrier

Membrane
Mark III

- Primary barrier corrugated steel about 1.2 mm thick in direct contact with liquid.
- Primary insulation which in turn is covered by secondary barrier called triplex basically a metal foil sandwiched between glass wool sheet and compressed together.
- Again covered by a secondary insulation supported by ships structure.

Mark III

- Going from inside of the tank to outside

  LNG/ Primary barrier 1.2 mm thick corrugated stainless steel/ primary insulation (Inter barrier space)/ secondary barrier of triplex membrane/ secondary insulation/ ships hull structure.

Membrane GT No.96

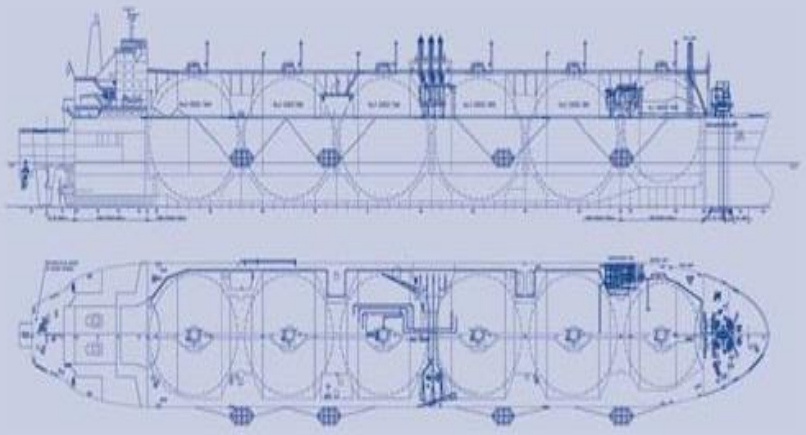
- Gaz Transport tank design.
- Tanks consists of primary and secondary thin membrane made of material Invar which ha almost no thermal contraction.
- Insulation is made of plywood boxes fitted with perlite.

FSRU's

•FSRU's are floating terminals where LNG is stored before being regasified.

•FSRU's have ability to move from one demand centre to another.

•FSRU may be designed to trade also as a LNG carrier.



Floating Storage and Regasification Unit (FSRU)

Business case for floating storage and regasification centers on three issues:

- Economic attractiveness
- Technical acceptability &
- Flexibility as FSRU's can be moved from one demand centre to another. Mitigates fluctuations due to seasonal demand.

In general FSRU's cost less than land based schemes of a similar size.

FSRU'S

- General cost comparisons must be treated with caution, as the circumstances surrounding floating and land based developments can affect the cost of both significantly.

- In general FSRU's may provide a faster return on capital.

- Attraction for FSRU's also lies in the fact that residents tend to favor energy supply solutions that are situated far away from where they live…NIMBY syndrome.

- Attraction is also obvious in areas where economic growth is uncertain or where there is an element of political or economic instability.

Onshore terminal development may require extensive planning. Depending on the topography, it may also take more construction time as compared to the FSRU's which are converted from an existing LNG carrier.

In LNG carriers, much of the required equipments are already available.

No generic solution to industry off shore's regasification needs. Each FSRU has to be designed to meet the specific requirements of the charterer for particular project.

Construction and Design of FSRU

Floating Storage Regasification Unit

FSRU may be

- Purpose built

Or

- A LNG carrier converted to FSRU

FSRU's are available in wide range capacities upto 305,000 cbm.

Typical details of a large purpose built FSRU

Length overall- 325m

Breadth- 55.0m

Depth-27.0m

Design draft- 11.5m

- Storage capacity- 305,000 cbm
- No of tanks-5
- Containment- GTT No 96
- Regasification capacity- 9 MMTPA

Typical details of a FSRU converted from a LNG carrier

- Length-289m,
- Breadth-44.6m,
- Draft-11.4m

- Performance
  - Tank type-Moss
  - No of tanks- 5
  - Cargo tanks capacity-129,000cbm
  - Gas send out-2.5 MMTPA
  - Time for berthing loading and unberthing-36 hrs

FSRU converted from LNG carrier

- No single factor to decide which type of LNG carrier makes the best FSRU.
- Availability and cost are the prime considerations when seeking candidate.
- Technically older Moss vessels are favored especially if intention is to just moor and vessel will not be utilized to trade LNG.

- Converting LNG carrier into FSRU is simple in principle but execution is challenge.

  - Risk of suitability and quality of design;
  - Quality of construction;
  - On time delivery of vessel;
  - High level of technical integration;
  - Long lead times for specialist equipment

- In general time required is 18 months for engineering and 6 months for the shipyard work.

- Add vaporizers, loading arms and extra pumps to the LNG carrier, upgrade its power, electrical and control systems and you have FSRU.

- Older vessels are generally more conservatively designed, more robust and provide easier foundations for major engineering modifications.

- More Modern membrane tank vessel, having efficient propulsion system is favored when intention is to continue using the vessel to trade LNG.

- The self supporting Moss type tanks have strong structural integrity and do not have operational cargo filling restrictions.

- A more modern membrane tank vessel has a more efficient propulsion system and may be more attractive if the intention is to continue using the vessel to trade LNG.

- FSRU Storage capacity is dictated by the port and supply logistics.

- Gas send capacities, temperatures and pressures will be influenced by maximum and minimum rate demands.

- Mooring system design will depend on the local weather conditions and the jetty configuration.

- FSRU's communication links and ESD systems are integrated with the onsite LNG and natural gas handling systems.

FSRU Feed Requirement

- Large FSRU operating at send out rate 5 to 6 MMTPA requires feeding of about 145,000 cbm LNG every 5th day.
- In Indian context possible?
- Nearest supply centre Qatar round trip voyage takes 8 to 9 days.
- So,FSRU peak capacity business case is more supported with spot trade unless multiple dedicated ships are being employed to feed FSRU.
- In case of reduced feed of LNG, send out rate modulation will be necessary.

The LNG tankers off loading to the FSRU may be moored in a side by side configuration.

This offloading tanker may also be moored across the pier.

Mooring

FSRU Terminal allows safe berthing of standard LNG carrier without need of extensive modification.

FSRU Terminal can also be moored to seabed with a turret mooring arrangement.

Turret is equipped with a turntable which allows 360 deg continuous rotation of the FSRU.

Loading Arms

- Standard loading arms to allow side by side transfer of LNG and vapor return.
- Loading arms similar to ones used on onshore terminals additionally modified to account for relative motions between carrier and FSRU.
- Fitted with equipment for guiding the arms onto the carrier's connection flanges.
- Wide capacities FSRU's with LNG capacity ranging from 1,25,000 cbm to 305,000 cbm are in operation.

LNG Regasification System

- LNG is sent from the tanks to the regasification skid. Which generally comprises of booster pumps and steam heated vaporizers. Few designs also use propane.
- The booster pumps will increase the pressure to about 85 to 90 bars.
- High pressure LNG is vaporized.
- Regasification can be both in open or closed loop mode.

Additional regas equipment fitted on one of the LNG carrier converted to FSRU

The new boiler in position at the aft end of Golar Winter

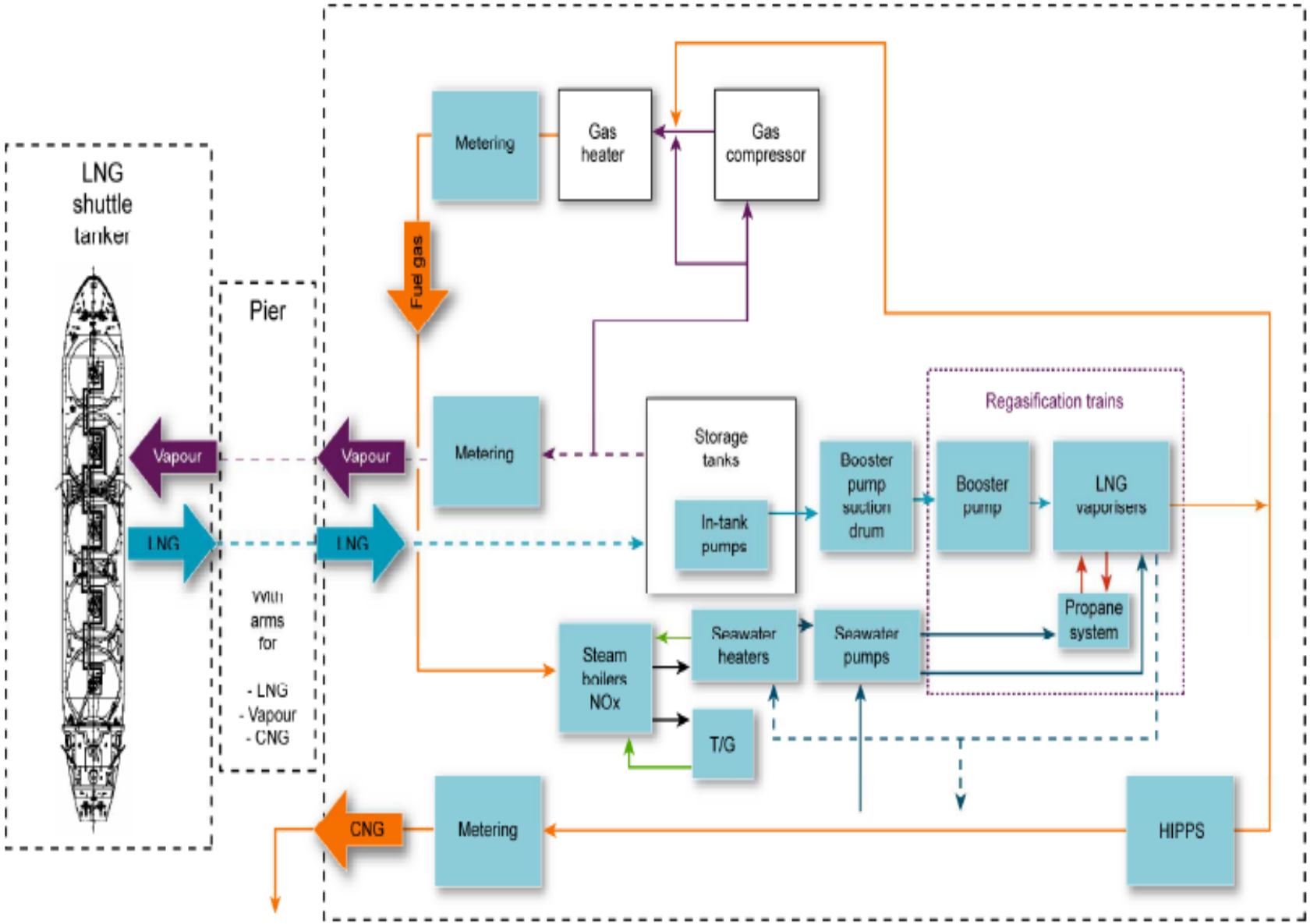
Skid Mounted Regasification unit

Gas Transfer

- May be via a riser to a subsea gas pipeline via gas swivel assembly.

  Or

- May be designed to allow gas transfer via a high pressure loading arms fixed on the jetty


LNG shuttle tanker
Pier
Vapour
LNG
with arms for
- LNG
- Vapour
- CNG
Vapour
LNG
Fuel gas
Metering
Gas heater
Gas compressor
Metering
Storage tanks
In-tank pumps
Booster pump suction drum
Booster pump
LNG vaporisers
Regasification trains
Propane system
Steam boilers NOx
Seawater heaters
Seawater pumps
T/G
CNG
Metering
HIPPS

FSRU

- Depending on whether FSRU is permanently moored or to retain the flexibility as a LNG carrier FSRU may adopt characteristics of:

- An LNG carrier
- A land based regasification facility and/ or
- An offshore floating crude oil storage and production unit

Charter Party to capture provisions accordingly.

Complexities of FSRU

- Technical specification must be robust capturing all the operational requirements.
- Vital to spend time with the end user, to make specifications of the FSRU as close as possible to the operational requirements.
- Converting existing LNG carrier into FSRU: Integration requires extreme efforts.
- High pressure associated with FSRU operations introduce a new set of risks not present on conventional LNG carriers.
- Operation and maintenance of the vessel.

Complexities of FSRU

- FSRU have upgraded fire and gas detection systems and fire fighting systems.
- In addition a more sophisticated emergency shut down system based on the rules for offshore oil and gas operations is provided.
- As an FSRU forms part of the shore infrastructure, EIA and assurance of vessels compliance with the local as well as international marine requirements are also central issues.

Infrastructure

- Dredging requirements- environmental approvals
- Emergency evacuation of FSRU
- Commensurate to the environmental conditions
  waves/ wind/ tidal levels / currents etc.
- Sheltered regions for stationing FSRU
  by means of either breakwaters or natural shelters
  Ships berthed to feed FSRU should be comfortable

Chartering FSU's

- Full fledged LNG carriers may be used as a FSU.
- Few LNG carriers built by shipowners for speculation remain open on offer most of the time.
- Shipowners owning old carriers may also remain interested in offering as FSU's in sync with prevailing LNG carrier long term charter rates.
- Owners of New LNG carriers may not remain interested in offering as FSU for longer duration.
- New carrier not being used entirely on the account of propulsion and auxiliary machinery may generate speed warranty & machinery issues.

Chartering

- Unlike LNG carrier, FSRU's is newly built or an existing LNG carrier is converted to FSRU when employment is in hand.
- Chartering is for relatively long term. Spot availability is difficult as very few owners FSRU's are built by owners on speculation basis.
- Majority of the FSRU's today under construction or delivered are already committed.

Summary

- Cost, speed of delivery and flexibility are the main advantages of FSRU's.
- Concept of FSRU's may provide in general a rapid and competitively priced turnkey alternative to a shore based gas terminal.
- FSRU business is challenging.
- It involves sound aggregation of shipping and energy technology, commercial skills and marine operating experience.

Thanks