

# Fueling LNG Fuel Market in Shipping Industry

Stephano Y. Heo



All data provided on the following slide is for information purposes only, explicitly non-binding and subject to changes without further notice.

# Table of Contents

## 1 LNG Fuel Market in Shipping Industry



## 2 Remarkable Projects



## 3 DSME's LNG Fueled Ship & LNG Technology



- **LNG Fuel Market in Shipping Industry**





# Environmental Driver

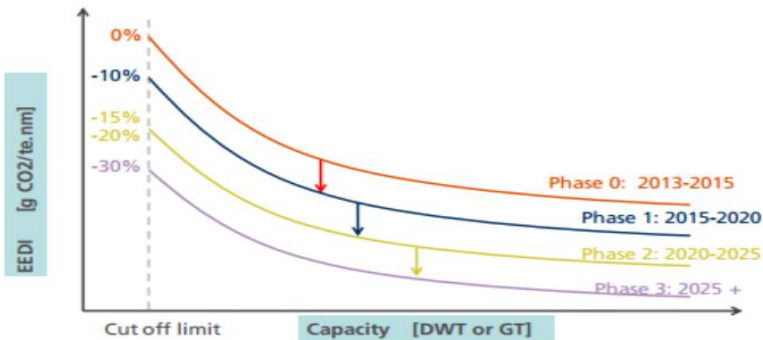
## SOx Regulation



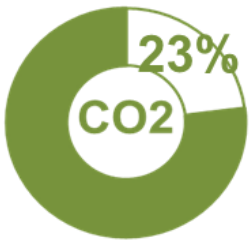
## NOx Regulation

| RPM        | Tier 1 (current)               | Tier II<br>(from 2011.1.1)      | Tier III<br>(from 2016.1.1) |
|------------|--------------------------------|---------------------------------|-----------------------------|
| Under 130  | 17.0 g/kWh                     | 14.4 g/kWh                      | 3.4 g/kWh                   |
| 130 ~ 2000 | $45.0 \times n^{(-0.2)}$ g/kWh | $44.0 \times n^{(-0.23)}$ g/kWh | $9 \times n^{(-0.2)}$ g/kWh |
| Over 2000  | 9.8 g/kWh                      | 7.7 g/kWh                       | 2.0 g/kWh                   |

## CO<sub>2</sub> Regulation



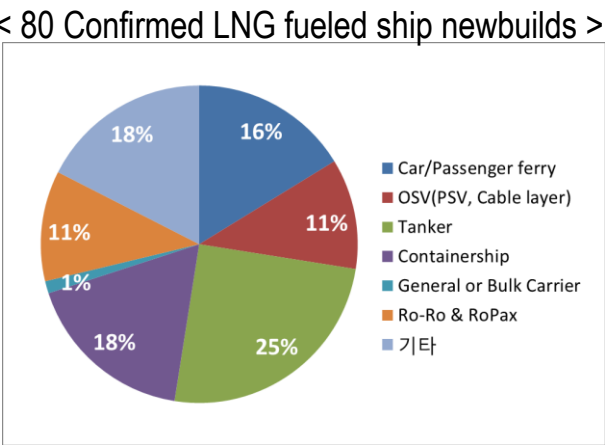
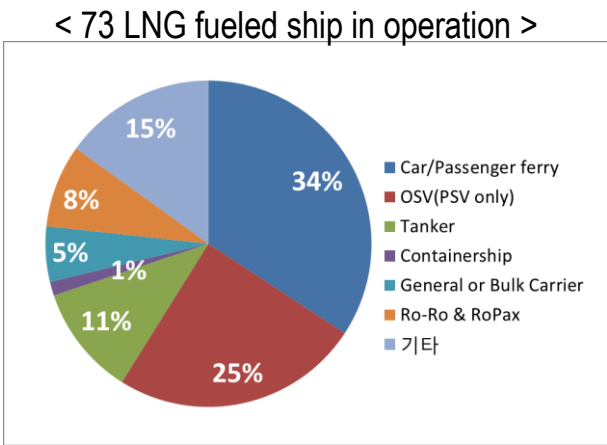
## LNG: Environment Friendly Fuel





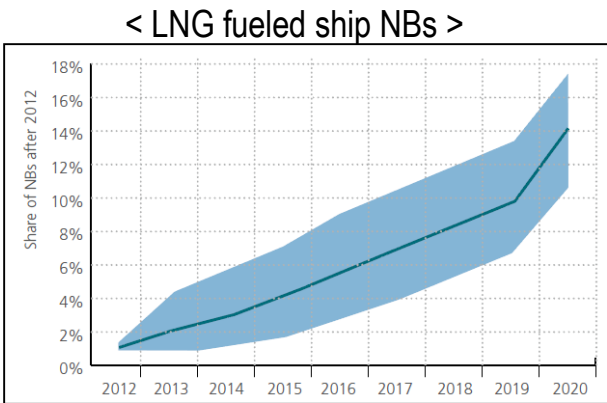
# LNG Fueled Ship Market

■ More commercial ships are powered by LNG

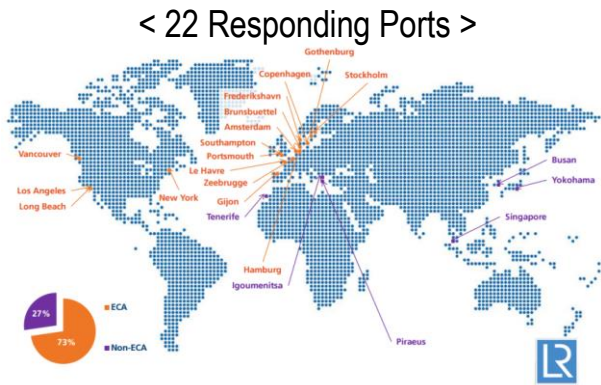


< Source: DNVGL, 2015 4Q >

■ Demand for bunkering vessel will be coupled with number of LNG fueled ships



< Source: DNVGL Shipping 2020 >

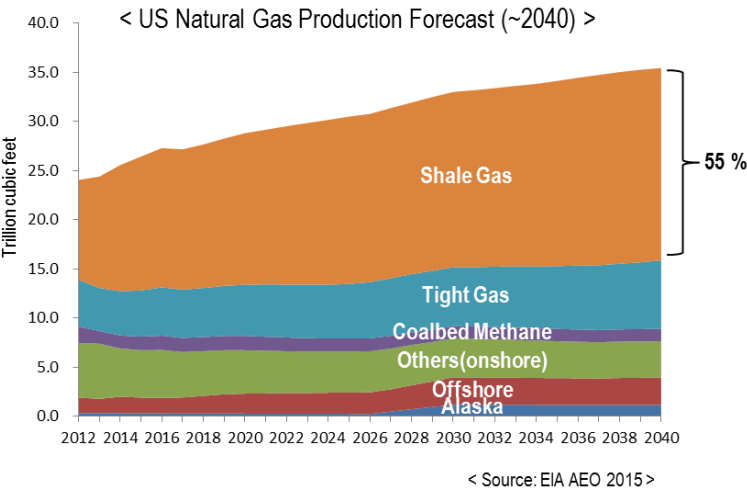


< Source: LR LNG Bunkering Infrastructure Survey 2014 >



# Increase of Gas Production

## ■ US Shale Gas Boom



## Cheniere ships first Sabine Pass LNG export cargo to Brazil's Petrobras



Image courtesy of Cheniere Energy

Cheniere has on Wednesday shipped the long-awaited first cargo from its Sabine Pass liquefaction and export facility in Louisiana. This event also marks a new era in global LNG trade as the U.S. is set to become a net exporter of domestically sourced shale gas.

LNG World News **reported** late Wednesday that the 160,000 cbm carrier Asia Vision, owned by energy giant Chevron, was fully loaded with LNG and ready to depart from the facility.

## ■ Australia Mega Gas Project

### Western Australia's Gorgon liquefied natural gas project begins production

WA Country Hour by Eliza Wood

Print Email Facebook Tweet More 22

Updated 8 Mar 2016, 2:59pm

After construction delays, union woes, and multi-billion-dollar budget blow-outs, the Gorgon liquefied natural gas project is finally up and running off WA's north-west coast.

Chevron Corporation has announced the first shipment is expected to leave the Barrow Island.

Gorgon is the largest project in Australia's history, a billion to build. It is built to produce 3.6 million tonnes of LNG per year.

Chevron Australia says



### First LNG export from Wheatstone Gas Project : Middle of 2017



## INPEX confident of 2017 start-up for Ichthys

Mon 18 January 2016

Facebook Twitter LinkedIn Google+

The INPEX-operated Ichthys LNG Project remains on track for start-up in the third quarter of 2017, a company spokesperson told PPO News.

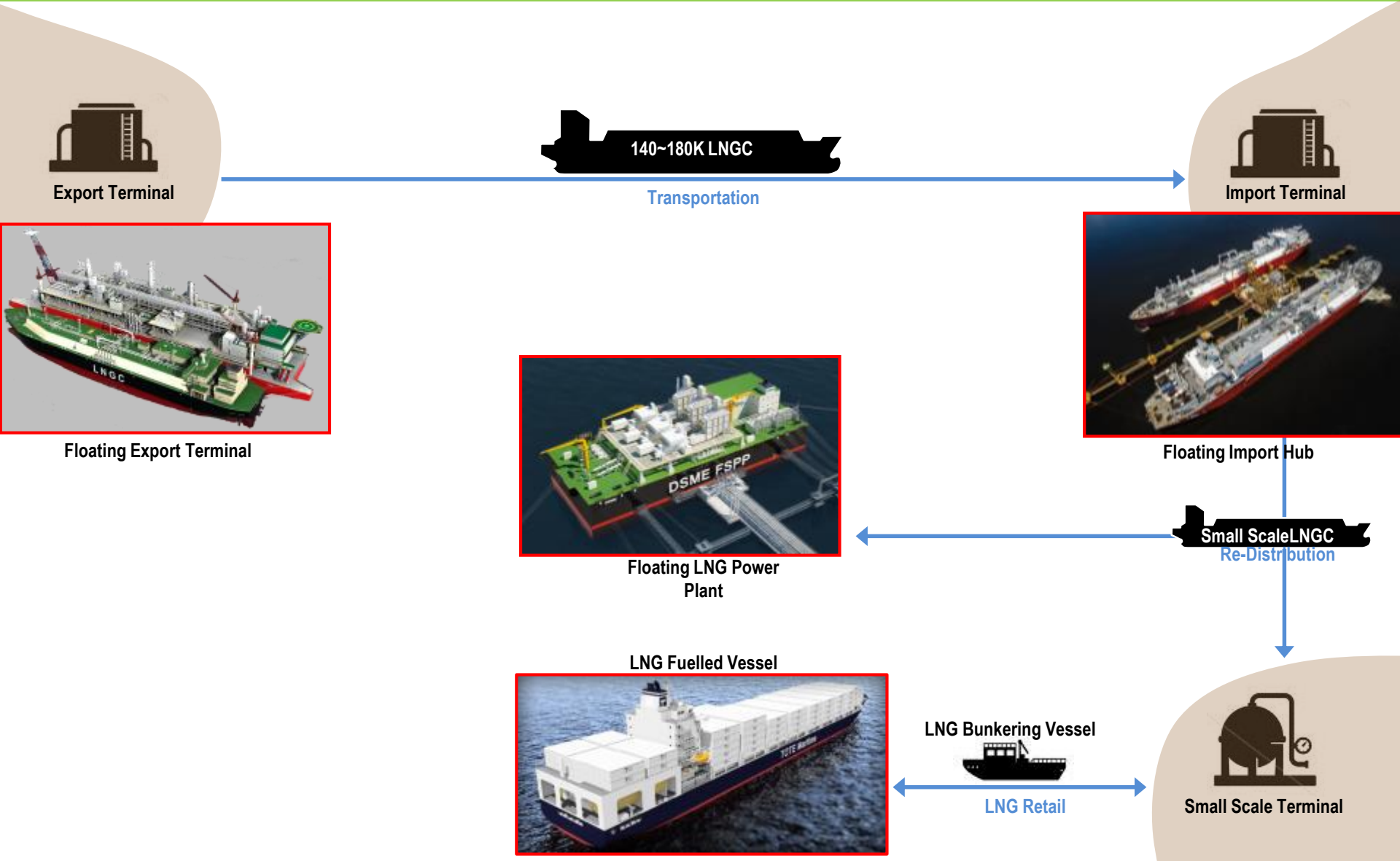
The spokesperson said INPEX is expecting to complete the concreting for the project's onshore LNG storage tanks in early February, following the completion of the project's 890 km gas export pipeline in November 2015.



An aerial view of the Ichthys Project's onshore facilities.



# Changes of LNG Value Chain



# Singapore LNG Bunkering Hub



Bunkering Jetty(Future) for reloading of 10,000 m<sup>3</sup> to 40,000 m<sup>3</sup> LNGC and bunkering vessel/barges



Recently, Keppel Offshore & Marine and BG Group have been selected **to supply liquefied natural gas(LNG) bunker to vessels in the Port of Singapore.**





# Busan Port LNG Bunkering Project

## BLNG Project

|               |                                                                                                                                    |
|---------------|------------------------------------------------------------------------------------------------------------------------------------|
| Partner       | : Polaris Shipping, LNG Suppliers                                                                                                  |
| Business      | : LNG Bunkering Service(3 MTPA) planned in 2020                                                                                    |
| Construction  | : Jan 2017 ~ Dec 2020                                                                                                              |
| Configuration | : Two LNG Storage tanks, 200,000 m <sup>3</sup> each<br>: Jetty for LNGC 210,000 m <sup>3</sup> , Three berths for bunkering ships |

## World Container Ports(2015)

| Rank | Port      | Throughput |
|------|-----------|------------|
| 1    | Shanghai  | 36.5       |
| 2    | Singapore | 30.9       |
| 3    | Shenzhen  | 24.2       |
| 4    | Ningbo    | 20.6       |
| 5    | Hongkong  | 20.1       |
| 6    | Busan     | 19.4       |
| ...  |           |            |



Busan Port has handled 19.4 million TEU of containers in 2015 and ranked 6<sup>th</sup> container port in the world.

- Remarkable Projects





# The World's First ME-GI LNG Carrier



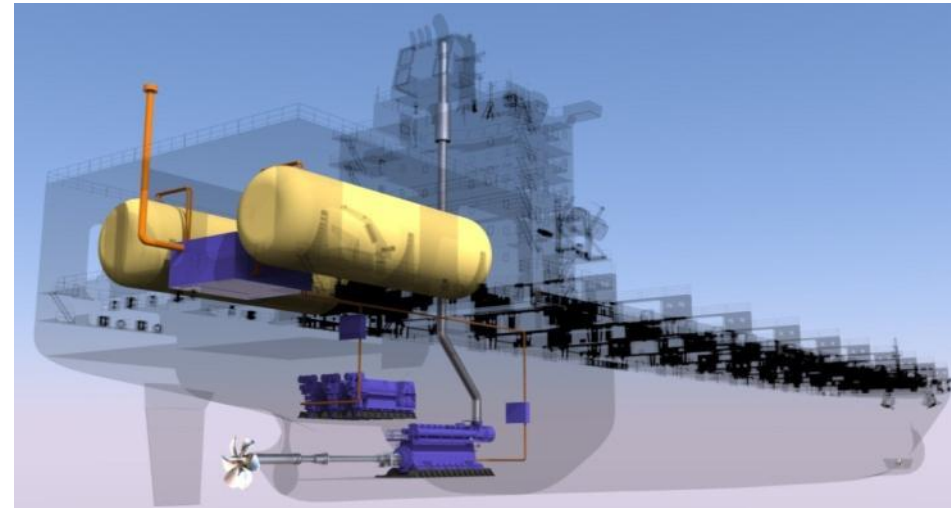
World first ME-GI LNG Carrier delivered in February of 2016. This new-build was constructed with ME-type, **Electronically Controlled, Gas Injection (ME-GI) twin engines**, which are expected to be significantly more fuel-efficient and have lower emission levels.





# TOTE 3,100 TEU LFS Containership

***'Isla Bella'*, The World's First LNG-Powered Containership**



- The World's First LNG-Fuelled Containership delivered on October 16, 2015
- DSME HiVAR<sup>®</sup> FGSS(Fuel Gas Supply System)
- Successful LNG fuel supply by HiVAR<sup>®</sup> during sea trial including gas trial
- USCG Certifies World's First LNG-Fuelled Containership



# Q-Max LNGC ME-GI Retrofit Project



Q-Max

- 266.000 m<sup>3</sup> LNG
- Length: 345 m
- Breadth: 54 m
- Depth: 27 m

Gas Valve Units



< Source: MAN Diesel & Turbo >

2 x ME-GI Engine conversions

HP Fuel Gas Supply System(FGSS)

The Q-Max LNGC retrofitting project successfully commissioned conversion of 2 x 7S70ME-C to 2 x ME-GI Engine. The HP fuel gas supply system(FGSS) was provided by TGE **under a patent license agreement between DSME and MAN Diesel & Turbo.**



< Source: TGE Marine >

- **DSME's LNG Fueled Ship & LNG Technology**





# LNGC with ME-GI engines

## DSME built LNGC with ME-GI engines

### 32 ME-GI Reference Vessels

as of Oct. 2015



### 90 DSME Patents

Patents issued globally for  
**Hybrid FGSS<sup>®</sup>, PRS<sup>®</sup>, and sLNGC<sup>®</sup>**

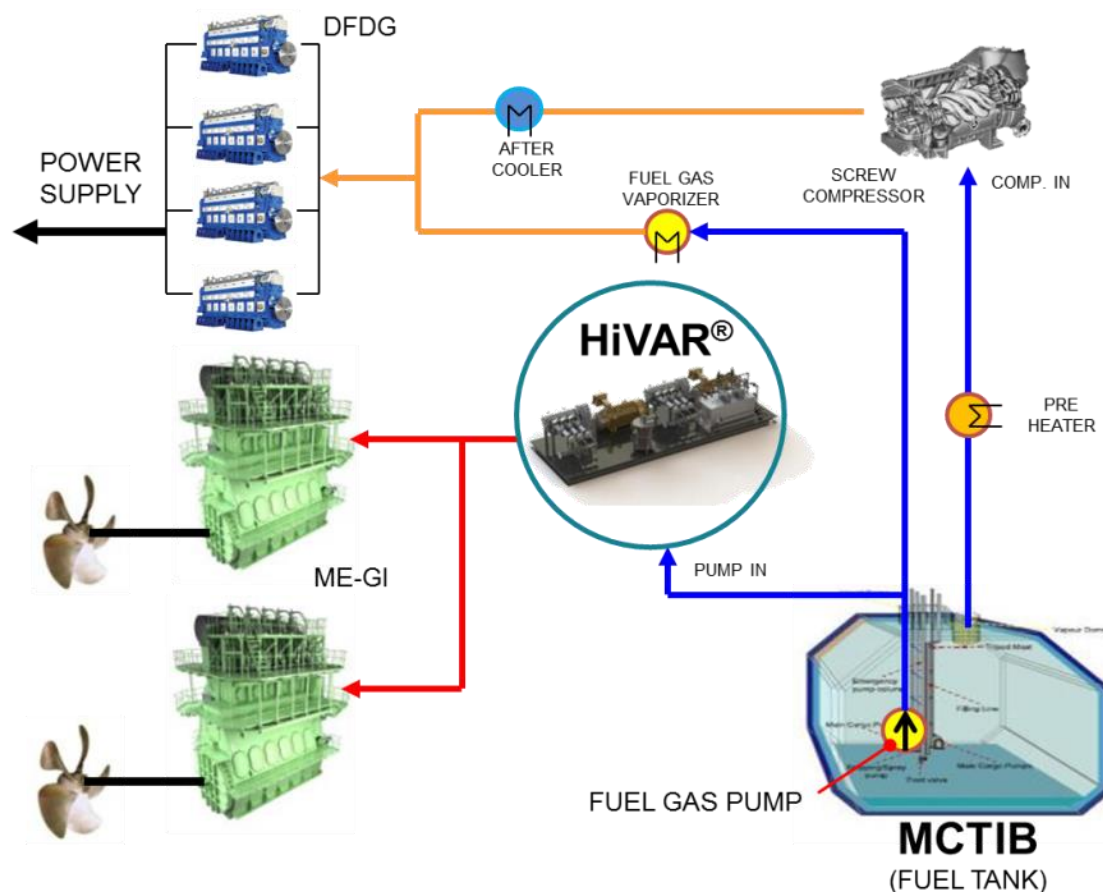
- “Liquefied Gas Treatment System for Vessel” (14/692,637 – US)
- “System and Method for Supplying Fuel Gas of LNG Carrier” (12/332,733 – US)
- “System for Supplying Fuel to High-Pressure Natural Gas Injection Engine Having Excess Evaporation Gas” (12/332,733 – US)



# DSME HiVAR® FGSS



## The Most Efficient Fuel Gas Supply System

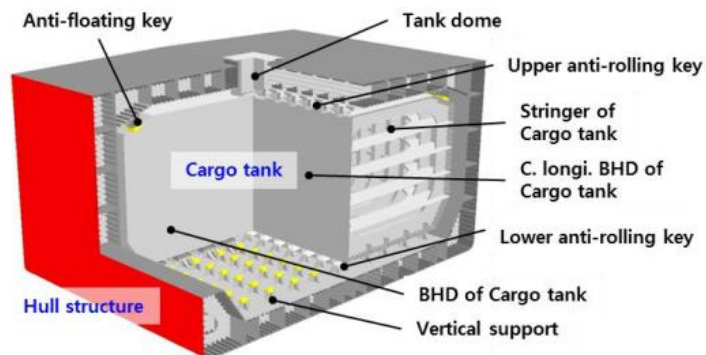


## SPECIFICATIONS of FGSS

- **LP (Low Pressure) System for DFDG**
  - Feed pump(Centri.) x 2ea, 100%
  - Pre gas heater x 1ea, 100%
  - FG compressor(Screw) x 2ea, 100%
  - After cooler x 1ea, 100%
- **HP (High Pressure) System for ME-GI**
  - HP pump x 2ea, 100%
  - HP vaporizer x 1ea
  - IHM pump x 2ea, 100%
  - IHM tank x 1ea
  - IHM heater x 1ea
  - Only **10-15% power consumption** compared to HP compressor system



# Type B LNG Fuel Tank



- Development of IMO Independent Type B Cargo Tank

**ACTIB**

Aluminum Cargo Tank IMO Independent Type B



*More economical*

**MCTIB**

High Manganese steel Cargo Tank IMO Independent Type B

- Advantages of Type B Cargo Tank

Operational Flexibility

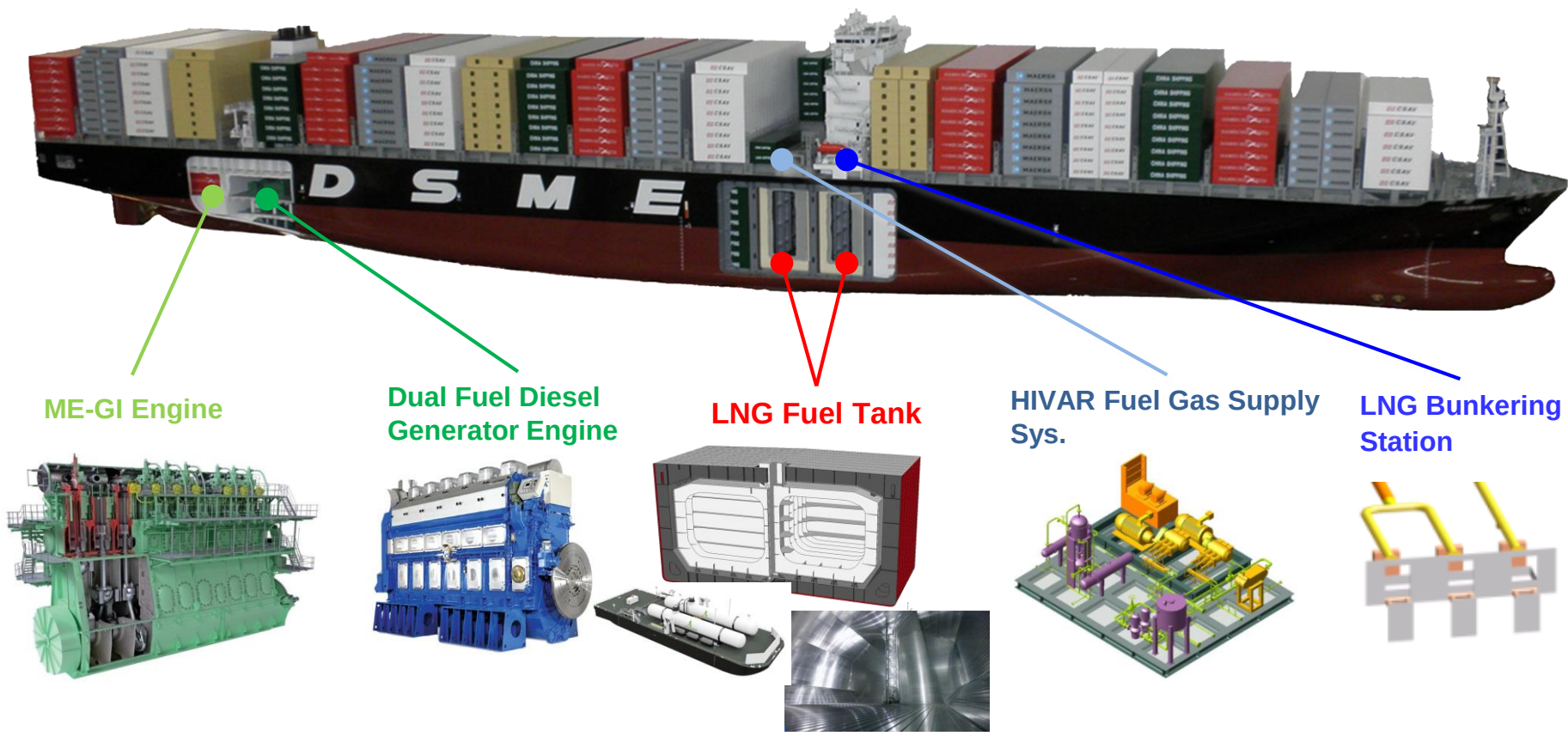
**Sloshing Free  
No Filling Limit**

Volume Efficiency

**Prismatic Shape  
Hull Optimized Tank**

# LFS Design and Technology

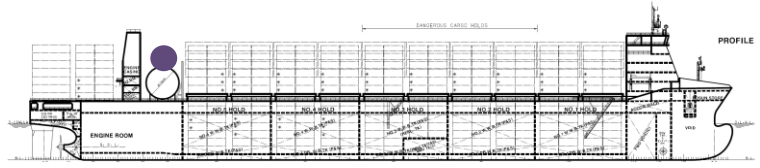
Overview



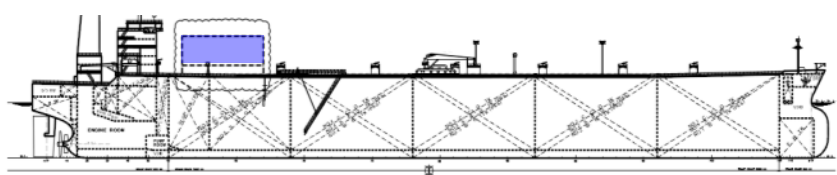
# LFS Design and Technology

## LFS Line-Up

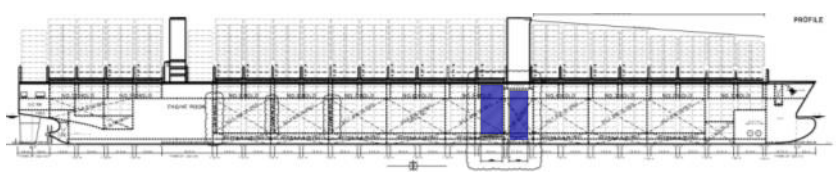
- 3,800 TEU Container Ship



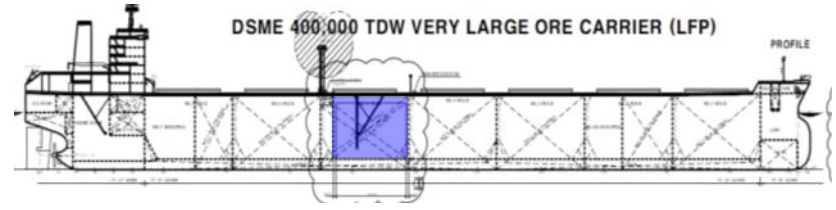
- VLCC



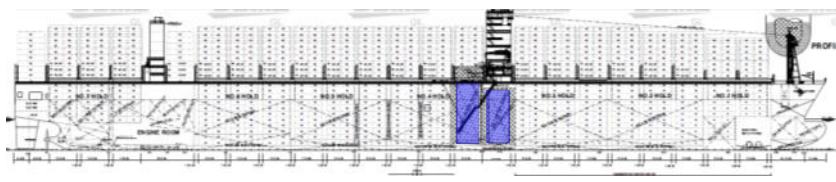
- 10,000 TEU Container Ship



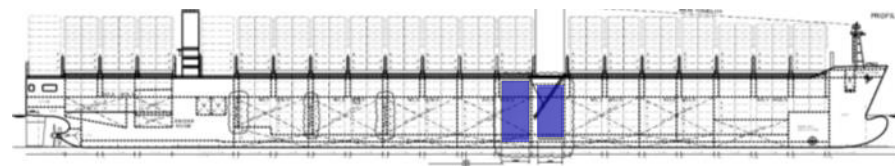
- 400k VLOC



- 14,000 TEU Container Ship



- 18,000 TEU Container Ship







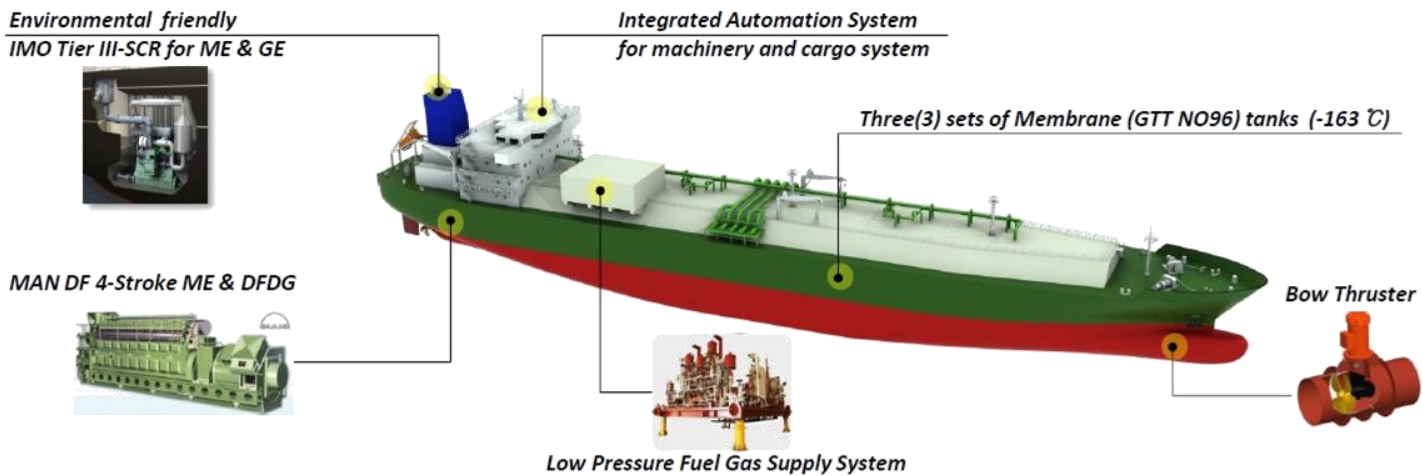
# LNG Bunkering Vessels on Order

Inquiries for LNG Bunkering Vessel are going to add up further during '17~'18.

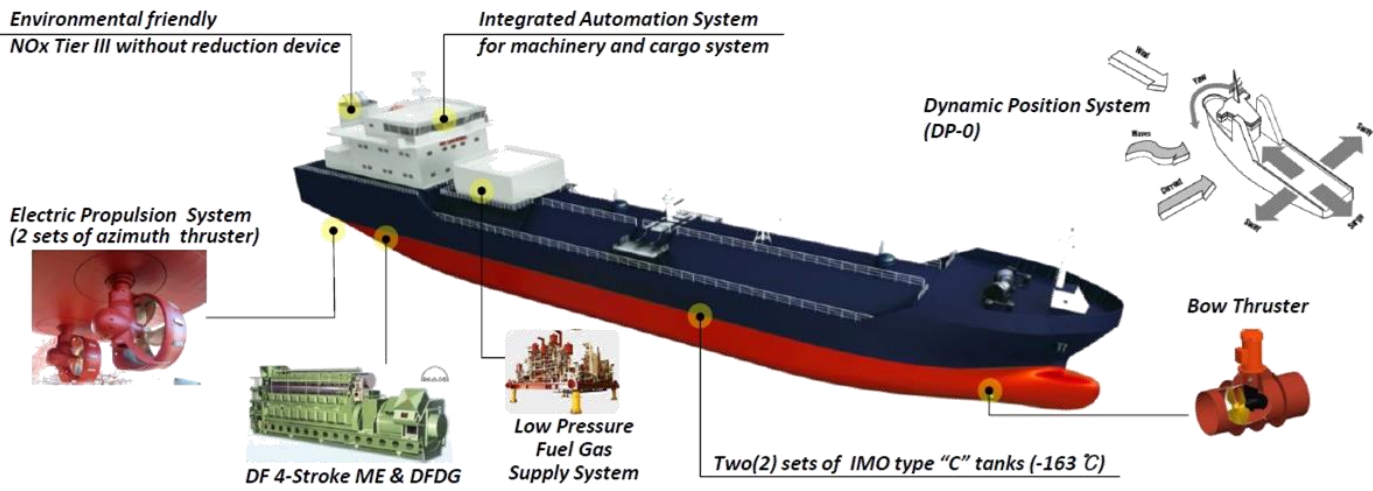
| Item                     | Company                            |                              |                                      |                        |
|--------------------------|------------------------------------|------------------------------|--------------------------------------|------------------------|
|                          | Shell                              | ENGIE<br>NYK                 | Sirius Veder Gas AB<br>Anthony Veder | WesPac Midstream       |
| Operation Area           | Port of Rotterdam                  | Port of Zeebrugge            | Northern Europe                      | Tacoma<br>USA          |
| LNG Cargo Capacity (CBM) | 6,500                              | 5,000                        | 5,800                                | 2,200                  |
| LNG Storage &            | Type C (TGE)                       | Type C (TGE)                 | Type C (TGE)                         | Mark III (GTT)         |
| BOG Re-liquefaction      | Air Liquid                         | -                            | Unknown                              | -                      |
| Class                    | LR                                 | BV                           | Unknown                              | ABS                    |
| Delivery                 | 2016                               | 2016                         | 2017                                 | 2016                   |
| Engine                   | Dual Fuel                          | Dual Fuel                    | Dual Fuel                            | Unknown                |
| Shipyard                 | STX offshore &<br>Shipbuilding(KR) | Hanjin Heavy<br>Industry(KR) | Royal Bodewes<br>(NL)                | Conard Orange<br>(USA) |
| Customer                 | Ocean going                        | UECC                         | Skangass<br>NEOT                     | TOTE                   |

# Concept Design of LNG Bunkering Vessel

## LNG Fuelled 35K CBM LNG Carrier



## LNG Fuelled 3.6K CBM LNG Bunkering Vessel





# Economics in the Recent Orders

## Recent Orders of Middle-scale LNGc

- To carry multi cargoes : LNG (-163°C), Ethane(-90°C), LPG(-50°C)
- China/South East Asia, South America, Scandinavia
- Abt. 20 vessels of 6.5K~45K m3 class LNGC in Operation, 18 vessels in Orderbook.

| Cargoes     | Size (m <sup>3</sup> ) | #Vessels | Owner               | C/A     | Price      |
|-------------|------------------------|----------|---------------------|---------|------------|
| LNG/Eth/LPG | 27.5K                  | 2        | Jaccar Holdings     | 2015.02 | 67.5mil    |
| LNG         | 45K                    | 1        | Landmark Capital    | 2015.01 | 80~85 mil. |
| LNG/Eth/LPG | 27.5K                  | 2        | Jaccar Holdings     | 2014.11 | 57mil      |
| LNG/Eth/LPG | 36K                    | 3        | Aker                | 2014.05 | 81mil      |
| LNG/Eth/LPG | 27.5K                  | 2        | Jaccar Holdings     | 2014.05 | 57mil      |
| LNG         | 30K                    | 1        | CNOOC               | 2013.04 | -          |
| LNG         | 28K                    | 1        | Dalian In the Group | 2013.04 | -          |
| LNG         | 30K                    | 1        | CNPC                | 2013.03 | -          |
| LNG/Eth/LPG | 27.5K                  | 4        | Jaccar Holdings     | 2013.01 | 57mil      |



# Economics in the Recent Orders

- Comparison of Unit Price per Cargo Volume**

|                                        |                  |                     |
|----------------------------------------|------------------|---------------------|
| <b>Middle-scale LNGC (27.5K ~ 45K)</b> |                  | <b>2,135 \$/m3</b>  |
| <b>5K LNG Bunkering</b>                | <b>50.0 m\$</b>  | <b>10,000 \$/m3</b> |
| VLCC                                   | 96.5 m\$         |                     |
| Suezmax                                | 65.0 m\$         |                     |
| Aframax                                | 53.5 m\$         |                     |
| MR                                     | 36.5 m\$         |                     |
| <b>160K LNGC</b>                       | <b>200.0 m\$</b> | <b>1,250 \$/m3</b>  |
| <b>82K LPGC</b>                        | <b>77.0 m\$</b>  | <b>940 \$/m3</b>    |

# Ship price is based upon Clarksons data

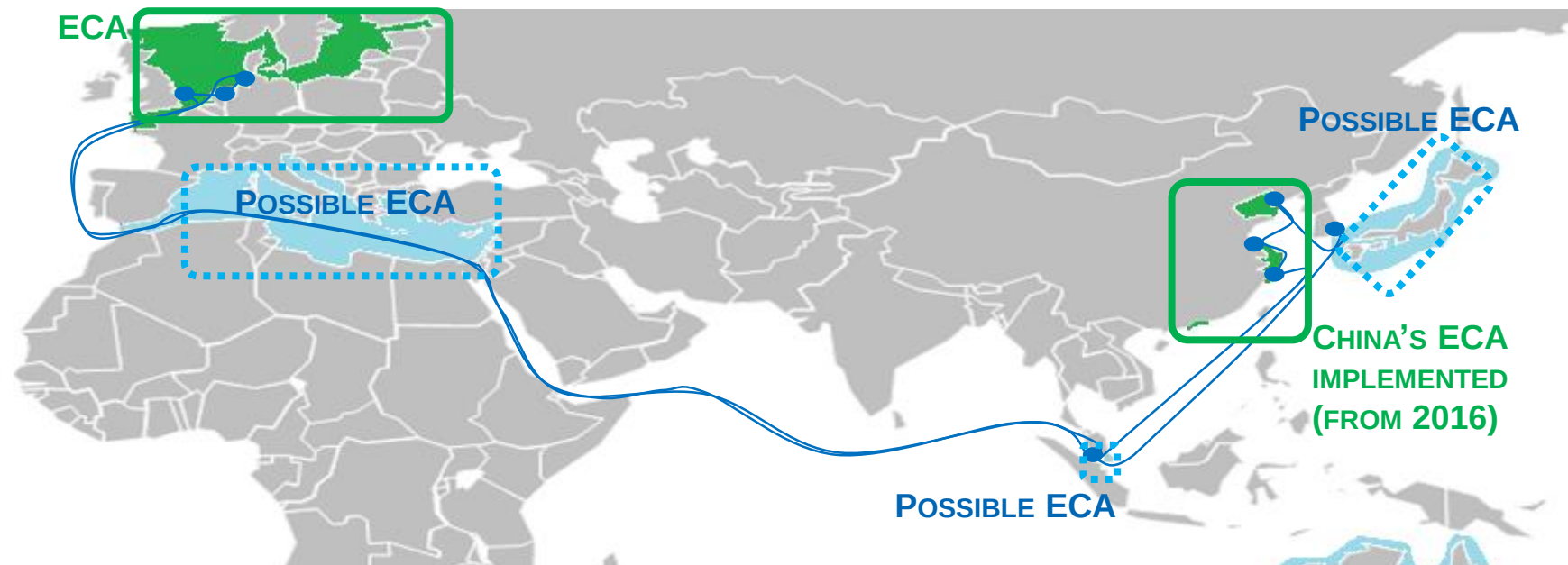
- What causes the price increase ?**

- The cost of Type C cargo tank and LNG fuel system accounts for nearly 30% of ship price
- Cost effective cargo handling system and gas management system to be developed



# Fuel Cost Analysis

- Voyage Route Scenario

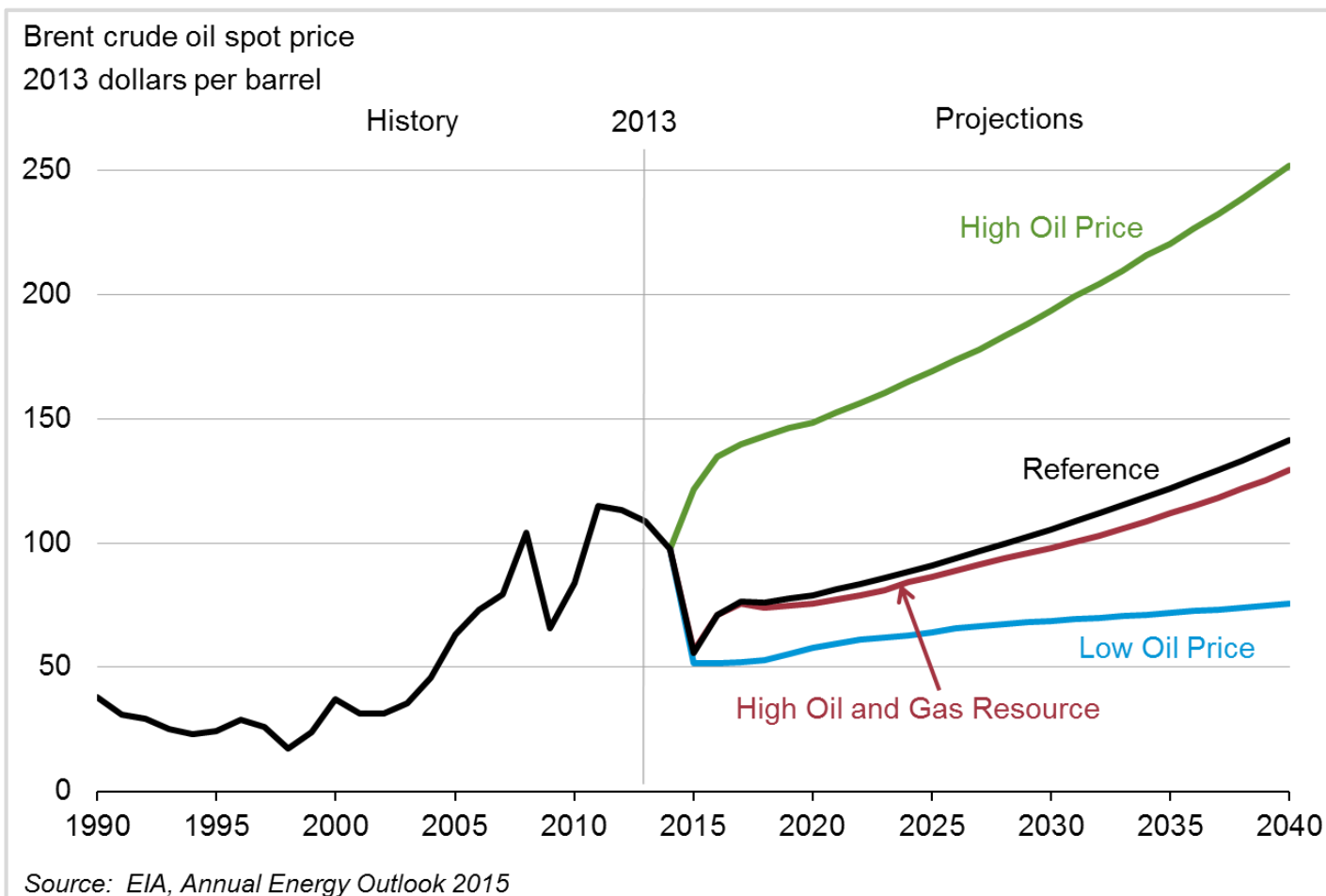


|                                              |                                                                                   |
|----------------------------------------------|-----------------------------------------------------------------------------------|
| Trade                                        | Far East ↔ Europe                                                                 |
| Ports                                        | Busan(South Korea), Hamburg(Germany), Rotterdam(Netherlands), Shanghai(China),... |
| Actual Speed Range                           | 9 ~ 21 Knots (Average 17.5 knots)                                                 |
| Cruising Distance                            | 24,000 NM (Round trip)                                                            |
| Cruising Duration<br>(including port in/out) | 59 days                                                                           |
| Port Duration (including canal)              | 11 days                                                                           |
| Number of Voyage                             | 5 voyages/year (350 days operation based)                                         |

# Fuel Cost Analysis



**LFS is not economical at the current low oil prices.  
However, what about oil price in the mid-term?**





# Fuel Cost Analysis

## MAJOR FUEL

|                   | Jan. 2020~            |
|-------------------|-----------------------|
| Regulation        | SOx 0.5%<br>in Global |
| Conventional Ship | LSMGO                 |
| LNG Fuelled Ship  | LNG                   |

## ASSUMPTION

- Price (As of W53, 2015)

| Oil Price | \$ 40 / Barrel                |
|-----------|-------------------------------|
| LNG       | \$ 359 / Ton (\$ 6.8 / mmbtu) |
| HFO       | \$ 166 / Ton                  |
| LSMGO     | \$ 378 / Ton                  |

- Price (mid-term future)

| Oil Price | \$ 80 / Barrel               |
|-----------|------------------------------|
| LNG       | \$ 528 / Ton (\$ 10 / mmbtu) |
| HFO       | \$ 460 / Ton                 |
| LSMGO     | \$ 740 / Ton                 |

## COST SAVING



from Jan. 2020



\* Ultra Low Sulphur HFO price is expected to be slightly lower than Low Sulphur Marine Gas Oil. However, ULSHFO is not commercialized yet and also faces technical issues to overcome.

# Summary



- **Small scale market is growing up, one step ahead.**
  - LNG Fueled Ship is spreading from ECA.
  - LNG Bunkering Vessel will be coupled.
- **Technical solutions to be developed to make the small scale market commercially viable.**
- **Port facilities to consider LNG bunkering.**



*End of Presentation  
Thank You*

*“ Best partner ...  
DSME will be around you ! ”*