Creating a better future
Global Leader

SHIP EFFICIENCY 2013
4th International Conference
Hamburg, 23-24 September 2013

HYUNDAI LNG CARRIER
– Now and in the Future

Hyundai Heavy Industries Co., LTD.
Shipbuilding Division

The German Society for Maritime Technology
Schiffbautechnische Gesellschaft e.V.

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

CONTENTS

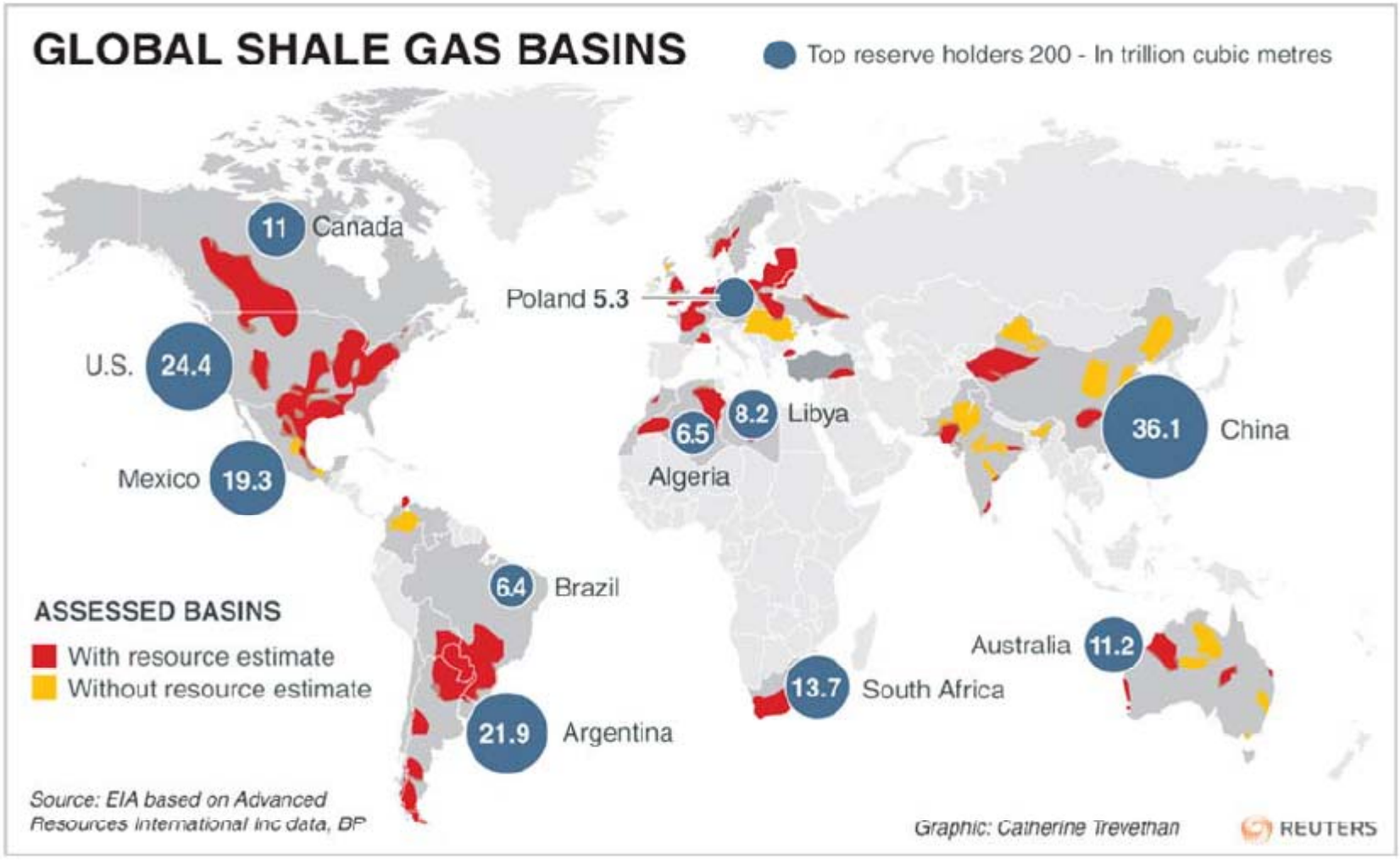
1. MARKET TREND & PERFORMANCE RECORD

◆ US Offtake Agreement for Shale Gas

Project	Offtaker	Volume (MMT/y)	Year Signed
Sabine Pass	BG Group (2 x Mara, 2 x Gaslog)	5.5	2011/2012
	Gas Natural Fenosa	3.5	2011
	Gail	3.5	2011
	Kogas	3.5	2012
	Cheniere Marketing	2.0	2012
	Total	2.0	2012
	Centrica	1.8	2013
Freeport LNG	Osaka Gas	2.2	2012
	Chubu Electric	2.2	2012
	BP	4.4	2013
Cameron LNG	Mitsubishi	4.0	2012
	Mitsui	4.0	2012
	GDF Suez	4.0	2012
Cove Point	Sumitomo	2.3	2012
	Gail	2.3	2013

1. MARKET TREND & PERFORMANCE RECORD

◆ POPULAR CARGO CAPACITY



1. PERFORMANCE RECORD (DELIVERED)

◆ Reference List - LNG Carriers Delivered

	Size	Owner	CCS Type	Propulsion	Delivery	Remarks
Total 42 Vessels	125K x 3	HMM x 1	Moss	Steam	1994	
		SK Shipping x 1			1994	
		HMM x 1			1996	
	137K x 8	HMM x 1			1999	
		HMM x 3			2000	
		Bonny Gas Transport x 3			2002/03	
		Golar LNG x 1			2004	
	140K x 2	Bonny Gas Transport x 1			2004	
		Golar LNG x 1	Mem. Mark III		2005	
	141K x 3	Bonny Gas Transport x 3	Moss		2005/06	
	150K x 8	Tsakos x 1	Mem. Mark III		2007	
		NYK x 1*+2			2007 / 08	* LU2
		Dynacom x 2*+1			2007 / 08	* ICE-1A
		KOGAS x 1*			2008	* LU2
	155K x 6	BP (HHI x 3, HSHI x 1)		DFDE	2007 / 08	
		Teekay (HHIx1, HSHI x1)			2008 / 09	
	177K x 2	MOL (HHI x 1, HSHI x 1)			2010	
	216K x 8	OSG + QGTC x 2		DRL	2007 / 08	
		J5 + QGTC x 3			2008	
		QGTC x 3			2009	
	155K x 2	Dynagas x 2	Mem. Mark III	DFDE	2013	* ICE-1A

15 Vessels

27 Vessels

1. ON ORDER LIST

◆ Reference List - LNG Carriers & LNG FSRU On Order

	Size	Owner	CCS Type	Propulsion	Delivery	Remarks
Total 29 Vessels	155K x 1	Dynacom x 1	Membrane Mark III	DFDE	2014	BOR :0.14%/d
	162K x 4	Dynacom x 4			2014 ~ 2015	BOR : 0.1%/d
	162K x 2	B.W. Maritime x 2			2014	
	162K x 4	Maran Gas (Samho x 4)			2013 ~ 2015	
	162K x 1	Oman Shipping x 1			2014	
	162K x 2	Golar LNG (Samho x 2)			2014	
	162K x 1	TSAKOS x 1			2015	
	170K x 4	Hoegh LNG FSRU x 4			2013 ~ 2015	FSRU
	155K x 2	Brunei x 2			2014 ~ 2015	BOR :0.15%/d
	174K x 6	Maran Gas (Samho x 6)			2015 ~ 2016	BOR : 0.1%/d
	177K x 2	NLNG (BGT)			2015	

2. HHI STANDARD LNGC

◆ Main Particulars of HHI LNG Carrier (Membrane MKIII Type)

	155K (RST)	155K (DFDE)	165K (DFDE)	174K (DFDE)	216K (MEGI)
Loa/B/D (m)	288 / 44.2 / 26	288 / 44.2 / 26	290/45/26.4	290/46.4/26.4	315 / 50 / 27
d_D / d_S (m)	11.48 / 12.5	11.48 /12.48	11.5 / 12.5	11.6/12.6	12 / 13
NO. of TANK	4	4	4	4	5
CARGO CAPACITY	154,880 ㎥	155,000 ㎥	165,100 ㎥	174,200 ㎥	216,200 ㎥
MAIN PROPULSION	Reheat Steam Turbine	DFDE	DFDE	DFDE	MEGI
BOR (%/day)	0.15	0.15	0.1	0.1	0.1
NO. of PROPELLER	Single	Twin	Twin	Twin	Twin
REFERENCE	Under development	Under construction	Under development	Under construction	Under development

2. HHI STANDARD LNGC

◆ Main Particulars of HHI LNG Carrier (MOSS Type)

	141K (CST)	150K (RST)	165K (MEGI)
Loa/B/D (m)	288 / 48 / 26.5	290/48.9/23.35	300 / 52 / 29
d_D / d_S (m)	11.25 /12.3	11.5 / 12.5	11.6 / 12.6
NO. of TANK	4	4	4
CARGO CAPACITY	141,000 ㎥	150,200 ㎥	165,000 ㎥
MAIN PROPULSION	Steam Turbine	Reheat Steam Turbine	MEGI
BOR (%/day)	0.15	0.1	0.15
NO. of PROPELLER	Single	Single	Twin
REFERENCE	Delivered	Under development	Under development

3. DESIGN DEVELOPMENT

DESIGN DEVELOPMENT

- LOW FOC
- LOW BOR
- REINFORCED CARGO CONTAINMENT SYSTEM
- NEW PANAMA CANAL REQUIREMENT
- POPULAR CARGO CAPACITY

3. DESIGN DEVELOPMENT

3.1 LOW FOC

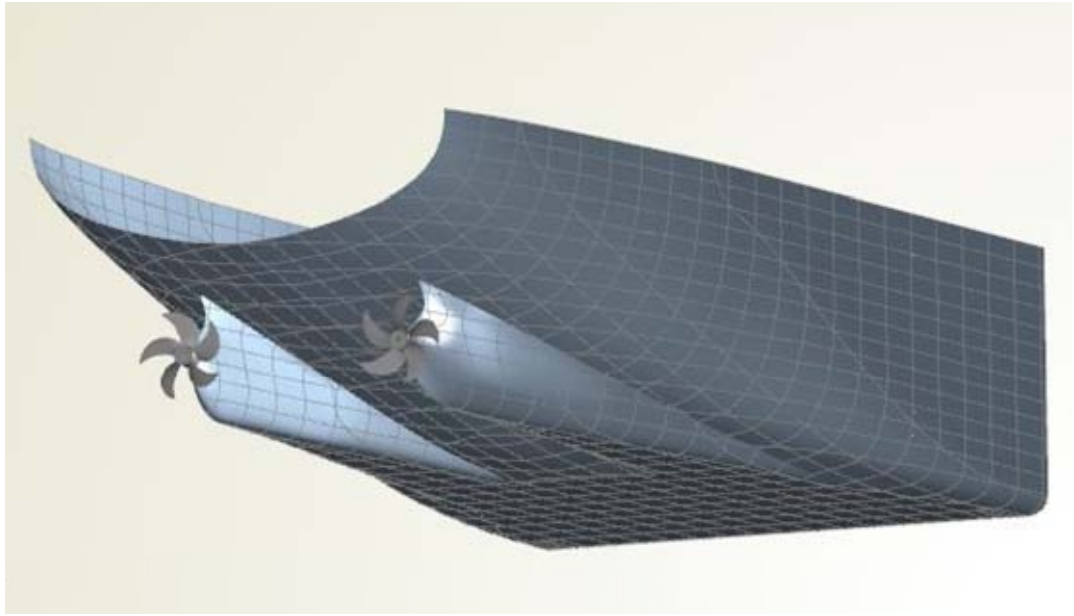
- **Stern Hull Form**

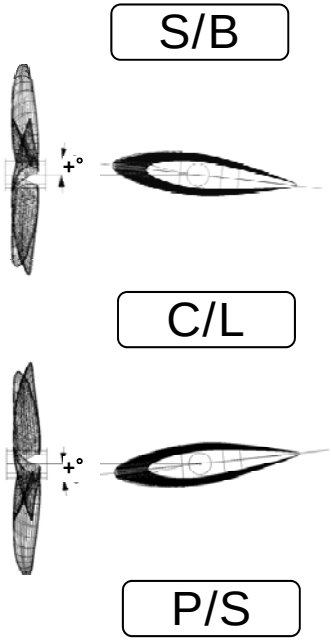
	164K (DFDE) + Single Screw	165K (DFDE) + Twin Screw
Loa/B/D (m)	289 / 45.6 / 26.0	290 / 45 / 26.4
Design Draft(m)/Cb	11.47 / 0.7635	11.5 / 0.7389
NO. of TANK	4	4
CARGO CAPACITY	163,700 ㎥	165,100 ㎥
MAIN PROPULSION	DFDE 6L50DF x 2, 12V50DF x 2	DFDE 6L50DF x 2, 12V50DF x 2
Hull Wight (%)	100%	101.3%
NO. of PROPELLER	Single	Twin
DFOC at NCR (t/day)	135.3	119.6

3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Twin Skeg**





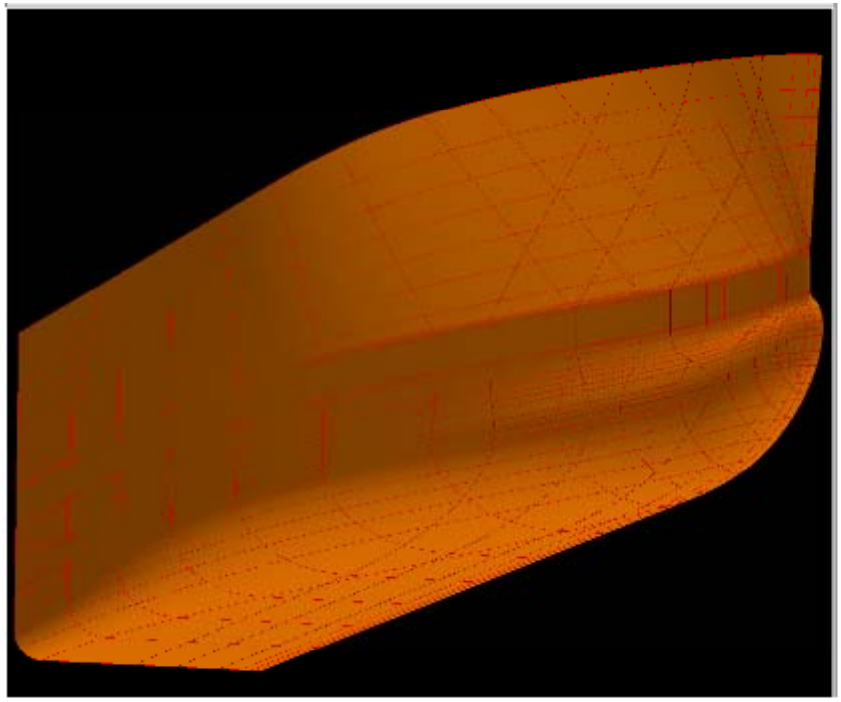
Wake pattern improvement and the propulsive efficiency increase.
(Shaft Angle optimization : 1.87%)

	Shaft & Rudder Angle
Previous	2.5 degree
Revision	4.5 degree

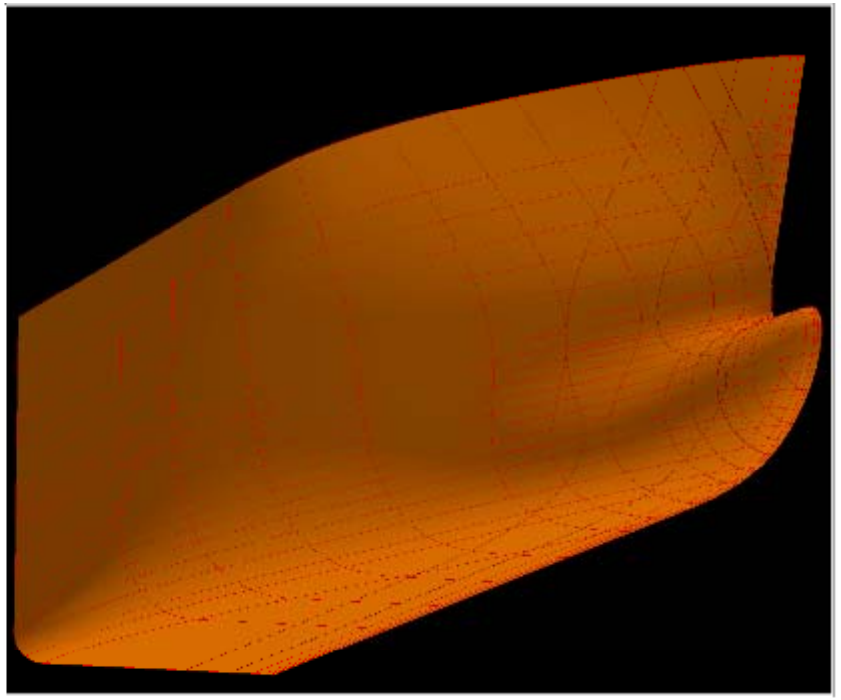
3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Development of FWD Hull Form**
  : Overview of Bow Hull Form



<T667 – New Bow>

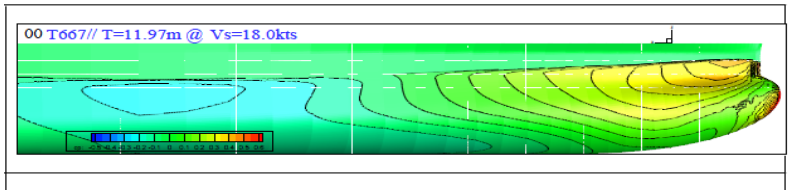


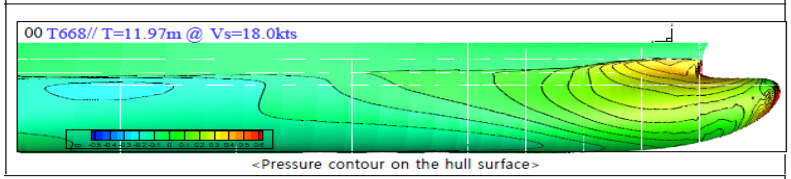
<T668 – Conventional Bow>

3. DESIGN DEVELOPMENT

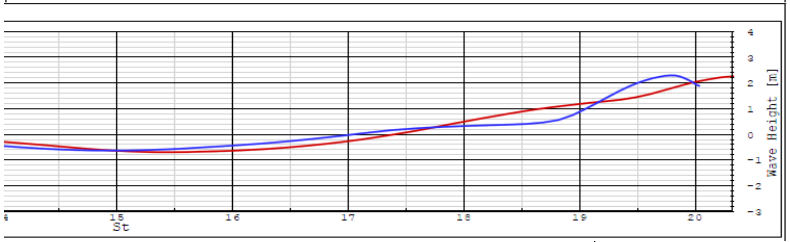
3.1 LOW FOC

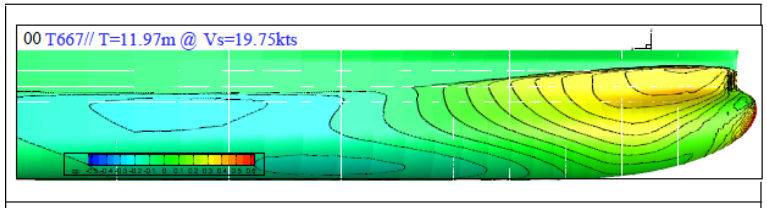
- **FWD Hull Form : Result of CFD at Design draft**

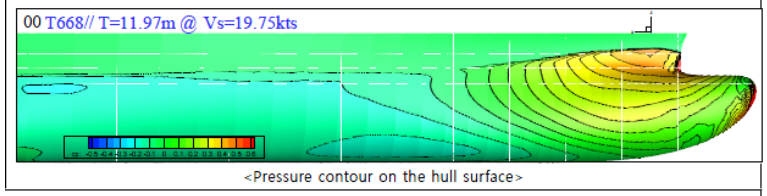




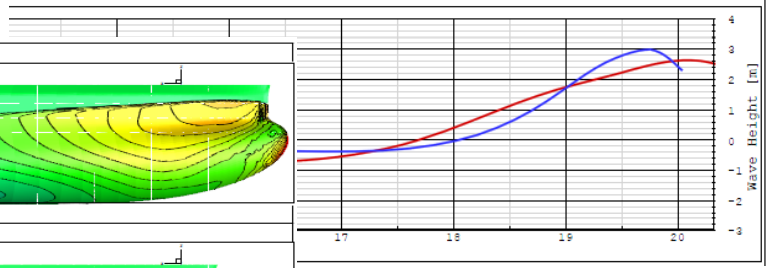
<Pressure contour on the hull surface>

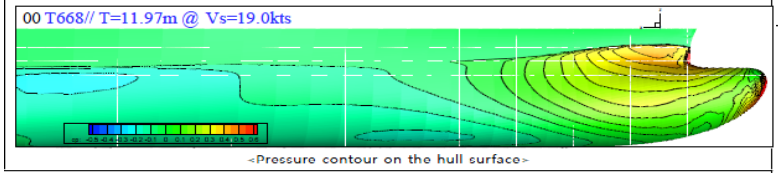




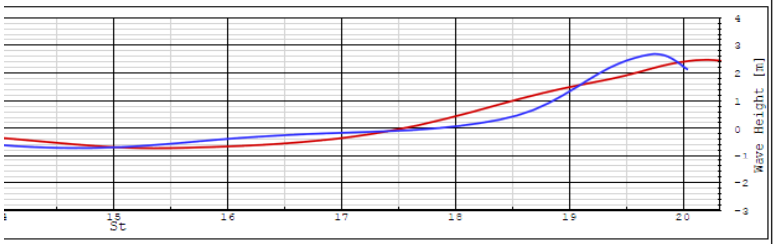


<Pressure contour on the hull surface>





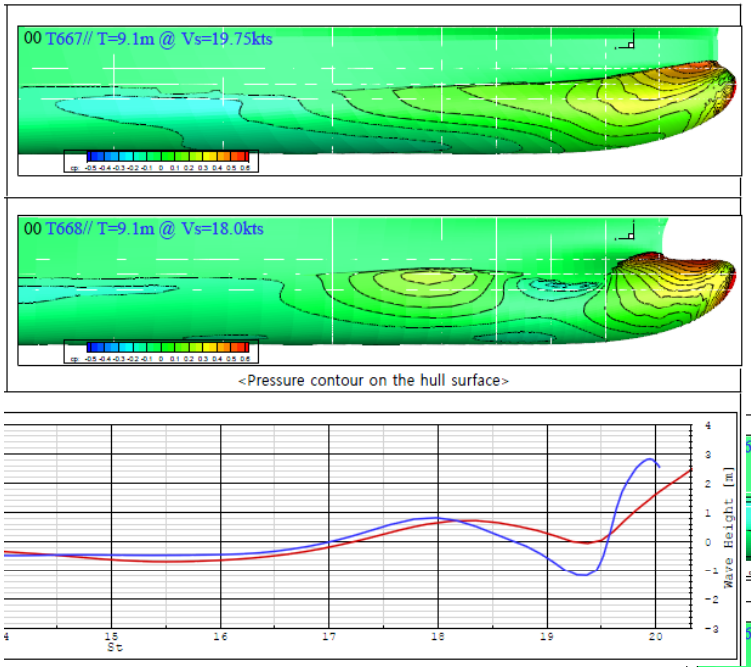
<Pressure contour on the hull surface>

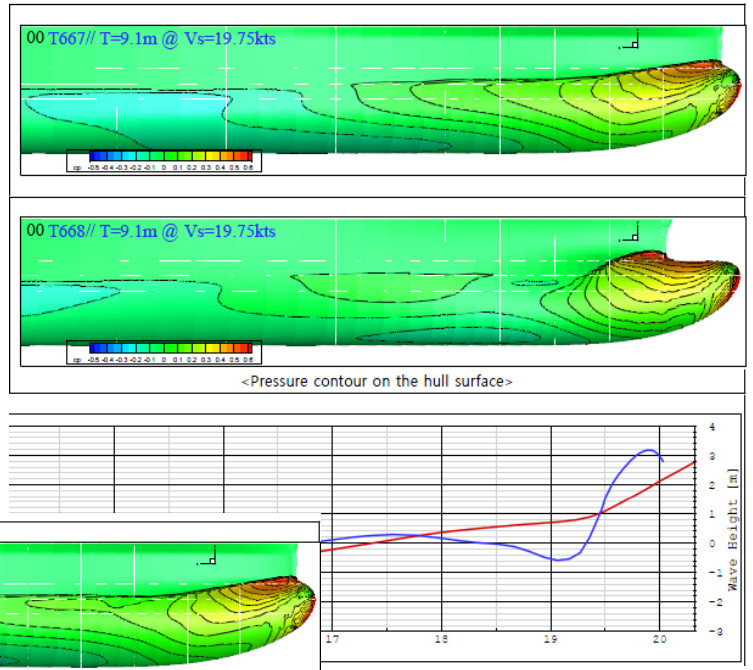


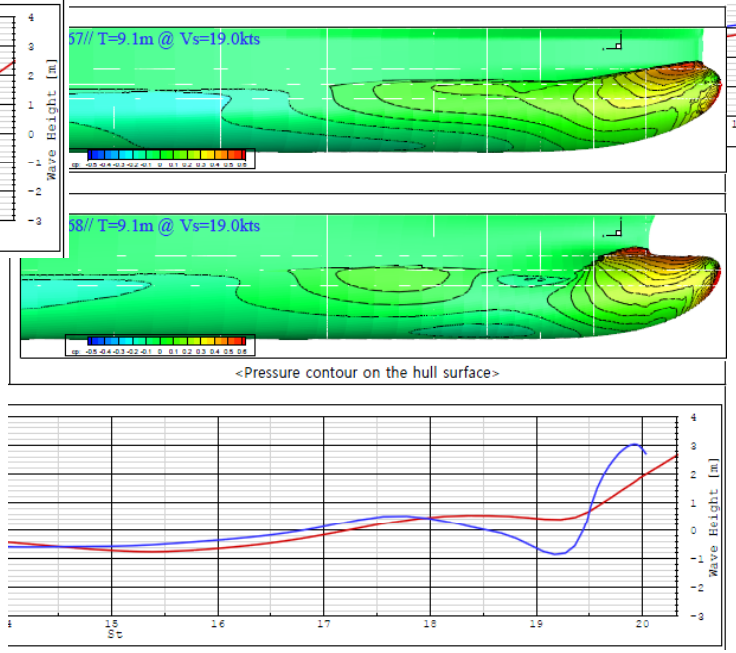
3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **FWD Hull Form : Result of CFD at Ballast draft**





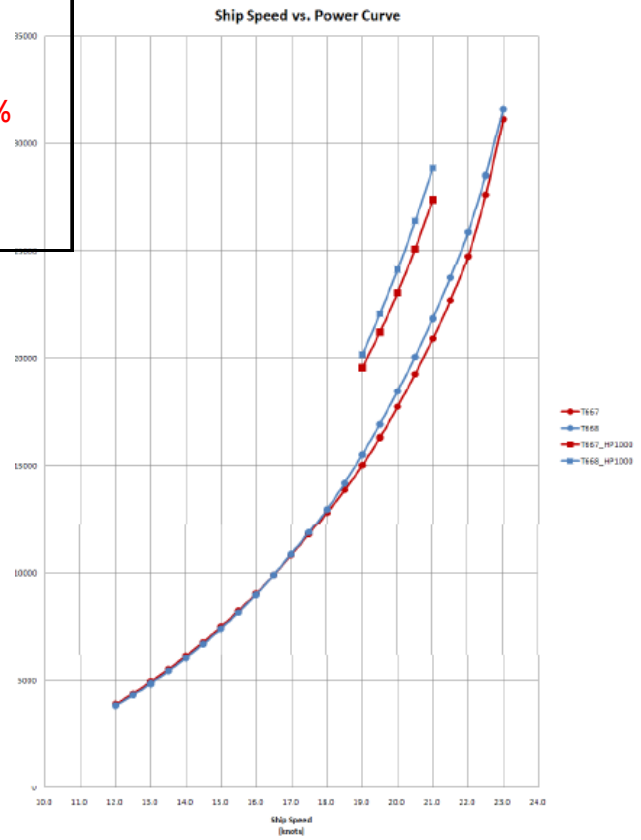


3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Result of CFD : about 1.8% of power saving to be expected**

Draft (m)	Speed (knots)	Propulsion Power (%)		differences	Average
		T667(NEW)	T668(CON)		
11.97 (design)	18.0	100	102.3	-2.3%	-1.8%
	19.0	100	102.3	-2.3%	
	19.8	100	102.1	-2.1%	
9.10 (ballast)	18.0	100	99.3	+0.7%	
	19.0	100	99.6	+0.4%	
	19.8	100	99.8	+0.2%	



- **Result of Model Test at Design draft : about 3.7% of power saving at service speed to be expected**

SPEED (knots)	T667(NEW) (kW)	T668(CON) (kW)	Differences	
			(kW)	(%)
16.0	9,049	8,999	50	0.6%
18.0	12,823	12,976	-153	-1.2%
19.0	15,016	15,513	-497	-3.2%
19.5	16,297	16,917	-620	-3.7%
20.0	17,725	18,451	-726	-3.9%

3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Result of Sea keeping test**

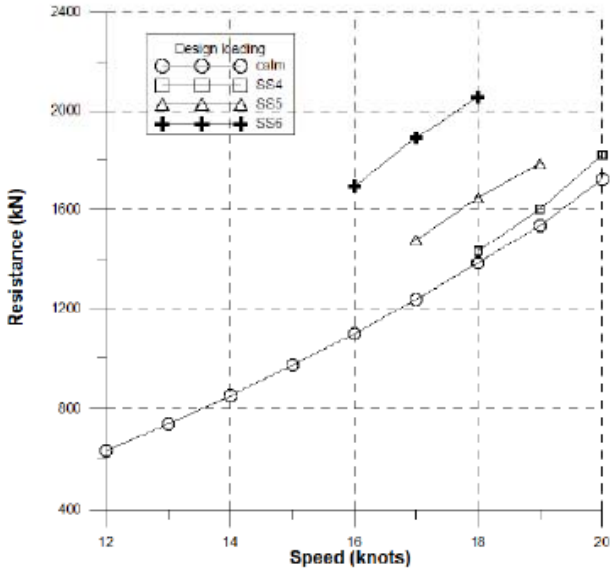


Figure 3 Resistance in irregular waves for T667

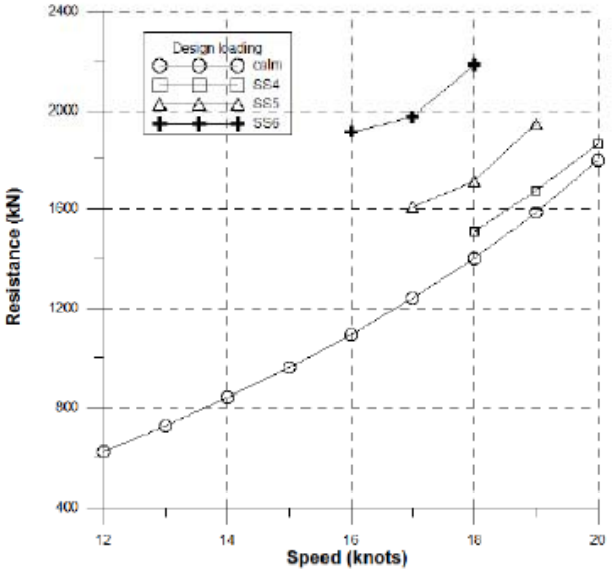


Figure 4 Resistance in irregular waves for T668

Table 9 Total resistance in irregular waves for T667

Ship speed (knots)	Resistance in calm sea (kN)	Resistance in waves (kN / %[1)])		
		SS4	SS5	SS6
16	1099	.	.	1693 / 54.05
17	1237	.	1479 / 19.58	1888 / 52.65
18	1385	1434 / 3.56	1650 / 19.10	2054 / 48.32
19	1536	1603 / 4.33	1784 / 16.18	.
20	1723	1819 / 5.55	.	.

[1)] (Resist. in waves – Resist. in calm sea) x 100 / Resist. in calm sea

Table 10 Total resistance in irregular waves for T668

Ship speed (knots)	Resistance in calm sea (kN)	Resistance in waves (kN / %)		
		SS4	SS5	SS6
16	1093	.	.	1825 / 66.97
17	1242	.	1608 / 29.49	2028 / 63.26
18	1401	1511 / 7.86	1711 / 22.13	2187 / 56.08
19	1587	1672 / 5.35	1947 / 22.69	.
20	1793	1860 / 3.75	.	.

3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Result of Sea keeping test at Design draft in irregular and regular wave conditions**

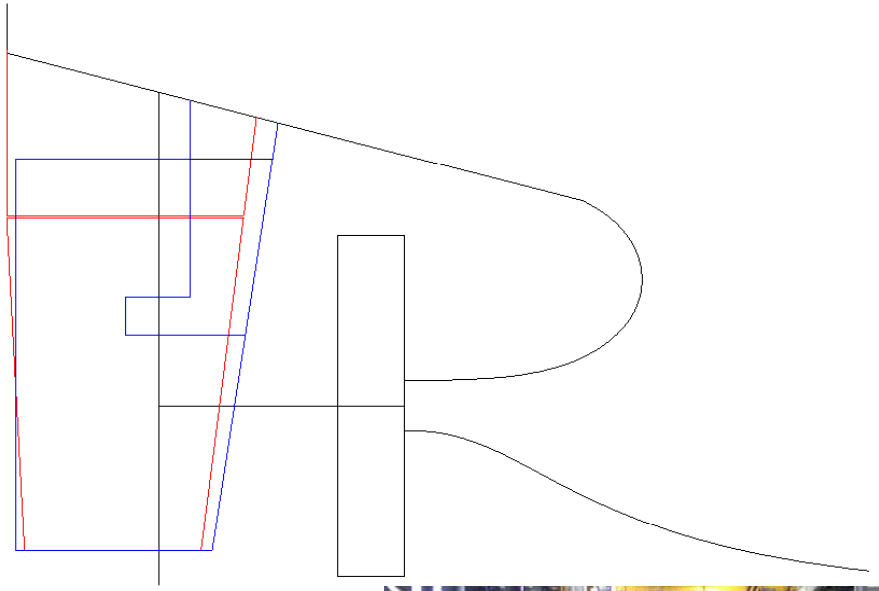
Sea State	Resistance			Max. differences of added resistance
	T667(NEW)	T668(CON)	differences	
Wave	Calm Sea			irregular wave
SS 4	3.6~4.3% (18~20 kts)	3.8%~7.9% (20~18kts)	-0.2~-3.6%	-55.23% (18 kts)
SS 5	16.2~19.6% (19~17kts)	22.1~29.5% (19~17kts)	-5.9~-9.9%	-33.86% (17 kts)
SS 6	48.3~54.1% (18~16kts)	56.1~67.0% (18~16 kts)	-7.8~-12.9%	-27.66% (16 kts)
Wave	regular wave(Wave HGT 2m, 19 kts)			
	30.38%	39.99%	-9.51%	

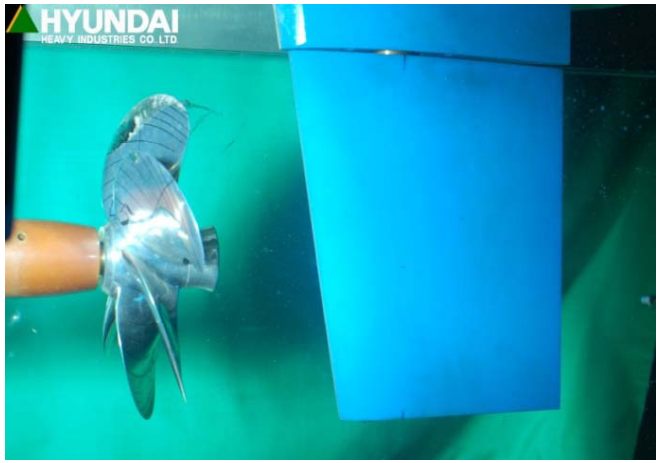
The New hull form shows better performance in sense of the resistance in wave.

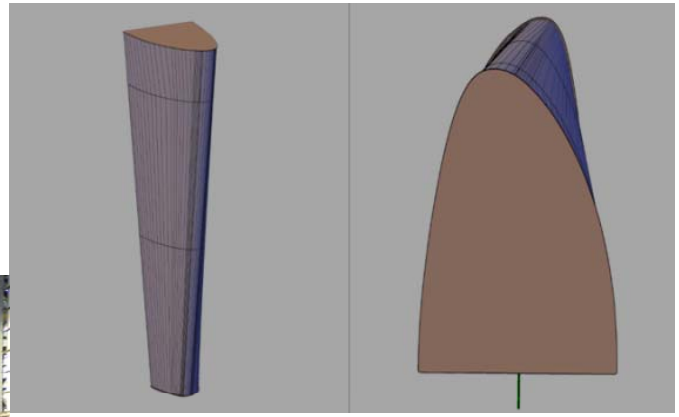
3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Rudder Type**







HHI X-Twisted (Single) or Full Spade Rudder (Twin)

Power saving : around 0.5%

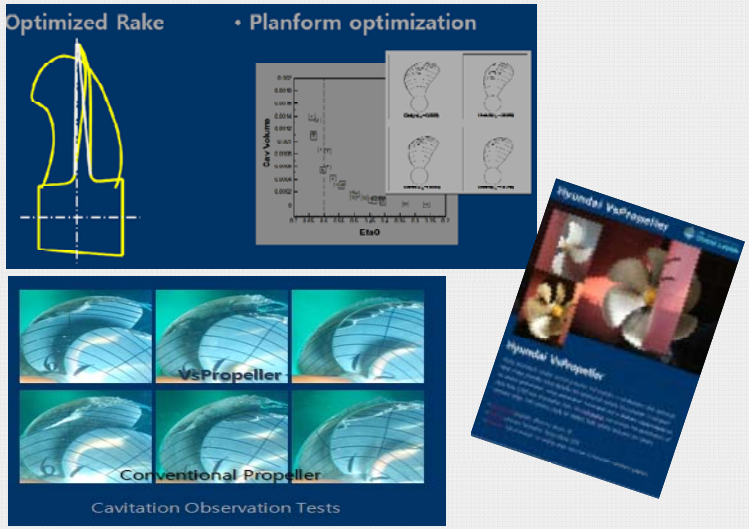
3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Propeller Blade**
  - ➢ **Optimum Propeller Design**

HHI Vs (variable Section)Propeller

➢2 % Increase in Propeller Efficiency (HD STD)
➢ Minimum risk of erosion on trailing edge



- ➢ **Propeller Blade No. Study**

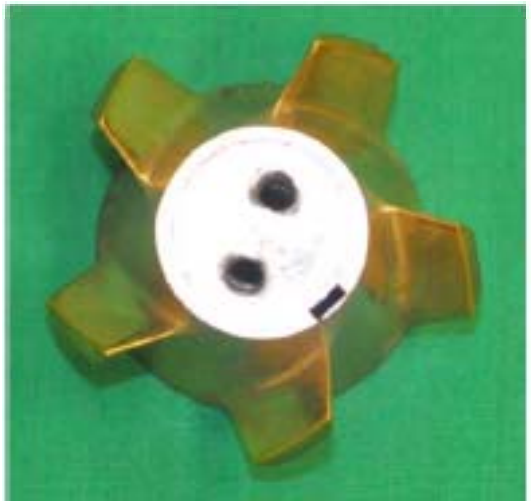
(Based on 174 K Twin LNGC)

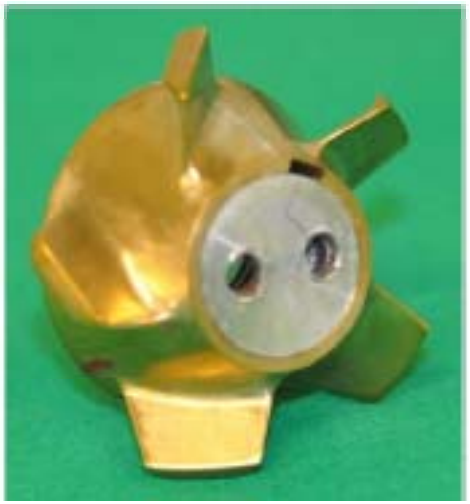
	3 Blade	4 Blade	5 Blade
Diameter	8.5 m	8.2 m	8.0m
Remark		Pump tower design to be changed.	It is generally used for LNGC.
Propulsion Power	98.84 %	99.87 %	100%

3. DESIGN DEVELOPMENT

3.1 LOW FOC

- **Energy Saving Device : Hi-FIN(Hyundai End-plated Cap Fin)**





● Propulsion Test

- about 1% power improvement
- No significant change of propeller revolution

● Cavitation Performance

- No observation of hub vortex cavitation
- No signification change of cavitation on propeller blade
- No signification change of hull pressure fluctuation level

3.2 LOW BOR

- **Typical 174K CLASS DFDE LNGC (0.1% BOR)**

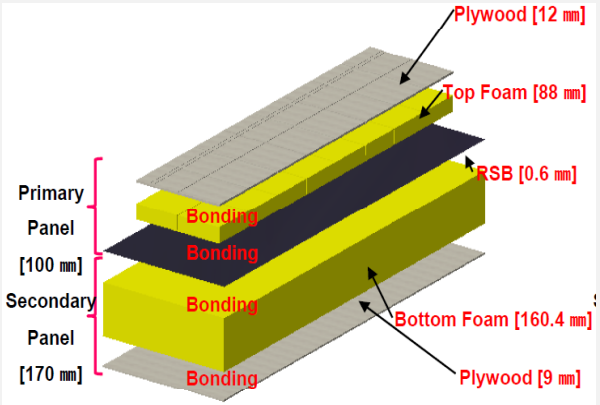
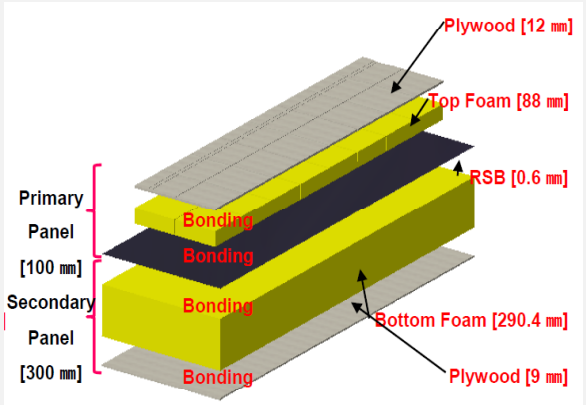
VOYAGE	SPEED	Calculation
		Excessive BOG
	(Kn)	(kg/hr)
LADEN	12.0	1,756.2
	13.0	1,487.3
	14.0	1,218.4
	15.0	867.6
	16.0	516.9
	17.0	55.8
	18.0	0.0
	19.5	0.0
BALLAST	12.0	290.4
	14.0	0.0
	15.0	0.0
	16.0	0.0
	17.0	0.0
	18.0	0.0
	19.0	0.0
	19.5	0.0

LOW BOR ⇨ SAVE CARGO AT SLOW STEAMING CASE

3. DESIGN DEVELOPMENT

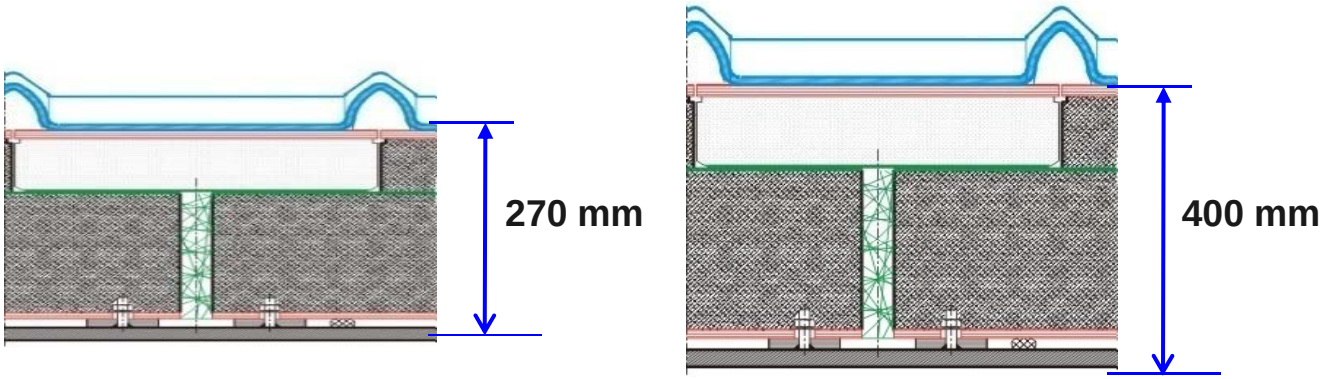
3.2 LOW BOR

- **Insulation Thickness**

	Mark III Standard I.P		Mark III Flex I.P	
Insulation Thickness	270 mm thick 		400 mm thick 	
Blowing Agent for R-PUF	HCFC-141B	CO2	HCFC-141B	CO2
Boil-Off Rate	0.14%	0.15%	0.1%	0.1%

3.2 LOW BOR

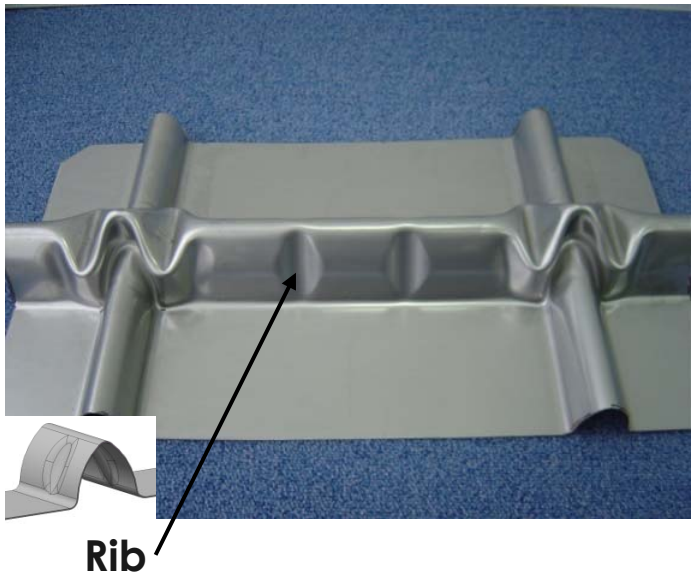
- **Blowing Agent**



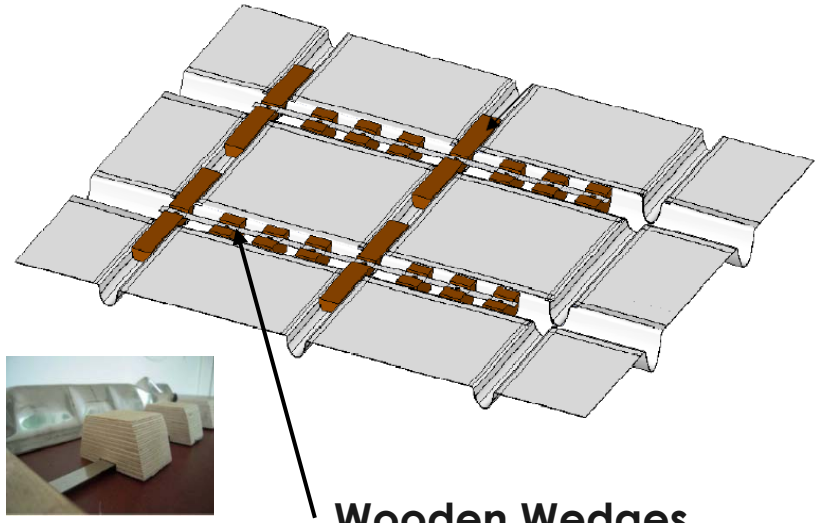
	Present		New	
Blowing Agent	CO2		HFC-245 fa	
Insulation Thickness	270 mm	400 mm	270 mm	400 mm
Boil-Off Rate	0.15%	0.1%	0.135%	0.09%

3.3 REINFORCED CARGO CONTAINMENT SYSTEM

Membrane Sheet with Ribs



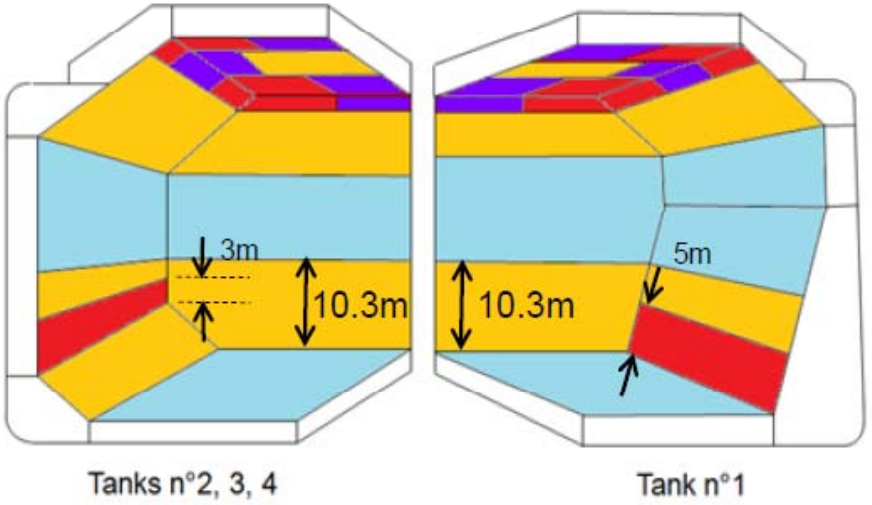
Membrane Sheet with Wooden Wedge



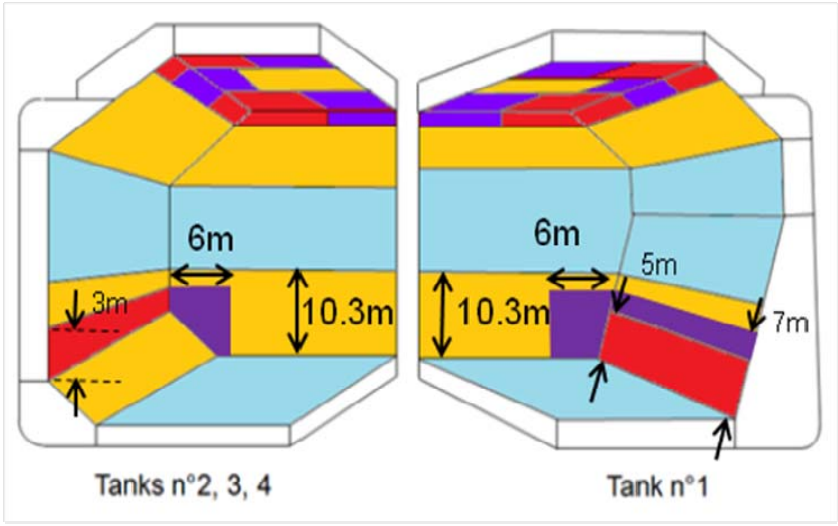
Ribs have been added to the large corrugation for better stiffness
Wedges under the corrugations have been developed for better stiffness.

3.3 REINFORCED CARGO CONTAINMENT SYSTEM

- **Membrane Tank Reinforcement for 174K LNGC(400mm thick insulation panel)**



Reinforcement Standard



BG Reinforcement

Std membrane
Rib membrane
Rib membrane + wedges (mandatory)
Rib membrane + wedges (extended)

(Fill. limit Upper : 70%H, Lower : 2.75m)

3.4 New Panama Canal Requirement

Ship's size for transit of Panama canal

- Existing Panama Canal : LOA : 294.3m, B : 32.3m, draft : 12.04m
- New Panama Canal : LOA : 366m, **B : 49m**, draft : 15.2m

Additional item for panama requirement from existing LNGC

- **Increased Accommodation Height** for satisfying Visibility Requirement
  => Equipment number 1 grade increased
- Mooring arrangement Modification
  => Additional chocks, bollards and deck stand roller
- Panama platform and Bridge wing shelter
- Push button for electric whistle and Remote controller for VHF radio telephone system on Wheelhouse front bulkhead

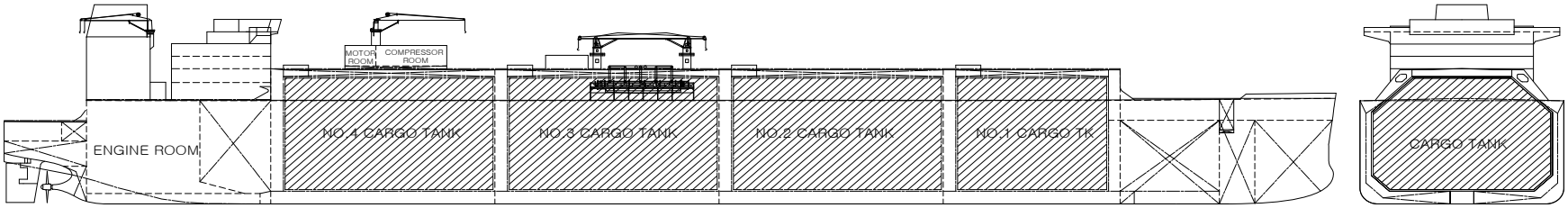
3.5 POPULAR CARGO CAPACITY – 165K TWIN DFDE LNGC

Building a better future
Global Leader
HYUNDAI

165K m³ CLASS LNGC - MARK III, DFDE (TWIN SKEG)

Head Office (http : //www.hhi.co.kr)
1, Jeonha-Dong, Dong-Gu,
ULSAN, KOREA

Proj. No. : 165L-13
Date :



MAIN DIMENSIONS

Length overall	abt.	290.0	m
Length between perp.		284.0	m
Breadth		45.0	m
Depth		26.4	m
Design draught (T_d)		11.50	m
Scantling draught (T_s)		12.50	m

DEADWEIGHT

Deadweight at T_d	abt.	78,500	MT
Deadweight at T_s	abt.	89,600	MT

CLASSIFICATION

ABS +A1(E), +AMS, Liquefied Gas Carrier, SH, SHCM, +ACCU, NBLES, TCM, UWILD, ENVIRO, BWT, GP, CPS.

COMPLEMENT 38 + 6 p

TANK CAPACITIES

Cargo tanks (excl. domes) 165,000 m^3

MAIN ENGINE

Wartsila 6L50DF x 2 sets, 12V50DF x 2 sets
MCR 35,100 kW x 514.0 rpm

DESIGN SPEED AT MPP WITH 21% S.M.

Service speed at T_d abt. 19.5 kts

FUEL OIL CONSUMPTION OF MAIN ENGINE

D.F.O.C at NCR (incl. General S.) abt. 122.1 t/d

CRUISING RANGE AT SERVICE SPEED

abt. 16,200 NM

NAVIGATION EQUIPMENT

1 - ECDIS, Conning Display & Route Planning
2 - Radar (ARPA)
2 - Gyro Compass
1 - Auto Pilot
1 - Speed Log
2 - DGPS Navigator

B.O.R. : 0.1% / day

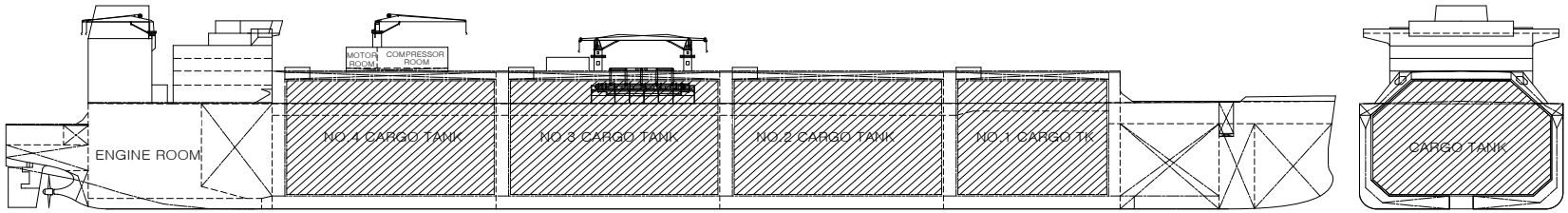
3.5 POPULAR CARGO CAPACITY – 174K TWIN DFDE LNGC

Building a better future
Global Leader
HYUNDAI

174K m³ CLASS LNGC - MARK III, DFDE (TWIN SKEG)

Head Office (http : //www.hhi.co.kr)
1, Jeonha-Dong, Dong-Gu,
ULSAN, KOREA

Proj. No. : 174L-13
Date :



MAIN DIMENSIONS

Length overall	abt.	290.0	m
Length between perp.		284.0	m
Breadth		46.4	m
Depth		26.4	m
Design draught (T_d)		11.60	m
Scantling draught (T_s)		12.60	m

DEADWEIGHT

Deadweight at T_d	abt.	82,700	MT
Deadweight at T_s	abt.	93,800	MT

CLASSIFICATION

ABS +A1(E), +AMS, Liquefied Gas Carrier, SH, SHCM, +ACCU, NBLES, TCM, UWILD, ENVIRO, BWT, GP, CPS.

COMPLEMENT 38 + 6 p

TANK CAPACITIES

Cargo tanks (excl. domes) 174,000 m^3

MAIN ENGINE

Wartsila 8L50DF x 2 sets, 12V50DF x 2 sets
MCR 39,000 kW x 514.0 rpm

DESIGN SPEED AT MPP WITH 21% S.M.

Service speed at T_d abt. 19.5 kts

FUEL OIL CONSUMPTION OF MAIN ENGINE

D.F.O.C at NCR (incl. General S.) abt. 124.4 t/d

CRUISING RANGE AT SERVICE SPEED

abt. 15,900 NM

NAVIGATION EQUIPMENT

1 - ECDIS, Conning Display & Route Planning
2 - Radar (ARPA)
2 - Gyro Compass
1 - Auto Pilot
1 - Speed Log
2 - DGPS Navigator

B.O.R. : 0.1% / day

4. MEGI FUEL SUPPLY SYSTEM

➢ STRONG INTEREST in MEGI PROPULSION SYSTEM

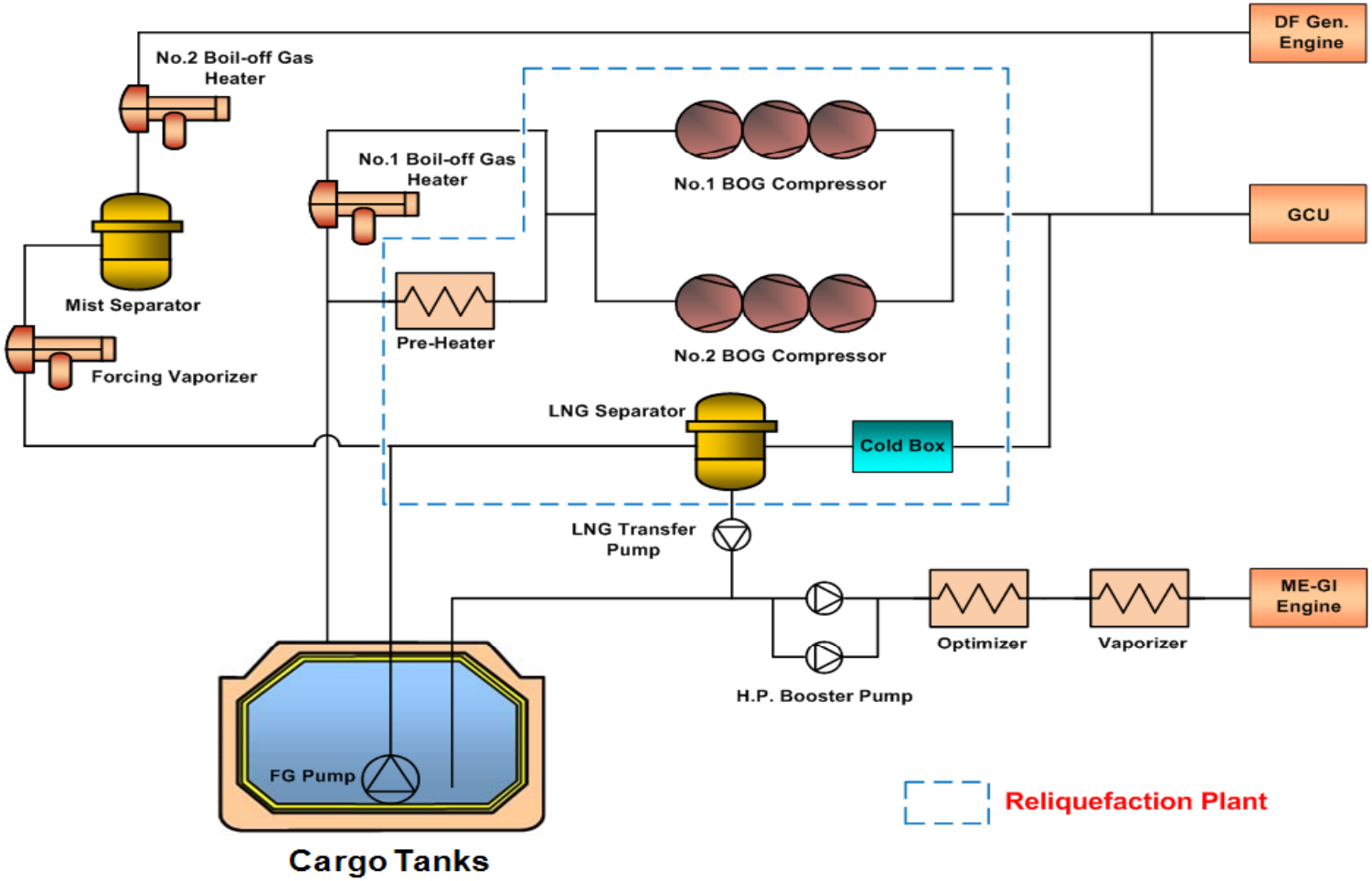
- **Comparison among RST, DFDE and MEGI Propulsion Systems**

	RST	DFDE	MEGI
Propulsion Efficiency	Abt. 34%	Abt. 43%	Abt. 48%
Fuel Using	Selective or mixing	Selective use	Selective or mixing
Maintenance Cost	Low	High	Moderate
Fuel cost (Gas mode)	High	Middle	Low
Emission	Moderate	Good	Moderate

4. MEGI FUEL SUPPLY SYSTEM

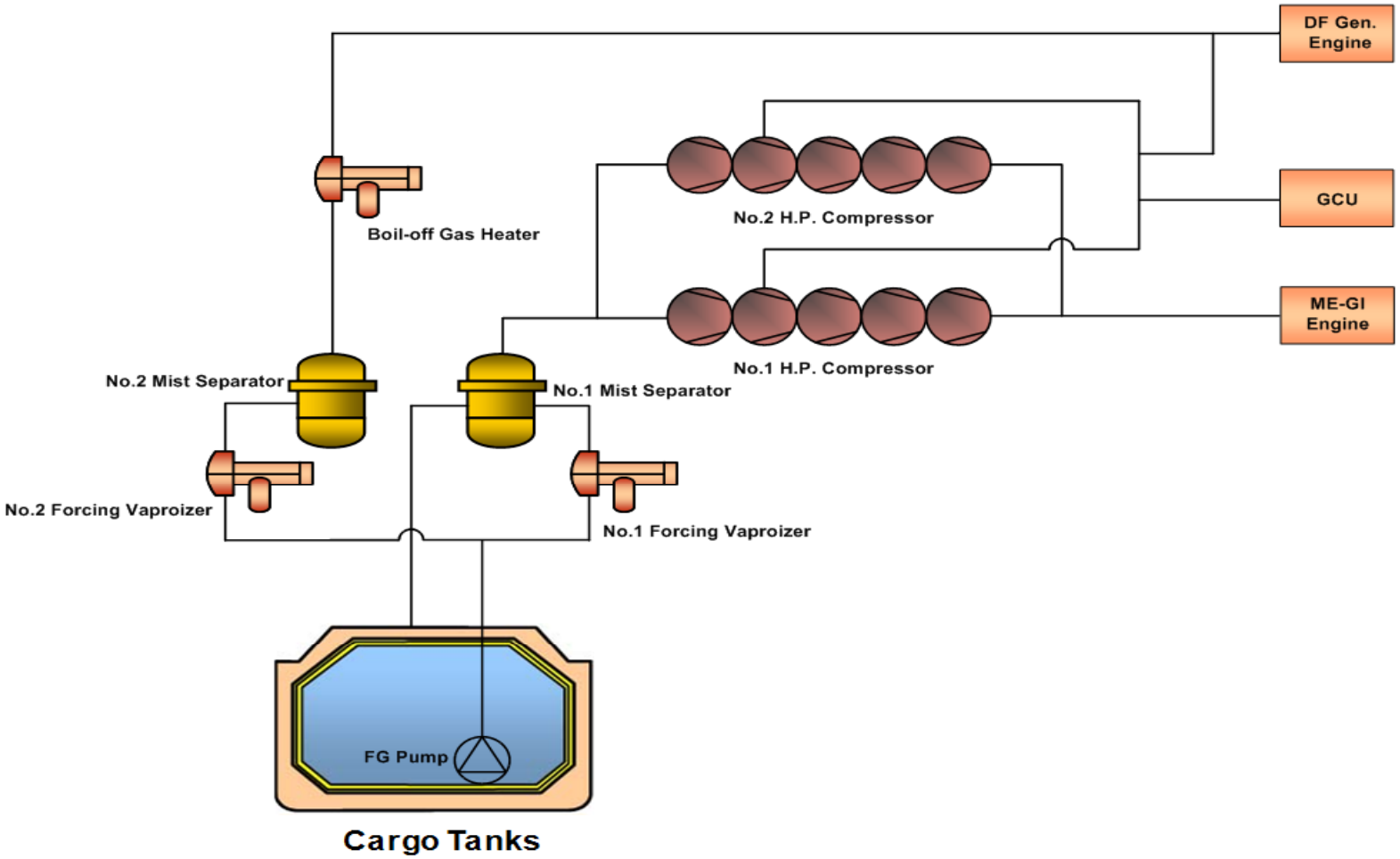
- **MEGI F.G.S.S with Reliquefaction Plant**

  (High Pressure Pump + Vaporizer)



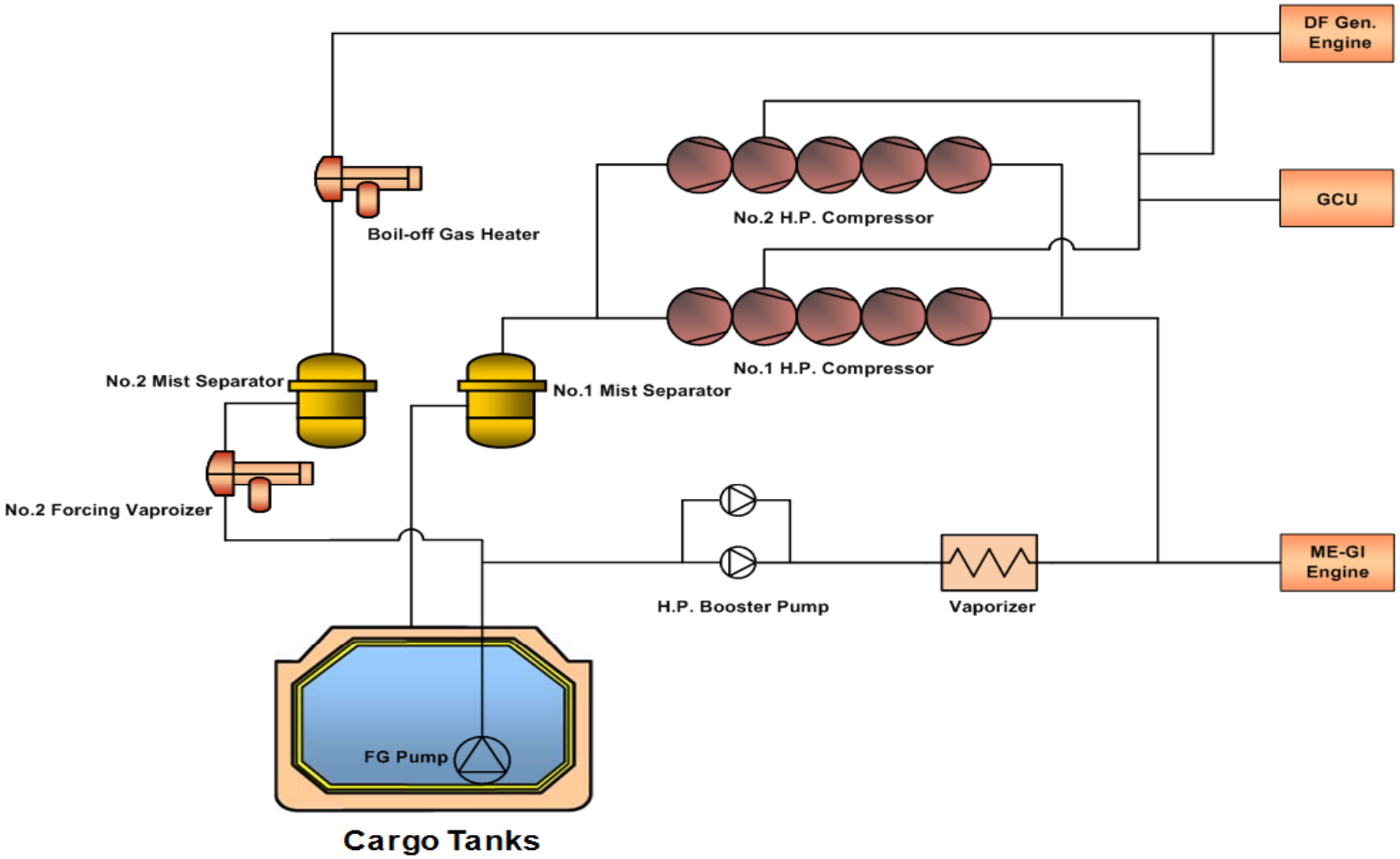
4. MEGI FUEL SUPPLY SYSTEM

- **MEGI F.G.S.S. with High Pressure Compressor (Alt.1)**



4. MEGI FUEL SUPPLY SYSTEM

- **MEGI F.G.S.S. with High Pressure Compressor + High Pressure Pump (Alt.2)**



4. MEGI FUEL SUPPLY SYSTEM

- **Comparison between MEGI Fuel Gas Supply Systems**

	Base	Alt.1	Alt.2
F.G.S.S. Configuration	Reliquefaction + H.P. pump	H.P. Compressor	H.P. Compressor + H.P. Pump
CAPEX (Mil. USD)	-	- 2.5	+ 1.5
Advantage	No loss of BOG	Simple control	Low power consumption
Disadvantage	High power consumption	Moderate power consumption BOG loss	BOG loss

4. MEGI FUEL SUPPLY SYSTEM

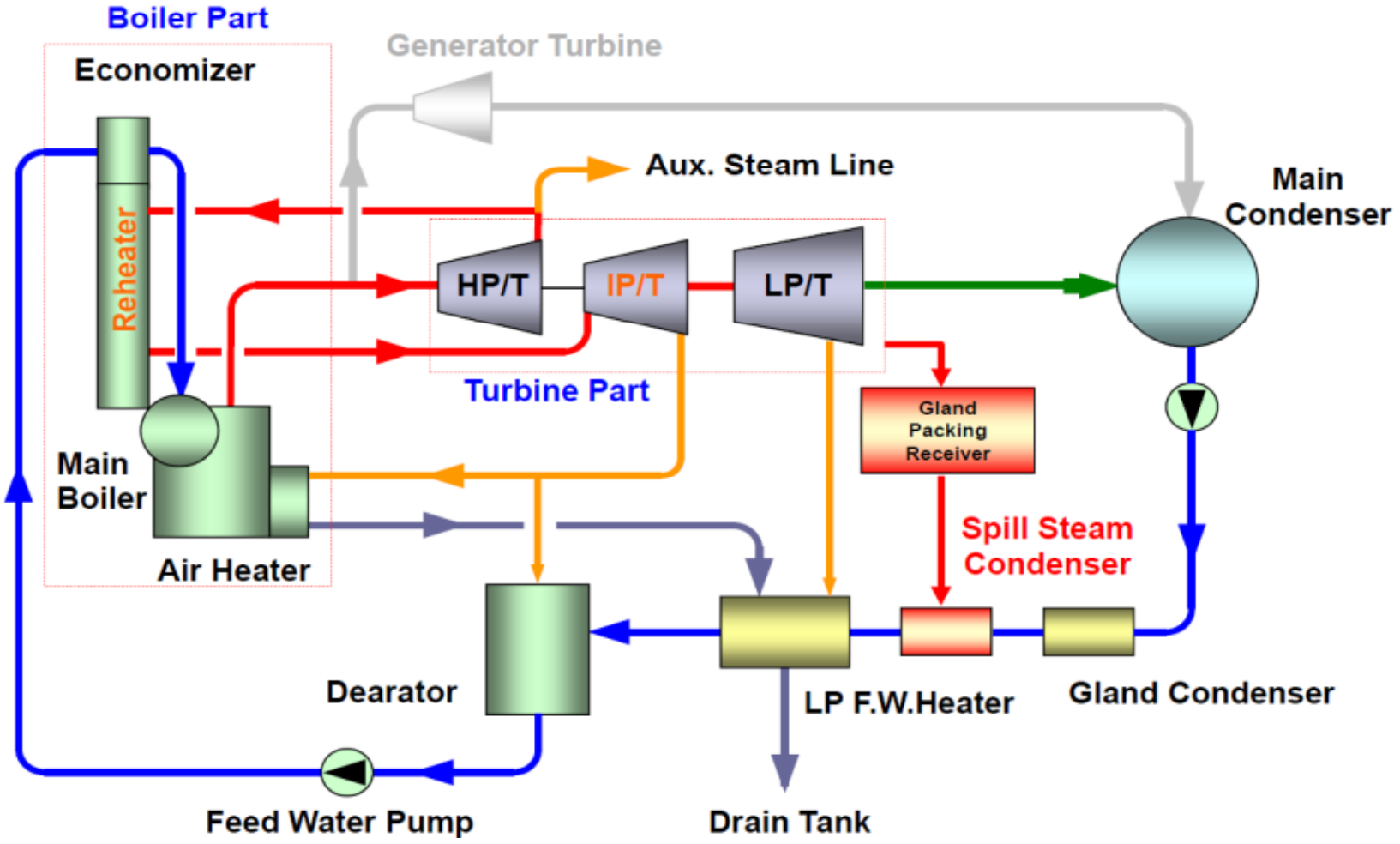
- **Power Consumption Comparison**

  (174K LNGC Main Engine :6G70ME-C9.2-GI x 2 sets)

	Base	Alt.1	Alt.2
F.G.S.S. Configuration	Reliquefaction + H.P. pump	H.P. Compressor	H.P. Compressor + H.P. Pump
19.5 knots Laden Voyage	★	★★	★★★
19.5 knots Ballast Voyage	★★	★	★★★
18 knots Slow Steaming Laden Voyage	★	★★	★★★
15 knots Slow Steaming Ballast Voyage	★	★★	★★★

◆ RST (Reheat Steam Turbine) Application

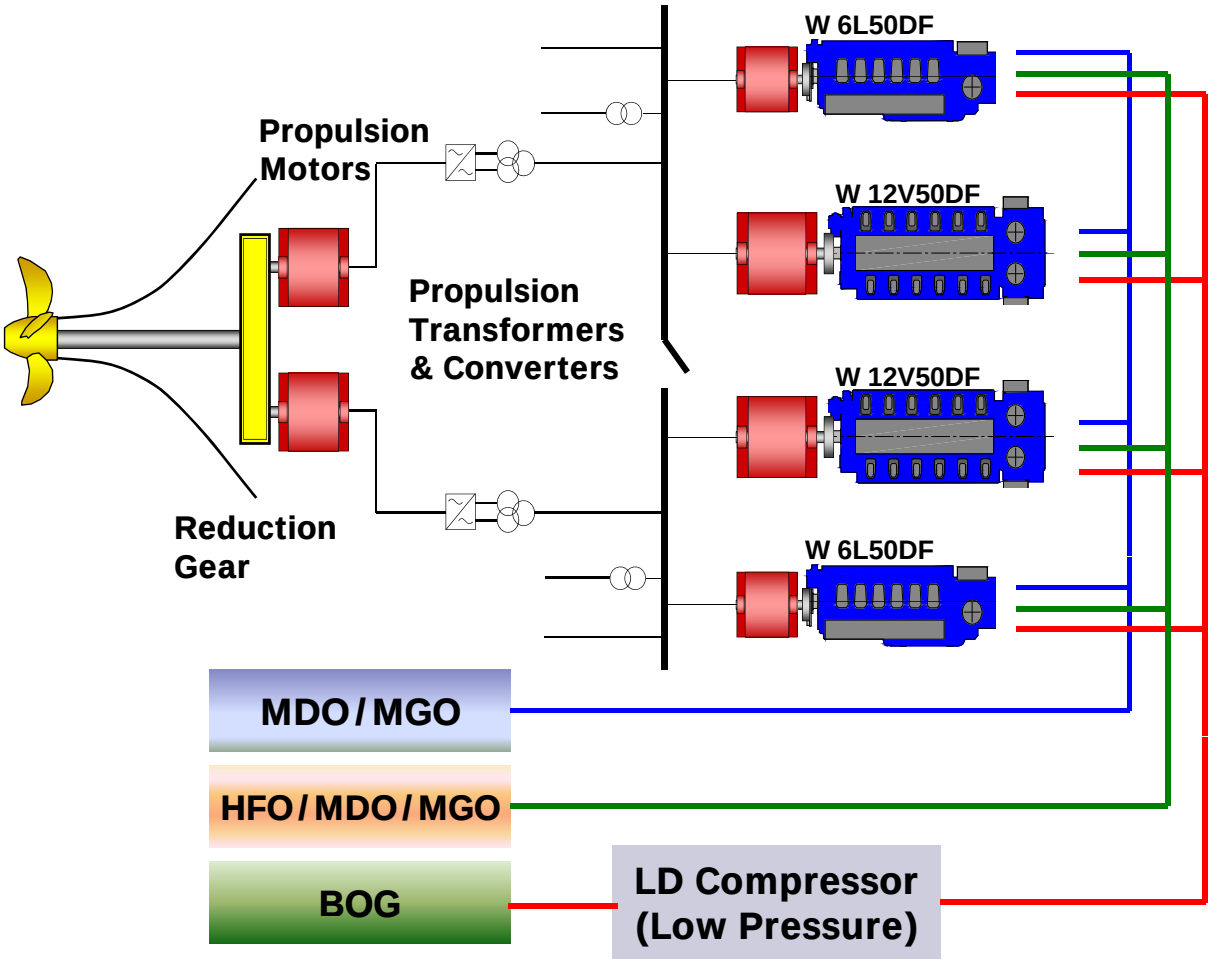
- Typical configuration for LNG Carrier



5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ DFDE (Dual Fuel Diesel Electric) Application

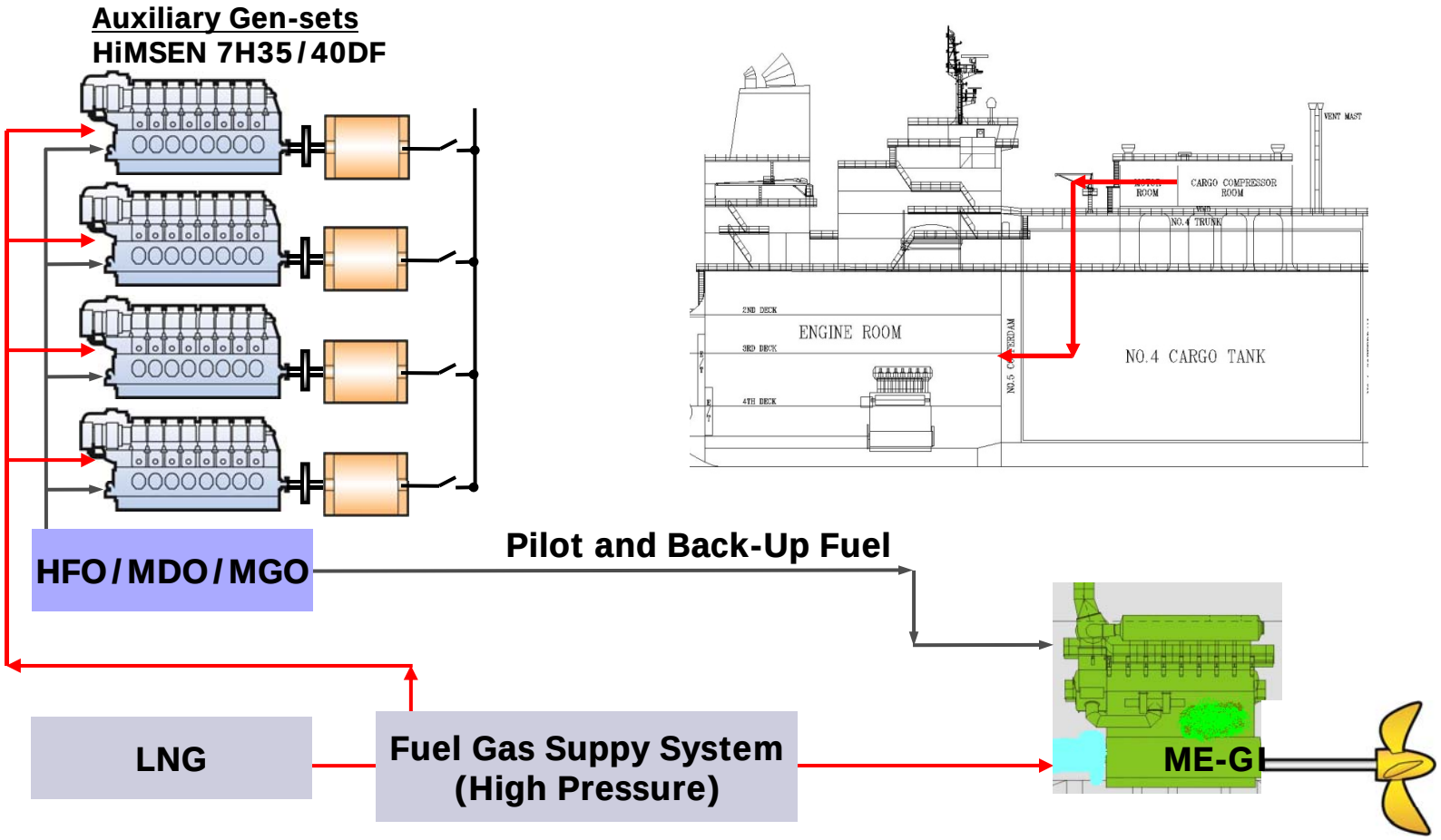
● Typical configuration for LNG Carrier



5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ MEGI (Slow Speed Dual Fuel Diesel Engine) Application

● Typical configuration for LNG Carrier



5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

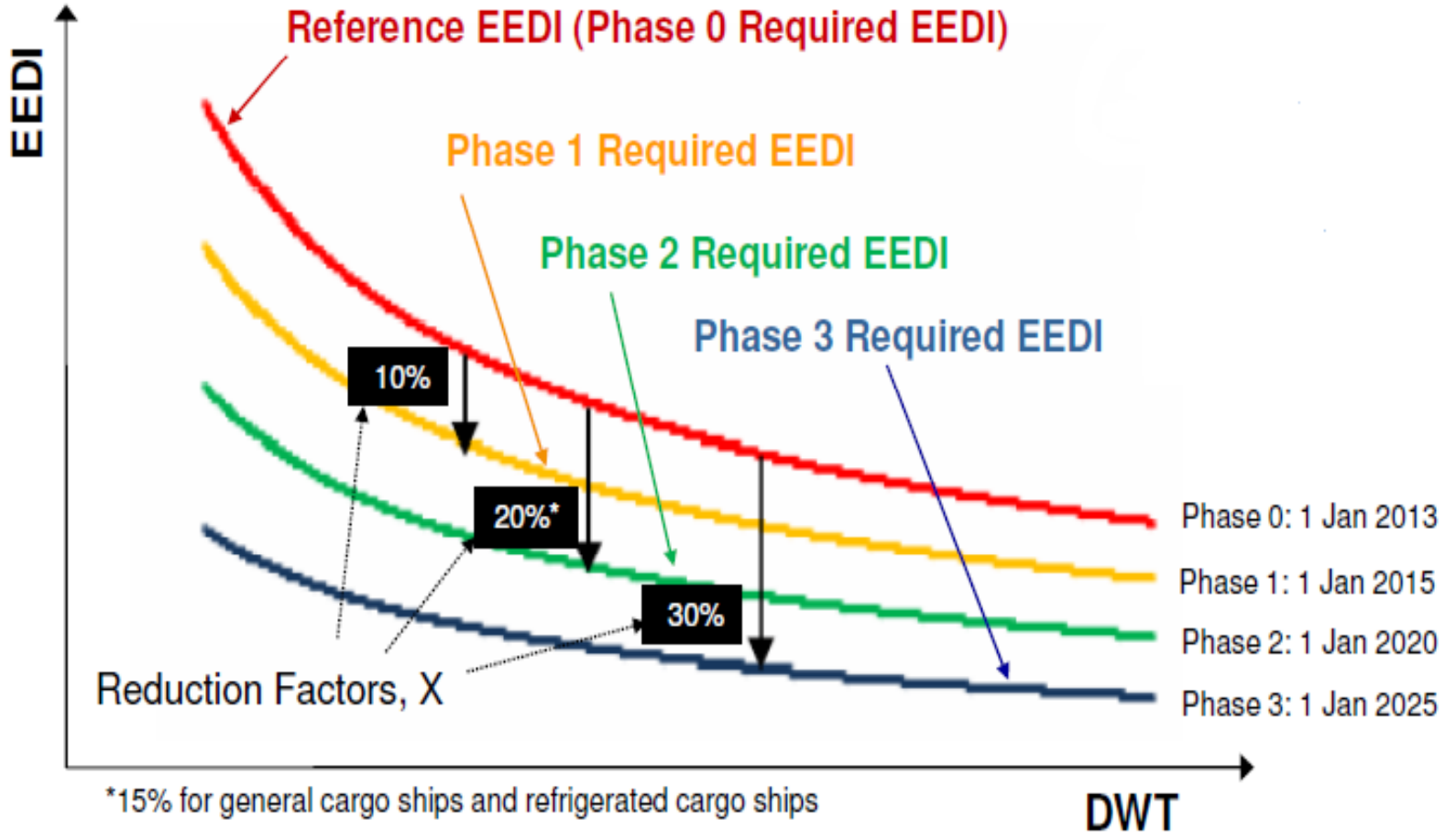
◆Stricter Emission Limits

NO_x	IMO Tier III (80% of Tier I)	1st Jan. 2016
SO_x	0.1% Sulphur contents in ECA	1st Jan. 2015
CO_2	EEDI (Energy Efficiency Design Index)	1st Jan. 2013

◆Global Expansion of ECA

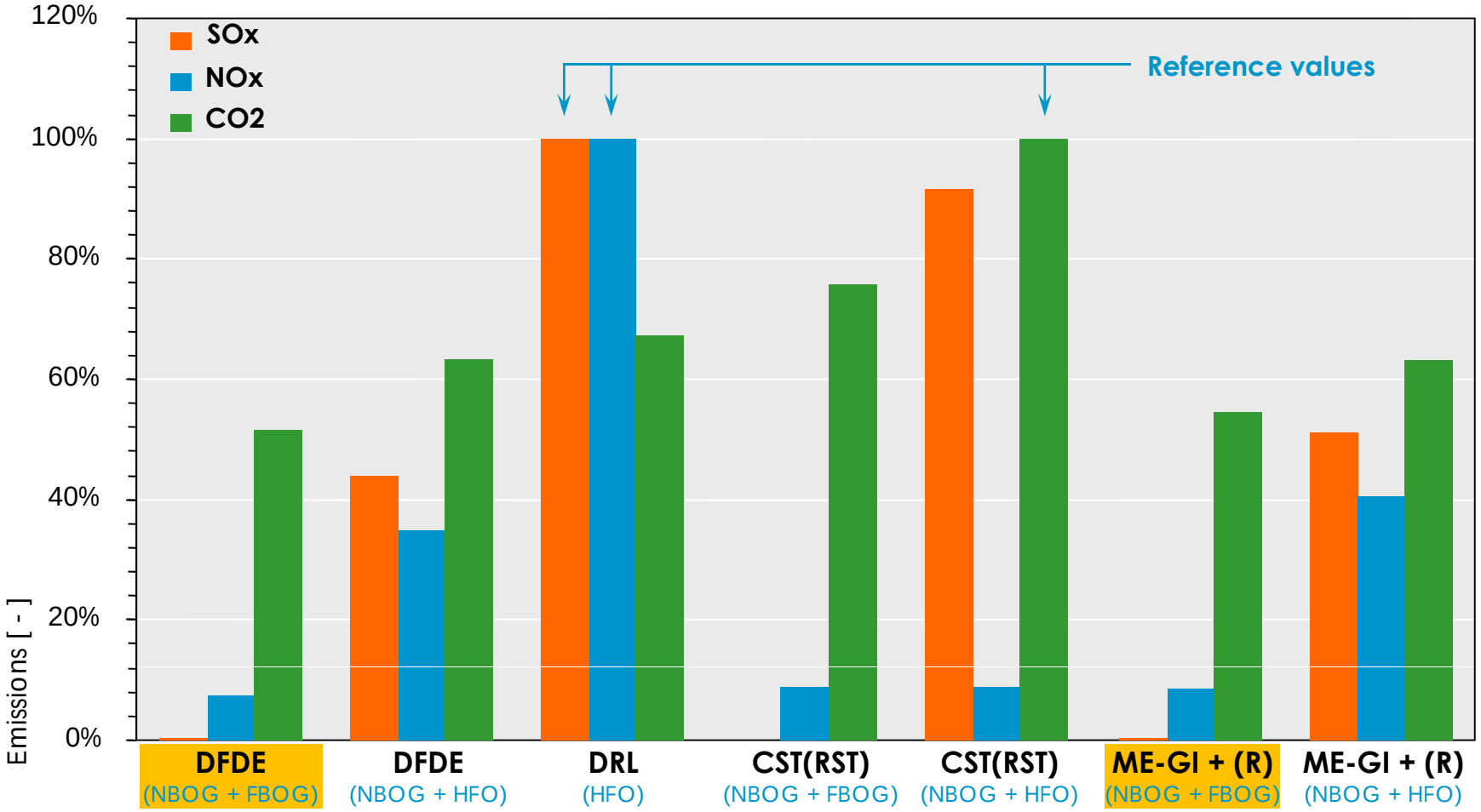
Present ECA	North Sea, Baltic Sea, Near of England	Present
New Area	North America	1st Aug. 2012
Expansion of ECA	Near sea of Central and South America, Mediterranean sea, Australia, Japan and Korea.	Future

5. COMPARISON OF VARIOUS PROPULSION SYSTEMS



5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ Environmental Friendly (Emissions)

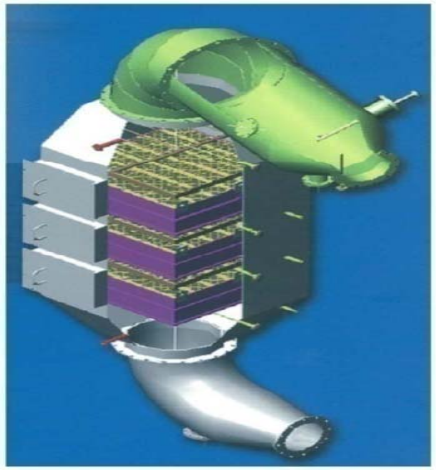


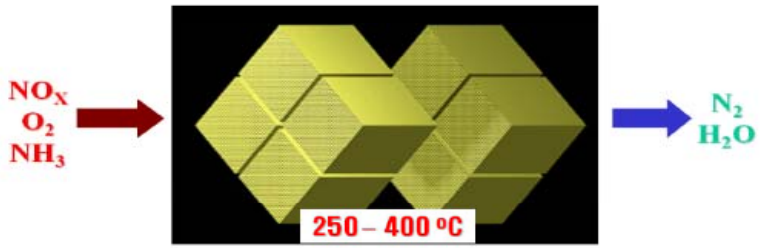
5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ Nox Reduction Method for Tier III (January 2016)

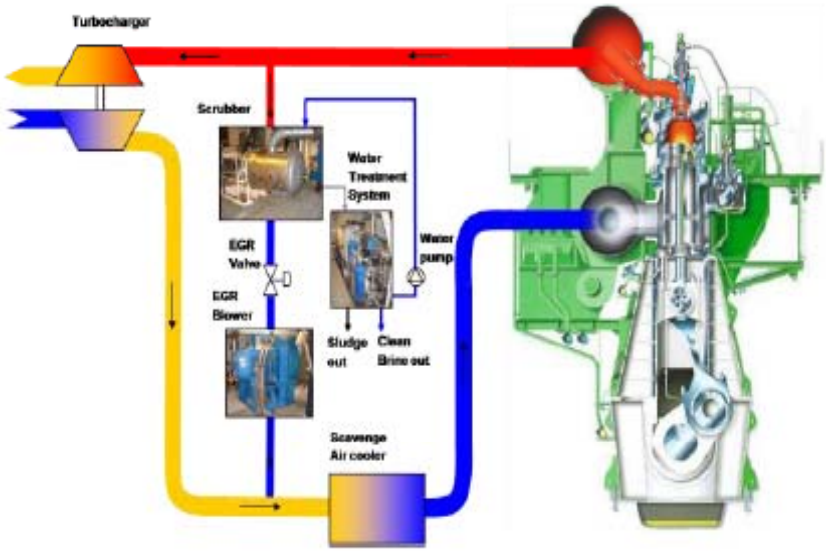
DFDE	MEGI
➢ Gas burning ➢ SCR : MDO or HFO burning	➢ EGR ➢ SCR

SCR (Selective Catalytic Reduction)





EGR (Exhaust Gas Recirculation)



5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ CAPEX Evaluation (165K CLASS LNG CARRIER)

● Main Particular

	164K RST (Single)	165K DFDE (Twin)	165K ME-GI (Twin)
Propulsion	► Main Boiler : 2 sets ► Main Turbine : 1 set	► Main D/G engine : 12V50DF x 2 sets, 6L50DF x 2 sets	► Main engine : 6G70ME-C9.2-GI x 2 sets
Electric Generation	► Turbo generator : 2 sets ► Diesel generator : 8H32/40 x 1 set		► Auxiliary D/G engine : 6H35/40DF x 4 sets
Fuel Gas Supply System	► Conventional FGSS	► Conventional FGSS	► Re-liquefaction plant + HP pump & Vaporizer
Excess BOG	► Main boiler steam dumping	► GCU burning	► Re-liquefaction or GCU burning
CAPEX	**100%**	**102 %**	**105%**

5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ OPEX Evaluation (165K CLASS LNG CARRIER)

Estimation Base

- Service Route : USA (Lake Charles) ↔ KOREA (Kwangyang) :
  9,700 mile : One way
- Operation Mode : Gas Mode (90%), Diesel Mode (10%)
- Service Speed : 19.5 knots (40%), 16 knots (40%), 12 knots (20%)
- Service Days : 345 days / year (7 trips / year, 49 days for 1 trip)

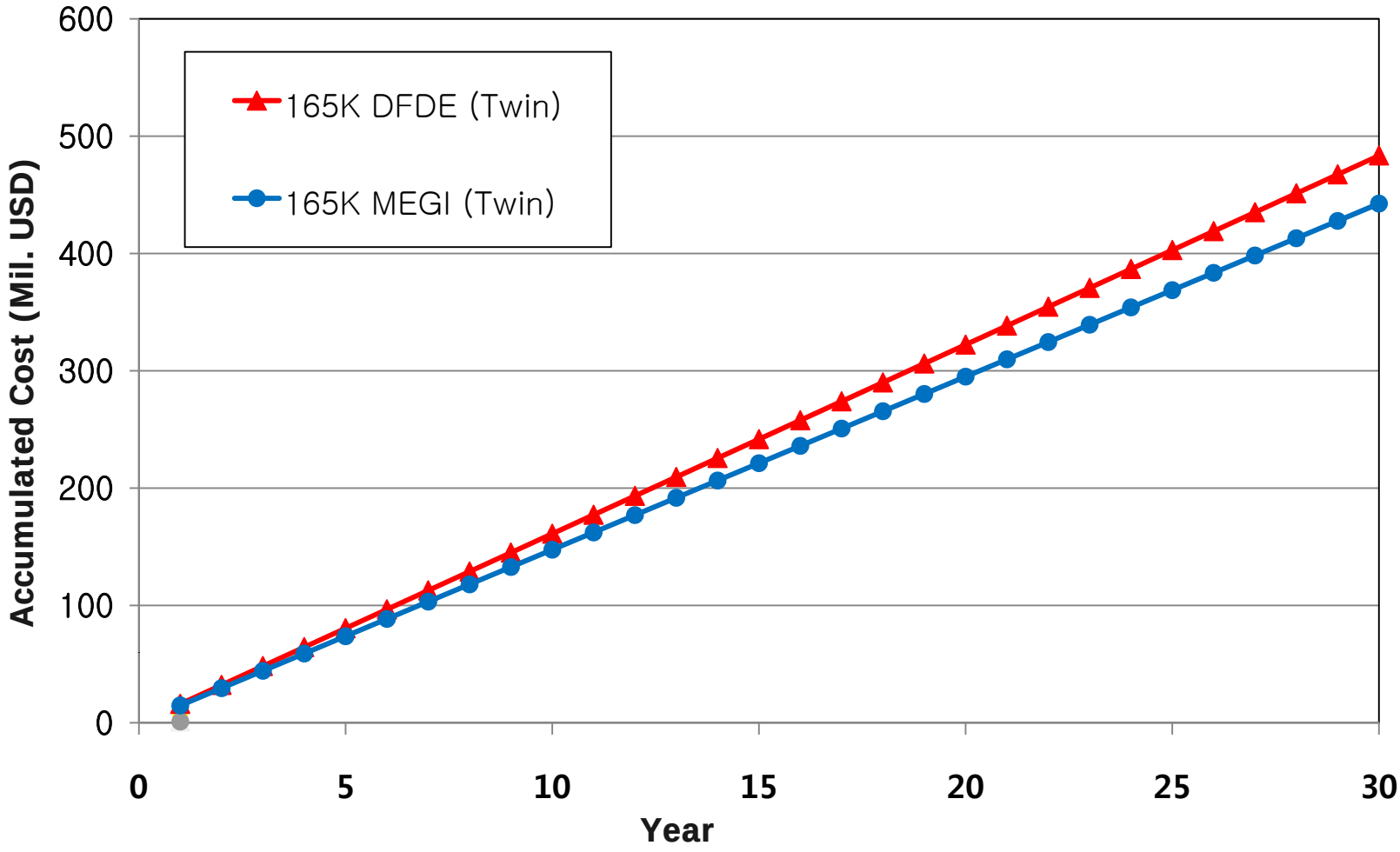
Fuel Price

- Fuel Oil : 600 USD/Mt (HFO), 1,000 USD/Mt (MDO)
- Fuel Gas : 600 USD/Mt (12 USD/mmBTU)

5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ OPEX Evaluation (165K CLASS LNG CARRIER)

- **Fuel Cost + Maintenance Cost**



5. COMPARISON OF VARIOUS PROPULSION SYSTEMS

◆ OPEX Evaluation (165K CLASS LNG CARRIER)

● Sensitivity study of Annual Fuel Cost

	LNG price				
	8 USD /mmbtu	10 USD /mmbtu	12 USD /mmbtu	14 USD /mmbtu	16 USD /mmbtu
165K DFDE (Twin)	10.9 Mil USD	13.1 Mil USD	15.2 Mil USD	17.4 Mil USD	19.6 Mil USD
165K ME-GI + REL (Twin)	10.2 Mil USD	12.1 Mil USD	14.0 Mil USD	15.8 Mil USD	17.7 Mil USD
Difference (DFDE – ME-GI)	0.7 Mil USD	1.0 Mil USD	1.2 Mil USD	1.6 Mil USD	1.9 Mil USD

미래를 개척하는 현대중공업
Global Leader

THANK YOU

Our past 30 years is just a minute
for the everlasting future...

Questions ?

The German Society for Maritime Technology
Schiffbautechnische Gesellschaft e.V.

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.