Welcome to the CIMAC Cascade 2014 Busan

" New Era Has Begun - LNG "

Dept. of Offshore Plant Management
College of Maritime Science
National Korean Maritime & Ocean University

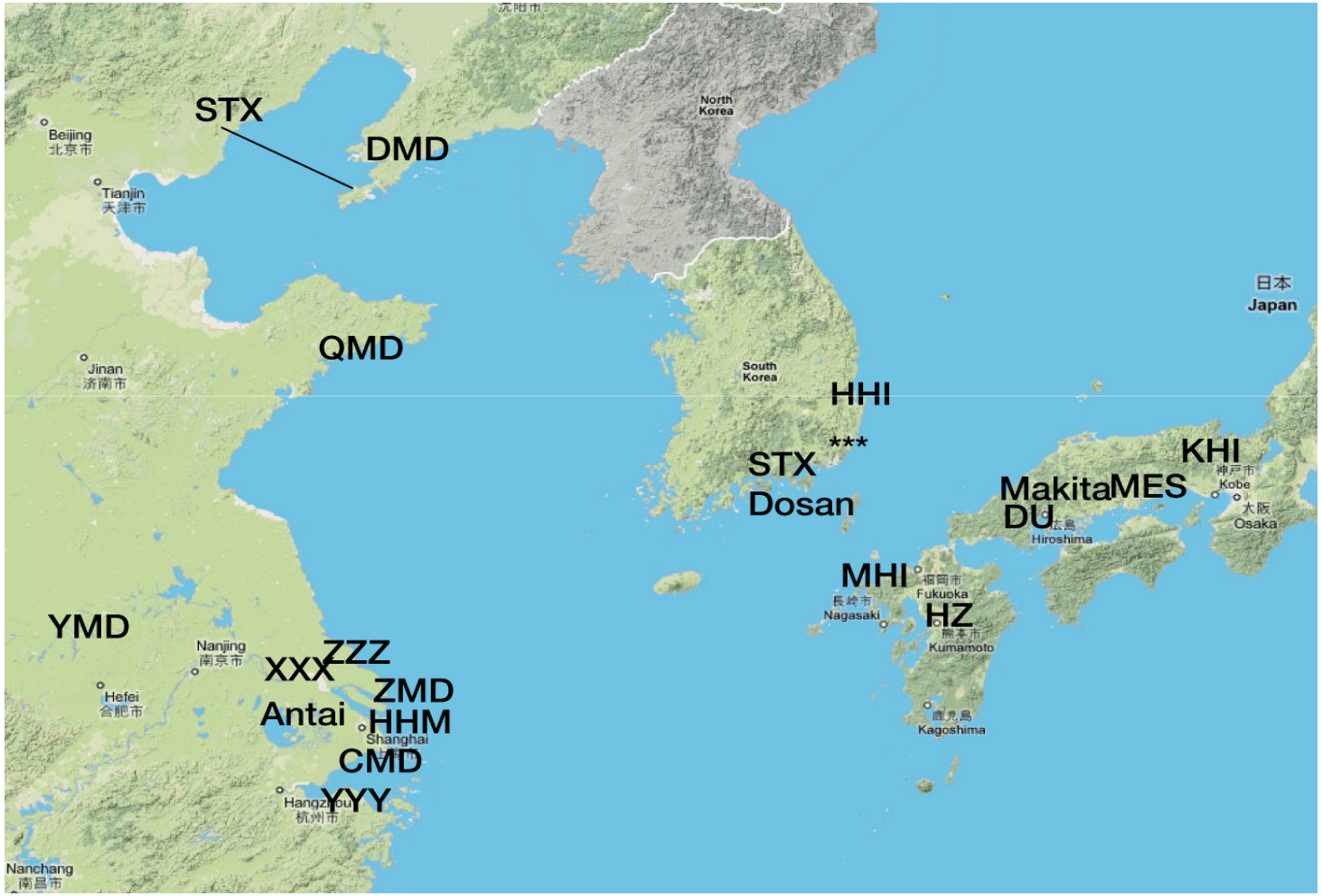
Professor KangKi Lee

23 Oct. 2014

Note: There are slides sourced from DNV-GL, MDT, Wartsila being released at their promotional events.

❖ Diversity of Engine Building in Europe in the 1970s

❖ Map of Asia for Diesel Engine Production following Shipbuilding



Gas is Future !!!
Fuel Change for Ship Propulsion

Coal
고체연료

Diesel Oil / HFO
액체연료

LNG
기체연료

1912

2012

Solid → **Liquid** → **Gas**

- 7,000DWT Cargo & Passengership (M/V Selandia)
  - 2 x 8cyl., 4cycle, 1,250hp

2 TOTE 3,100teu Container ship by 8L70ME-C8.2-GI
2 Teekay 173K LNG Carrier Powered by 2 x 5G70ME-C9.2-GI

- Only 1 Oil Station
- Ship Dieselization: ~20years

- Several Gas Stations
- Innovative Technology on S, T, L & E
- >80% New Shipbuilding is Electronic Engines : ~5years
- Scale Economy on Ships in Number.
-→ LNG lization ~ 20 years ?

Applicability of LNG fuel

Lloyd's List MONDAY MARCH 1, 2010

Analysis: Emissions reduction

EU operators consider LNG fuel as a viable alternative

LNG powered ships are already a reality in Norway—The engine technology exists, and there is no denying its ability to reduce emissions.

LNG if bought in sufficient quantity is cheaper than marine gas oil.

...for 0.1% fuel could mean phasing ... burning of heavy fuel entirely in the so-called sulphur emission control areas — the North Sea, Baltic Sea and Channel.

LNG-powered ships are already a reality in Norway, where a fleet of around 20 vessels plies regular services. The engine technology exists, and there is no denying its ability to reduce emissions.

Burning LNG is sulphur-free. It also produces 86% less nitrogen dioxide and 100% less particulate matter than traditional fuels.

To make it even more attractive, it produces 25% less carbon dioxide, a bonus given shipping's struggle to contribute to the fight against climate change.

But will it catch on? Aside from the obvious hurdle — a lack of LNG fuelling stations — there are those who believe natural gas will not become viable without government intervention. Ferry operator Stena Line has investigated and rejected investing in LNG-powered engines.

"We are not comfortable with the overall energy balance," said Stena sustainability director Johan Roos.

"We have not yet decided to make any investments in LNG and we will not do so until we see a proper study with details of the total energy cost."

LNG suffered from the same doubts as fuel-ethanol when it came to its appropriateness for reducing climate change emis-

...could be ...d gave ...e equa- ...roduc- ...extrac- ...as not ...ment ...mple ...vern- ...need ...said. ...rine ...new ...as ...e's ...el

Seca requirements.

Others, on the other hand, feel LNG's time could well have come.

"LNG if bought in sufficient quantity is cheaper than marine gas oil. Shipowners are now making their calculations," said European Maritime Safety Agency executive director Willem de Ruiter.

"Scandinavian industry has got wind of the change. Paper exporters, for example, are aware transport costs will go up. There are lots of investment decisions in the pipeline among northeast ferry operators and shortsea operators. By 2015, LNG will be an economic alternative."

Regulators would have to invent a regime for safely handling, distributing and storing LNG along the lines of the Rotterdam petroleum regime, Mr de Ruiter said.

The International Maritime Organization has already developed rules for gas-propelled ships designed to make engine rooms safe, though there is still a need for them to be formally adopted.

"These rules cover the ship side. Now there is a similar need for the bunkering side," Mr de Ruiter said.

Retrofitting is complex, so the technology is aimed at newbuildings. LNG tanks reportedly need to be two or three times larger for the same quantity of fuel.

The big question is whether governments, or perhaps the European Union, will have to intervene to give LNG a helping hand. EU subsidies from funds such as Marco Polo or the Trans-European Transport Network could, for example, be used to build fuelling stations.

Subsidising LNG might bring more concrete rewards than the EU's modal shift policy.

Mr. de Ruiter
(European Maritime Safety Agency executive director)

Other Alternative Fuel

- Bio Diesel
- Ethanol
- LPG (Liquefied Petroleum Gas)
- Hydrogen(H2)
- Fuel Cell
- Etc.

<The source of the article : Lloyd's List>

Market Challenge and Environment : GAS Engine

Emission : MUST

Economy : Survival

Availability : Shale Gas +

Safety : MUST

LNG/NG is fuel what can be burnt and combustible upon certain condition. Since the 1st LNG accident in Cleveland, Ohio, analysis of CEE(Center for Energy Economics) based on intensive survey by US DOE(Department of Energy) and DOT(Department of Transport) through 45,000 voyages between global 23 LNG export terminals and 58 LNG import terminals shows that LNG is safer than other petroleum and/or refinery facilities.

National Natural Gas Market Overview: World LNG Landed Prices

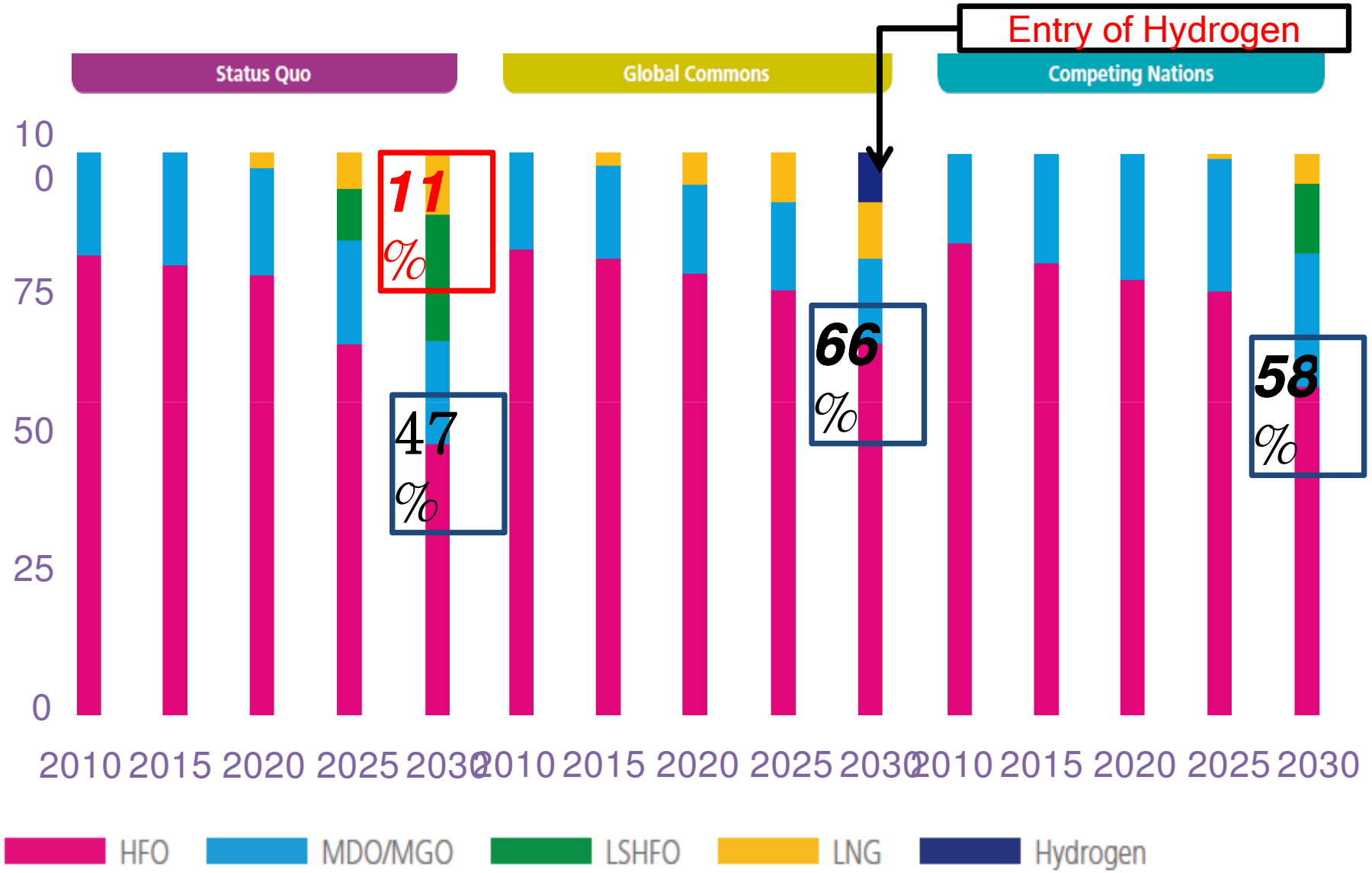
Federal Energy Regulatory Commission • Market Oversight • www.ferc.gov/oversight

World LNG Estimated August 2014 Landed Prices

Source: *Waterborne Energy, Inc.* Data in $US/MMBtu

Updated July 2014

Up to 11% LNG share for deep sea shipping (Lloyd)



Lloyd at World Ocean Forum 2014

50 LNG fuelled ships in operation worldwide (DNV-GL)

Ships in operation

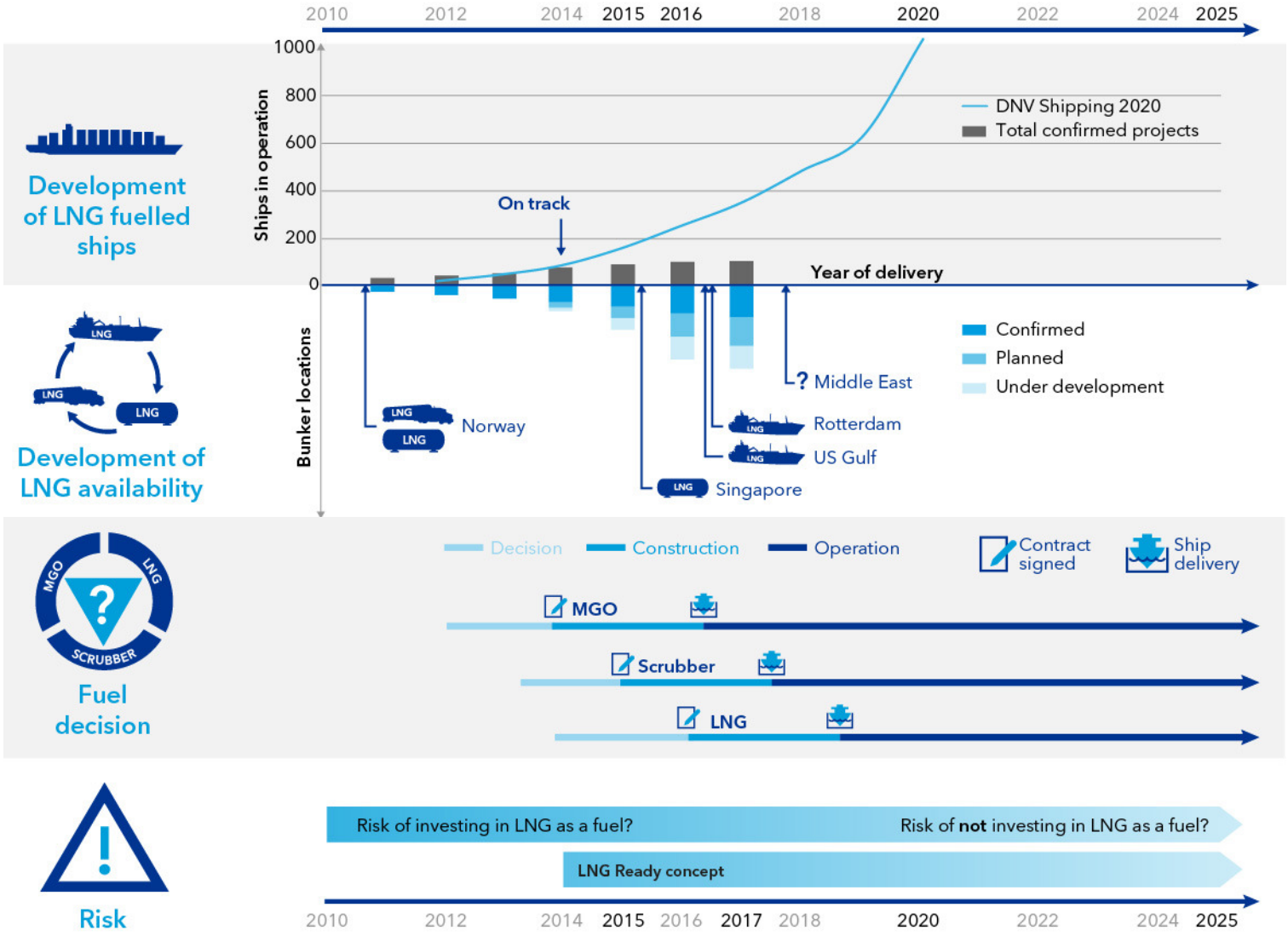
Year	Type of vessel	Owner	Class
2000	Car/passenger ferry	Fjord1	DNV
2003	PSV	Simon Møkster	DNV
2003	PSV	Eidesvik	DNV
2006	Car/passenger ferry	Fjord1	DNV
2007	Car/passenger ferry	Fjord1	DNV
2007	Car/passenger ferry	Fjord1	DNV
2007	Car/passenger ferry	Fjord1	DNV
2007	Car/passenger ferry	Fjord1	DNV
2008	PSV	Eidesvik Shipping	DNV
2009	PSV	Eidesvik Shipping	DNV
2009	Car/passenger ferry	Tide Sjø	DNV
2009	Car/passenger ferry	Tide Sjø	DNV
2009	Car/passenger ferry	Tide Sjø	DNV
2009	Patrol vessel	Remøy Management	DNV
2009	Car/passenger ferry	Fjord1	DNV
2010	Patrol vessel	Remøy Management	DNV
2010	Car/passenger ferry	Fjord1	DNV
2010	Patrol vessel	Remøy Management	DNV
2010	Car/passenger ferry	Fjord1	DNV
2010	Car/passenger ferry	Fjord1	DNV
2010	Car/passenger ferry	Fosen Namsos Sjø	DNV
2011	PSV	DOF	DNV
2011*	Chemical tanker	Tarbit Shipping	GL
2011	Car/passenger ferry	Fjord1	DNV
2011	PSV	Solstad Rederi	DNV
2012*	Car/passenger ferry	Fjord1	DNV
2012	PSV	Eidesvik	DNV
2012	PSV	Olympic Shipping	DNV
2012	PSV	Island Offshore	DNV
2012	General Cargo	Nordnorsk Shipping	DNV
2012	PSV	Eidesvik Shipping	DNV
2012	PSV	Island Offshore	DNV
2012	Car/passenger ferry	Torghatten Nord	DNV
2012	Car/passenger ferry	Torghatten Nord	DNV
2012	Car/passenger ferry	Torghatten Nord	DNV
2013	PSV	REM	DNV
2013	RoPax	Viking Line	LR
2013	Car/passenger ferry	Torghatten Nord	DNV
2013	Harbor vessel	Incheon Port Authority	KR
2013	General Cargo	Eidsvaag	DNV
2013	RoPax	Fjordline	DNV
2013	High speed RoPax	Buquebus	DNV
2013	Tug	CNOOC	CCS
2013	Tug	CNOOC	CCS
2013	Car/passenger ferry	Norled	DNV
2014	Car/passenger ferry	Norled	DNV
2014	Tug	Buksér & Berging	DNV
2014	RoPax	Fjordline	DNV
2014	Patrol vessel	Finish Border Guard	GL

Updated 16.07.2014

**** Conversion project***

Excluding LNG carriers and inland waterway vessels

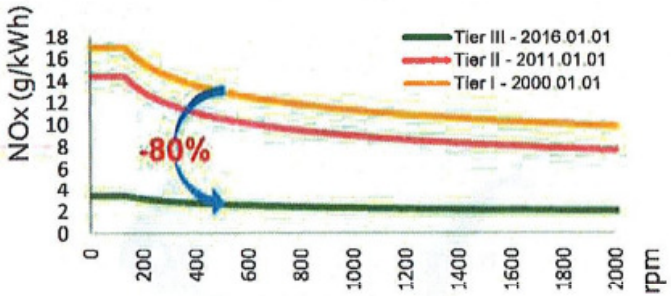
Careful evaluation of fuelling options is required due to exponential growth in LNG bunkering infrastructure



Emissions

◆ NOx (Depends on ship construction date)

Construction Date	Inside NOx ECA	Outside NOx ECA
Before 2000	Uncontrolled	Uncontrolled
2000 to 2010	Tier I (17.0 g/kWh)	Tier I
2011 to 2015	Tier II (14.4 g/kWh)	Tier II
After 2016	Tier III (3.4 g/kWh)	Tier II



◆ SOx / Fuel Sulphur (all ships)

Construction Date	Inside SOx ECA	Outside SOx ECA
Before May 2005	Uncontrolled	Uncontrolled
May 2005 ~ July 2010	1.5%	4.5%
July 2010 ~ 2014	1.0%	3.5%
After 2015	0.1%	0.5%

Conclusion

Challenges are Economy to survive, tough emission regulation to comply, and safety to control.
GAS is the solution as ships fuel. And GAS engine is a viable alternative.

The ME-GI & LGI are HP-DF diesel engines that can run on gas.

An LP-DF Otto engine is that can run on fuel.
An W-X LP Otto/Diesel engine that can run on DF.

Quantified speed of “Gas-Fuelisation” is now measurable and large enough for the associated equipment industries.
Diesel engines will prevail due to highest efficiency.

Heavy fuel even for ECA and SECA will not go away due to footprint economy which will serve as major marine fuel till foreseeable years to encounter.

Wishing you a pleasant stay !


NEW SUPER NEO CITY


VISA
VISA
CNG
সি.এন.জি চালিত


Friendly Sails?


BBC Chartering


The Monorotor
www.monorotor.com
PoulsenHybrid


UT WIND CHALLENGER


LNG fuel tanks
TBS
TBS


Eco-friendly Sailing!


TOTE Maritime

Emission + Economy → Gas Fuel !!!

New Era has come ! → Equipments for Offshore, Ship and Engine must follow !

Gas Fuels	Know as	Supply condition	Supply pressure	Supply temperature
CH4	LNG, NG Methane	Gas	300 bar	Appr 45 deg C
C2H6	LEG Ethane	Gas	600 bar	Appr 70 deg C
Propane & Buthane	LPG	Liquid	30-40 bar	Appr 45 deg C
C2H5OH	Ethanol	Liquid	To be decided	To be decided
CH3OH	Methanol	Liquid	To be decided	To be decided

ME-GI, LGI or SOx Scrubbers will be used

Source: MDT

:

62 confirmed LNG fuelled newbuilds - DNV GL also first choice for future projects (1/2) – DNV-GL

Confirmed orderbook

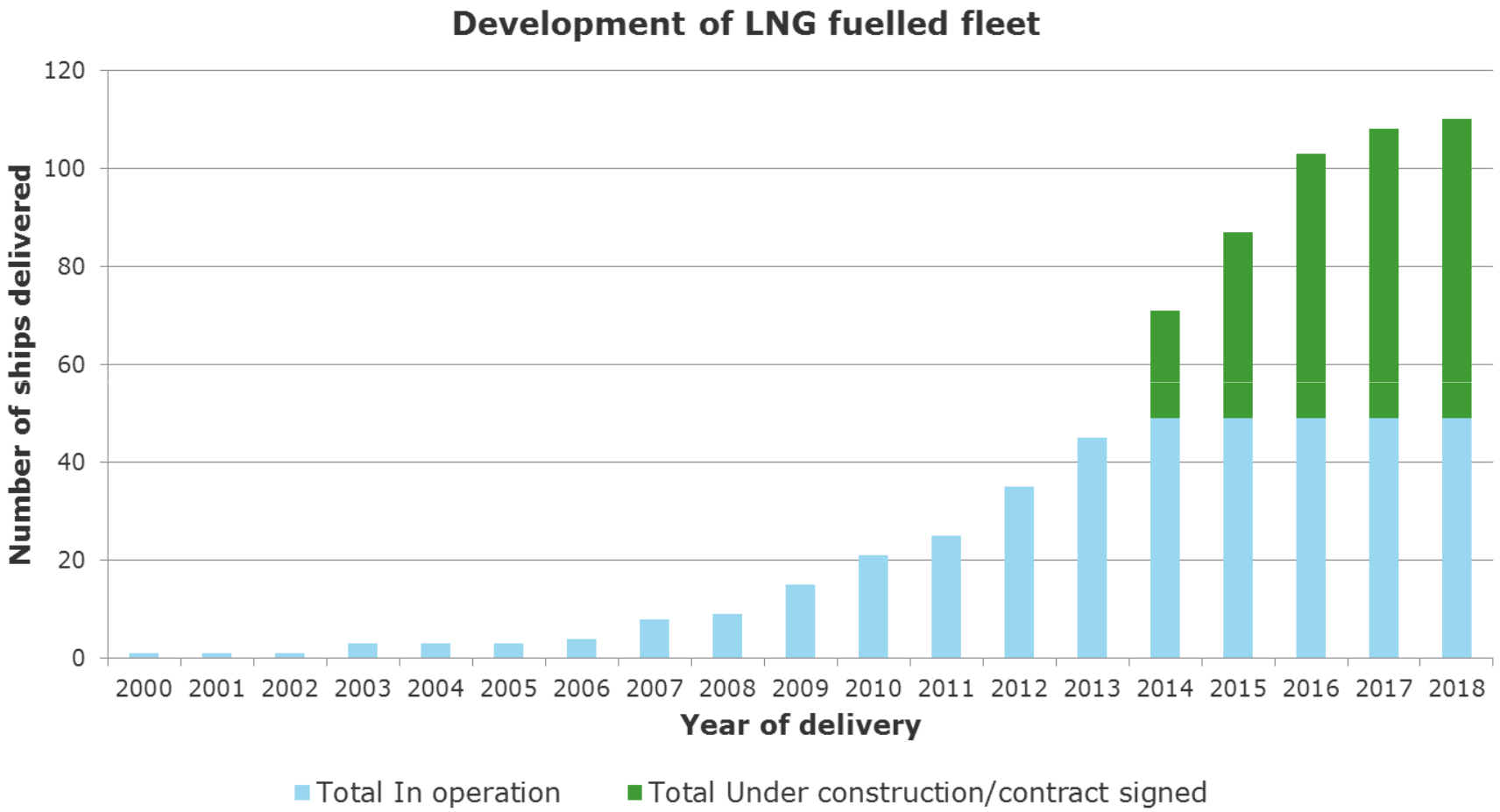
Year	Type of vessel	Owner	Class
2014	Ro-Ro	Norlines	DNV
2014	Ro-Ro	Norlines	DNV
2014	Car/passenger ferry	Society of Quebec	LR
2014	Car/passenger ferry	Society of Quebec	LR
2014	Car/passenger ferry	Society of Quebec	LR
2014	Tug	Buksér & Berging	DNV
2014	PSV	Harvey Gulf Int.	ABS
2014	PSV	Harvey Gulf Int.	ABS
2014	PSV	Harvey Gulf Int.	ABS
2014	PSV	Harvey Gulf Int.	ABS
2014	Gas carrier	SABIC	BV
2014	Gas carrier	SABIC	BV
2014*	Product tanker	Bergen Tankers	LR
2014	General Cargo	Egil Ulvan Rederi	DNV
2014	General Cargo	Egil Ulvan Rederi	DNV
2014	PSV	Remøy Shipping	DNV
2014	Car/passenger ferry	AG Ems	GL
2014*	Car/passenger ferry	AG Ems	GL
2014	Car/passenger ferry	Samsoe Municipality	DNV
2014	Ro-Ro	Sea-Cargo	DNV
2014	Ro-Ro	Sea-Cargo	DNV
2014	Tug	CNOOC	CCS
2015	Tug	CNOOC	CCS
2015	PSV	Siem Offshore	DNV
2015	PSV	Siem Offshore	DNV
2015	PSV	Simon Møkster	DNV
2015	PSV	Harvey Gulf Int.	ABS
2015	PSV	Harvey Gulf Int.	ABS
2015	Tug	NYK	NK
2015	LEG carrier	Evergas	BV
2015	LEG carrier	Evergas	BV
2015	LEG carrier	Evergas	BV
2015	Bulk ship	Erik Thun	LR
2015	Container Ship	Brodosplit	DNV GL
2015	Container Ship	Brodosplit	DNV GL
2015	PSV	Siem Offshore	DNV GL
2015	PSV	Siem Offshore	DNV GL
2015	Container Ship	TOTE Shipholdings	ABS
2016	Container Ship	TOTE Shipholdings	ABS
2016	Icebreaker	Finnish Transport A.	LR
2016	PSV	Siem Offshore	DNV GL
2016	PSV	Siem Offshore	DNV GL
2016	Chemical tanker	Terntank	BV
2016	Chemical tanker	Terntank	BV
2016*	Ro-Ro	TOTE Shipholdings	ABS
2016*	Ro-Ro	TOTE Shipholdings	ABS
2016	Car carrier	UECC	LR
2016	Car carrier	UECC	LR
2016	Car/passenger ferry	Boreal Transport	DNV GL
2016	Car/passenger ferry	Boreal Transport	DNV GL

Updated 06.06.2014

**** Conversion project***

Excluding LNG carriers and inland waterway vessels

There are currently 111 confirmed LNG fuelled ship projects (DNV-GL)



Updated 06.06.2014

Excluding LNG carriers and inland waterway vessels

Kogas' LNG Receiving Terminals

LNG Fueled Containership

- **Length : approx. 23x.0 m**
- **Breadth : 32.x m**
- **Deadweight : 31,830 MT**
- **Speed : 22.0 knots (at 10.xm draft with 15% sea margin)**
- **Cargo Capacity : 3,xxx TEU (Nominal)**
- **Range : 10,000nm (HFO 6,000nm + LNG 4,000nm)**
- **Fuel Consumption : 85.xxMT/day @NCR (MAN B&W 8L70ME-C8.2-GI)**

Source: DSEC Press Release

The 5th CIMAC Cascade Meeting 2014, Busan I

The 5th CIMAC Cascade Meeting 2014, Busan
October 23, 2014

Dear Friends,

I dearly call you, friends as we're all gathered here in this room under diesel family.
Dear valuable Guests, Ladies and Gentlemen
I do welcome you all here at this venue by the beautiful Heaundae beach although some of you have already been here and eventually it's a bit too late to go for swimming, though.
This is a great pleasure and honor for me to address a keynote speech for the 5th CIMAC Cascade Meeting 2014 in Busan ! Let me introduce myself shortly. I'm known as KK Lee who have started career in 1981 and served MAN B&W which is now renamed to MDT since 1987.
I would like to thank specially to Mr. Yasuhiro Itoh, former chairman of CIMAC who devoted his time and effort to hold this meeting in Busan, Mr.Feng Wang, chairman of CIMAC China, (Mr.J.T.Kim, C.O.O. of HHI-EMD and his knight) Mr.JongSeok Kim, senior vice president of HHI-EMD who dare to take all works on his shoulder together with Professor Mr.JeongRyul Kim and Professor DonChul Lee for this wonderful event and those who took their valuable time and effort to attend the 5th CIMAC Cascade meeting 2014 in Busan.

The 5th CIMAC Cascade Meeting 2014, Busan II

The 5th CIMAC Cascade Meeting 2014, Busan
October 23, 2014

Upon this opportunity while we're here in Korea still intensive activities deployed at shipbuilding and offshore plant industries, I feel obliged to brief you about the history of diesel engine in Korea which currently shares the major role together with two neighbouring and very important countries that is Japan and China.

Since the world's first Diesel engine was developed by Rudolf Diesel at M.A.N. from 1893 to 1897, Rudolf Diesel had signed his first licensing agreement with B&W in 1898, which was shared with other licensees and flowered in the glorious period of 70's when European shipbuilding and engine building industries. And the glory of shipbuilding moved to Japan on the next decade when the history of diesel engine industries had begun in this region of the world.

The 5th CIMAC Cascade Meeting 2014, Busan III

The 5th CIMAC Cascade Meeting 2014, Busan
October 23, 2014

I've learned that B&W's first licensee in 1910 was the Scottish company Barclay Curle & Co., and Mitsui joined in 1926 as the 1st licensee in Asia. MAN's first licensee, in 1911, was Kawasaki which start was already in Asia. Hyundai followed as 1st licensee in Korea in 1976 for B&W and Sulzer which is now Wartsilae, soon after followed by SSHI which later was reborn as STX and KHIC later renamed by HSD(in 2000) and Doosan Engine Co., Ltd in 1983 later CSSC and CSIC with their subsidiaries in China had joined licensee family in 1980. Japanese makes led by Mitsubishi, Niikata, Yanamr and Daihatsu had licensed to Korean engine builders separately following upon shipbuilding boom. Over all these years, we have enjoyed a close and friendly cooperation which has gone hand in hand with the impressive development. I do believe that this spirit of 3C's will prevail i.e. Challenge, Cooperate and Collaborate !

It is notable that ships fuel was shifted from solid coal to liquid oil in 1912 at the occasion of MV Selandia which lasted for 100 years as marine fuel. So called dieselization had begun which means to convert ship propulsion to diesel engine and changed most of the ships in 20 years.

The 5th CIMAC Cascade Meeting 2014, Busan IV

The 5th CIMAC Cascade Meeting 2014, Busan
October 23, 2014

After having Lehman crisis in 2007, the party is over for shipping market. Thereafter, with oil price still high, huge offshore market emerged and also renewed speculative newbuilding activities and cheap money from Wall Street for the ECO ships.
Challenges are Economy to survive, tough emission regulation to comply, and safety to control.
Shipping companies have to struggle just for survival.
Is LNG the solution as ships fuel ? And is GAS engine a viable alternative ?
Having thanks to the development of Shale gas initiated from Northern America which will be followed by other LNG reservoir countries. **Technology has developed so that have led to the answer "YES"**

On December 2012, new era has begun again but this time by gas fuel at the occasion of signing the contract for two 3,100 teu class container ships for TOTE Corporate USA which I was honoured to be a part of this transaction owing to my former career at DSEC and soon after followed by another contract for 173,000 cbm LNG carriers for TK Canada.
Both projects were to be equipped with ME-GI high pressure gas injection for propulsion engines.
Besides almost 50 ships were converted and over 60 newbuilding ships to be LNG fuelled according to DNV-GL being announced during the 8th World Ocean Forum in Busan a month ago. At the same forum, it was the first time that those associated entities had announced their perceptives and quantified figures about how fast “Gas-Fuelisation” will prevail.

The 5th CIMAC Cascade Meeting 2014, Busan V

The 5th CIMAC Cascade Meeting 2014, Busan
October 23, 2014

Lloyd seemingly had done an intensive job besides other entities like DNV-GL which prediction shows that **up to 11% LNG share and approximately 8% Hydrogen for global deep sea shipping by 2030.** Hence mass production of the kind of hydrogen demand can most probably be possible using LNG, this is remarkable demand of LNG.
DNV-GL predicts 1,000 ships till 2020 which is still big number, though.

This made me possible dare to predict that over 100 ships annually are to be LNG fuelled ships increasing in average for next decade.
So far it has been 4-stroke low pressure for DF engines on relatively smaller ships while newbuilding of larger ships tend to high pressure for ME-GI engines. W-X 2-stroke engine low pressure DF claims all -in-one solution which can run for both mode of Otto cycle and Diesel cycle respectively but seemingly having still with some degree of home work.

I get closer to conclusion saying that the technology endeavours towards the future.
Thus, I feel confident that those demand on emission issues and multi-point optimizations for economy will not be an obstacle for the state of art of current diesel engine technology.
Quantified speed of "Gas-Fuelisation" is now measurable and large enough for the associated equipment industries.
Diesel engines will prevail due to highest efficiency.
And Heavy fuel even for ECA and SECA will not go away due to the footprint economy being established which will serve as major marine fuel till foreseeable years to be encountered on shipping industry.

The 5th CIMAC Cascade Meeting 2014, Busan VI

The 5th CIMAC Cascade Meeting 2014, Busan
October 23, 2014

Although we're passing through the tough time owing to the downturn of the market, we all know that there is a light at the end of the tunnel. And we are in the industry with a future, with smiling faces.

I believe that Organizing team led by Professor Don-Chul Lee has done their utmost to make your stay comfortable and enjoyable for next two days through memorial event of HHI tour in parallel to the many technical presentations.
I do hope that your CIMAC Cascade meeting 2014 will be successful both in technical and social and wish you wonderful stay in dynamic and sunny Haeundae.
And I would like to conclude my speech by saying
" LNG is the viable alternative. Let's keep it up as new era has come."
Thank you very much for your attention !

2007 Lehman Crisis: The party is over for shipping market

Thereafter, with oil price still high, huge offshore market emerged and also renewed speculative newbuilding activities and cheap money from Wall Street with QE for the ECO ships.

What does CIMAC stand for?

Conseil International des Machines A Combustion

International Council on Combustion Engines

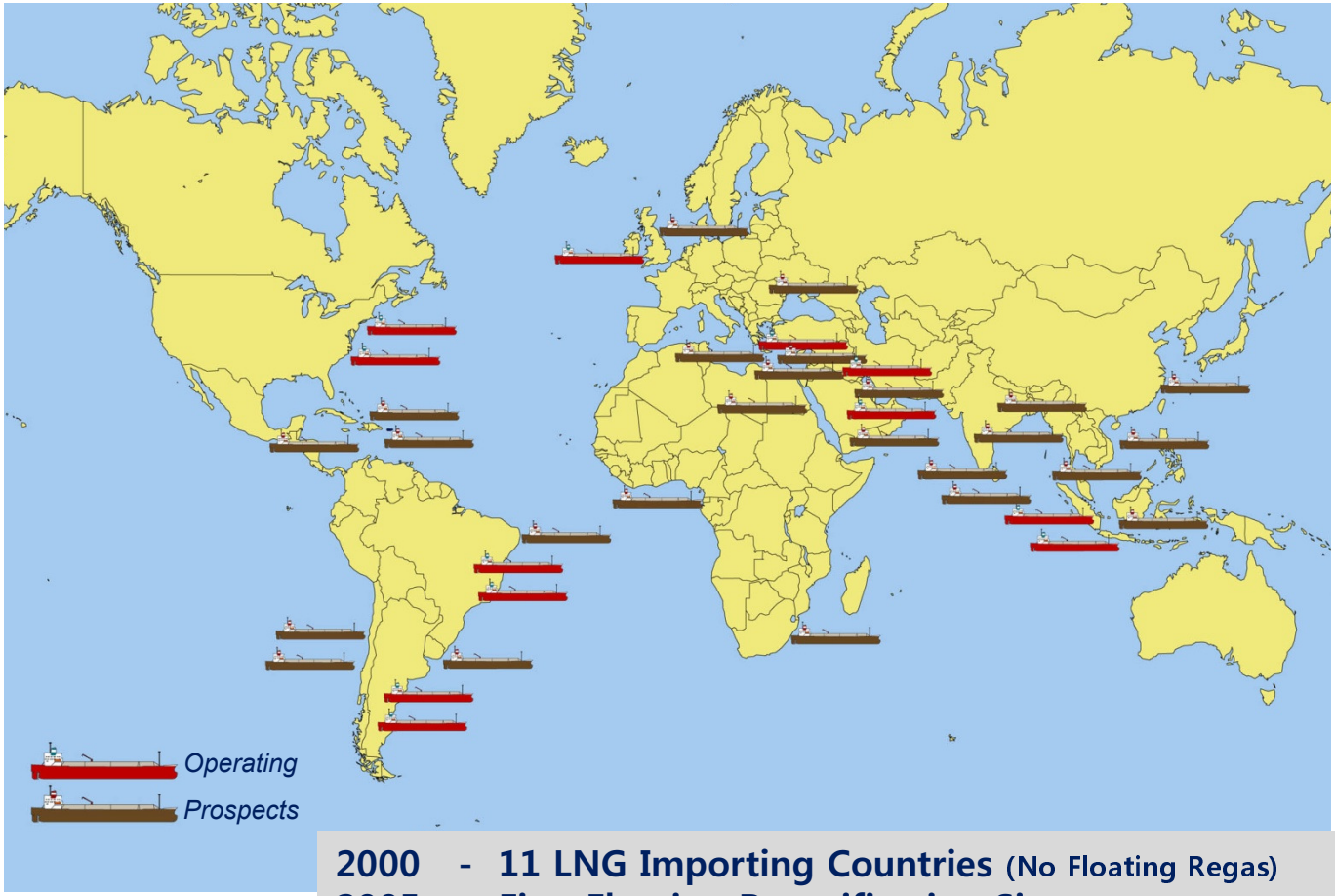
Founded 1951 in Paris to bring together:

- → **Engine manufacturers (Diesel and gas turbine)**
- → **Users (Ship owners, utilities, rail operators)**
- → **Engine operators**
- → **Component suppliers**
- → **Oil companies**
- → **Classification societies**
- → **Research organisations**
- → **Universities**

More information: CIMAC History Book 'The first 50 years (1951-2001)'
www.cimac.com /About CIMAC/History/

Availability: FSRU - The Present and Future

NEXTDECADE
A Portfolio LNG Company



2000 - 11 LNG Importing Countries (No Floating Regas)
2005 - First Floating Regasification Site (Gulf of Mexico)
2010 - 22 LNG Importing Countries
2013 - 14 Floating Regasification Sites
2015 - 30 or So Floating Regasification Sites *(Projected)*

Operating
Argentina (2)
Brazil (2)
China
UAE (Dubai)
Israel
Italy
Indonesia (2)
Kuwait
United Kingdom
United States (2)

Prospects
Bangladesh
Bahrain
Brazil (#3)
Chile (2)
Dominican Republic
Egypt
Ghana
India
Indonesia (#3)
Jamaica
Jordan
Kuwait (#2)
Lebanon
Lithuania
Malaysia
Pakistan
Puerto Rico
South Africa
Sri Lanka
Ukraine
UAE (Abu Dhabi)
Uruguay
Vietnam

30