Methanol: The bridging marine fuel

Dubai. Dec 11th 2018

Presented by: Captain Saleem Alavi

At Methanol as marine fuel seminar

Address Hotel, Dubai.

Dec. 11th 2018

Our Expertise

Consulting assignments are client-specific, and conducted on a confidential basis. These assignments are diverse in nature but are typically undertaken to assist clients assess particular opportunities or to help develop strategic investment plans.

Commercial consultancy assignments have included the following:

- LNG Consultancy
- Corporate Strategy , KPI and balance scorecard
- Project Evaluation
- Fees Reviews
- Trade and Market Share Projections
- Market Research/Surveys
- Fleet Portfolio and sector Reviews
- Strategic Market Positioning
- Vessel Size and Route Evolution

Furthermore, we can mobilize additional expertise in the following areas:

- International Macroeconomic Forecasts
- Transportation Logistics
- Shipping and Project Financing

Ship Owning and Management:

- Gap Analysis
- KPI’s
- Strategy
- HR Plan
- Fleet Utilization
- Ship Management Systems
- Procurement processes evaluation
- Fleet Portfolio Reviews
- Market Risk and Sensitivity Studies
- Drydock repair specifications
- Collision investigations
- Setting up of Ship Management division
- Crewing
- Crew competency evaluation
- Risk Analysis

Recent Assignments

- Provided consulting services to a shipowner to set up in-house shipmanagement.
- LNG offshore regasification terminal concept development.
- Monetization of Offshore services off the coast of an East African country.
- LNG Procurement strategy
- Ship/LNG Terminal interface – regulatory requirements.
- LNG Terminal revenue stream identification and projections.
- Study on prospects of LNG as a bunkering fuel.
- Study on alternate marine bunker fuels including well-to-propeller life cycle analysis.
- Drafting of maritime regulations and laws (UAE)
- Review of Fees structure of Maritime Administration (UAE)
- Study on FSRU economics: FSRU new build vs conversion
- Study on possibility of setting up of natural gas trading hub in UAE.
- Study on Global shale gas and business opportunities.

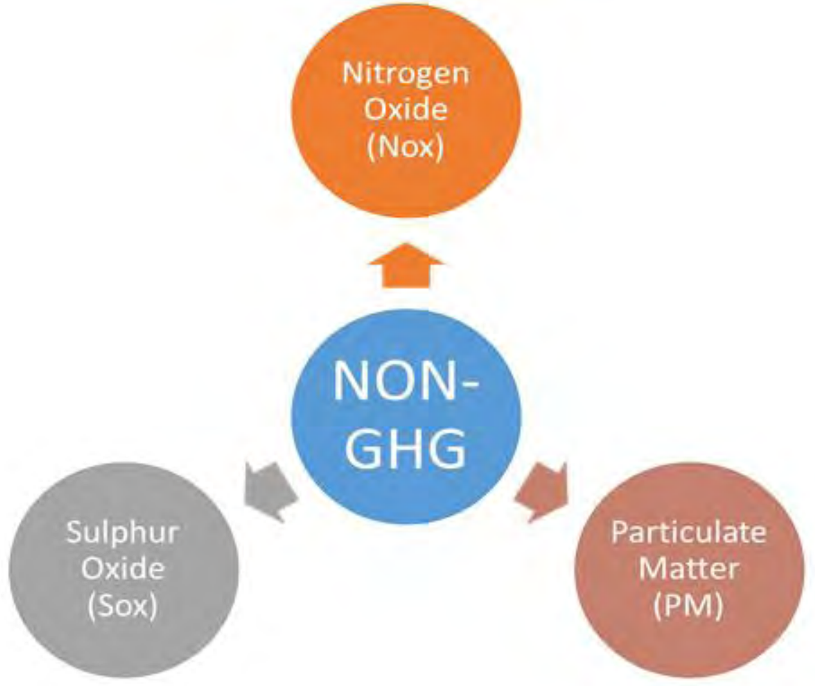
GHG and Non-GHG Emissions: Ships

Under the **GHG** Protocol:
six gases are categorized as greenhouse gases:

- carbon dioxide **(CO_2),**
- methane **(CH_4)**,
- nitrous oxide **(N_2O),**
- hydrofluorocarbons (**HFCs**),
- perfluorooctane sulphonate (**PFCs**),
- and sulphur hexafluoride (**SF_6**).

Non-GHG Emissions In addition to GHGs, shipping produces other air emissions, most notably:

- sulphur oxides (**SOx**),
- nitrogen oxides (**NOx**)
- particulate matter (PM).

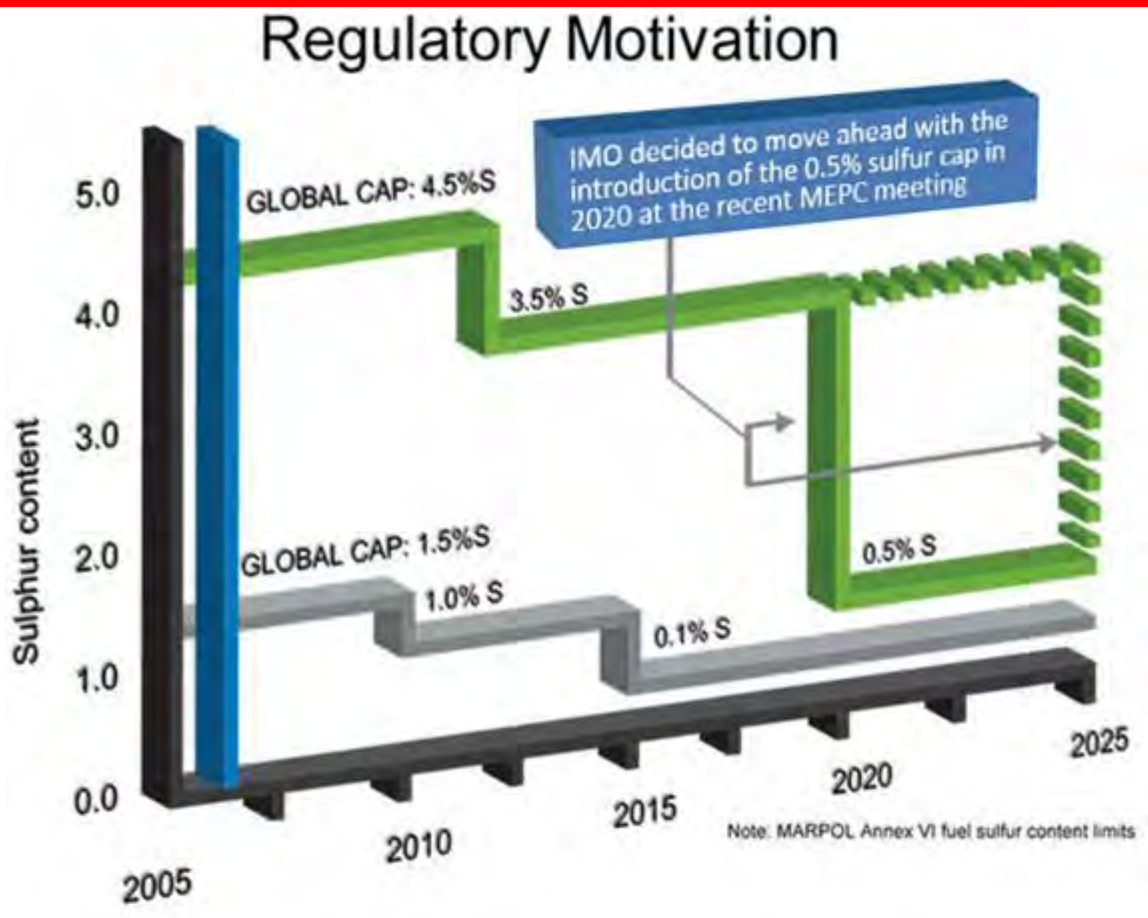


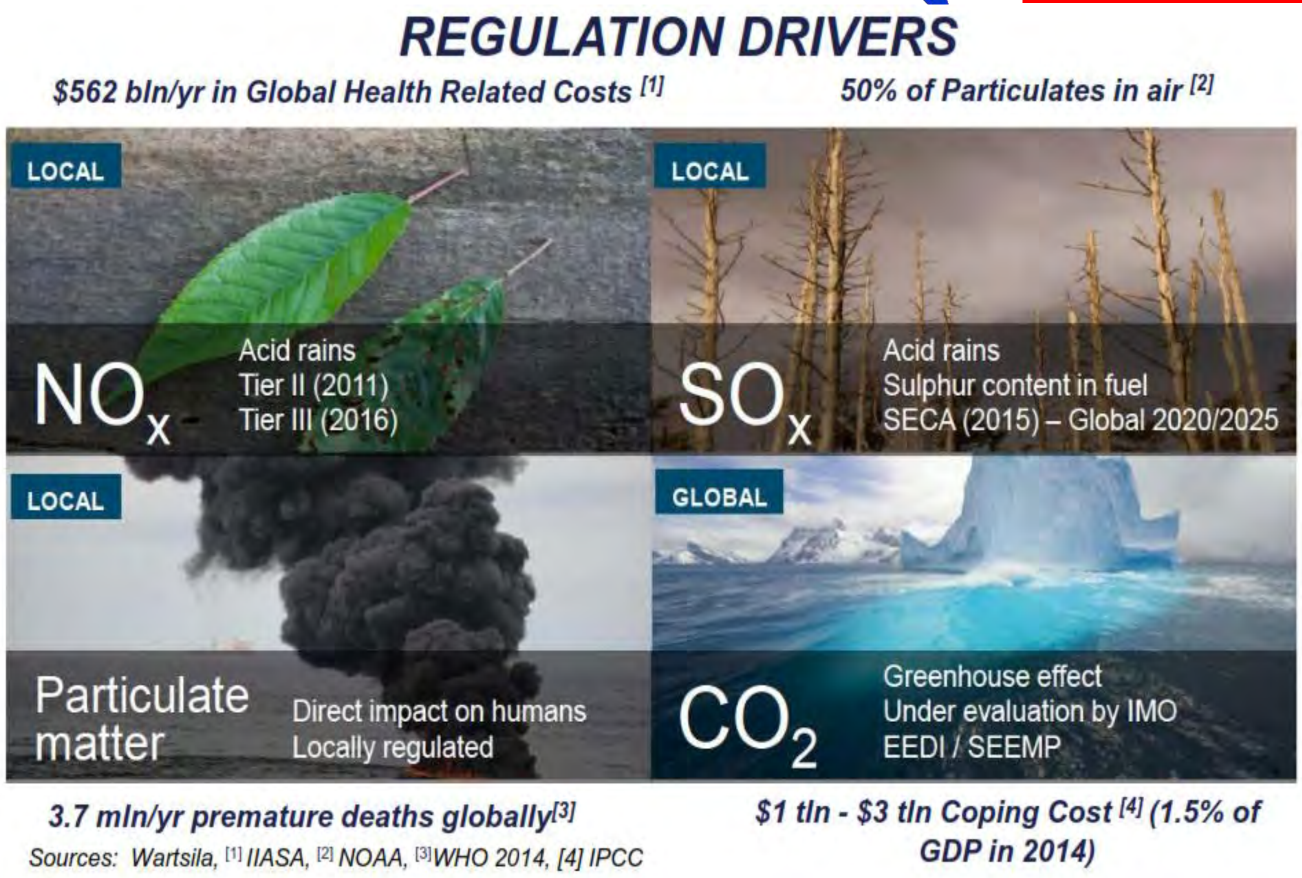
Global warming potential for different time horizons expressed relative to CO_2 (IPCC, 2014)

	GWP 20 years (kg CO_2 eq./kg)	GWP 100 years (kg CO_2 eq./kg)	GWP 500 years (kg CO_2 eq./kg)
Carbon dioxide (CO_2)	1	1	1
Methane (CH_4)	85	25	7.6
Nitrous Oxide (N_2O)	298	289	153

NMVOC = Non-methane volatile organic compounds, such as benzene, ethanol, formaldehyde etc
CO = carbon monoxide gas produced by incomplete combustion of fossil fuels (coal, natural gas petroleum)

Regulation Drivers

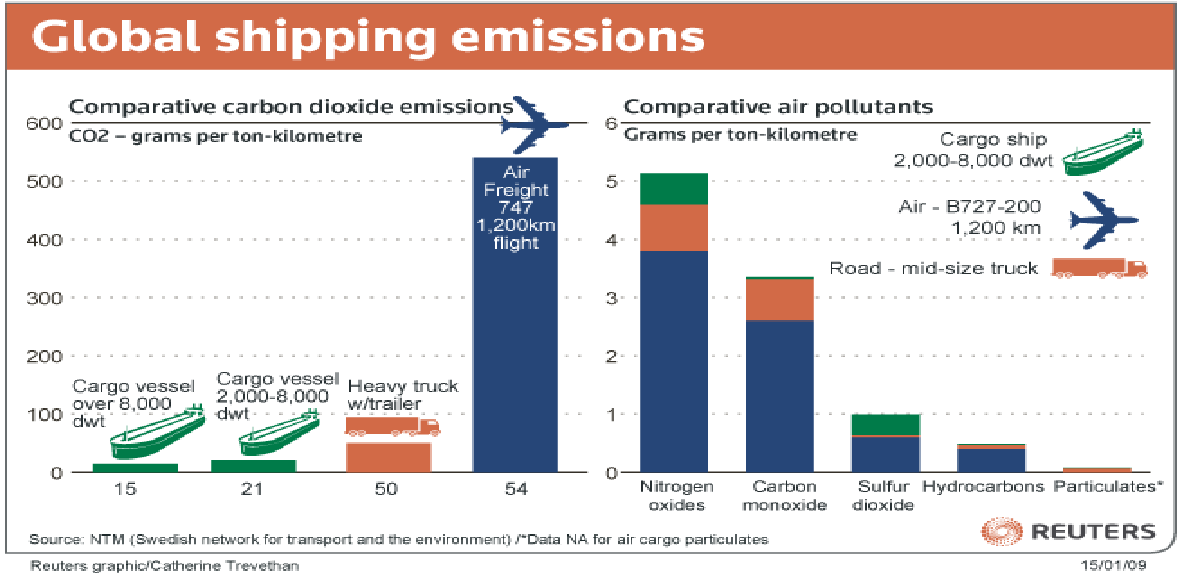


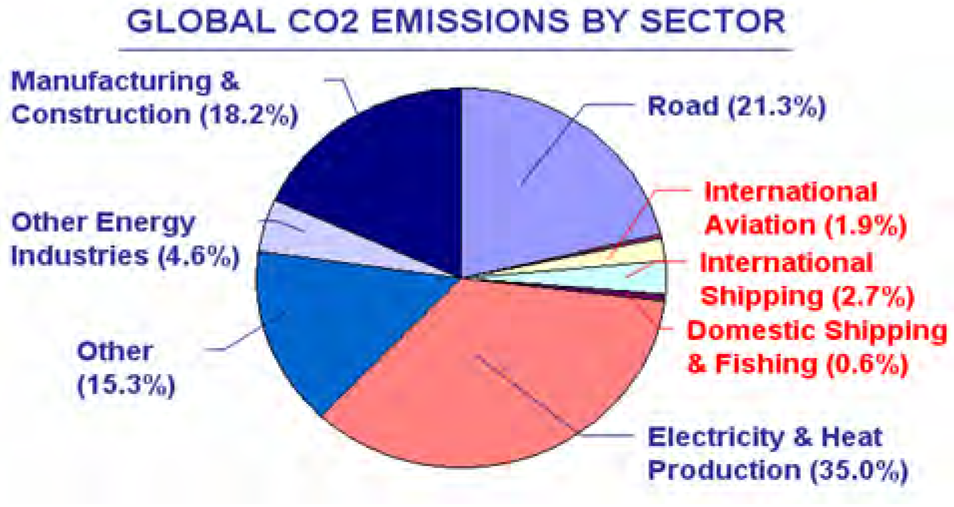


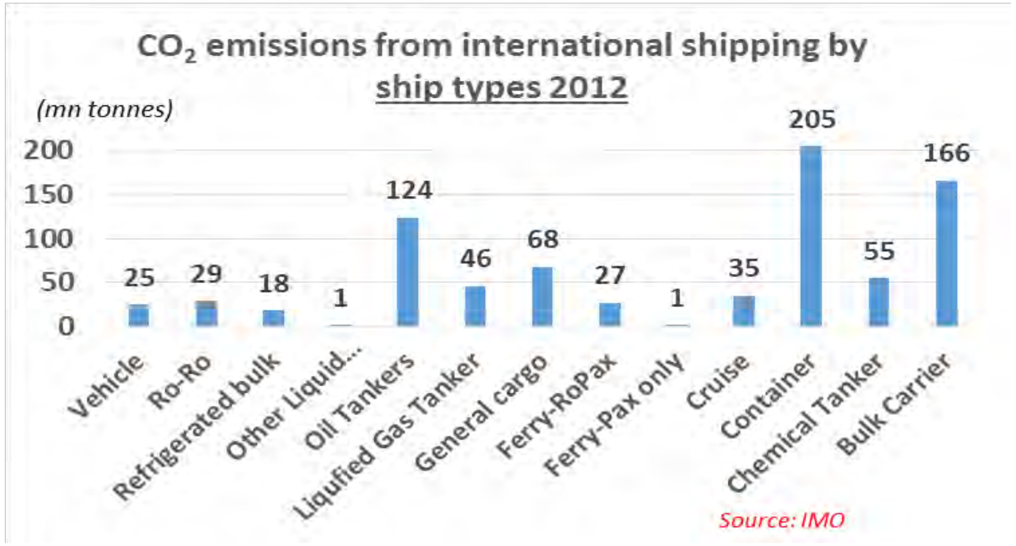
IMO's Future Greenhouse Gas Regulations

IMO's initial GHG strategy was adopted at its MEPC 72 meeting in April 2018 and would limit total GHG emissions in 2050 to 50% of actual GHG emissions in 2008. Additionally, IMO aims to have **future GHG regulations defined and adopted by 2023**. Shipowners are reluctant to invest in stack gas scrubbers if traditional marine fuels will have to be phased out over the next few years in favor of suitable alternate fuel that will address the forth coming sulfur deadline as well as have the potential to address upcoming GHG related regulations.

International Shipping GHG Footprint



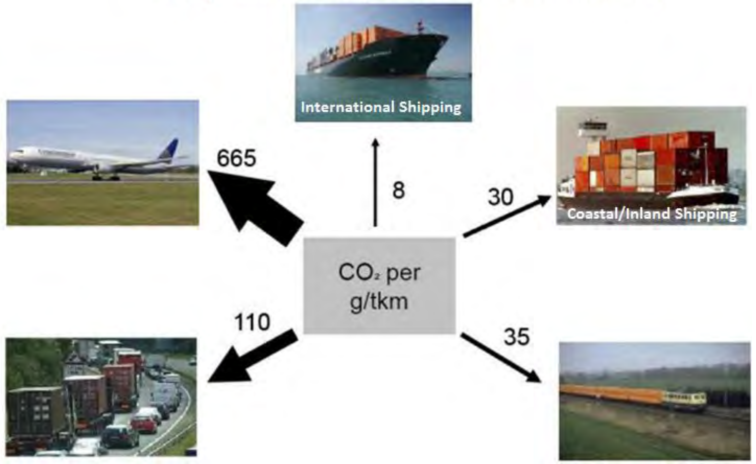




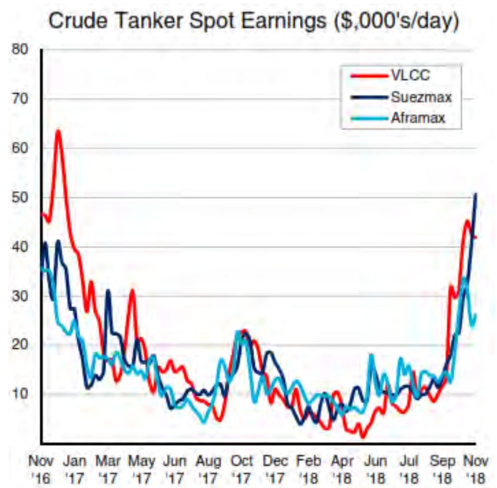
Emissions from shipping industry 2012 (IMO)

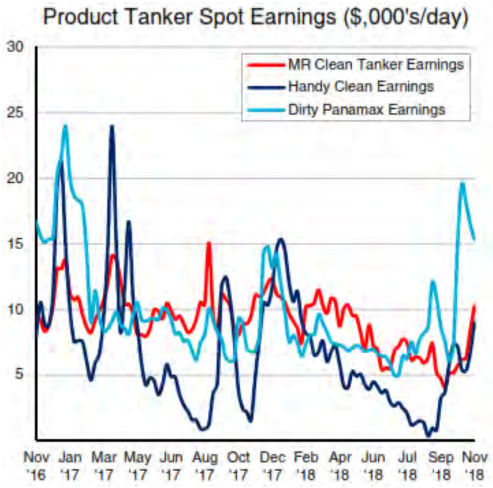
Type (tonnes)	International	Domestic	Fishing
CH_4	286,520	1,060	700
N_2O	36,680	3,560	2,400
SOx	9,712,000	268,000	261,000
NOx	16,997,000	1,171,000	834,000
PM	1,317,000	44,000	41,000
CO	806,000	76,000	53,000
NMVOC	609,000	53,000	35,000

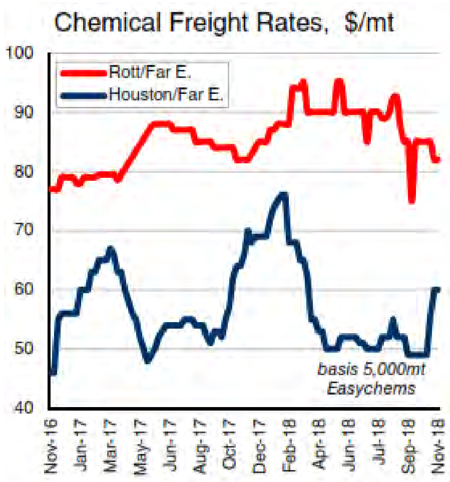
(CO_2 Emissions per mode of transport)

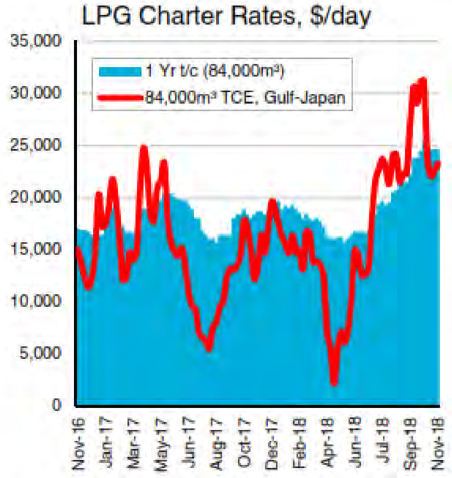


Shipping industry at a glance (>1,000 gt) – still a roller coaster ride

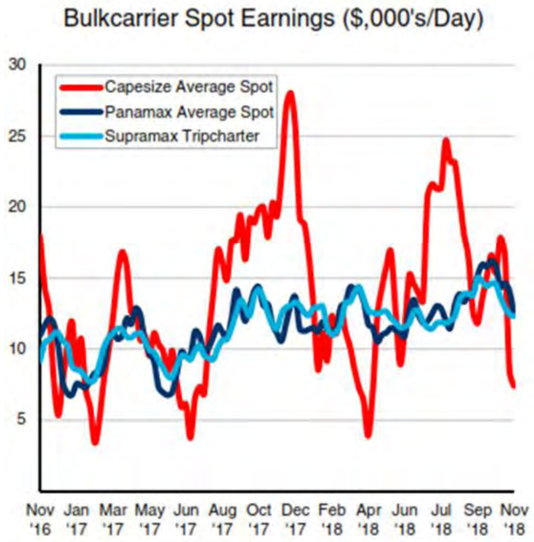


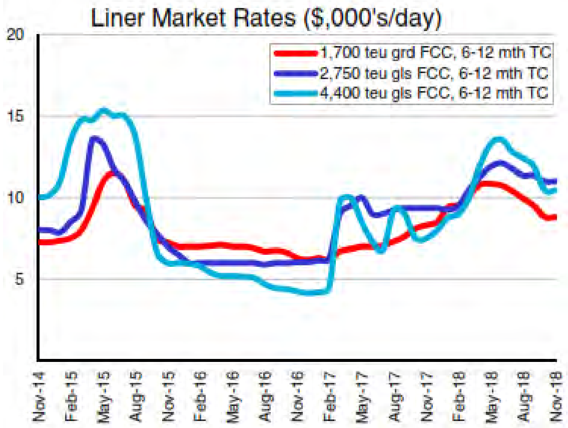


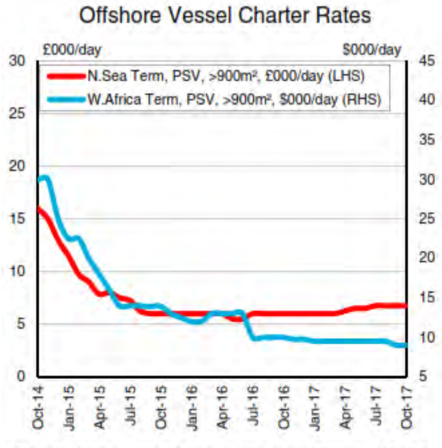




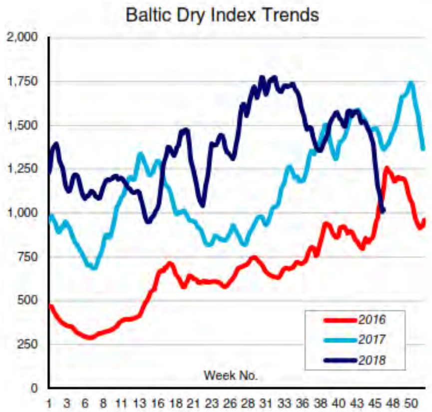
Total world fleet stands at **94,585** vessels plus and orderbook of **3530** vessels.







Offshore fleet includes all mobile units; for more detailed coverage of the full range of offshore sectors see Offshore Intelligence Monthly. See also Offshore Drilling Rig Monthly and Offshore Support Vessel Monthly.



Ave. Scrap Age	
Type of Vessel	Average Demolition age (yrs)
Bulkers	25.9
Tankers	27.4
Gas ships	28.7
General cargo	27.8
Container	22
Passenger	35.7

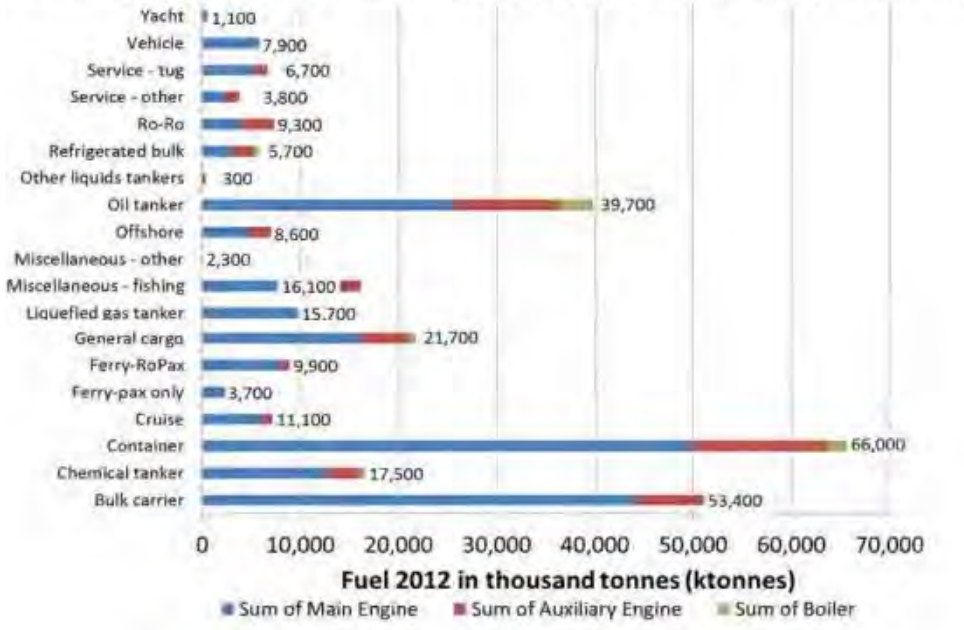
Graph Source: Clarksons - SIW (11/18)

Bunkers: Summary of annual bunker consumption and by ship type

Container vessels by far the largest consumer of marine fuels followed by oil tankers, bulk carriers, liquefied gas tankers and cruise ships.

In domestic shipping fishing vessels are followed by Ferry-Ropax and offshore

Summary of annual fuel consumption by ship type and machinary component



Summary of the IEA fuels sales data in shipping (million tonnes)

Marine Sector	Fuel Type	2007	2008	2009	2010	2011
International Marine bunkers	HFO MDO NG	174.1 26.0 0	177.0 22.7 0	165.9 24.9 0	178.9 28.2 0	177.9 29.6 0
International Total		**200.1**	**199.7**	**190.8**	**207.1**	**207.5**
Domestic navigation	HFO MDO NG	19.9 22.7 0.04	14.2 23.9 0.05	15.3 23.6 0.05	14.3 25.7 0.05	12.7 27.4 0.07
Domestic Total		**42.64**	**38.15**	**38.95**	**40.06**	**40.17**
Fishing	HFO MDO NG	1.1 5.4 0.04	1.1 4.9 0.02	1.0 5.0 0.04	0.8 5.2 0.02	0.8 5.1 0.05
Fishing Total		**6.54**	**6.02**	**6.04**	**6.02**	**5.95**
Total		**249.28**	**243.87**	**235.79**	**253.17**	**253.62**

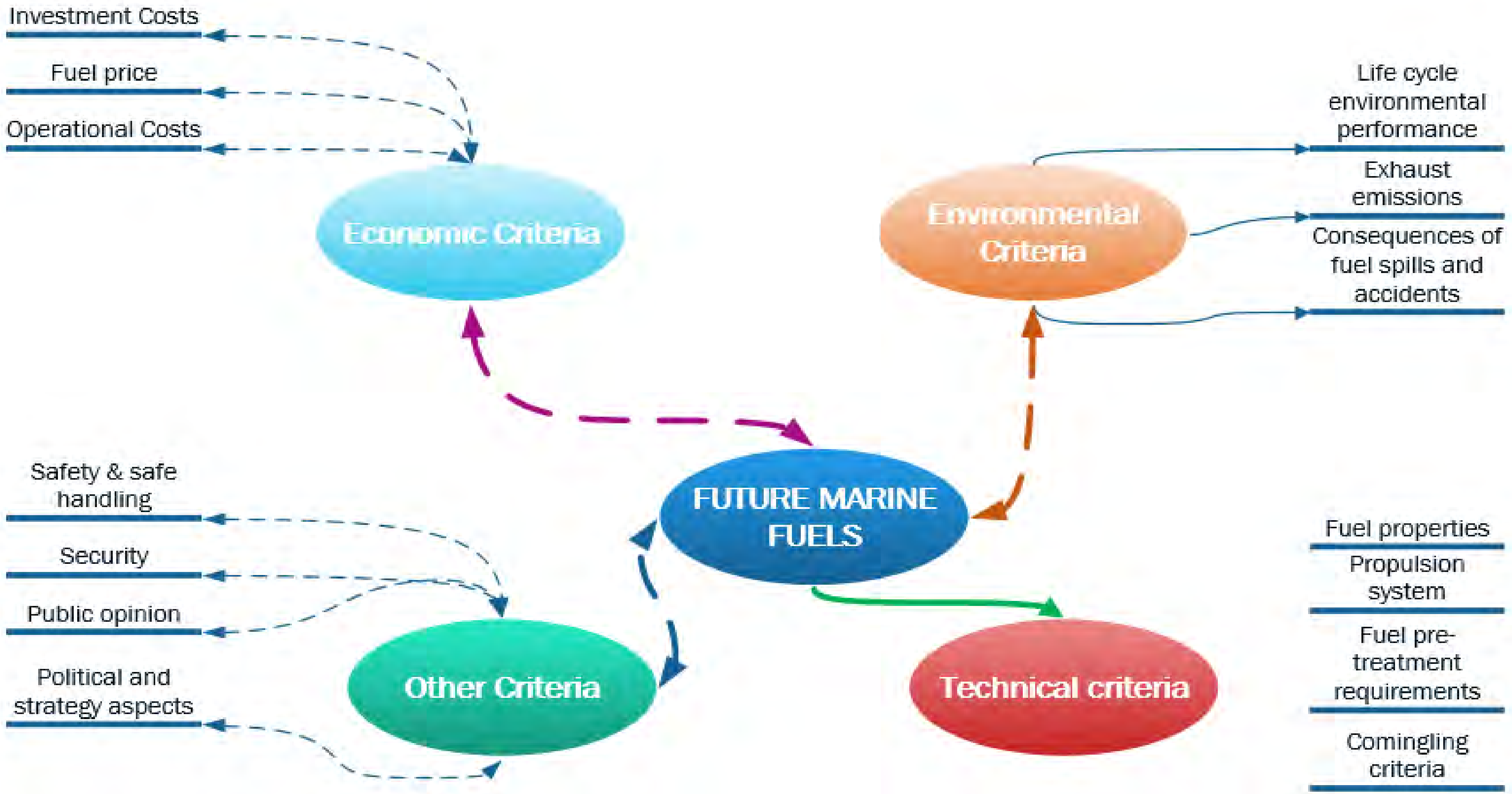
Typical Bunker Capacity

Ship Type	Bunker Volume
Service vessels, tug boats, Patrol boats and fishing boats	50 m^3
Small RoRo and Ro Pax vessels	400 m^3
Large RoRo and RoPax vessels	800 m^3
Cargo vessels and small container ships	2,000 – 4,000 m^3
Large tankers and container ships	10,000 m^3
Very large oil tankers and container ships	20,000 m^3

Fuel Consumption (Ts/d)

Ship Type	Size Category	Daily fuel Consumption at sea (Ts/d)
Bulk Carrier (dwt – ts) (Ave 85% MCR of main engine load factor))	0-9999 10-34999 35-59999 60-99999 100-199999 200000 plus	5.5 17.6 23.4 28.8 42.3 56.3
Container (teu) (Ave 70% MCR of main engine load factor)	0-999 1-1999 2-2999 3-4999 5-7999 8-11999 12-14500 14500 plus	14.4 26.0 38.5 58.7 79.3 95.6 107.8 100.0
Oil Tanker (dwt –ts) (Ave 52.5% MCR of main engine load factor)	0-4999 5-9999 10-19999 20-59999 60-79999 80-119999 120-199999 200000 plus	4.3 7.1 10.8 22.2 31.4 31.5 39.4 65.2

Factors that the ship owners need to consider in order to decide on technology selection



Alternative Marine fuels

These fuels are:

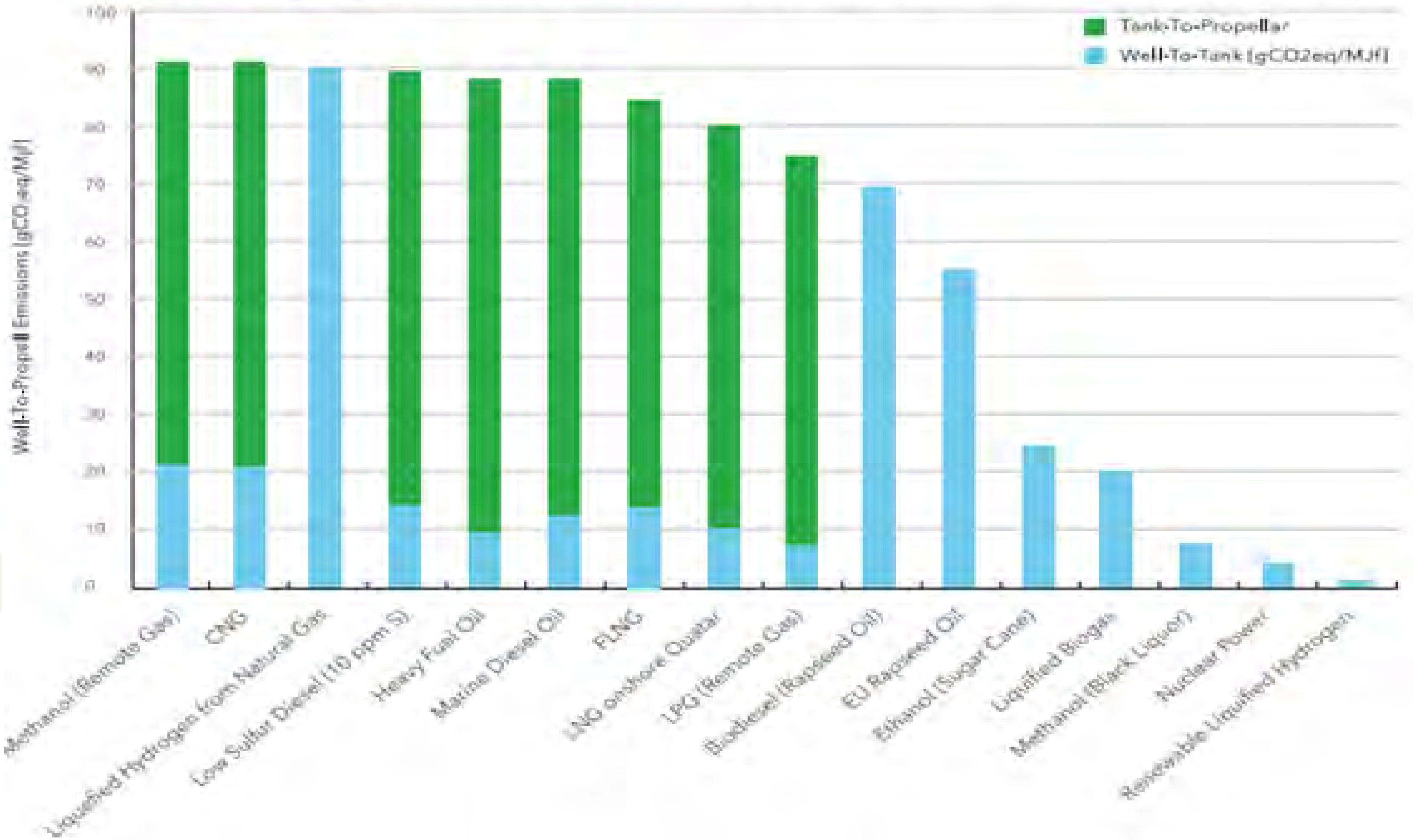
1. Liquefied Natural Gas (LNG)
2. Liquefied Petroleum Gas (LPG)
3. Methanol and Ethanol
4. Di-Methyl Ether (DME)
5. Synthetic Fuels (Fischer-Tropsch)
6. Biodiesel
7. Biogas
8. Use of electricity for charging batteries and cold ironing
9. Hydrogen
10. Nuclear Fuel

Global fuel consumption volumes of various fuels in 2010.

Fuel type	2010 total consumption (million TOE/year)	Consumption for methane transportation (million TOE/year)
Oil	4,028	>>330 (HFO/MDO: >>280/50)
LPG	275	0
Methanol	23	0
Ethanol	58	0
DME	>3-5	0
Fisher-Tropsch	>15	0
Biodiesel	18-20	0
Liquefied Biogas	Very low	0
Nuclear	626	Very low
Hydrogen	Very low	0
Rapeseed Oil	5	0

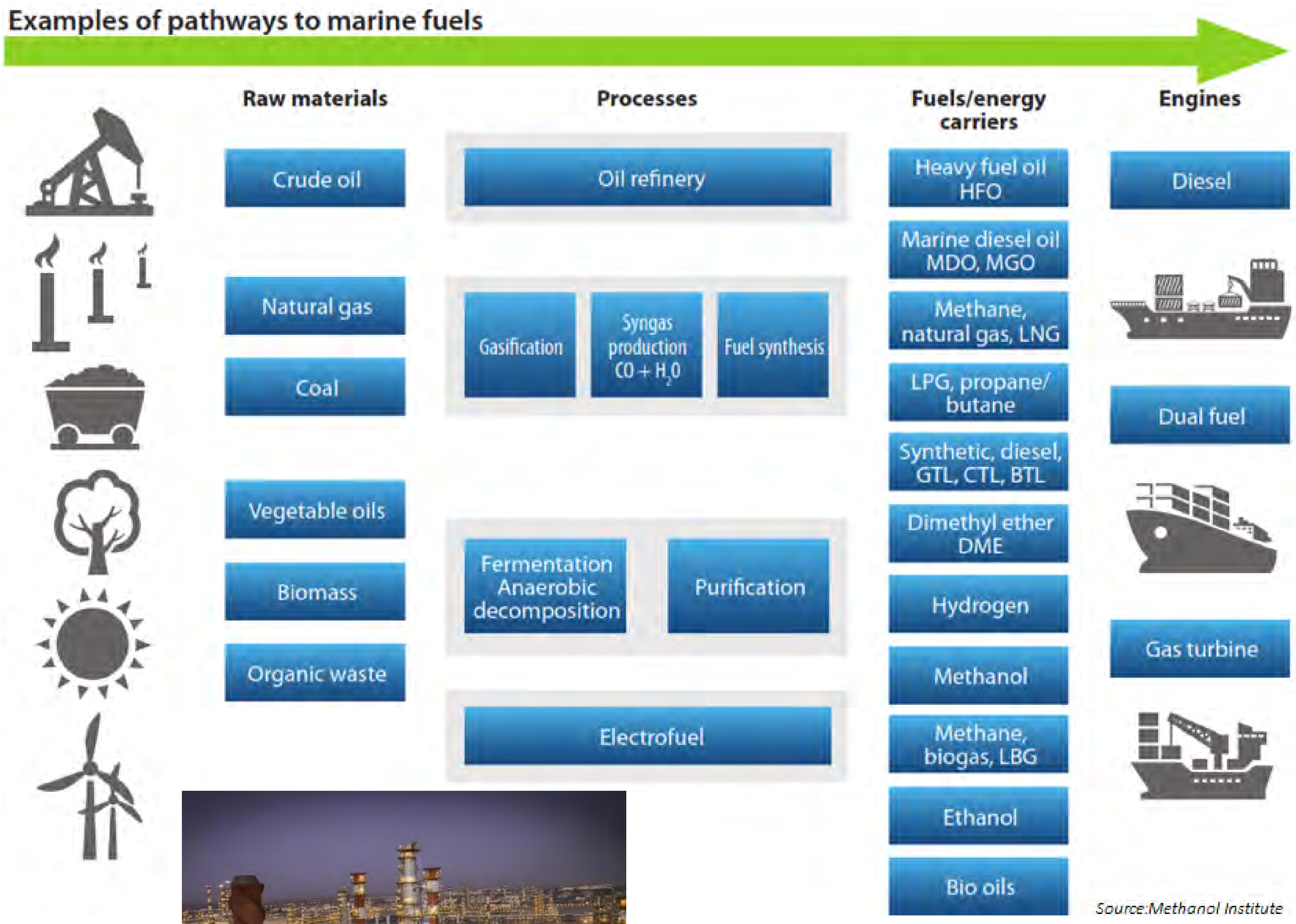
Source: BP 2011

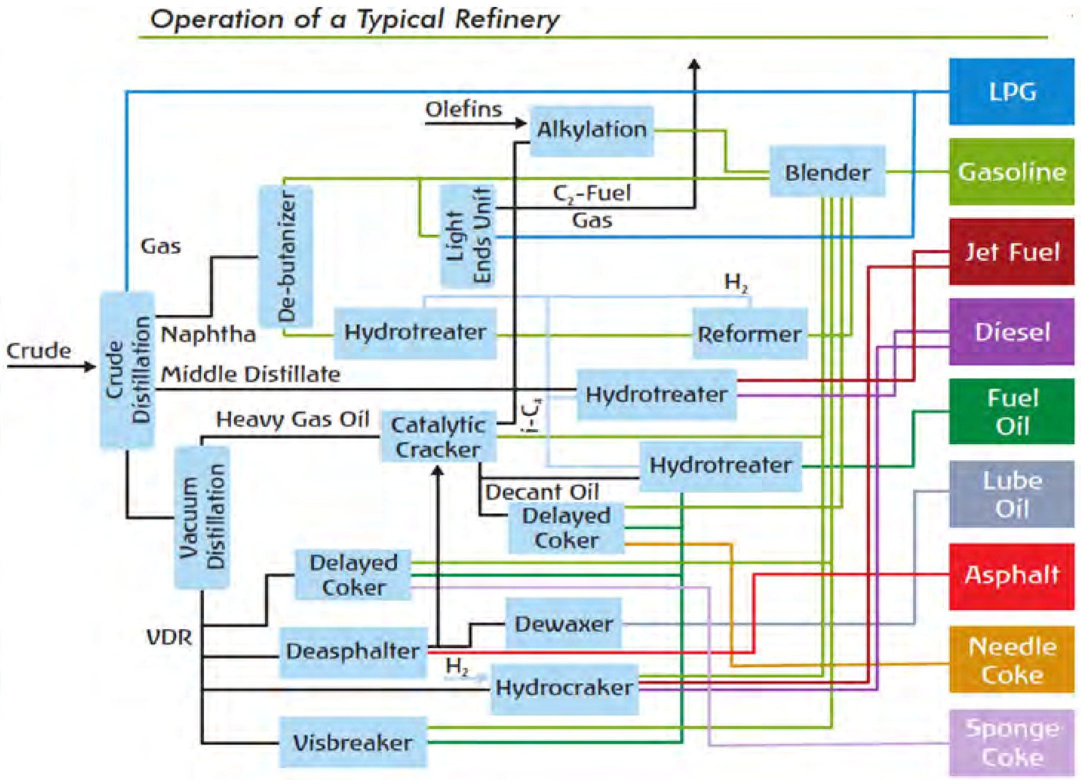
Well-to-propeller GHG emissions results for marine alternative fuels



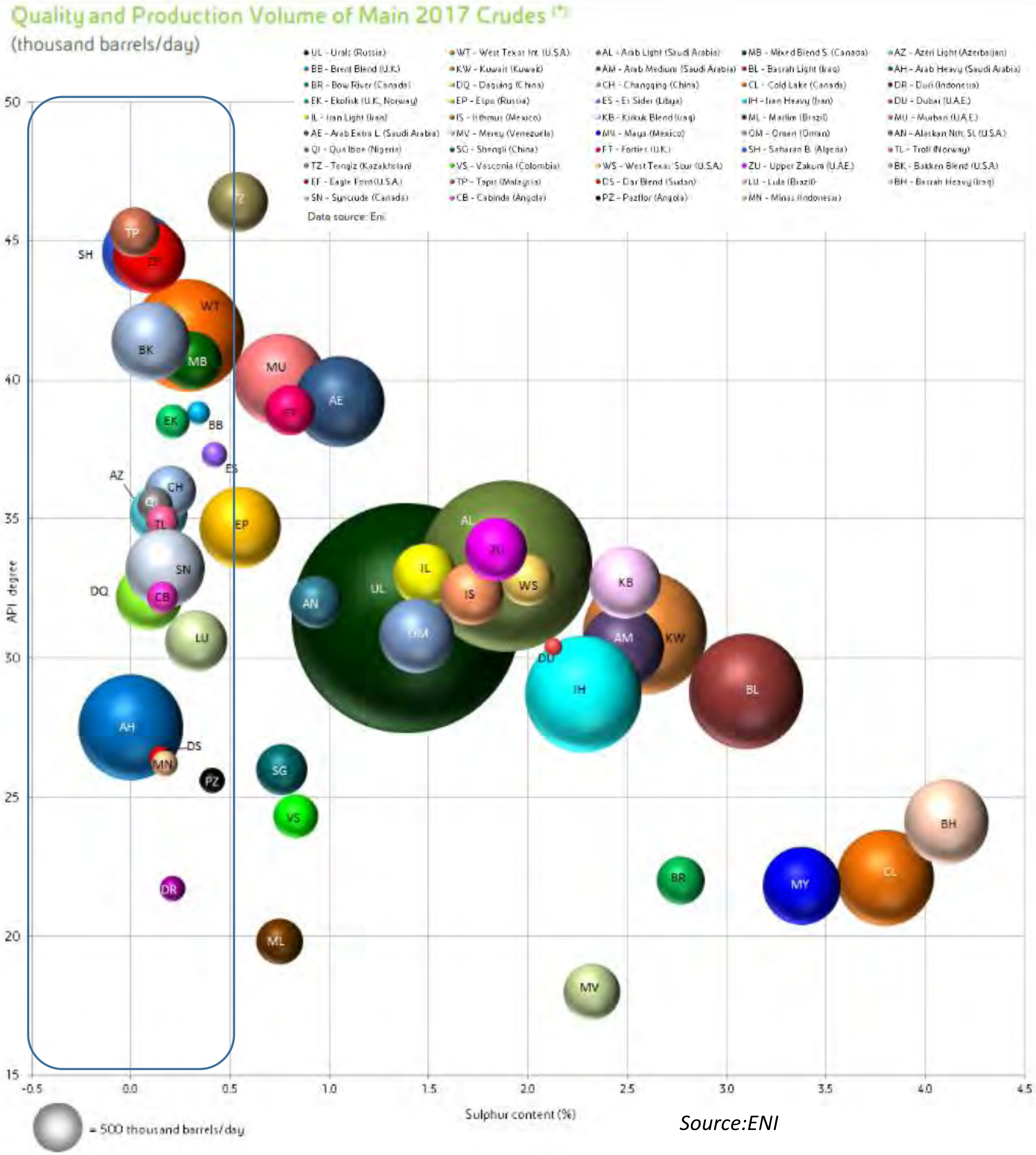
Source:DNV-GL

Pathways to Marine Fuels

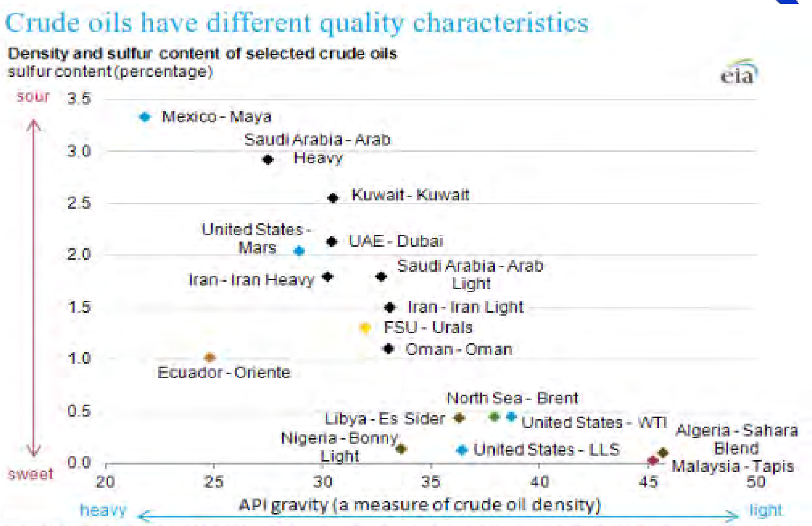




Hydrotreater. Also known as: **hydrodesulfurization**, HTU, HDS unit. The purpose of a **hydrotreater** unit is primarily to remove sulfur and other contaminants from intermediate streams before blending into a finished refined product or before being fed into another **refinery** process unit.



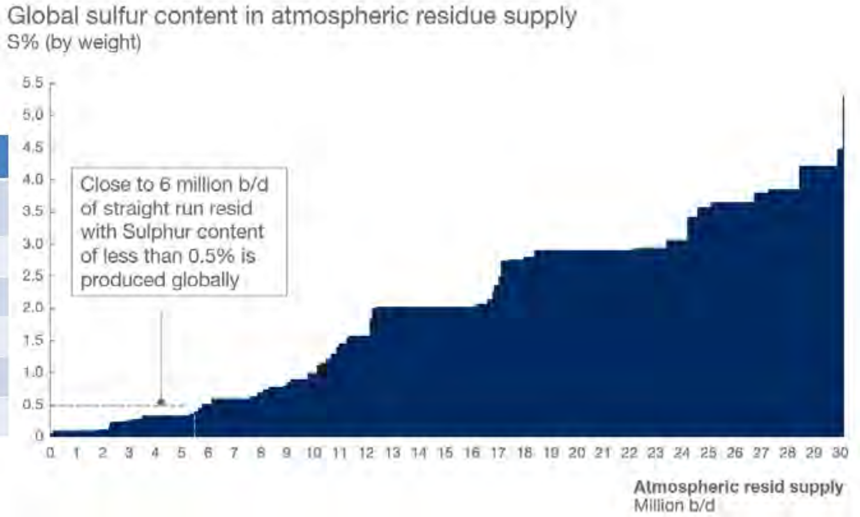
Source:ENI



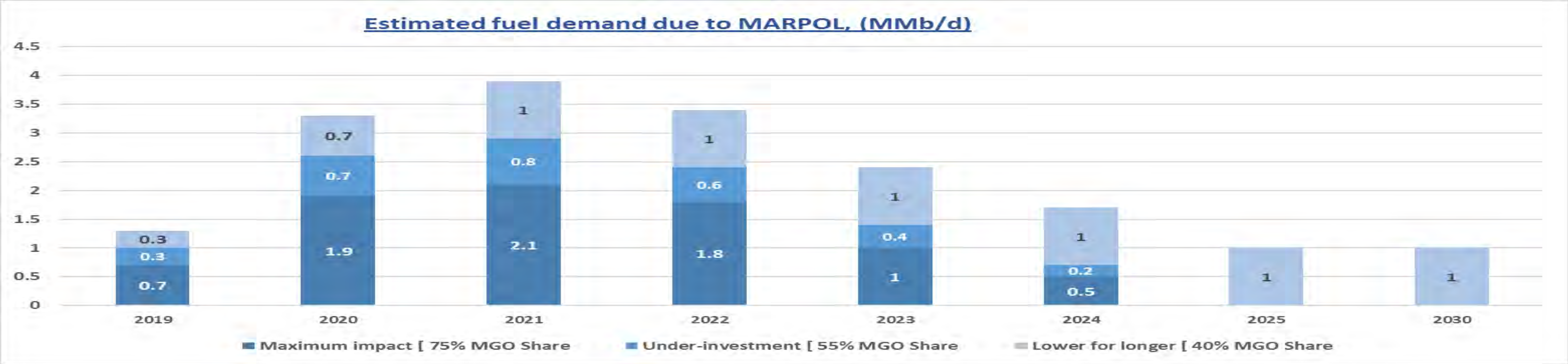
Source: U.S. Energy Information Administration, based on Energy Intelligence Group—International Crude Oil Market Handbook.
Notes: Points on the graph are labeled by country and benchmark name and are color coded to correspond with regions in the map below. The graph does not indicate price or volume output values. United States-Mars is an offshore drilling site in the Gulf of Mexico. WTI = West Texas Intermediate; LLS = Louisiana Light Sweet; FSU = Former Soviet Union; UAE = United Arab Emirates.
Republished: June 26, 2013: Map was corrected.

Types of crude oil

Crude Oil Class	Property Range	
	Gravity (°API)	Sulfur (wt.%)
Light Sweet	35-60	0-0.5
Light Sour	35-60	> 0.5
Medium Sour	26-35	> 1.1
Heavy Sweet	10-26	0-1.1
Heavy Sour	10-26	> 1.1



Estimated fuel demand due to MARPOL (MMb/d)



Maximum Impact [75% MGO Share

- If ~ 90% compliance, is achieved primarily through MGO use:
- Can add up to 3.8MMb/d of crude to global oil demand by 2021.
- 75% MGO share is the best highest possible under current refinery configurations.
- full refinery utilization is highly unlikely.
- Fuel switch will allow use of LSFO pushing MGO share down.

Under Investment [55% MGO Share

- ~ 90% compliance is more likely to be achieved through a more equal split between MGO and low sulfur fuel oil, adding about 1.8MMb/d of demand by 2021.

Lower for longer {40% MGO Share

- Reduce compliance of ~80% caps uptake of MGO and adds -1MMb/d p.a. to global demand

[1] compliance includes scrubbers and fuel switching to LNG, Methanol etc

Source: Mckinney Energy Insight

Abatement Technologies

Opting for an alternative fuel like LNG or Methanol is one possibility for meeting the EEDI requirements, but many other technical options are also available. It is therefore assumed that currently, EEDI is not a major driver for LNG as a shipping fuel.

Sulphur reduction

Combustion modification (efficiency: 50-60%)	• It uses the addition of limestone ($CaCO_3$) or dolomite in conventional boiler.
Sea Water Scrubbing (efficiency 95%)	• It is an extremely efficient method used to reduce Sulphur and PM concentration in exhaust gas.
Fresh water Scrubbing (efficiency 90%)	• Is an alternative to sea water scrubbing if high efficiency cleaning is needed.
Changes in energy system (N/A)	• Lead to a lower consumption of Sulphur by energy conservation of fuel substitution.
Fuel switching (efficiency 2.7 to 0.5% = 81%)	• Low Sulphur diesel (0.5%) • Ultra-low Sulphur diesel (0.03%) • Alternative fuels: Bio-fuels, natural gas, hydrogen
Desulphurization (N/A)	• Generally, low-Sulphur fuels go to substitute fuels of the same category having higher Sulphur content.

Nox Reduction

Pre-Treatment

1. Related to nitrogen content of fuels

Primary

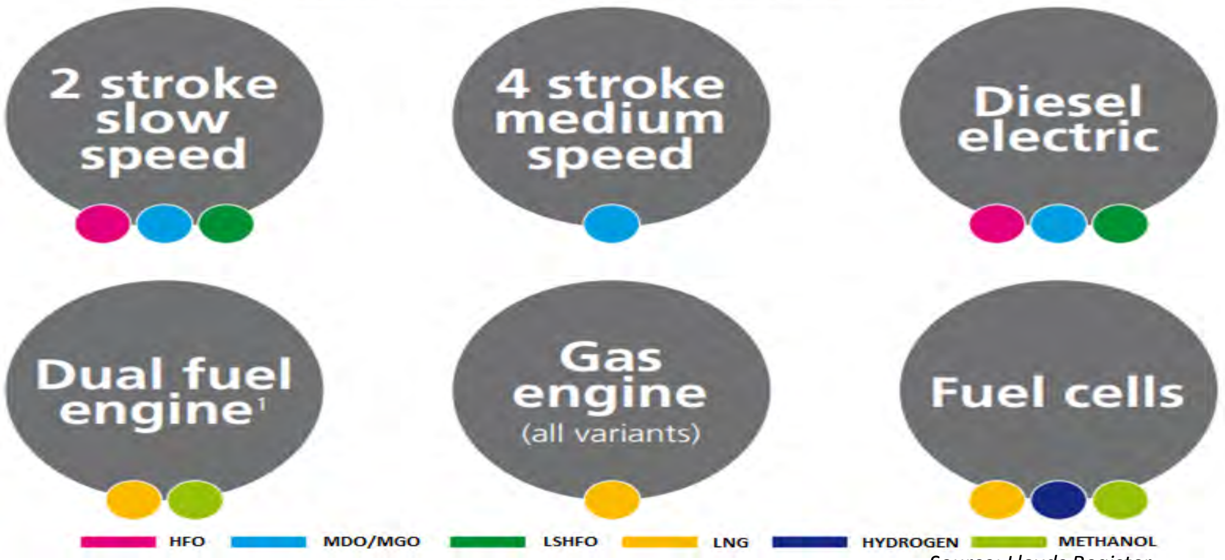
1. Internal modification of engines (IEM):
   - Injection retardation
   - Increase of injection pressure
   - Modification of compression ratio
   - Optimization of induction swirl
   - Modification of injector specification
   - Change in number of injector
   - Scavenge/charge air cooling
   - Increasing the scavenge/change air pressure
2. Water injection:
   - Water injection
   - Water injection + EGR
3. Exhaust gas circulation
4. Humid air motor (HAM)

Secondary

1. Re-burning
2. Selective Catalytic Reduction (SCR)
3. Plasma Reduction System
4. WiFE (water in fuel emulsion)

Technological challenges for the Shipowners

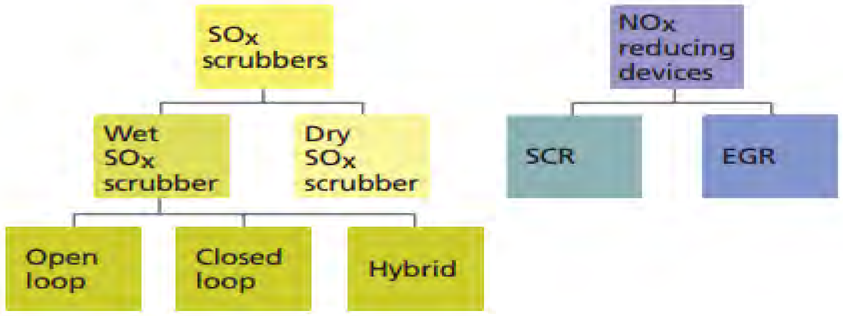
Main machinery and fuel type compatibility matrix

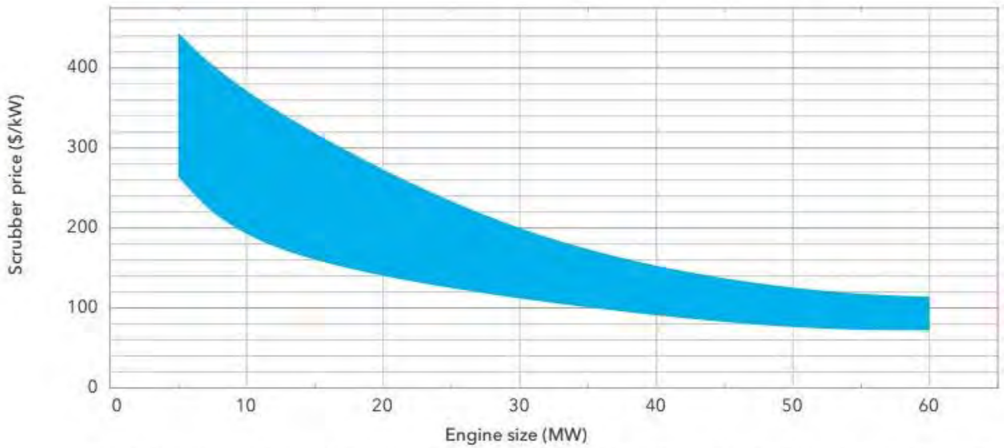


Source: Lloyds Register

Dual fuel,, main engines able to run on either diesel and LNG or diesel and methanol.

Strategy of a ship owner on how to cope with environmental requirements and high fuel prices in the coming decade is dependent on which assumptions are most likely to be realized, how other ship owners are likely to act, and the willingness to take risks.

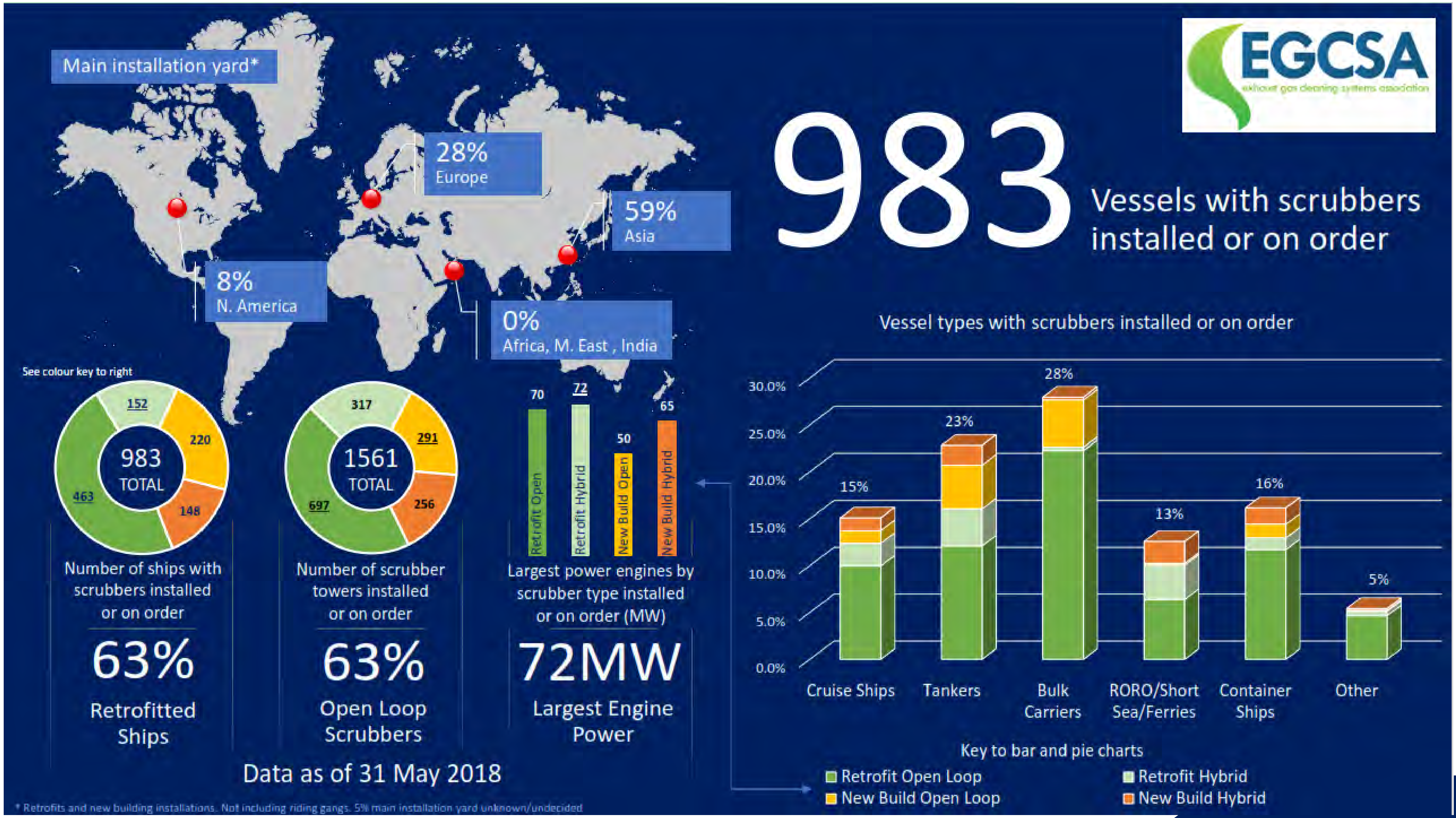




Range of scrubber prices in USD/kW for various marine engine sizes. Some of the largest ones on offer have not yet been installed on ships.

It is not only the gas engine itself that has to be considered when one is talking about methane slip, but rather, the entire supply chain must be considered.

Global Scrubbers



LNG Industry – A snap shot

Global LNG Trade
- 293.1 mtpa

Global Liquefaction Capacity
- 19 countries
- 369 mtpa

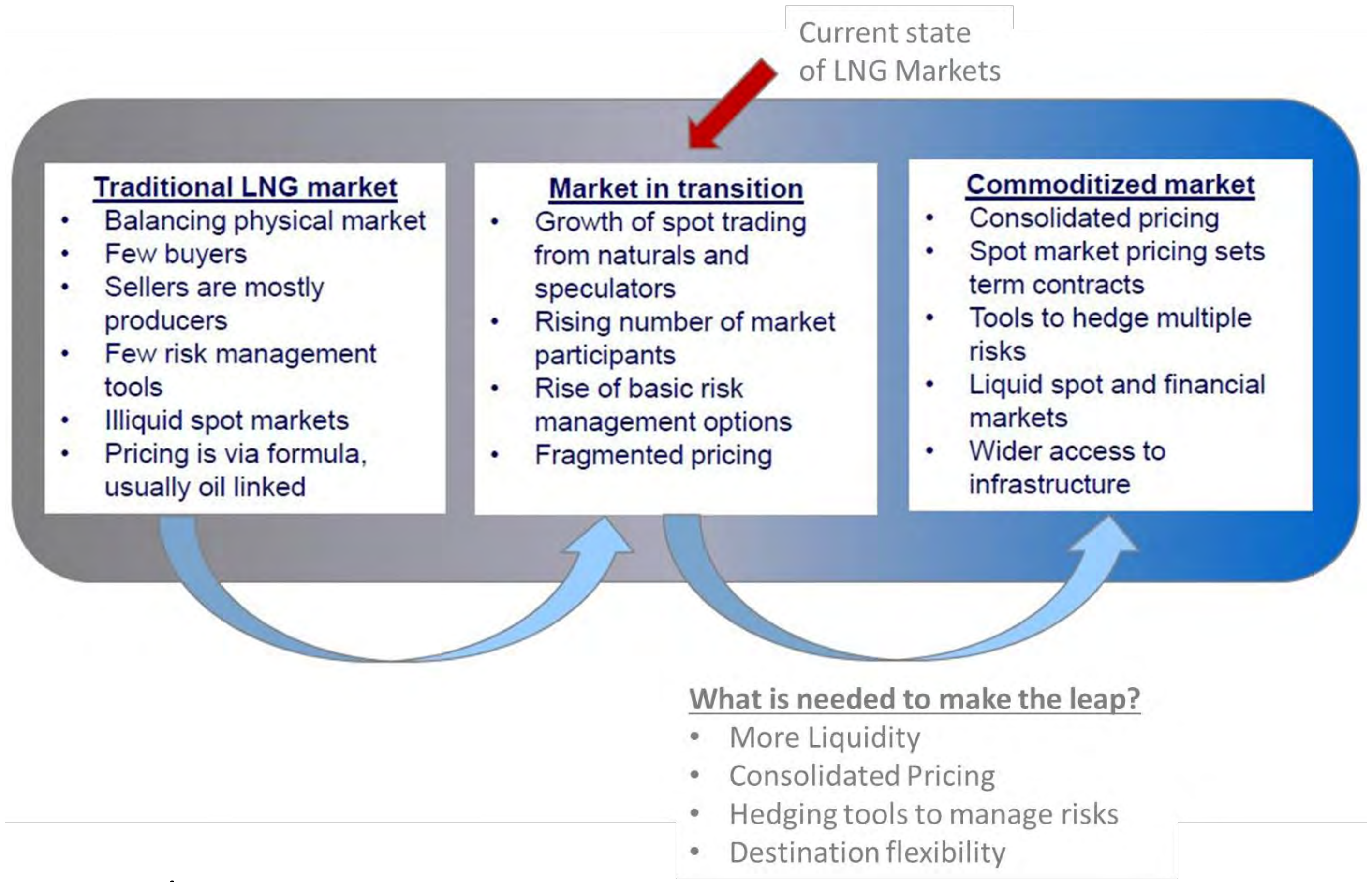
Global Regasification Capacity
- 31 countries
- 851 mtpa

Global FSRU Fleet
- In service – 27
- On order - 7

Global LNGC Fleet
- In-service – 480
- On-order - 116

Yearly Average price of LNG
- US$6.85/MMBtu
- Basis DES Asia

Yearly Average LNGC Charter Rate
- DFDE - US$44500 per day
- ST – US$26700 per day



Spot/Short term trade = 88mtpa or 30% of total trade

LNG: Commercial & Technical Factors To Consider

COMMERCIAL

Which infrastructure investment model works best?

What guarantees are there for investors?

What size should a LNG bunker barge be?

How will LNG bunkers be traded? Mass, Volume or Energy content?

Who will be responsible for the Custody Transfer? Seller or Buyer?

Who will pay for the BOG and BOG management?

Who will pay for the time for inerting of filling lines?

Who will monitor gas quality? Existing bunker surveyors?

Trained personal availability?

Will we develop standards for delivered temperature and pressure?

Does colder gas have a higher commercial value than warmer?

If excess BOG generation is reduced by lowering pumping rate, who pays for the extra bunkering time?

Custody Transfer.

LNG Pricing

TECHNICAL

Manpower Competency

Gas grade/class/quality/measurement

Ship design optimization (cradle to grave philosophy)

Total Energy Management

Risk Management

- HAZID
- HAZOP

BOG Management

Filling Operations - the last metre

Ice and moisture.

Tank cooling issues

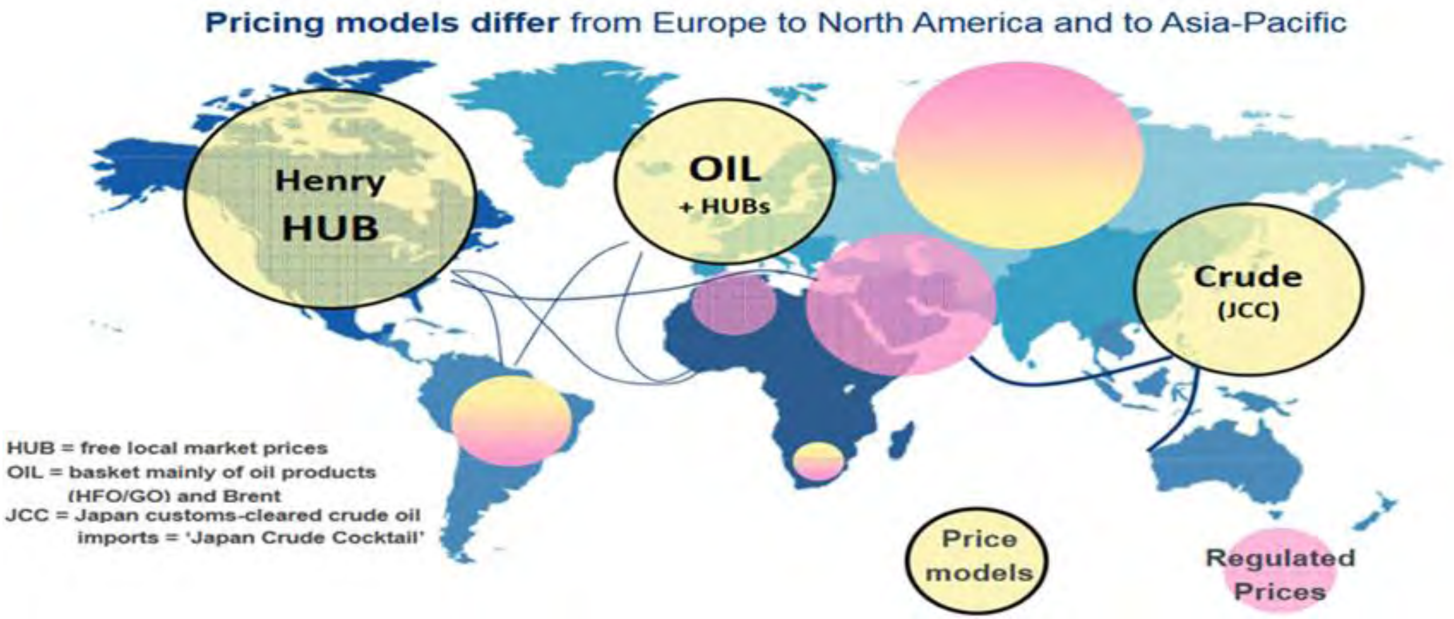
Rollover / Stratification

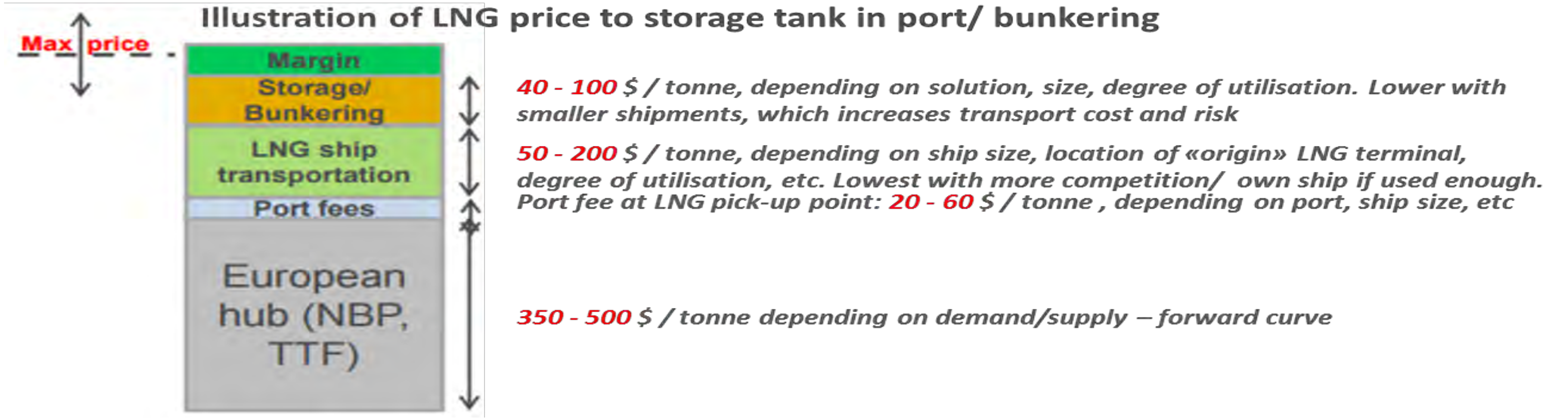
Supply source composition differences – mixing of different specs LNG?

Difference in Methane Number

As per IGF code #6.9, in case vessel is not fitted with a Type C tank , calls for BOG system management irrespective of the fact that whether it is used or not used.

Global Gas Prices: three different models



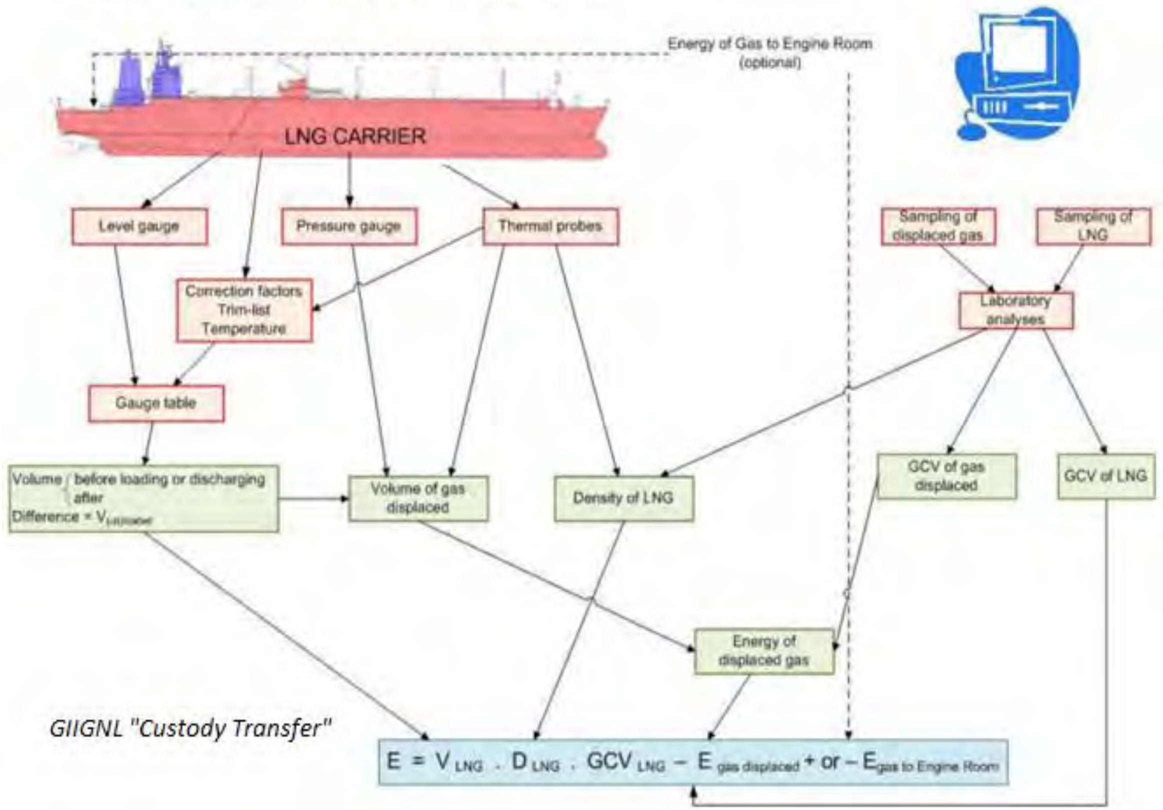


The delta between wholesale and retail prices is still significant for LNG - very small for crude oil- based fuels

It is *possible* that this that this delta may significantly reduce with competition, bringing gas priced LNG down by $200 – 250 / tonne, which would be competitive with MGO at current levels

Custody transfer: Flowchart to determine the energy transferred.

Flowchart for determining the energy transferred



1% uncertainty on total value of global trade of LNG (200 mtpa in 2010)

= 440 M€/year (2010) 900 M€/year (2015)

LNG fuel qualities – variable composition

Worldwide LNG composition

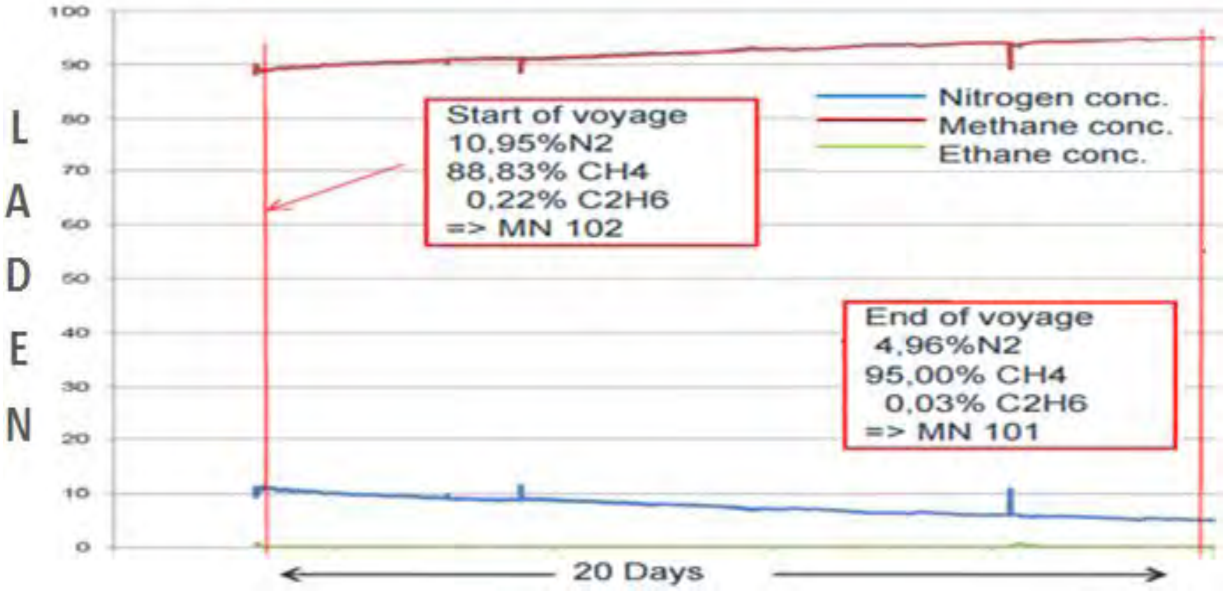
	Typical LNG composition in volime %							
LNG export terminals	C1	C2	C3	C4	C5+	N2	LHV[MJ/kg]	MN
Arun (Indonesia)	89,33	7,14	2,22	1,17	0,01	0,08	49,4	70,7
Arzew (Algeria)	87,4	8,6	2,4	0,05	0,02	0,35	49,1	72,3
Badak (Indonesia)	91,09	5,51	2,48	0,88	0	0,03	49,5	72,9
Bintulu (Malaysia)	91,23	4,3	2,95	1,4	0	0,12	49,4	70,4
Bonny (Nigeria)	90,4	5,2	2,8	1,5	0,02	0,07	49,4	69,5
Das Island (Emirates)	84,83	13,39	1,34	0,28	0	0,17	49,3	71,2
Lumut (Brunei)	89,4	6,3	2,8	1,3	0,05	0,05	49,4	69,5
Point Fortin (Trinidad)	96,2	3,26	0,42	0,07	0,01	0,01	49,9	87,4
Ras Laffan (Qatar)	90,1	6,47	2,27	0,6	0,03	0,25	49,3	73,8
Skida (Algeria)	91,5	5,64	1,5	0,5	0,01	0,85	49	77,3
Snøhvit (Norway)	91,9	5,3	1,9	0,2	0	0,6	49,2	78,3
Withnell (Australia)	89,02	7,33	2,56	1,03	0	0,06	49,4	70,6

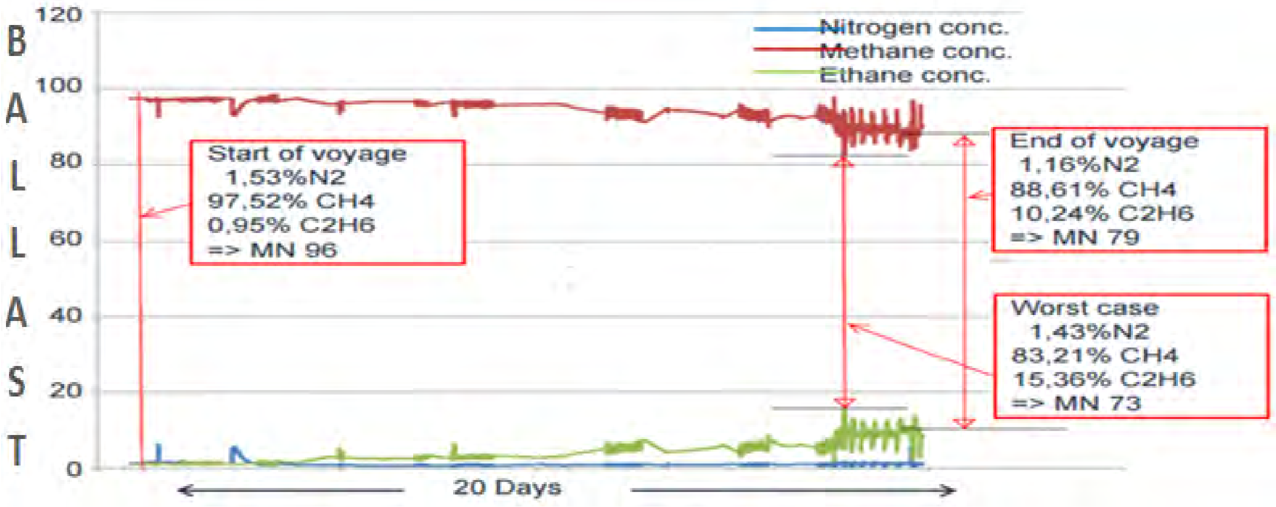
Note the variation of Methane Number (MN) 69.5 – 87.4

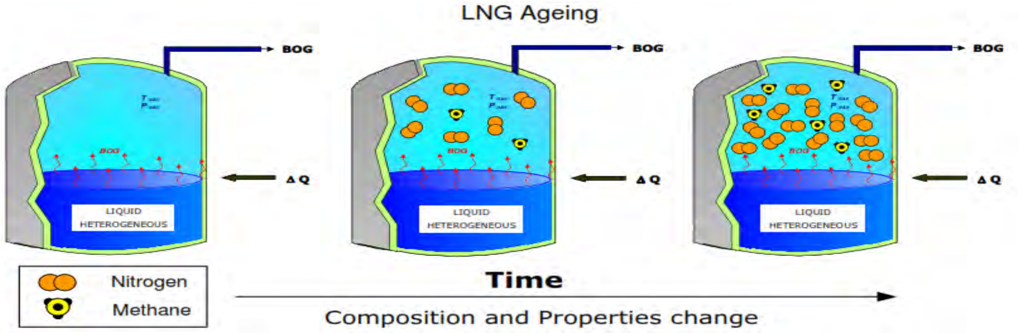
Methane Number Range (AVL)	Global LNG production (mtpa)	% of Total LNG produced
0-70	29.3	10%
70-75	126	43%
75-80	26.4	9%
80-100	111.3	38%
0-100	**293**	**100%**

AVL method - AVL Inc. developed a method to calculate the methane number, based on experimental measures of different gas mixtures (up to C_4, H_2, CO_2 & SH_2).

LNG Ageing or weathering







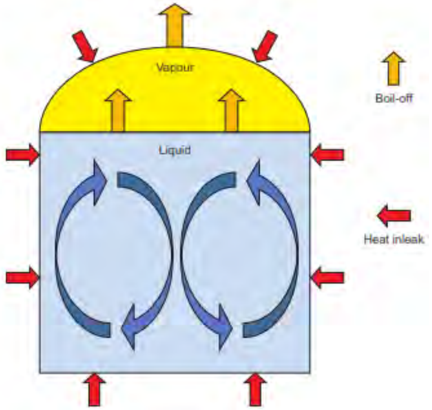
Vessel	Bunker Capacity	Range @ full power (-162oC)	Range @ full power (-126oC)	Difference
Small Ferry	50m3	39 hours	34 hours	- 5
Offshore Vessel	1500m3	236 hours	203 hours	-33
Cont Vessel	10,000m3	793 hours	681 hours	- 112 (4.5 days)

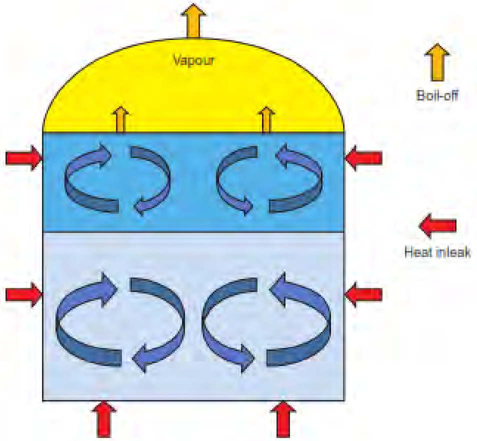
LNG State	Location	Temperature	Pressure
Standard LNG	Terminal	-163 Celcius	1 bar
Cold LNG	Intermediate storage	-150 Celcius	3 bar
Saturated LNG	Customer	-130 Celcius	8 bar

BOG Creation by design

BOG is generated while bunkering or loading.

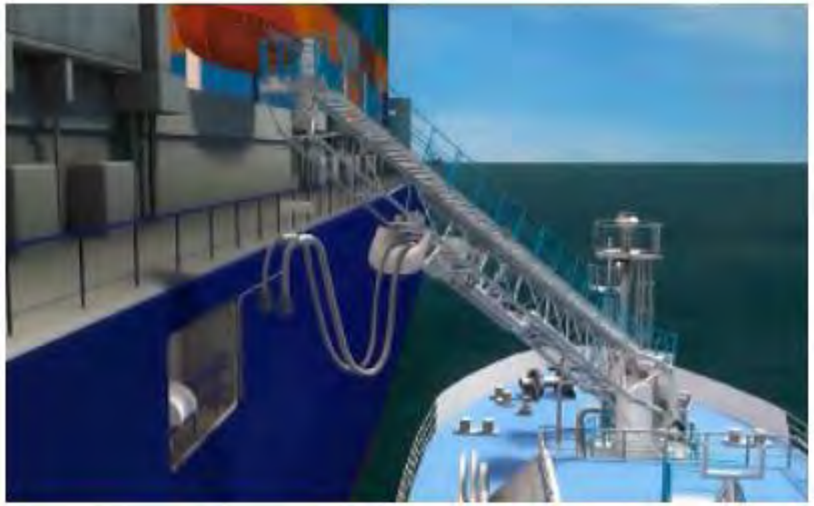
Tank Size	60m³		1000m³		1000m³	
Quantity in Tank at Start (Heel) (m³)	6		100		100	
Pressure (Bar)	9		9		Atms	
Temperature (°C)	-126		-126		-162	
Loading Rate (m³/hr)	2	60	100	500	100	500
Loading Time (hrs)	30	1	10	2	10	2
Boil of Gas Generated (m³)	3.25	2.97	53.8	51.69	1.4	1.46
Average Boil Of Gas Rate (m³/hr)	0.1	2.97	5.4	25.8	0.14	0.73
Max BOR (m³/hr)	7	20	20	79	0.6	2.47
Min BOR (m³/hr)	1	2.5	2.5	11	0.06	0.4
Boil of Gas Generated (kg) @-162	2	1.8	33.2	31.9	0.865	0.9
Boil Off Gas as CO_2 Equivalent (kg)	42	37.8	697	667	18	18.9





BOG = Boil of Gas

LNG Transfer System



Loading arm challenge

Ice and Moisture

- When transferring LNG the moisture in the air surrounding transfer equipment like flanges, connectors and hoses condensates on the cold parts and freezes to frost or ice.
- This concern especially bunker vessels or bunker facilities that are or will be **frequently used and the transfer equipment does not have** time to dry by itself.
- LNG systems contain filters that shall capture ice. If ice or moisture still gets into the LNG system, such as a tank, it will be a serious problem.

If flanges and connectors are not warmed and dried sufficiently and if hoses not air free or filled with NG or nitrogen (N2) the condensed moisture, frost and ice may come into the LNG stream and into LNG tanks and further into the fuel systems. (Cryo has introduced a limit for water vapour in air at -40 C or 125 ppm)

And what could happen if the staff is not properly trained

LNG Spill - Metal Fracture

Carbon steel will become brittle and crack when in contact with LNG. **So will you and your equipment!**

LNG Bunkering Structure and Value Chain Costs

LNG Bunkering Infrastructure

LNG port case	large	medium	small
Throughput/year	343,000 m^3	204,000 m^3	52,000 m^3
Tank size	no separate tank	20,000 m^3	2 x 700 m^3
Tank turnover/year	n/a	20	40
Installations	one bunkering berth, one jetty	one bunkering berth, one jetty	one bunkering berth
	one small-scale bunkering verssel (4,000 m^3)	two small-scale bunkering vessel (3-4,000 m^3)	one tank truck, 50 m^3
	two tank trucks, 50 m^3	one tank truck, 50 m^3	
	one truck filling station	one truck filling station	one truck filling station
Costs of LNG distribution at 10 years payback	€118/tonne (US$2.2/MMBtu)	€137/tonne (US$2.6/MMBtu)	€194/tonne (US$3.7/MMBtu)

Cost to construct a LNG storage tank varies between US$1500-$2000/cum – for 20000 cum tank = US$30-40 million.

Delivery cost per tonne basis (Medium Scale) facility: $137/t or 22% of total cost of LNG fuel price.

LNG bunkering facilities around the world

Operational facilities

Europe
Rotterdam
Hammerfest
Barcelona

Americas
Montreal
Jacksonville
Port Fourchon
Panama
Dominican Republic

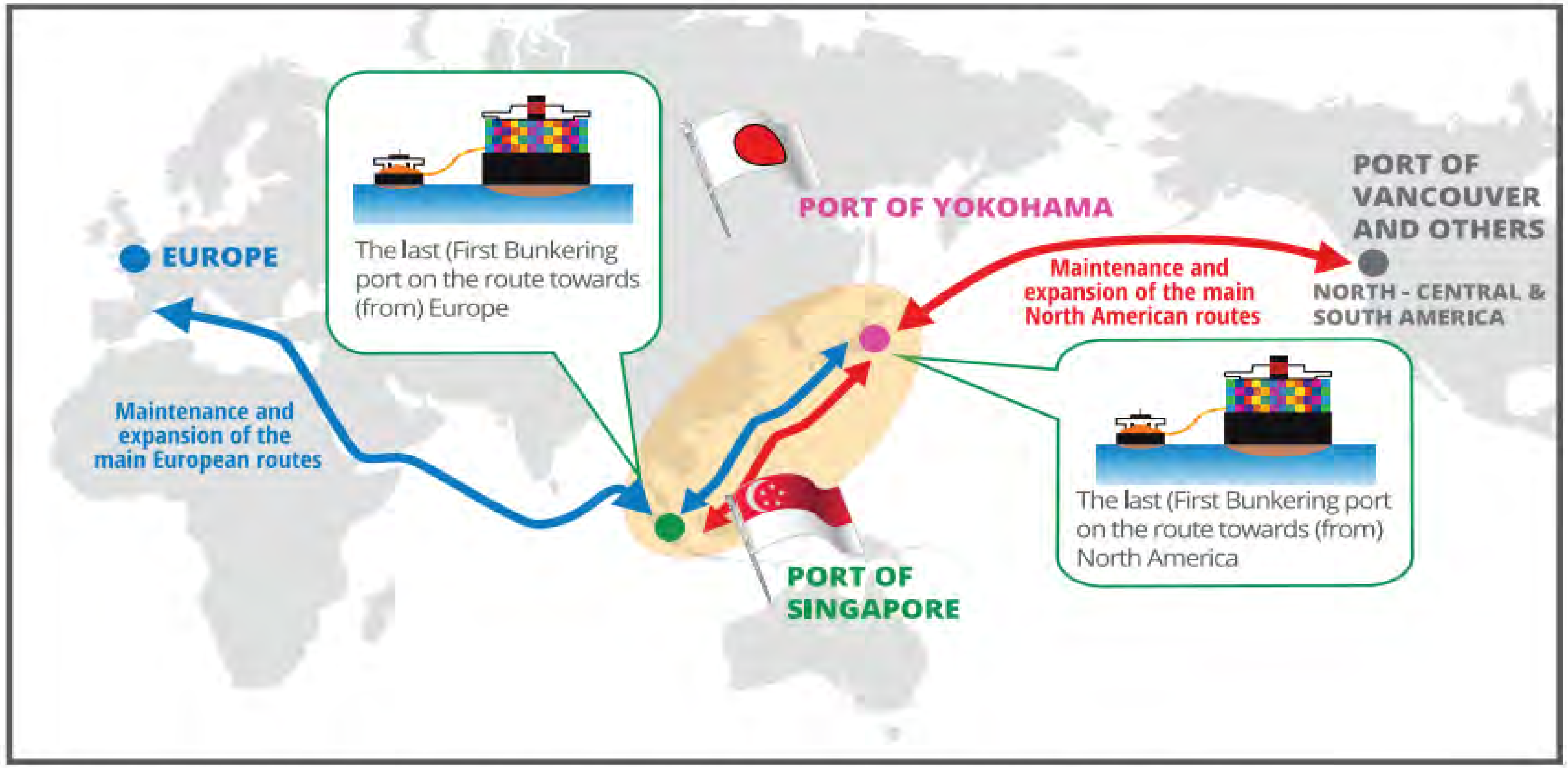
Asia
Singapore
Kochi
Yokohama

Planned facilities

Europe
Gibraltar
Dunkirk
Hamburg

Asia
Busan
Zhoushan

Formation of LNG bunkering hubs by collaboration between the Port of Yokohama and the Port of Singapore

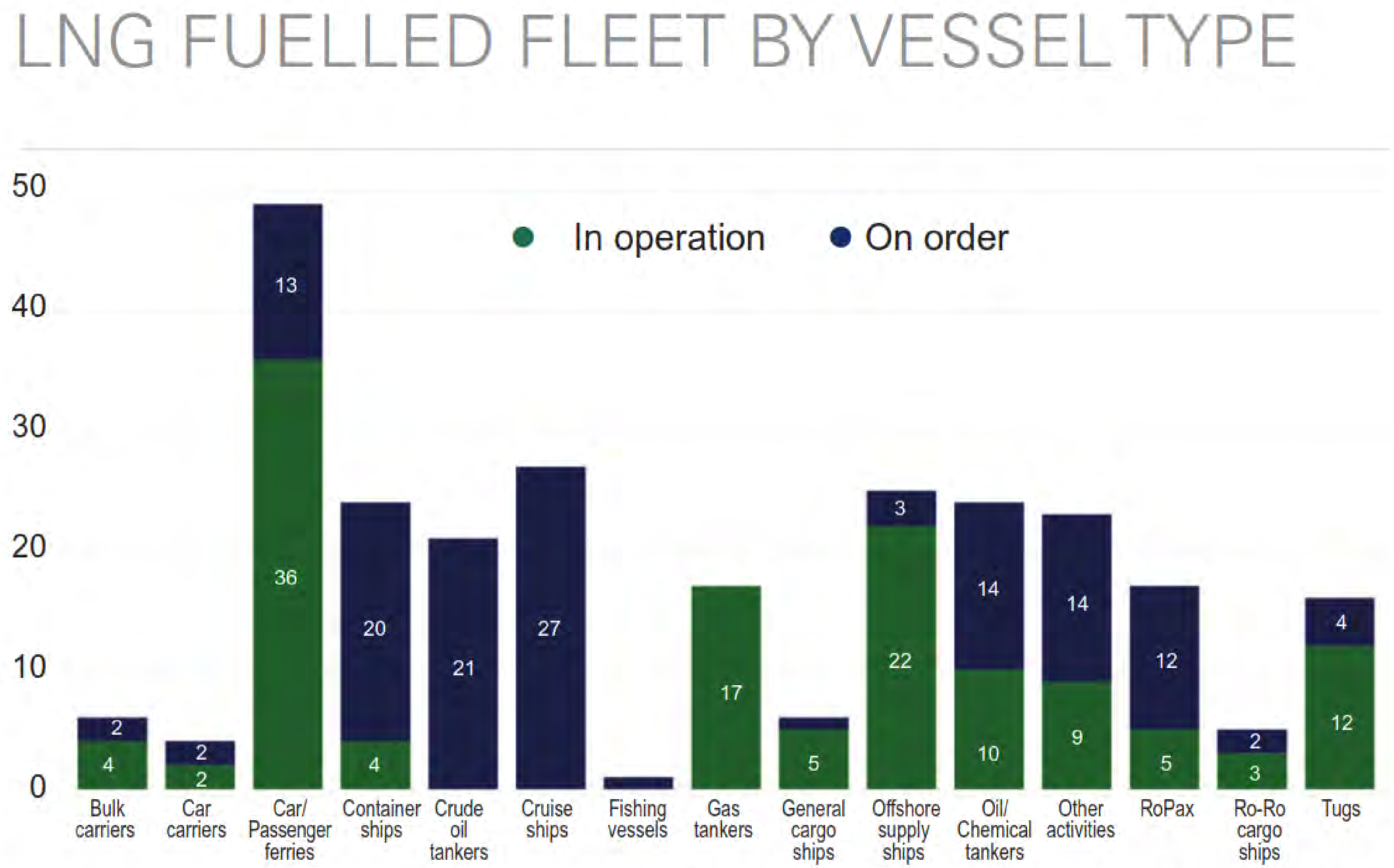


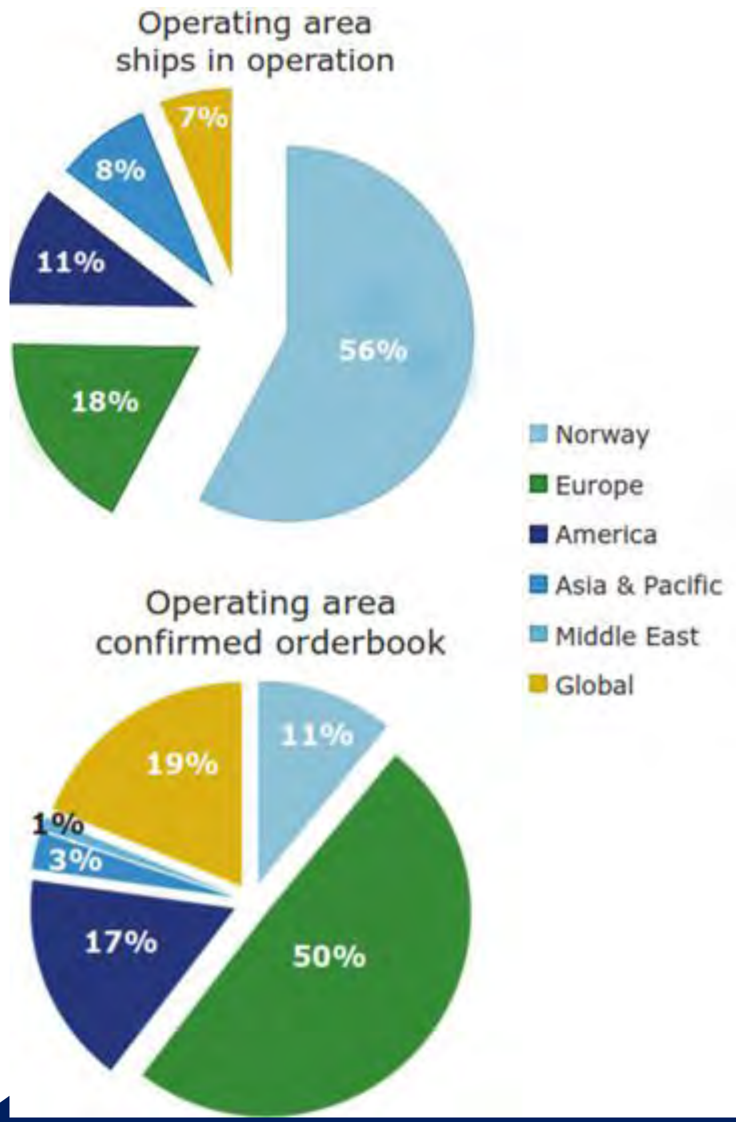
Source: Ministry of Land, Infrastructure and Tourism (Japan). Press Release: Building international cooperation on the development of LNG bunkering hub. October 6, 2016.

Source: https://www.ship-technology.com/features/lng-bunkering-facilities-around-the-world/

Nov 2018

LNG as ship fuel Fleet





Charts updated 1 October 2018

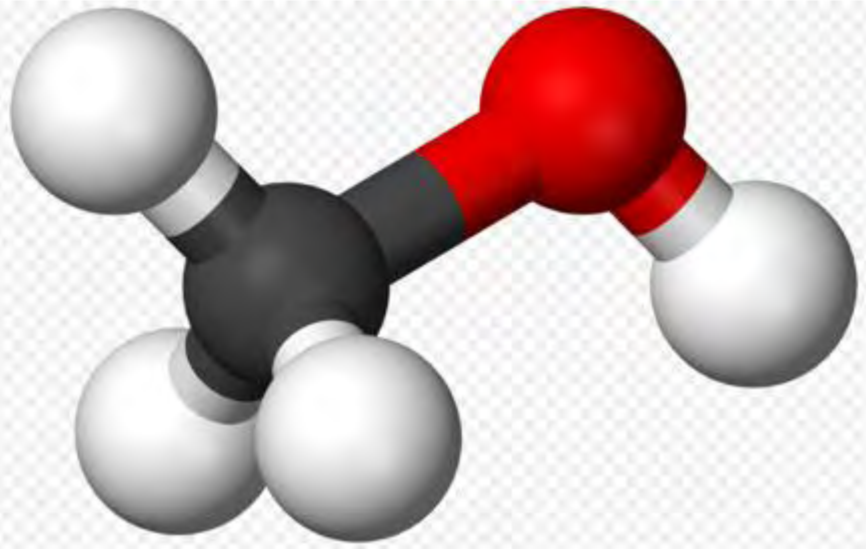
Methanol Production Bridge to Sustainability

Methanol is a "future proof molecule that can be made from conventional fossil sources and emerging renewable feedstocks.

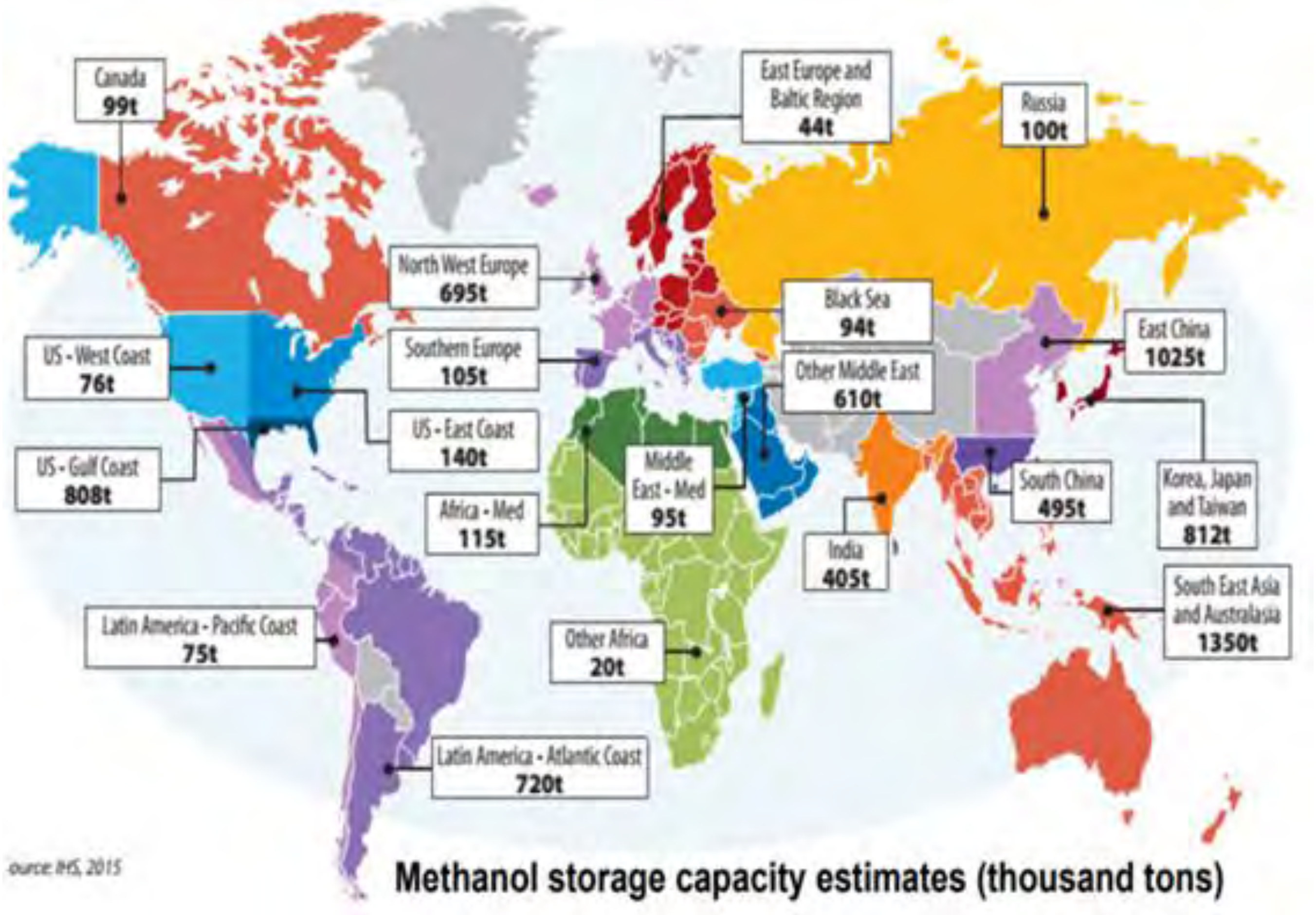
Expansion of energy markets for methanol builds demand for sustainably sourced and locally produced methanol.

Methanol

- Liquid at atmospheric pressure
- Available in many ports around the world and along rivers
- Low infrastructure cost
- Flexible, modular system
- Environmentally friendly as it's biodegradable
- Is plentiful, available globally
- Can be made 100% renewable
- Runs well in existing engine technology and has potential for further optimization
- Complies with increasingly stringent emission reduction regulations
- Requires only minor modifications to current bunkering infrastructure
- Is biodegradable!
- Safe handling can rely on long history and experience in shipping and industry
- Cost are relatively modest and drop as experience mounts
- Shows slight regional price variation



METHANOL: WIDE AVAILABILITY & LOW INFRASTRUCTURE COSTS

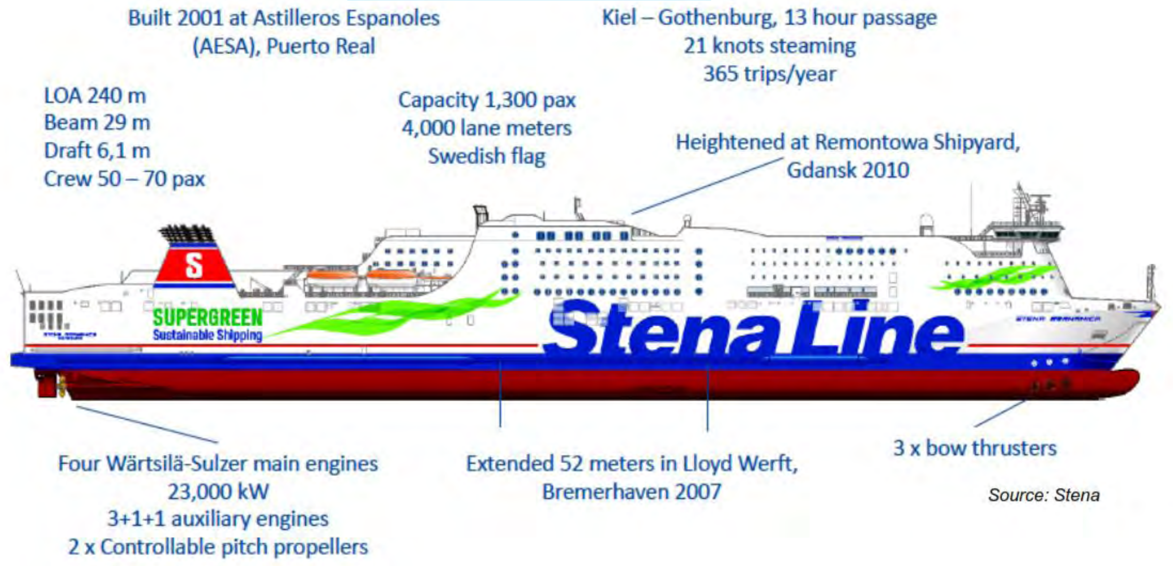


- Current bunkering infrastructure needs only minor modifications to handle methanol.
- Infrastructure costs are relatively modest compared to potential alternative solutions. Estimated costs for constructing a 20,000 CuM storage tank US$ 2-4 million (depending on the location and country)
- Bunkering and distribution costs are estimated to be in a range of $30-40 per tonne.
- In the case of Stena Germanica – bunkering to the ship is carries out by specially built pump station at a estimated cost of around €400,000(Stefenson, 2015) no storage tanks were constructed.

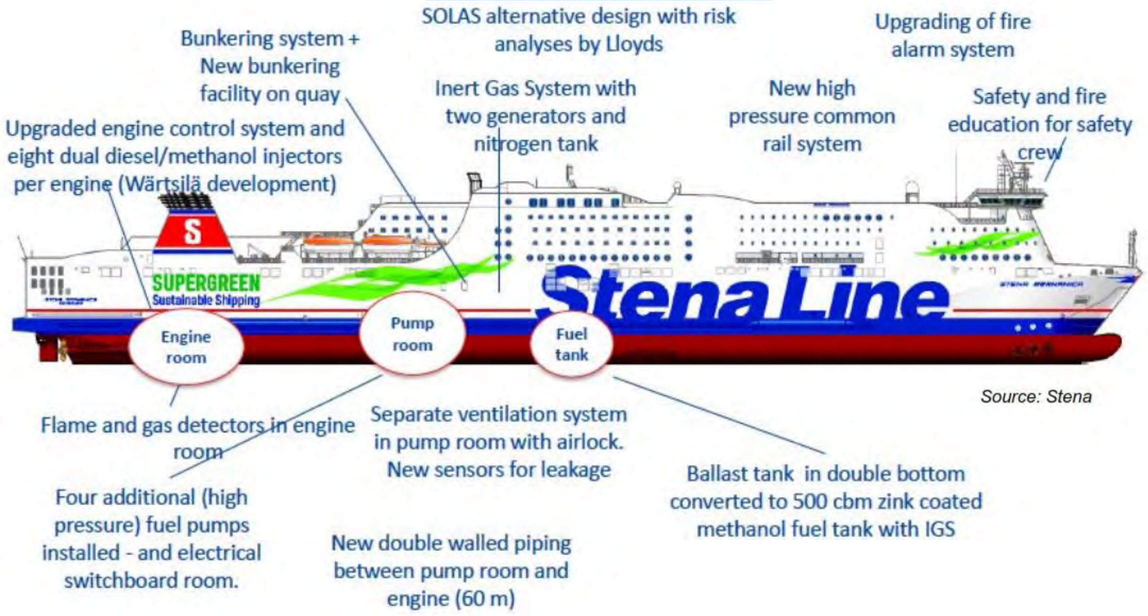
Source: Methanex

Methanol: Engine Technology and Modification to the Ship

Before Conversion



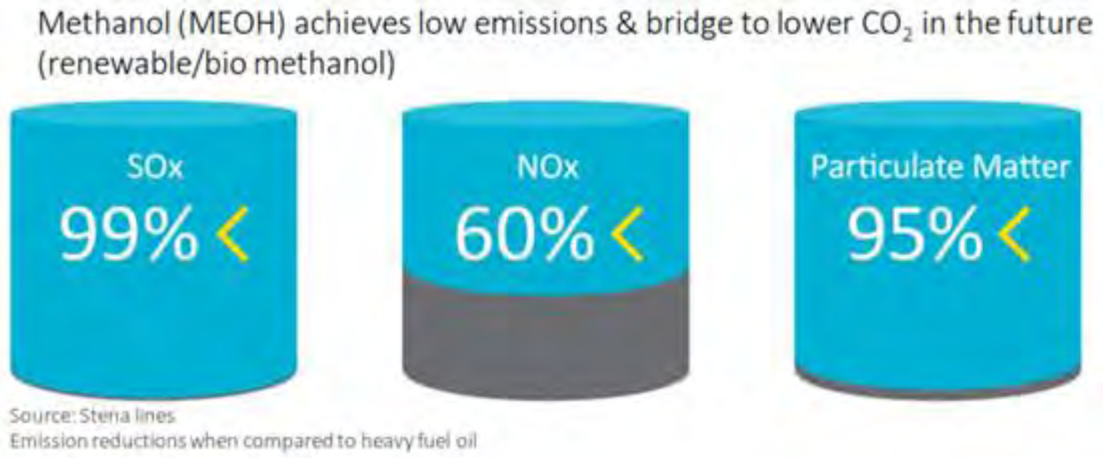
After Conversion



THE GERMANICA – RESULTS

- Nox 3-5g/kWh (Low Tier II, no major conversion)
- CO <1g/kWh
- PM only from MGO pilot fuel (FSN ~ 0.1)
- Sox only from MGO pilot fuel (99% reduction)
- Formaldehyde emissions (below TA-luft)
- No formic acid detected in exhaust gas
- No reduction in output and load response unchanged, full fuel redundancy
- Higher efficiency (testing showed lower fuel consumption in methanol mode)

Methanol or diesel can be selected or re-selected as primary fuel quickly and reliably, without the need to stop the engines and without loss in engine speed or output



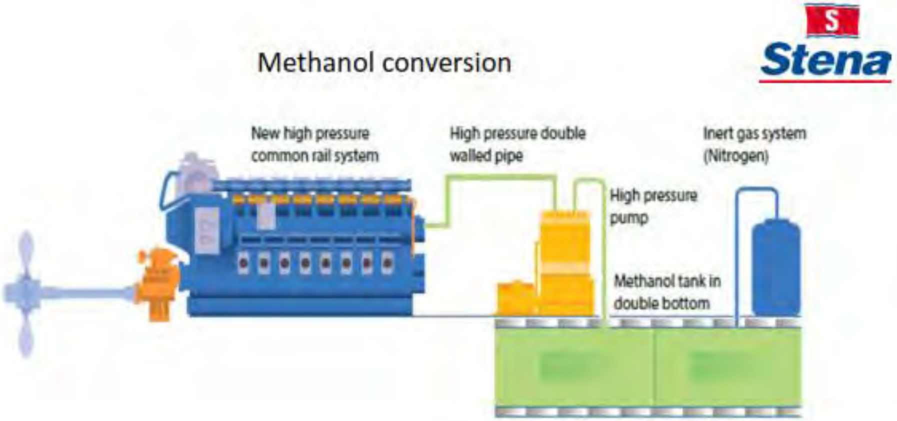
Methanol Experience: Stena's Experience on Ferry "STENA GERMANICA" converted in 2016 to use Methanol as fuel

Why methanol?

- Clean fuel
- Large commodity
- Feedstock is natural gas (Natural Gas)
- Methanol is soluble in water.
- Methanol is sustainable fuel.
- Bio-methanol has near zero carbon foot print.
- Easy to handle (liquid)
- Economically feasible

Challenges

- Low flashpoint
- Toxic
- Low viscosity
- Corrosive
- Low energy content (half compared with oil)



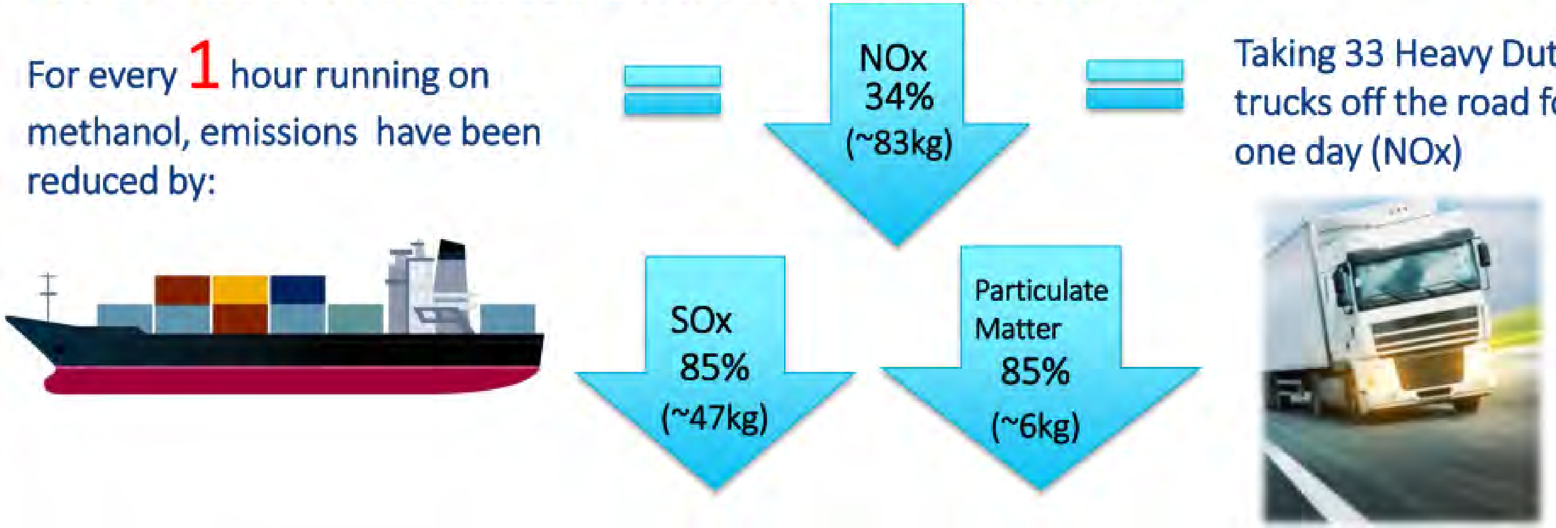
Conclusions after >2000 running hours on methanol:

- Some technical issues with pipe connections due to low viscosity.
- Vibrations in high pressure pipes recalculated and fixed
- Sensitive control and alarm system needed to be fine tuned
- Failing injectors due to under dimensioned spring re-designed
- Methanol works fine as marine fuel
- Very few technical issues - but they are time consuming

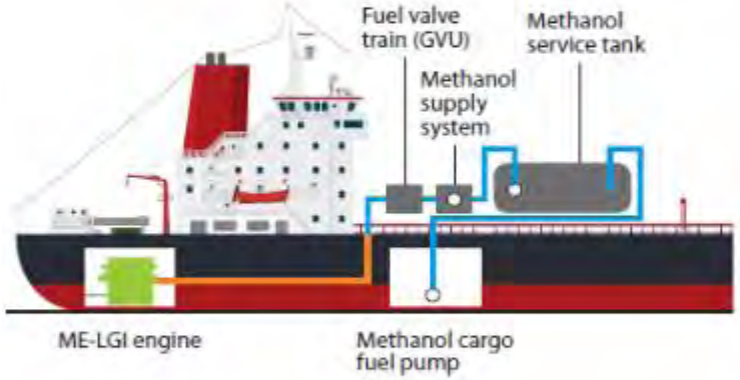
METHANOL AS MARINE FUEL EXPERIENCE : WATERFRONT SHIPPING COMPANY

The world's first seven methanol-fueled tankers

WFS Vessel Results: Emission Reductions



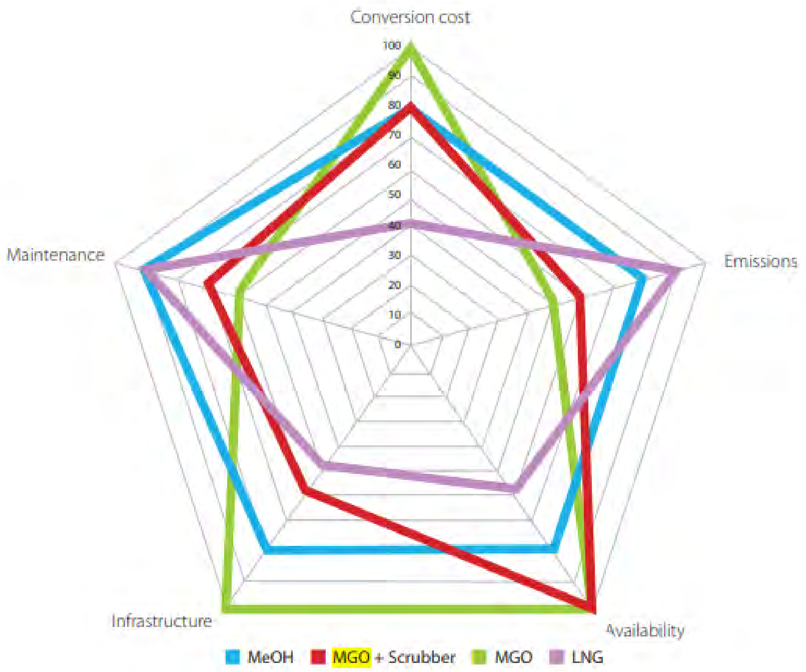
- Commercial-ready MATURE technology
- In 2016, Waterfront Shipping launched seven vessels with methanol dual-fuel MAN ME-LGI 2-stroke engines .
- WFS have 4 additional vessels on order.
- Tankers are owned by Multiple ship owners



MARINVEST
WATERFRONT Shipping Company Limited
A Responsible Care® Company
MOL Mitsui O.S.K. Lines
WL WESTFAL-LARSEN
MAN

Alternate Fuels Comparison

Alternative Fuels	MGO + Scrubber	MGO	LNG	Methanol
Investment	Median	Low	High	Low
Fuel Cost Relation	Low	High	Low	Median
Fuel Storage Space	Low	Low	High	Median
Additional Equipment	Yes	Yes	No	No
Machinery and Piping	Low	Low	High	Low
Additional Risk Investigation	No	No	Yes	Yes
Sludge Handling	Yes	Yes	No	No
Infrastructure Available in 2018	Yes	Yes	Low	Median
Additional Chemicals	Yes	No	No	No
Sustainability	No	No	Yes	Yes
Pollution Risk	Yes	Yes	No	No



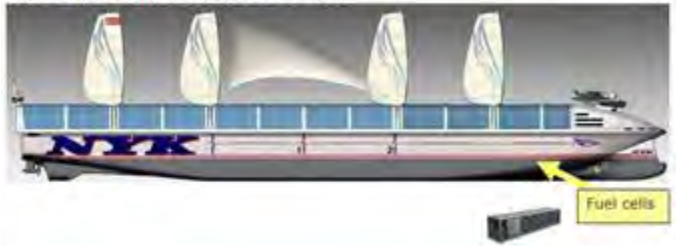
	MeOH	MGO + Scrubber	MGO	LNG
Conversion cost	80	80	100	40
Emissions*	80	60	50	90
Availability	80	100	100	60
Infrastructure	80	60	100	50
Maintenance	90	70	60	90

Emissions are considered from a well to propeller perspective.

Future Ships/Technology

Super ECO 2030

Concept study for large container vessel (NYK) various technolgies incl. fuel cells (claiming 32% less CO2 due to fuel cells.



GL (Zero Emission Feeder)
Concept study of Germanischer Lloyd fuel cells +batteries (Technology 2010)

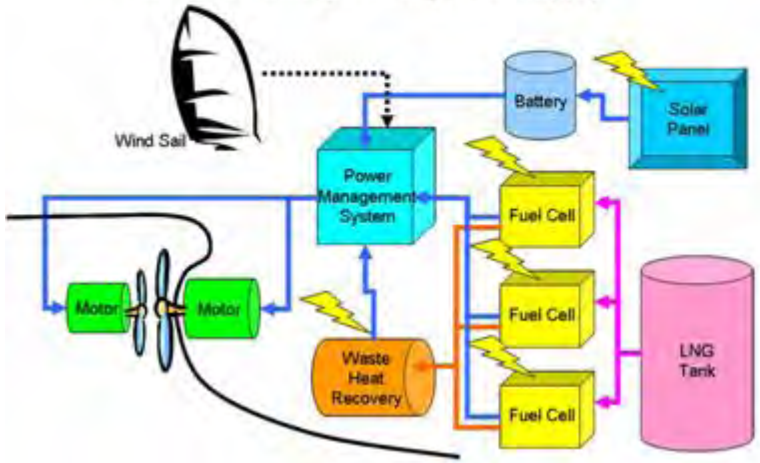
The use of Carbon Capture Systems (CCS) on board of ships was investigated in the Eurostar project of DNV and PSE. The project, that was concluded in 2013, successfully developed a concept design for on-board chemical capture, liquefaction and temporary storage of CO2 for ships in transit until discharge into transmission and storage infrastructures at the next suitable port.

The results show that the concept is technically feasible and capable of reducing maritime CO2 emissions by up to 65%.

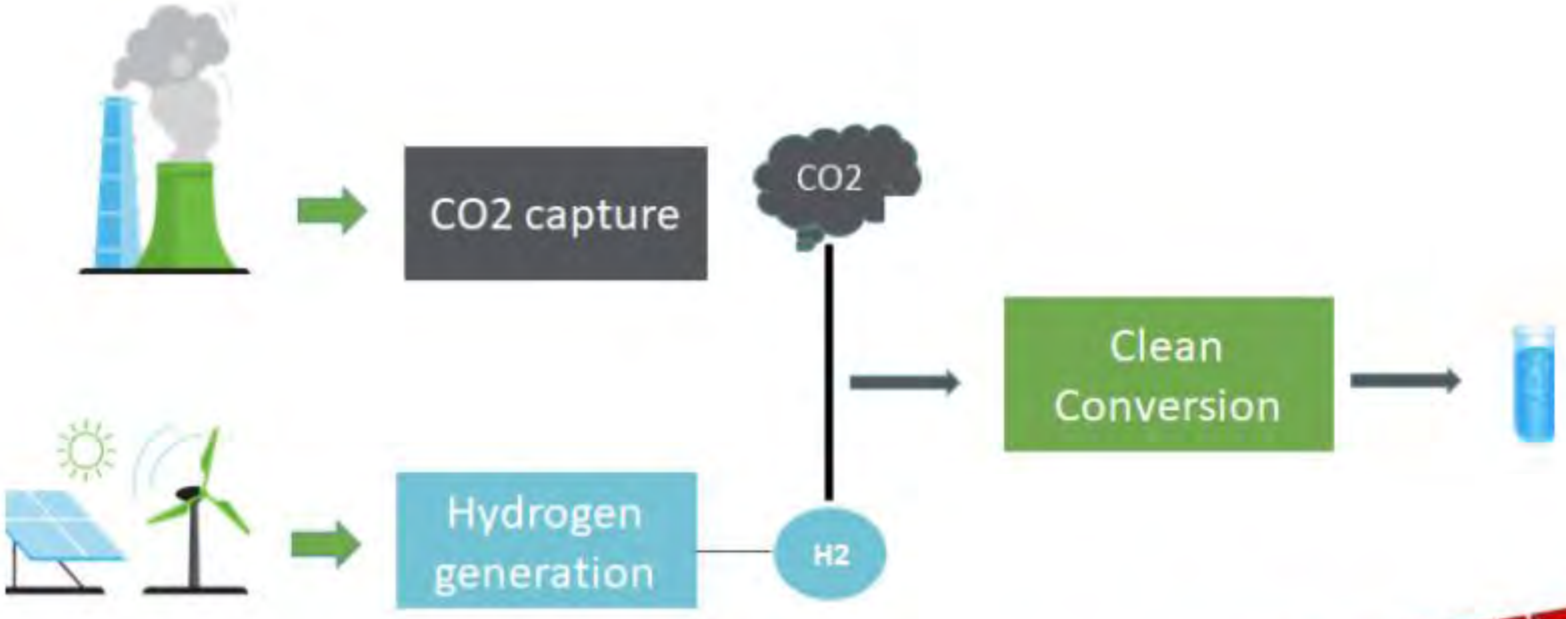
For a Very Large Crude Carrier (VLCC), this could correspond to capturing more than 70,000 tonnes of CO2 per year, transforming them from emissions to a tradable product.

Zero-Emission Scandlines project (futureShip design) Hydrogen powered fuel cells. Use excess windpower to generate hydrogen

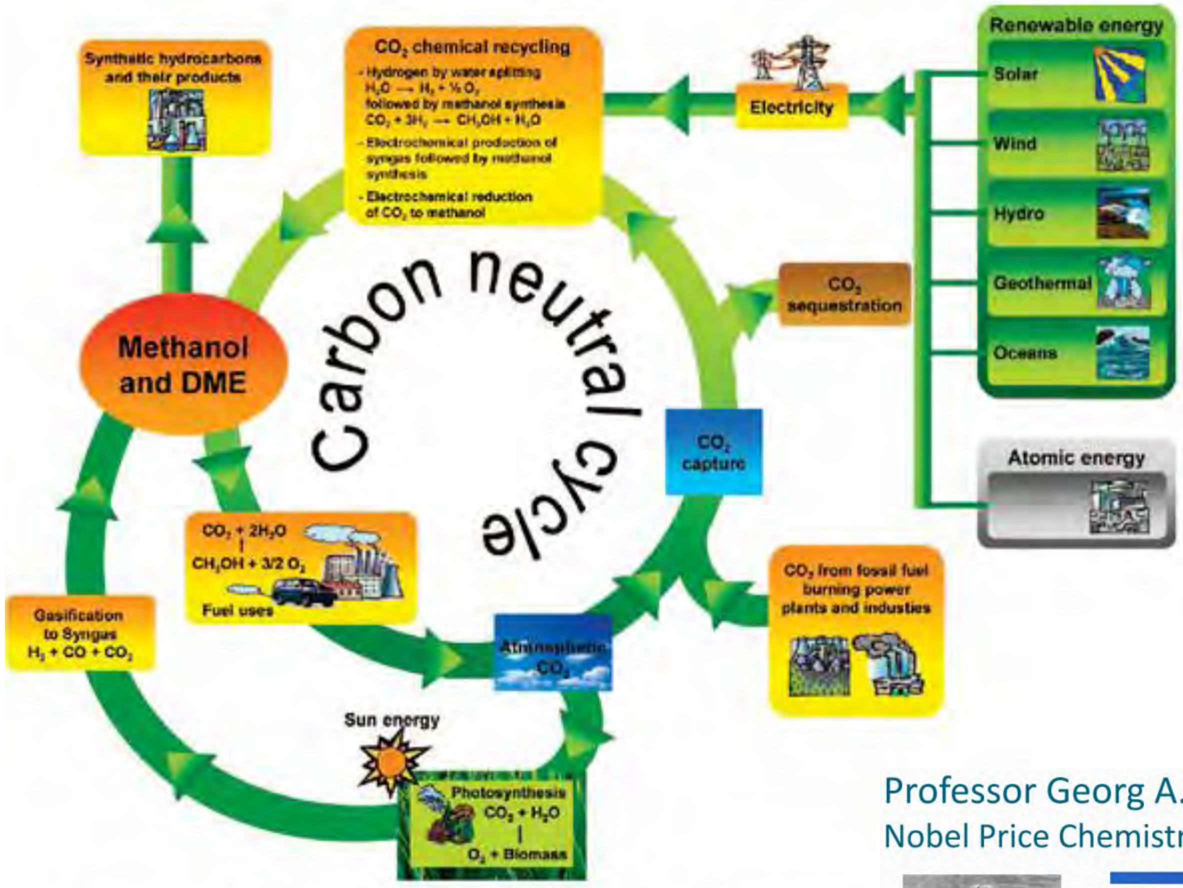
Mix of technologies for power supply



Methanol: Potential to address the GHG (CO2 Emissions) requirements

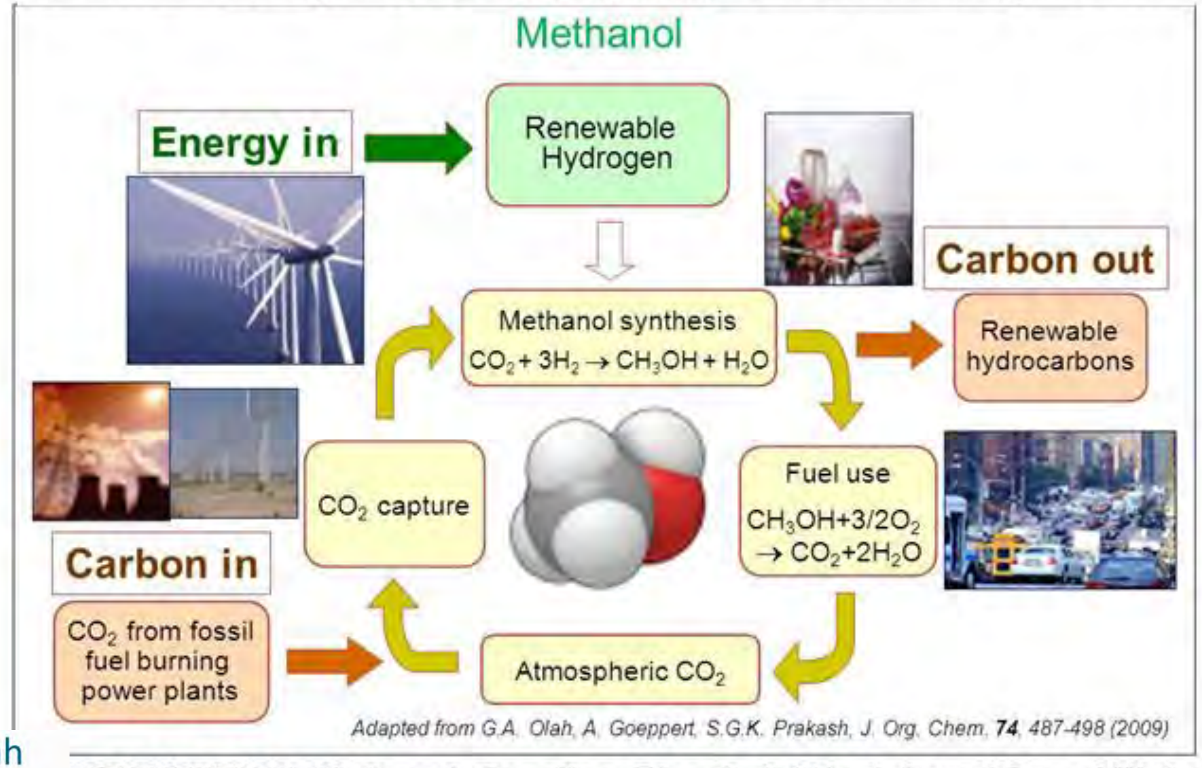


Methanol Economy



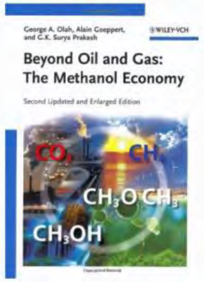
Carbondioxide recycling in the Methanol Economy

Carbon-Neutral Recycled CO2 Indirect Synthetic Fuels Manufacturing Processes

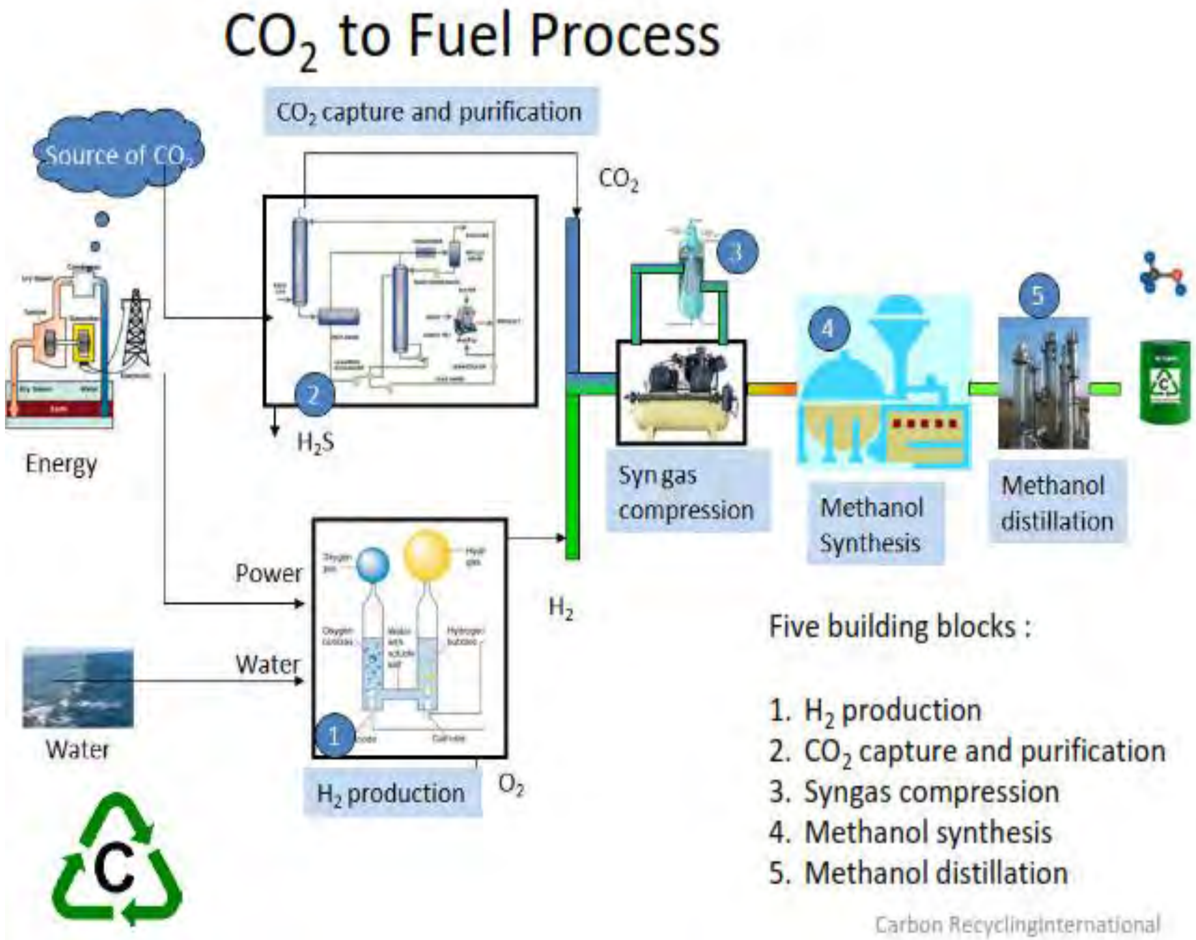


BON-NEUTRAL Methanol, Gasoline, Diesel, Jet Fuel, from CO2 and Water

Professor Georg A. Olah
Nobel Price Chemistry 1994



CRI: Emission-to-liquid (ETL) Technology (Patented by Carbon Recycling International)



Emission-to-liquid 5 technological building blocks in the patented process by Carbon Recycling International.

1.The CO2 in the waste gases is piped from the points of emission at the stack to the purification system. The removal of impurities is completed in steps.

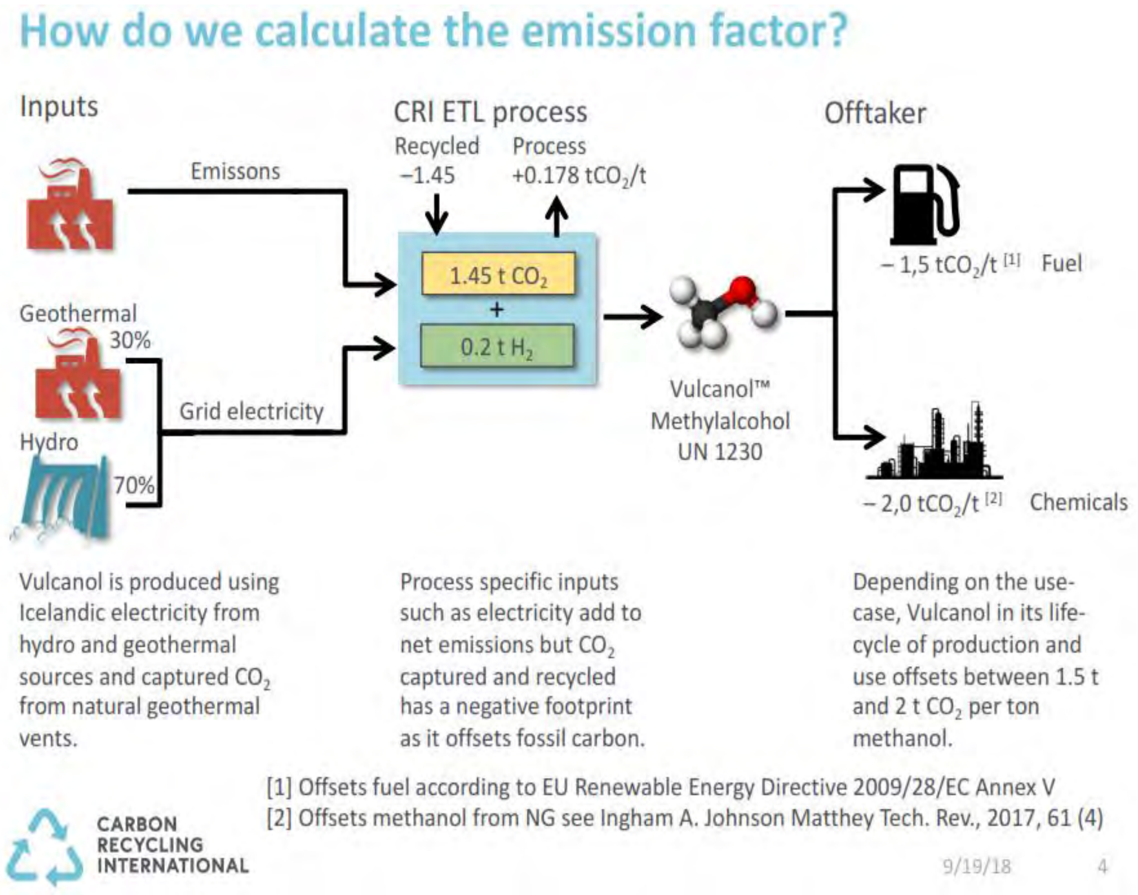
2.The hydrogen generation system is engineered with the state of the art electrolyzers technology by modules allowing expansion of the plant

3.The conversion of syngas – a mixture of hydrogen and carbon dioxide – is pressurized to the targeted pressure and mixed to the ratio of 3 to 1.

4.The system of methanol synthesis is engineered to have flexible capacity to adapt to the possible addition of modules of electrolyzers at a later phase.

5.The distillation column is designed to purify the renewable crude to a proprietary fuel grade renewable methanol for blending with gasoline.

CRI's Emission to liquid (ETL) process

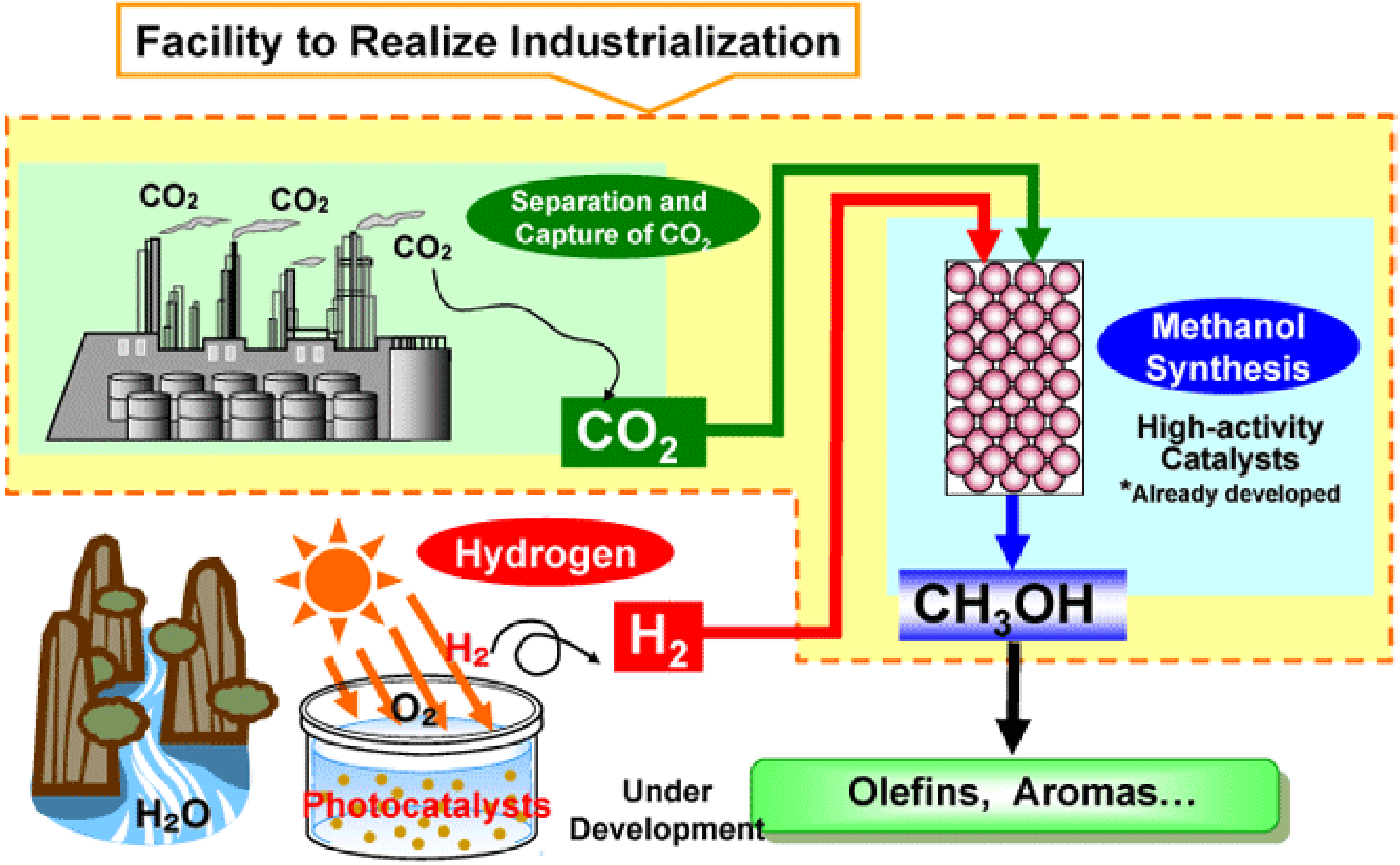


1. CRI's patented technology can convert up to 100% of emissions from an industrial manufacturing or power generating facility.
2. Currently the pilot plant at Iceland uses about 10% of emissions emitted from the Geothermal powerplant it gets the CO2 from.
3. This capacity is scalable. For this particular production facility, CRI would need to upscale its capacity to generate more hydrogen, by adding more electrolysers. **For each 1 ts of renewable methanol produced, 1,45 ts CO2 and 0,2 ts hydrogen is required**.
4. All CO2 that enters CRI process is converted into methanol in a one-step catalytic reaction. If the reaction does not occur in the first application of the syngas (CO2 and H2), a loop circulation is initiated where the remaining syngas goes through compression again and is re-applied to the reactor.

Future Development
We are far along in developing a project in Norway, where CRI will build a 100.000 t plant.

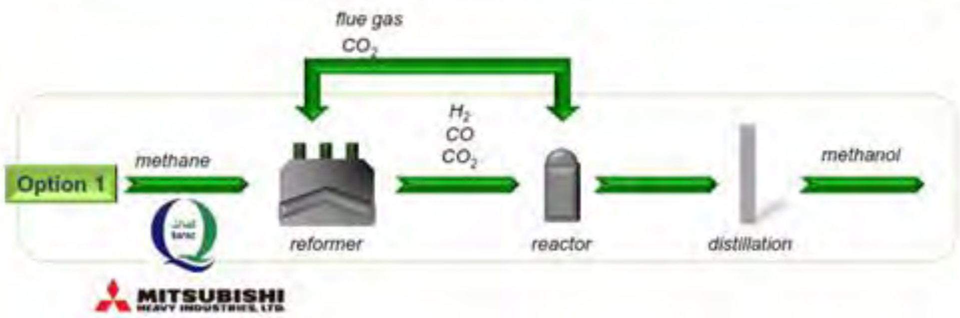
Another leading process for CO2 to Methanol that can be used

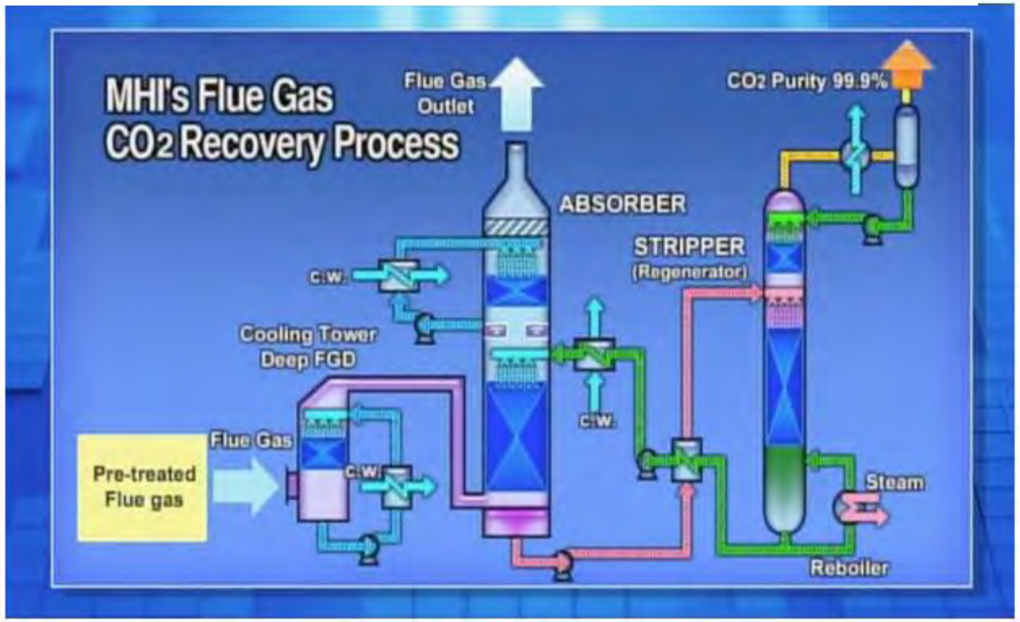
Pilot Plant Location: Osaka Japan
Company: Mitsui Chemical Inc. of Japan
Begin operation in: 2009
Feedstock: 150-160 tpy CO2 from chemical plant emissions
Annual yield :33000 USGallons of Methanol
Plant utilize nearly 82% of the CO2 emissions, remaining 18% was looped back for reprocessing.
Plant is scaleable.



Various Technologies for CO2 to Methanol

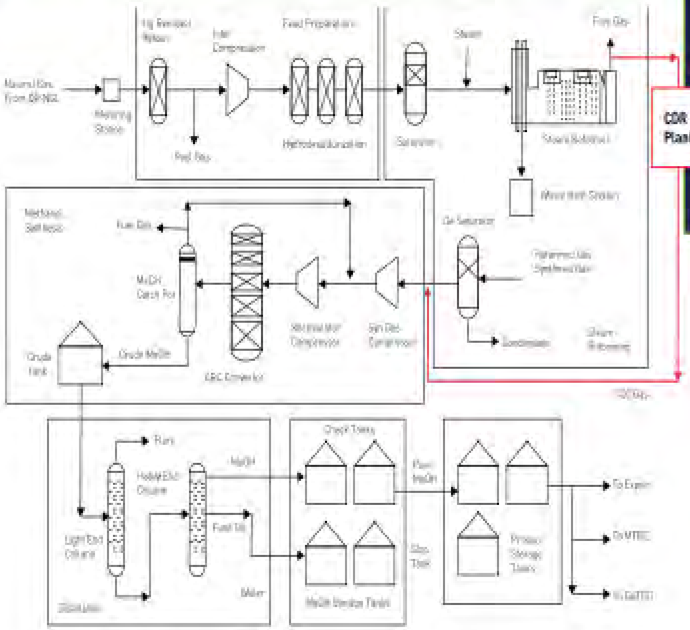
CO_2 Recovery & Utilization



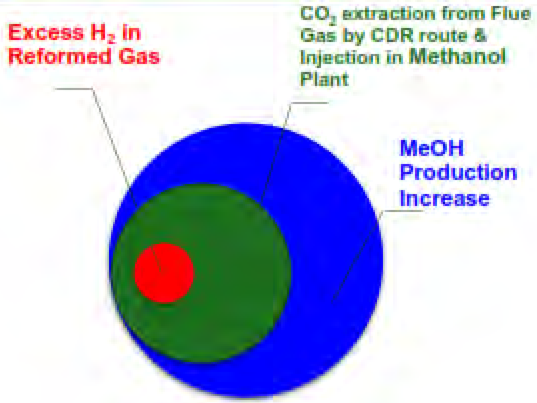


CO2 Recoverv & Utilization

QAFAC Utilization of Recovered CO_2



- 500 MTPD of CO2 is recovered from the flue gas using MHI's proprietary KS–1™ solvent and injected in synthesis loop for boosting Methanol production.
- The capacity of Methanol Plant has increased by 300 MTPD with addition of CO2 in synthesis gas mixture as excess H2 is available for the methanol reaction.
- Thus, QAFAC's Methanol Plant became Self–sufficient for raw material (CO2).



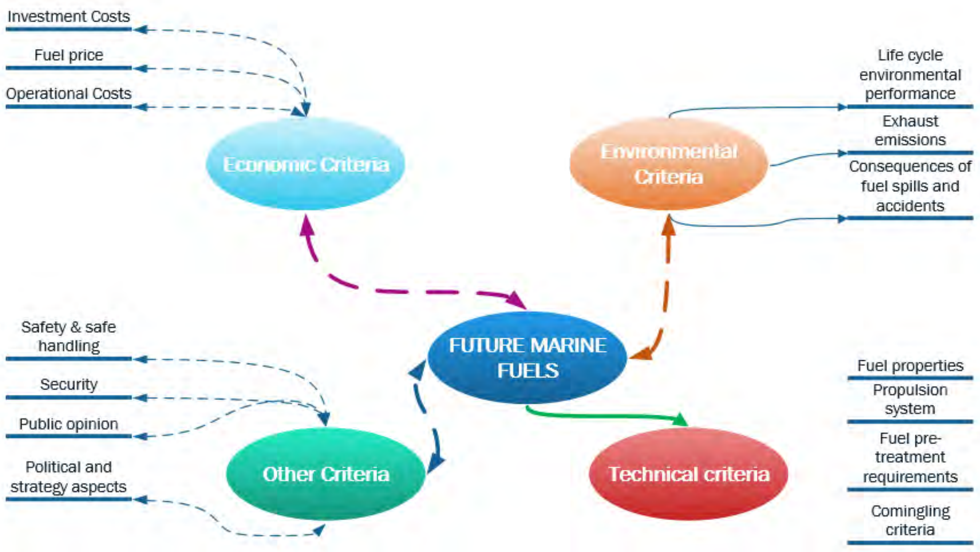
Conclusion

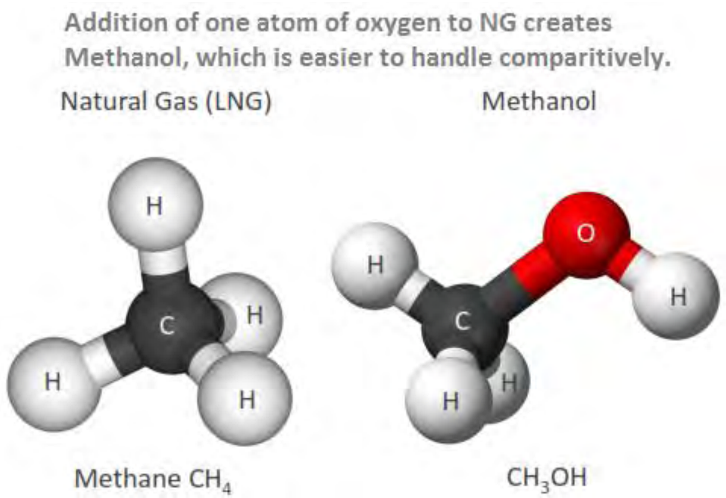
Shipowners need to get the complete picture and understand the fundamentals (commercial, technical and environmental) of alternate fuels before opting to spend millions on conversion.

In comparison to LNG – methanol is easier to handle marine fuel and conversion and maintenance is much less expensive

Further regulations to limit CO2 emissions remain a real possibility. Methanol has the potential to address this issue going in to the future.

Given the current global economic growth and uncertainty about the future growth, there will be an impact on the scrapping age of the ships.
Some sectors may see loss of earnings by 5 to 6 years of earning life of the vessels due to early scrapping, which will affect the payback calculations.





Headline news

Guidelines on Methanol Fueled Vessels

Rev 1, December 2018

IRCLASS
Indian Register of Shipping

Ships in India soon may run on methanol: Nitin Gadkari

PTI | Updated: Oct 03, 2017, 06.55 PM IST

1 Comments

A+

To cut the high cost of logistics in the country, inland waterways are being developed in a major way while methanol will soon be made the fuel for ships.

AMARAVATI: Ships in India may soon ru methanol as Centre is drawing up plans regard, Union minister Nitin Gadkari sai today.

Gadkari also stressed the importance of developing waterways for their cost effectiveness.

"To cut the high cost of logistics in the co inland waterways are being developed i major way while methanol will soon be r

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EGCSA: 983 Ships Opt fo

Scrubber; Image Courtesy: Wartsila

Bulk and Spliethoff have opted for scrubbers and rum players from the container shipping sector has jumpe said.

"EGCSA believes that although there has been a surge forward, however other constraints such as the availa experienced installation teams mean that it may not b slot nor coincide a scrubber installation with an alread

Scrubbers: the industrialisation of pollution or saviour of the planet?

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Markets

Some Oil Refineries Are Getting a Licen to Print Money

By Bill Lehane

March 21, 2018, 9:00 AM GMT+4 *Updated on March 21, 2018, 8:11 PM GMT+4*

- Sophisticated plants can already comply with 2020 sulfur rules
- Demand and prices for compliant marine diesel fuel are rising

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WTI Crude
50.93
-0.52 -1.01%

Ready the cash-printing machines -- the world's most sophisticated refineries are about to enjoy great times thanks to what might seem like a minor tweak in rules for the type of fuel ships consume.

From 2020, vessels must buy fuel with less sulfur, or alternatively be fitted with equipment to curb emissions of the pollutant. One thing is clear: only a tiny fraction of the merchant fleet will have such gear when the rules enter force, since many shipowners argue it's the responsibility of refineries to sell the right fuel.

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Scrubber orders full ahead

July 19, 2018 / in Commentary, EGCSA Members / by EGCSA Admin

A survey of EGCSA members has revealed that scrubber uptake is rapidly accelerating with the number of exhaust gas cleaning systems installed or on order standing at 983 as of 31 May 2018.

This follows a slew of recent reports that major ship operators, including Spliethoff, Frontline, DHT and Sta for scrubbers. One of the 'big' container companies has confirmed it will use scrubbing as part of its 2020 portfolio and there are rumours that others will do likewise.

Until relatively recently the largest installed exhaust handling capacity has been for engine powers in the r 30MW. However, the latest data shows that this has been well and truly exceeded by a retrofitted hybrid s container ship engine. Large capacity scrubbers are not confined to retrofits as the maximum size new bu is a hybrid system for a 65MW engine.

Merkel allows Coal Commission to delay pre-2020 action

The German Chancellor Angela Merkel has extended the deadline for a much-awaited report from the country's coal exit commissions. Elections in three coal states in eastern Germany in 2019, as well as lobbying from utilities prompted her to effectively axe the opportunity of having a report on pre-2020 action ready before the COP24 climate meeting in Poland next week.

COP24, staged in the Polish town of Katowice, is the informal name for the 24th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). Delegates will discuss the economics of coal-fired power plants across all regions of the world, and consider opportunities of a staggered exit.

The task force of Germany's Coal Commission met on 26 November to discuss the upcoming timeline.

As one of Europe's biggest polluters next to Poland, Germany has pledged to gradually

Paddle wheel for open-cast coal mining

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