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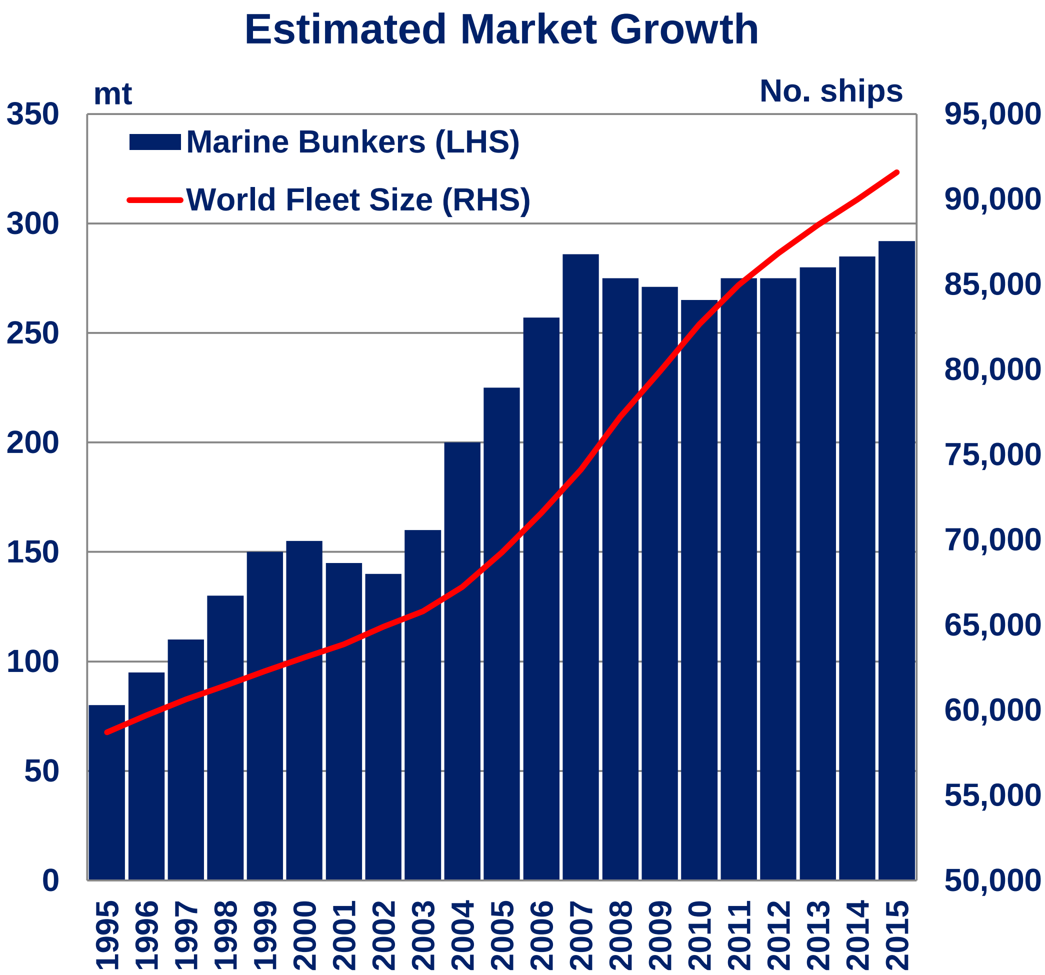
SOx 2020:
Effects On The Oil Products Markets

- How will refiners react?
- What effects will that have on products pricing?
- What choices will shipowners be presented with?
- LNG capable and SOx scrubber equipped ships

Size Of The Marine Fuels Market



Source: OW Bunker, Clarksons Research

- Current global bunker demand is 275-325mt per annum (depending on how much coastal tonnage is included).
- Fuel oil represents 80% of all bunkers consumed.
- This fuel oil volume consumed by ships represents **45%** of all fuel oil output by the global refinery sector.
- Consumption of gas oil by shipping increased by around 55% as a result of the 0.1% ECA sulphur limit (2015).

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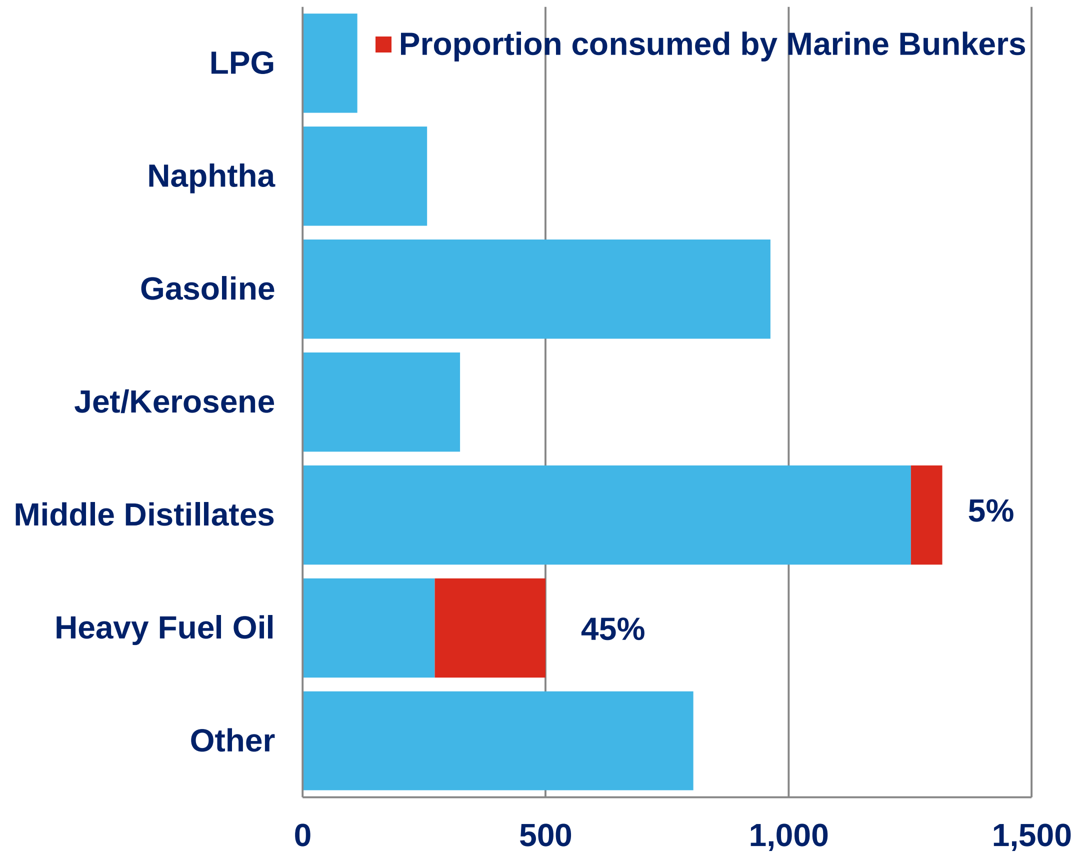
Supply/Demand For Fuel Oil

- Roughly **5m bpd** of fuel oil output by refineries ends up as marine bunkers.
- Note that fuel oil is almost never the primary purpose of a refinery. Most refineries aim to produce less of it and target products with higher resale value (see slide 11).
- Simpler refineries produce more fuel oil, whereas more complex refineries are often equipped with downstream processing equipment to convert fuel oil into more valuable products.
- However, adding such equipment to respond to the IMO's 2020 ruling would be very expensive, and the oil industry is not currently focussed on increasing spending.

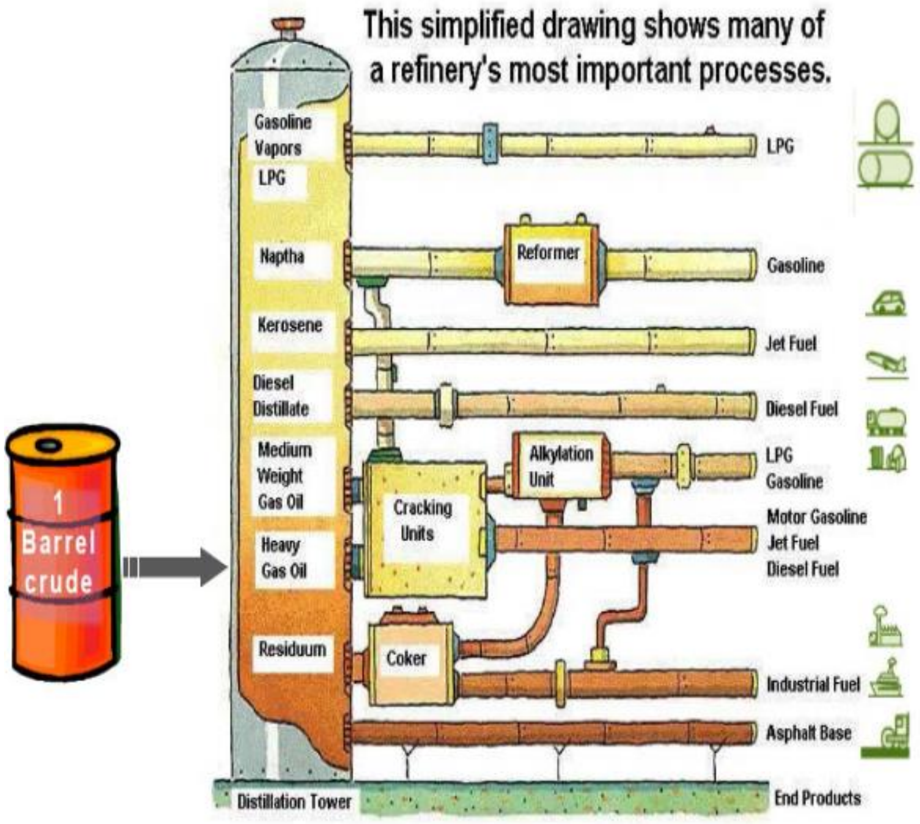
Global Refinery Output (2012, million tonnes)



Source: IMO

Lower Crude Oil Prices And the Sulphur Cap

- For refiners, the decision to invest in capacity is largely an economic one: there is little incentive to support shipowners by suddenly providing a large supply of low-priced, sulphur-free marine fuels.
- **Current Situation:** Fuel oil is the least valuable part of the products output from a refinery's fractional distillation column. Many refineries are set up with coking units and crackers to upgrade parts or all of the residual fuel oil fraction to more valuable products like gasoline.
- **Different Crude Inputs produce different outputs of products.** In raw form, heavy crudes such as Mexico's Maya, or many Russian crudes, will produce more fuel oil than (e.g.) Brent. But refineries designed to receive these grades may well have more complex equipment installed to ensure that they can upgrade the oil input.

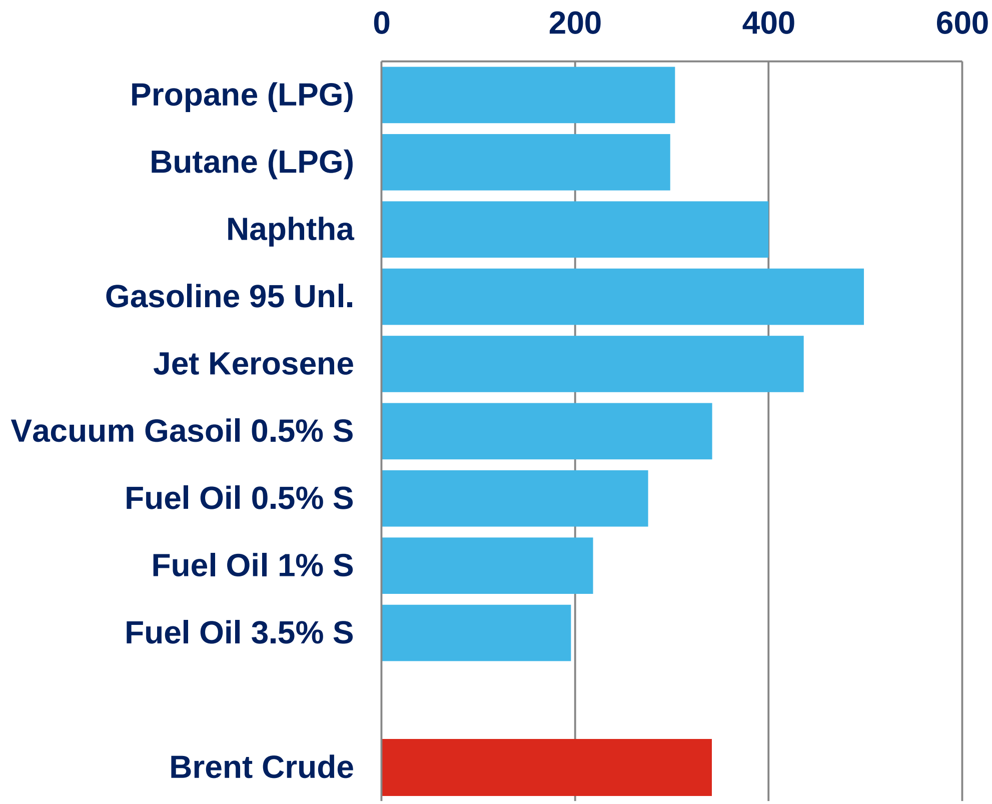


Lower Crude Oil Prices And the Sulphur Cap (2)

Specifying A Refinery Is A Complex And Expensive Task

- The CAPEX spent on a refinery will be large, and will be dedicated to installing the equipment to most efficiently maximise the required products output.
- This will have regional differences e.g. US's large gasoline demand, versus Europe's greater gasoil demand due to the larger local fleet of diesel vehicles.
- Refineries have some potential to vary the products output slightly according to market conditions, but only slightly, and changes take weeks.
- **In short:** Fuel Oil is the **residual,** least valuable fraction, and most refineries are designed to produce less, not more.

Oil Product Prices (NW Eur, $/t cif, Avg.Q2 2016)



Refinery Types

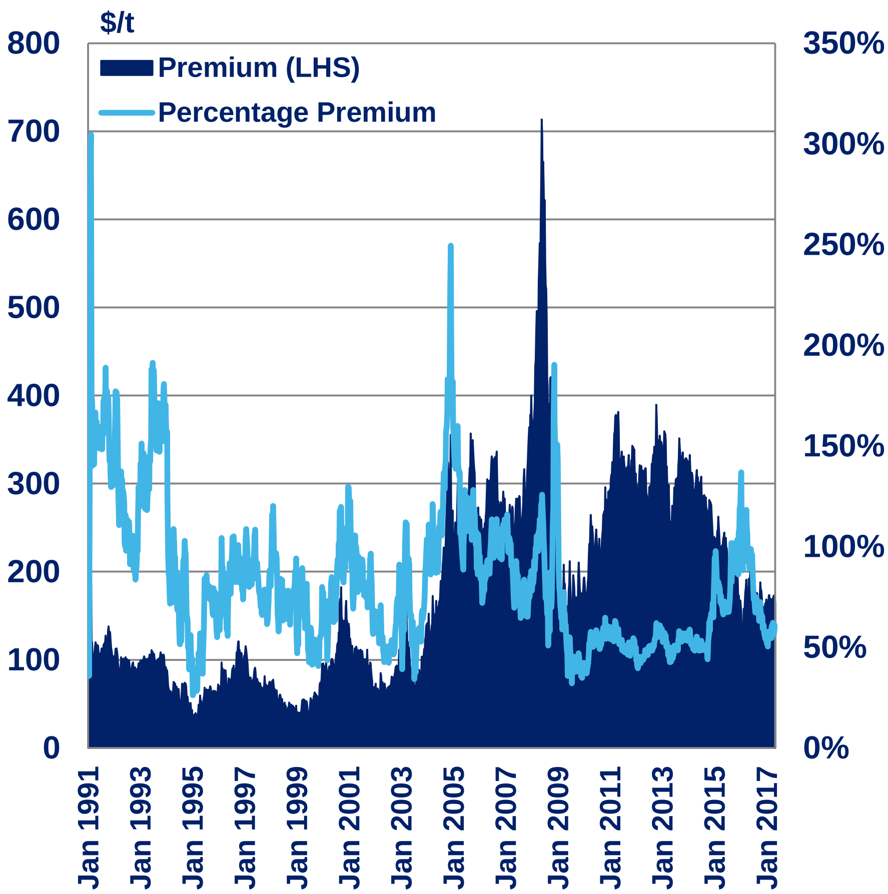
There Are Four Main Types of Refinery:

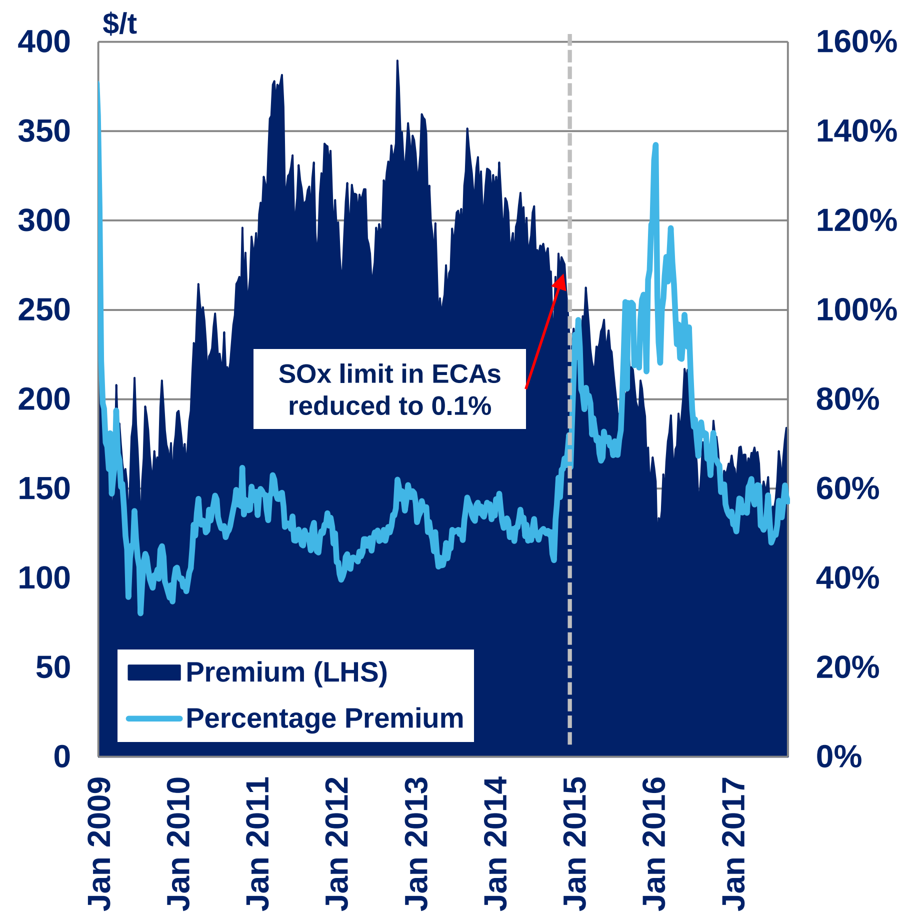
- **Topping Refinery:** Conducts basic atmospheric distillation of crude oil into products. This will produce naphtha, but not gasoline, and produce about 40% straight run fuel oil (**<3%** of global refining capacity).
- **Hydroskimming Refinery:** In addition to atmospheric distillation, hydroskimmers are equipped with naphtha reforming units, which allow the refinery to produce gasoline (plus aromatics like benzene, toluene and xylene. (**9%** of global refining capacity).
- **Cracking/Hydrocracking Refinery:** In addition to hydroskimming capabilities, these refineries have vacuum distillation and catalytic cracking capabilities. These produce vacuum gas oil which can then be cracked into gasoil + naphtha. Reduces fuel oil to c. 10% of output (**50%** of global refining capacity, up from 25% in the mid-1980s).
- **Coking Refinery:** As above, but equipped with coking units that can break down the residual fuel oil from the vacuum distillation unit into distillates + petroleum coke, meaning that fuel oil is reduced to c. 3-5% of output and gasoil increased to c 38-40% (**37%** of global capacity).

Increasing level of complexity

Current Price Premium in the Bunkers Markets

Rotterdam MGO Premium over 380cst: Long-Term… **…Short-Term**





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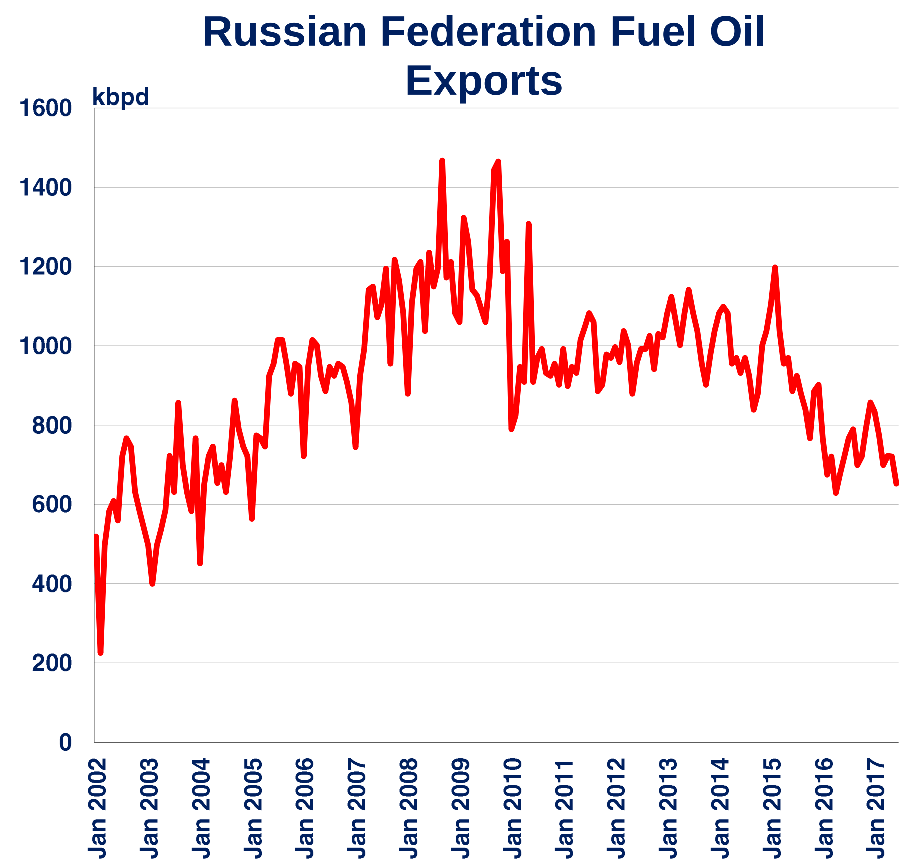
Russian Fuel Oil Output Is Set To Fall

Russian Refinery Upgrades

- Russia is the largest single producer of fuel oil globally, and at its peak was responsible for around 50% of global fuel oil exports.
- This makes it a key country for fuel oil provision, particularly to Europe, and relevant to the marine bunkers situation.
- Most of Russia's refineries were built in the Soviet era, when the focus was on maximising fuel oil output to supply the Red Army.
- The Russian government altered the tax regime in 2011 to incentivise upgrading of refinery capacity.
- Russian oil companies have embarked on a program of adding cracking capacity to Russian refineries over the course of the 2010s.
- This has already reduced fuel oil exports by Russia, which has consequent implications for the supply/demand balance of fuel oil globally.
- However, the program of upgrades is aimed at maximising production of additional gasoline for domestic consumption, to reduce reliance on imports, rather than at helping gasoil supply.



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Options For Refiners/Bunker Suppliers

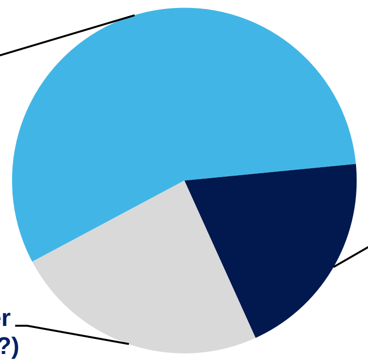
Solution	Method	Pros	Cons	Volume/Price Impact	Likelihood
Do Nothing	• Assume that market mechanisms can adjust the supply/demand situation	• No upfront costs to suppliers.	• Likely to involve the biggest swings to prices. • Likely to have largest knock-on effects on supply/demand in automotive fuels markets.	• Could be expected to produce relatively larger swings in gasoil/ auto diesel prices (upwards) and fuel oil prices (down).	• Inertia & wish to avoid upfront costs could make this reasonably likely. Refiners have low incentives to solve the shipping industry's problem.
Produce More Gas Oil	• Increase utilisation of existing upgraders (limited but some scope for this). • Alter refinery slates (complicated. Limited but some scope for this). • Add more cracking or coking capacity (expensive, unlikely in short term).	• Marine gas oil prices are already higher than fuel oil bunker prices, so refiners would increase revenue from shipping.	• Likely to require CAPEX by refiners. Unlikely. • If one is going to spend money on upgrading, the logical incentive would be to maximise gasoline output, since this is higher priced.	• Higher gasoil supply. • Reduced fuel oil output.	• CAPEX commitments unlikely (at least pre-2020).
Produce New <=0.5% HFO Bunkers Through Blending	• Establish new bunker standards involving blending down of existing fuel oil grades with some gasoil until they meet sulphur content thresholds.	• Requires least in terms of upfront capital expenditure from suppliers. • Doesn't leave a fuel oil surplus.	• Does require the use of some additional gasoil. Uncertain whether this would be new supply, or cannibalised by competition with existing demand.	• Could put some upward pressure on gasoil prices • This also implies <0.5%S HFO would be at a reasonably large price premium to HFO, at least initially.	• **Considered to be the most likely option**
De-Sulphurise Fuel Oil	• Hydrodesulphurisation of products at refinery, plus scrubbers to capture the sulphur exhaust gases.	• Produces low sulphur FO at the refinery	• Produces sulphur dioxide at the refinery, needing scrubbers to convert to elemental sulphur or Sulphuric Acid. • Again, requires CAPEX before any payback, which could be unlikely.	• No net impact on fuel oil volume. Low sulphur fuel oil would have to cost more to fund the desulphurisation.	• Upfront capital investment required could reduce likelihood.

Fuel Choices For Shipowners

Mainstream Alternative Fuels:

- Heavy Fuel oil with <0.5% sulphur. Such a fuel oil would be most likely to be produced by blending distillate with a small volume of residual fuel oil.
- Marine Gas Oil (MGO)
- LNG as a marine fuel.
- Methanol (experiments taking place in short sea shipping).
- Non-compliant Heavy Fuel Oil in combination with exhaust gas cleaning systems ("*Scrubbers*").

Fuel Oil Demand from Marine = c.5m bpd



Volume Switching Within Petroleum Fuels

Organisation	M bpd	Via blending
IEA (2015 report)	2.2	-
IEA (2016 Report)	2.0	-
Ensys/Navigistics July 2016 study	3.8	74%
CE Delft	3.4	86%

Numbers above represent the expected requirement to switch from petroleum fuels of >0.5% sulphur to below. Most forecasters expect this to be done via blended grades, rather than using 100% MGO. These would be priced lower than MGO.

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Options For Ship Owners

Solution	Method	Pros	Cons	Likelihood
Do Nothing i.e. switch to distillate fuel in 2020	• Lower fuel sulphur content (including blended fuel)	• Safe • Proven • Limited technology investment needed	• Higher fuel cost • Fuel availability uncertain	• Considered to be the most likely option
Alternative Fuels e.g. LNG	• Use of less polluting fuels	• Very low NOx, SOx and PM • c.20% reduction in CO_2 emissions • Cost competitive fuel	• Retrofit complex and expensive • Technology is costly • Fuel availability uncertain • Bunkering infrastructure limited • Cargo capacity	• Retrofits of existing ships unlikely • 'LNG ready' designs most likely for newbuilds delivered <2020 • Expect greater uptake for ships delivered 2020 onwards
Exhaust Gas Cleaning Systems /SOx Scrubbers	• <u>Open Loop:</u> exhaust gases mix with sea water, forms sulphuric acid which is then neutralised by the alkaline components in seawater and discharged overboard • <u>Closed Loop:</u> gases are cleaned with seawater mixed with caustic soda.	• SOx emissions reduced by more than 90% • PM emissions reduced by 60-90% • Enables continued use of cheaper HFO	• Significant investment/ payback period • Additional operational costs associated with catalyst, increased power and disposal of sludge • Issues with washwater discharge • Long term availability of low cost HFO	• CAPEX commitments unlikely (at least pre-2020).

Global Fleet: Uptake of SOx Solutions So Far

- With only a small proportion of the fleet spending over 50% of its time in SOx Emission Control Areas (SECA), the uptake of SOx emission reduction solutions has been relatively limited, only 0.6% of the current fleet would be compliant with a 0.1% limit on the sulphur content of fuel.
- This reflects the fact that there is little incentive for owners to invest in these solutions at present, with over 2 years before the global sulphur cap enters into force.

Equipment Type	SOx Scrubbers	'LNG Capable'
Fleet	232	369
% of Total Fleet	*0.2%*	*0.4%*
Orderbook	77	263
% of Total Orderbook	*2.1%*	*7.3%*

Key Considerations

- Upfront investment
- Financing
- Logistics
- Technology performance
- Regulatory uncertainties e.g. will open loop scrubbers be allowed
- Enforcement/compliance

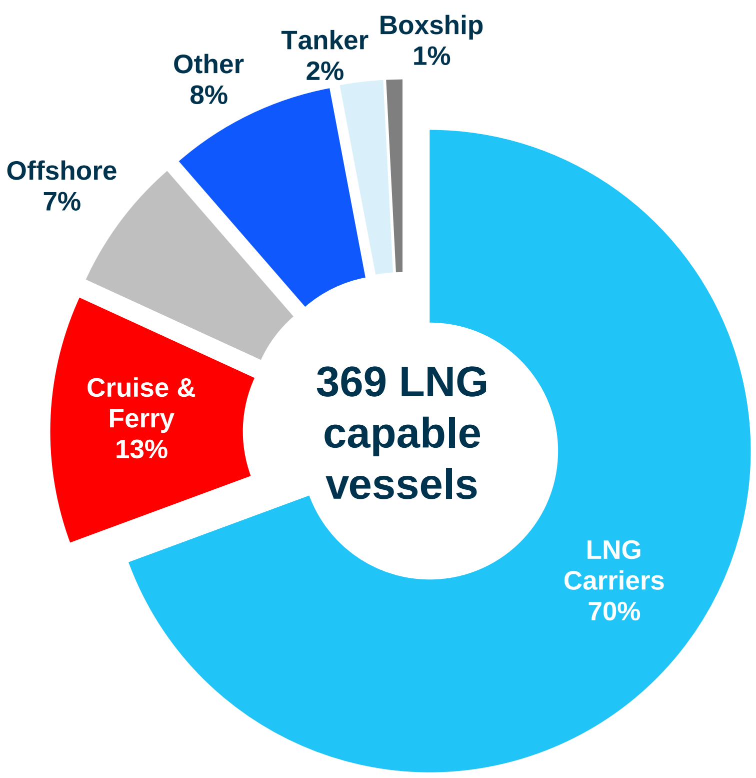
Please note: Based on reported equipment where design known.

Alternative Fuels

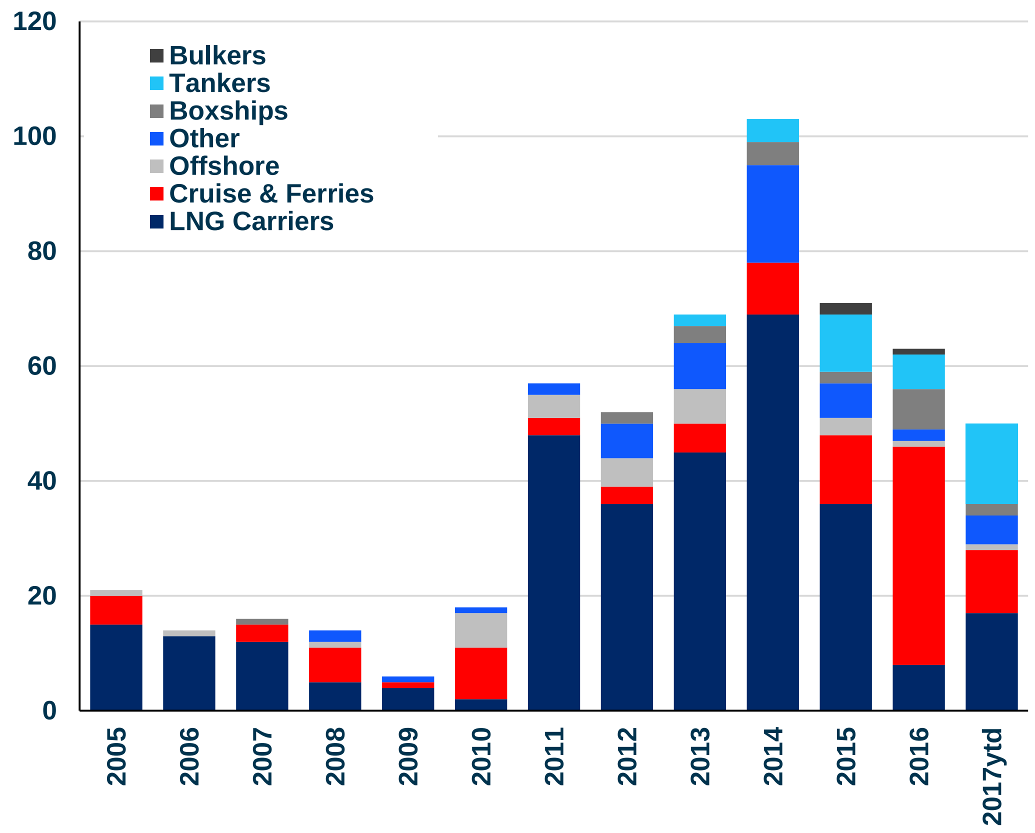
Solution	Details	Pros	Cons
MDO/MGO/LSFO	Used in many engines today	Easy to adopt	Price, can cause operational problems, future availability uncertain if widely adopted
LNG	Requires different type of fuel handing system, increased fuel storage space required	Safe to use, proven, limited technology investment required, low NOx, SOx, PM, CO_2.	Higher fuel costs, future availability uncertain, methane slip, difficulties retrofitting some ships
Biofuels	While many engines are compatible, some will require modification to fuel system and engine.	Biodiesel commercially available at prices comparable to those of marine diesel fuel. Fatty acid methyl ester (FAME) widely available.	Questions surrounding sustainability (i.e. relies heavily on palm oil production)
DME (Di-Methyl Ether)	Produced from conversion of a number of fuels (inc. natural gas, coal, biomass)	Reduced exhaust gases, spillages cannot contaminate water	Relatively low energy density and poor lubricating properties
Methanol	Primarily produced from natural gas, can be used in dual-fuel engines	Fuel handling and risk management simpler than LNG, reduced NOx, SOx and CO_2, extensive existing terminal infrastructure.	Retrofit can be complex, likely to be costly in short-term, toxic and flammable
Hydrogen		Potentially both clean and abundant	Energy-intensive fuel, large-scale production expensive.
LPG	Requires a different fuel handling system	Low NOx, SOx, PM, CO_2	Costly - widespread adoption likely to rest on economic incentive associated with use
Nuclear		Mature, clean and reliable	Widespread adoption faces political and regulatory issues

Update – 'LNG Capable' Ships

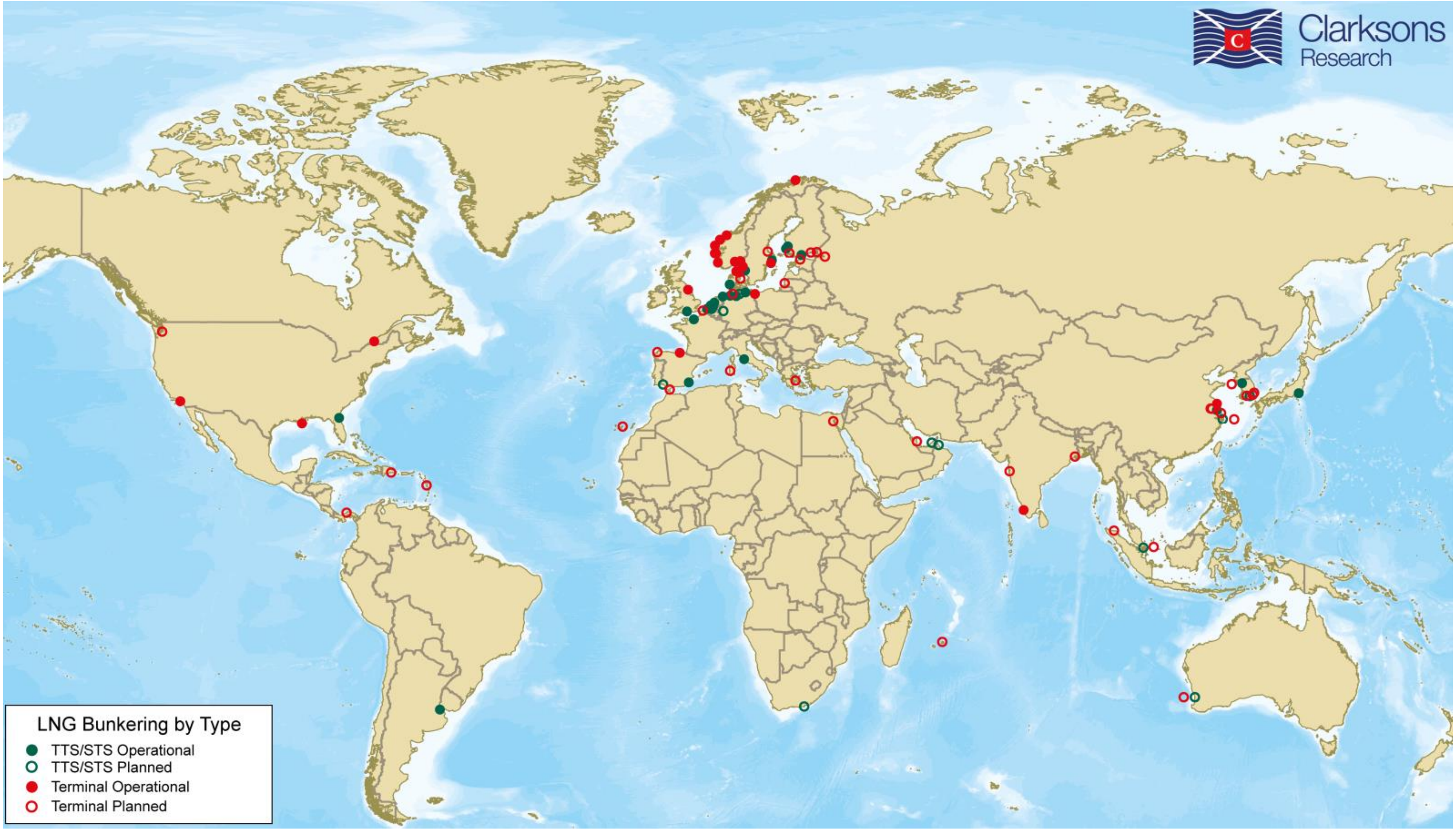
Global Fleet



'LNG Capable' Orders (No.)



Global LNG Bunkering Facilities



European LNG Bunkering Facilities

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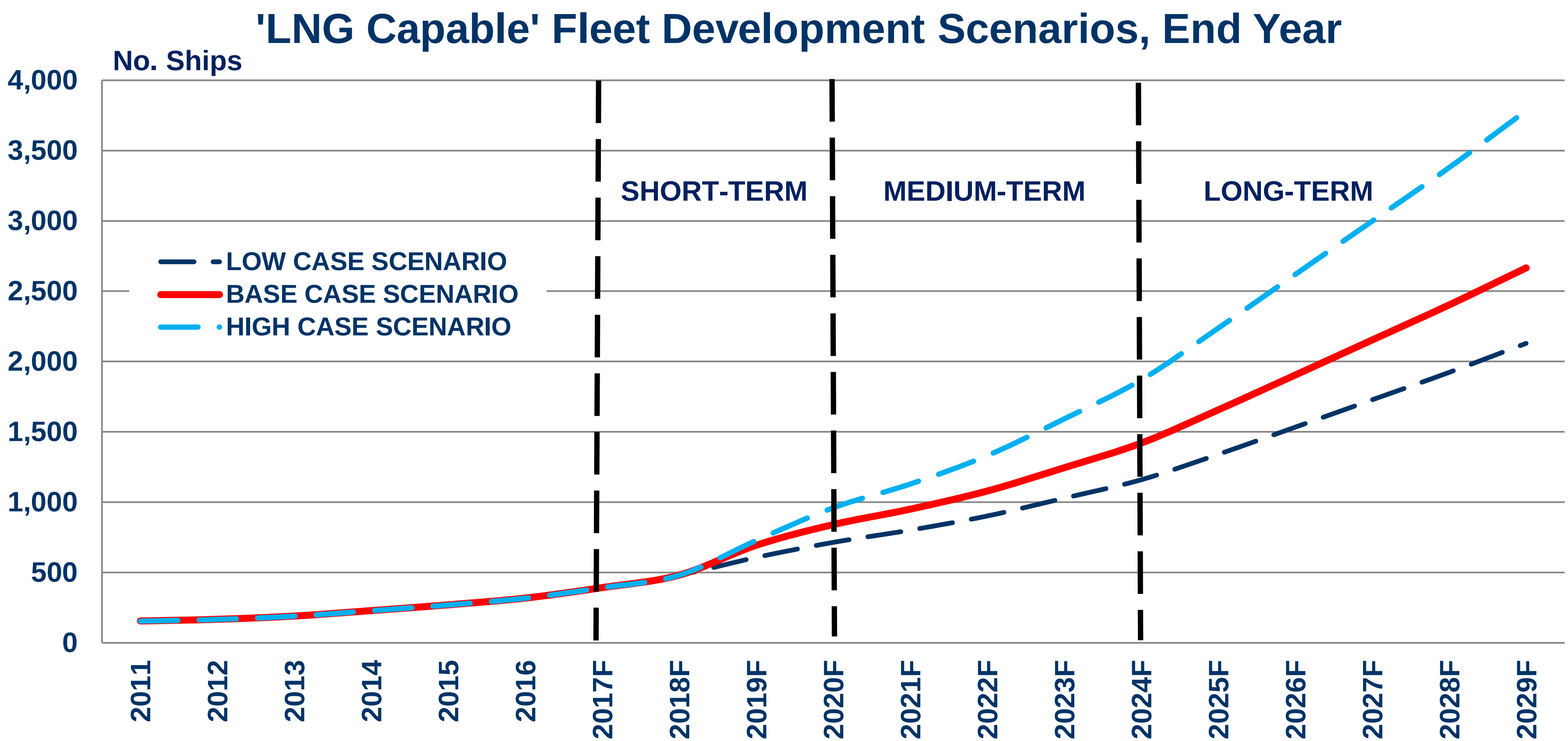
'LNG Capable' Fleet Development Scenarios



High level demand scenarios for 'LNG Capable' ships take into account:

(i) price differential between the cost of traditional marine bunker fuels and LNG

(ii) the exposure of different ship types and sizes to designated ECAs prior to the introduction of the global sulphur cap

(iii) the level of general market acceptance (including designs to deal with reduced capacity, investment costs, CAPEX & returns)

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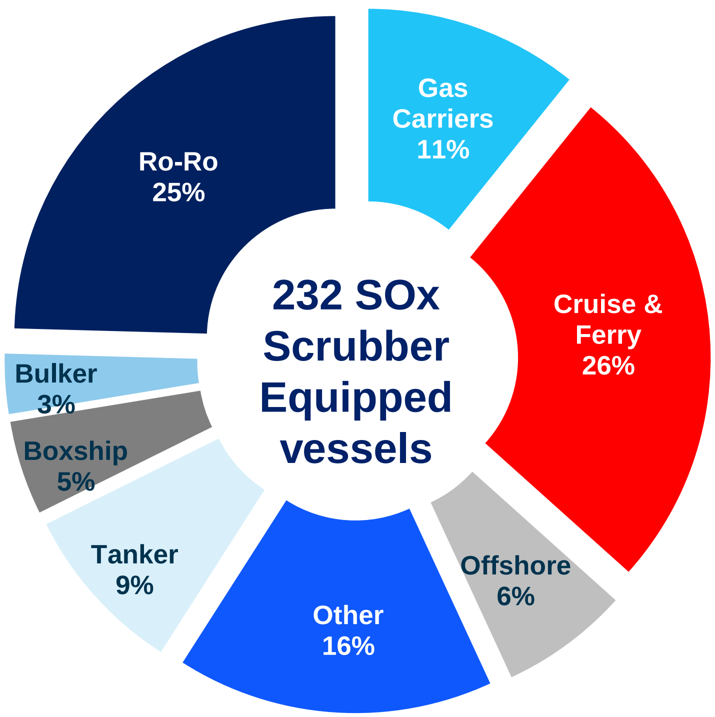
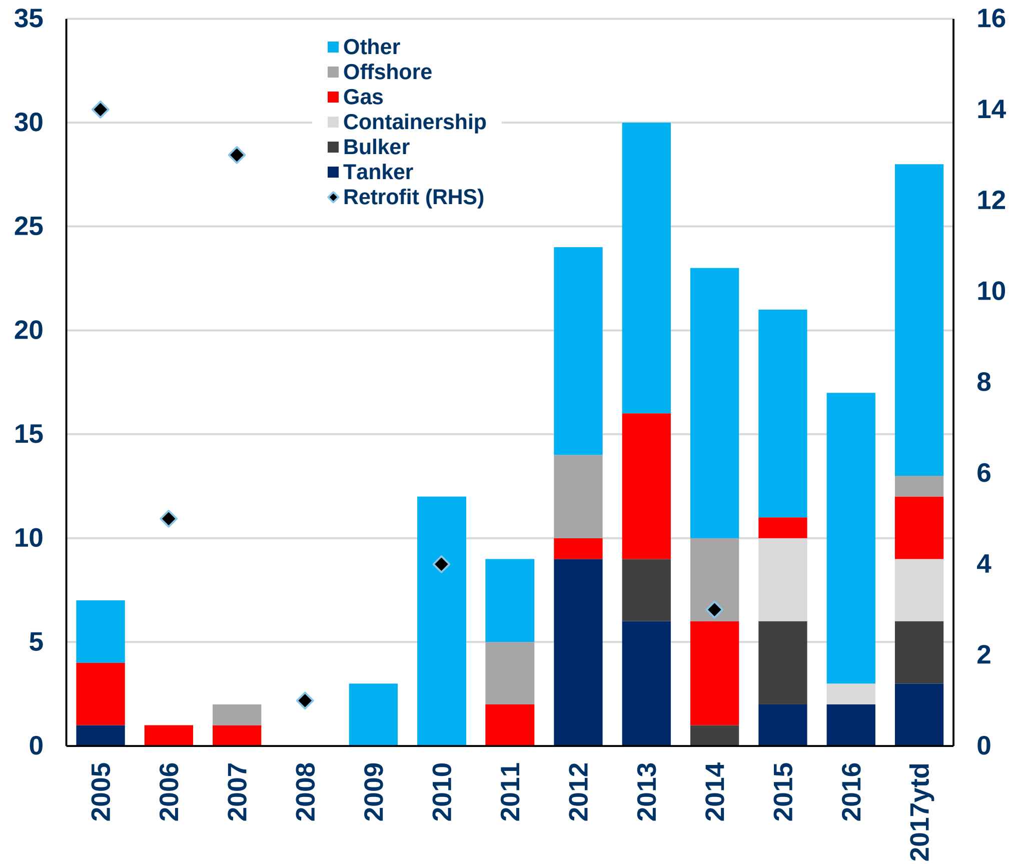
Update – SOx Scrubber Equipped Ships



Global Fleet

SOx Scrubber Equipped Orders (No.)



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SOx Scrubber Technology Costs

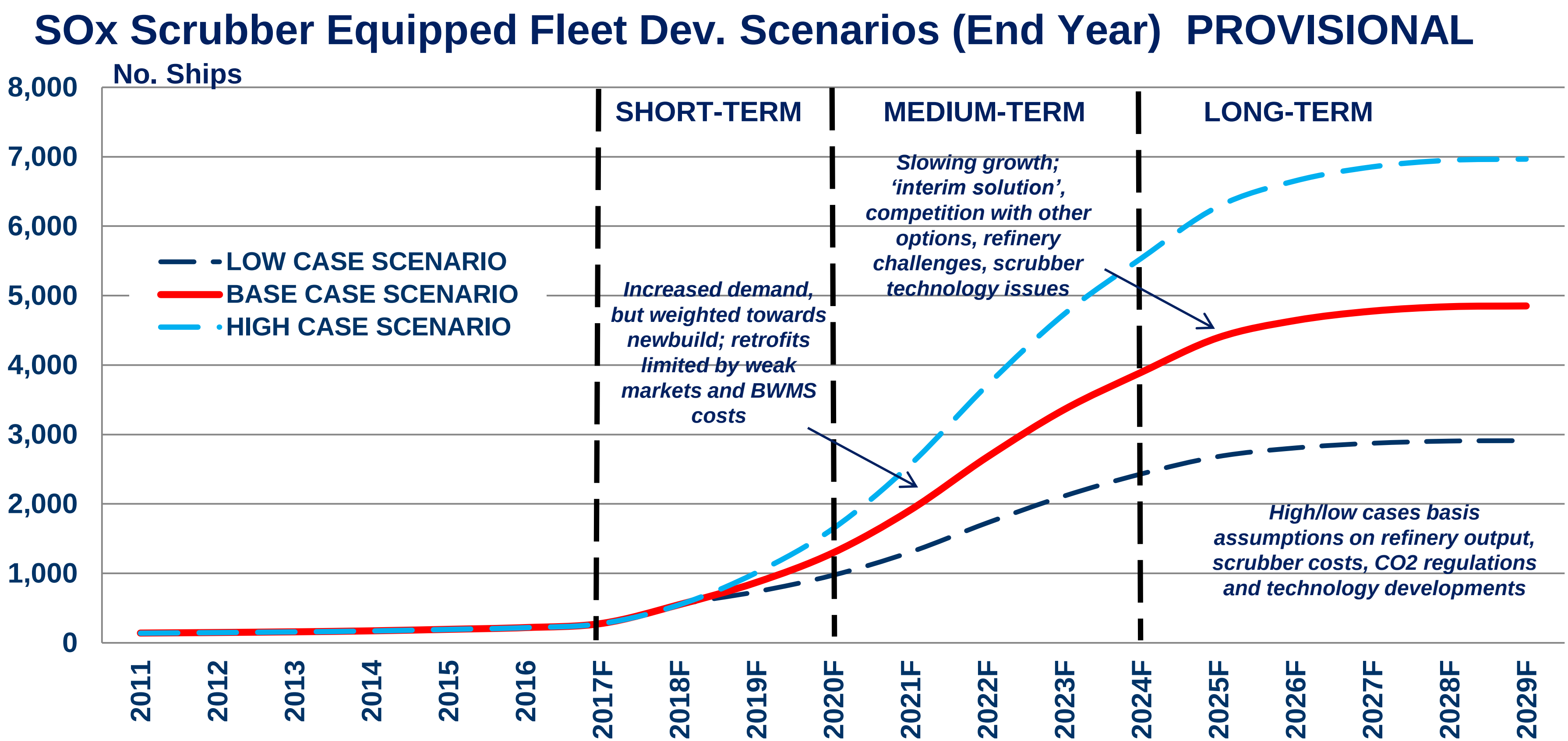
- SOx scrubber technology costs depend on the technology type (open/closed/hybrid systems), size of the engine, fuel to be used and retrofit feasibility (space, plumbing etc).
- Total estimated retrofit cost ranges between approximately $1m to $8m.
- Hybrid systems generally have the highest CAPEX while open loop systems have the lowest CAPEX, closed loop system CAPEX lies in between that of hybrid and open loop scrubbers.

Scrubber System	Method
Open Loop	*Seawater pumped from the sea through the scrubber, cleaned & discharged*
Closed Loop	*Fresh water treated with sodium hydroxide pumped through scrubber, cleaned in process tank and recirculated*
Hybrid	*Can operate in open and closed loop mode*

Vessel Type	Estimated Newbuild Cost*	Estimated Retrofit Cost*
VLCC	$3.0m - $5.0m	$4.0m - $8.0m
MR Tanker	$1.5m - $2.6m	$3.5m - $4.5m
Panamax	$2.0m - $5.0m	$5.0m - $6.0m
Handymax	$1.5m - $3.5m	$4.0m - $5.0m
Handysize	$1.0m - $3.0m	$3.0m - $3.5m
12-14,999 TEU	$5.0m - $6.0m	$6.0m - $7.0m
1-1,999 TEU	$0.9m - $1.2m	$1.0m - $2.0m

**Based on various industry sources and calculations based on manufacturer data*

SOx Scrubber Equipped Fleet Development Scenarios



- Analysis takes into account new deliveries into the fleet with scrubbers as well as retrofit demand.
- Some other forecasts are based on a refinery perspective; this model approaches from the point of view of scrubber demand and potential yard capacity to install both scrubber units and BWMS.
- Uptick in retrofit demand expected after implementation of SOx 2020, followed by reduced demand from 2025.

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