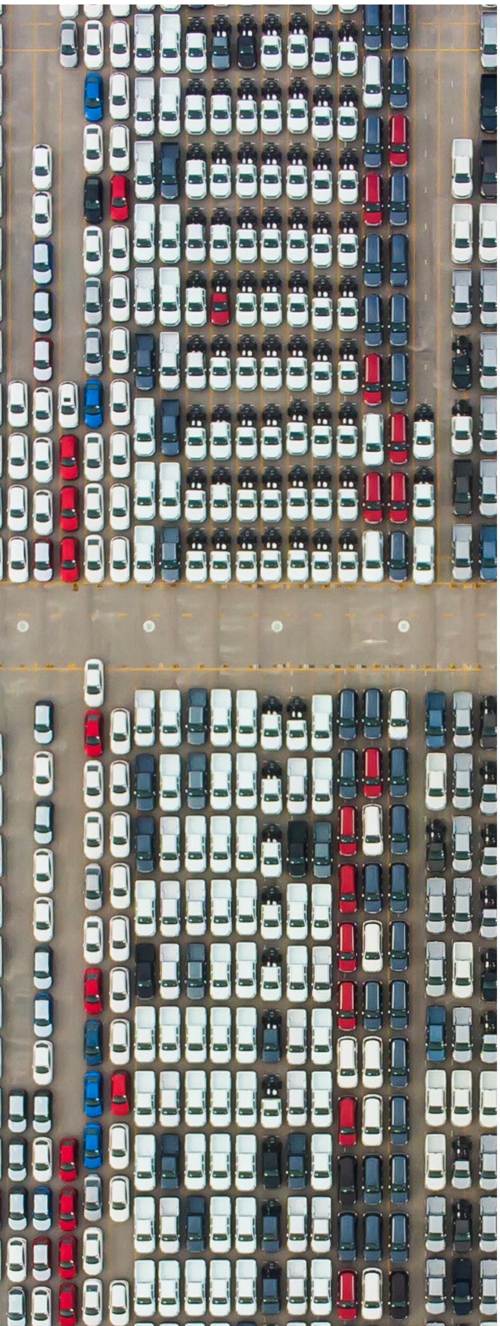
SEA\LNG

LNG AS A MARINE FUEL – THE INVESTMENT OPPORTUNITY

SEA\LNG STUDY - NEWBUILD PURE CAR AND TRUCK CARRIER (PCTC) ON PACIFIC AND ATLANTIC TRADE LANES



EXECUTIVE SUMMARY AND KEY FINDINGS

Liquefied Natural Gas (LNG) is a safe, mature, commercially viable marine fuel offering superior local emissions performance, significant Greenhouse Gas (GHG) reduction benefits and a potential pathway to a zero-emissions shipping industry.

To support shipowners and operators in analysing options in an informed way, while simultaneously providing a deeper analysis of the assumptions that go into the 2020 decision process, SEA\LNG commissioned this second in a series of independent studies by simulation and analytics experts *Opsiana*. To ensure the best possible data was available to *Opsiana*, SEA\LNG members contributed maritime expertise and current, timely background information to ensure a high level of creditability in the study and results. The study considered two PCTC trading scenarios using a 6,500 Car Equivalent Unit (CEU) vessel on the Atlantic Trade and an 8,000 CEU vessel on the Pacific Trade.

This study clearly indicates that LNG as a marine fuel delivers the best return on investment on a net present value (NPV) basis over a conservative 10-year horizon. The analysis shows fast paybacks from one to three years for the Atlantic Trade and below two years for the Pacific Trade.

Liquefied Natural Gas (LNG) is a safe, mature, commercially viable marine fuel.

The two routes were chosen based on trading scale with approximately 3.2M vehicles shipped each year on the Pacific Trade and 1.7M on the Atlantic Trade. LNG is proven to be the best investment across both trading zones. Whereas both high pressure (HP) and low pressure (LP) LNG dual fuel (DF) engines have clear benefits over other options, the study results portray one LNG technology investment as slightly better than the other. However, potential characteristic advantages in operations and technology between differing LNG engines are not further explored in this study.

This higher investment return was achieved without including the significant extra benefits and branding value gained[1] by choosing LNG as a more environmentally friendly marine fuel, which could be worth hundreds of millions of dollars across the global PCTC fleet. Customers of major car manufacturers are demanding action to address environmental sustainability goals. Recent actions by the European Union (EU) and International Maritime Organization (IMO) demonstrate implementation of these goals with requirements for monitoring, reporting and verification of vessel fuel consumption which will allow tracking of CO_2 emissions. Should CO_2 emission levels be taxed in future, LNG's competitive financial position against oil-based fuels will be strengthened.

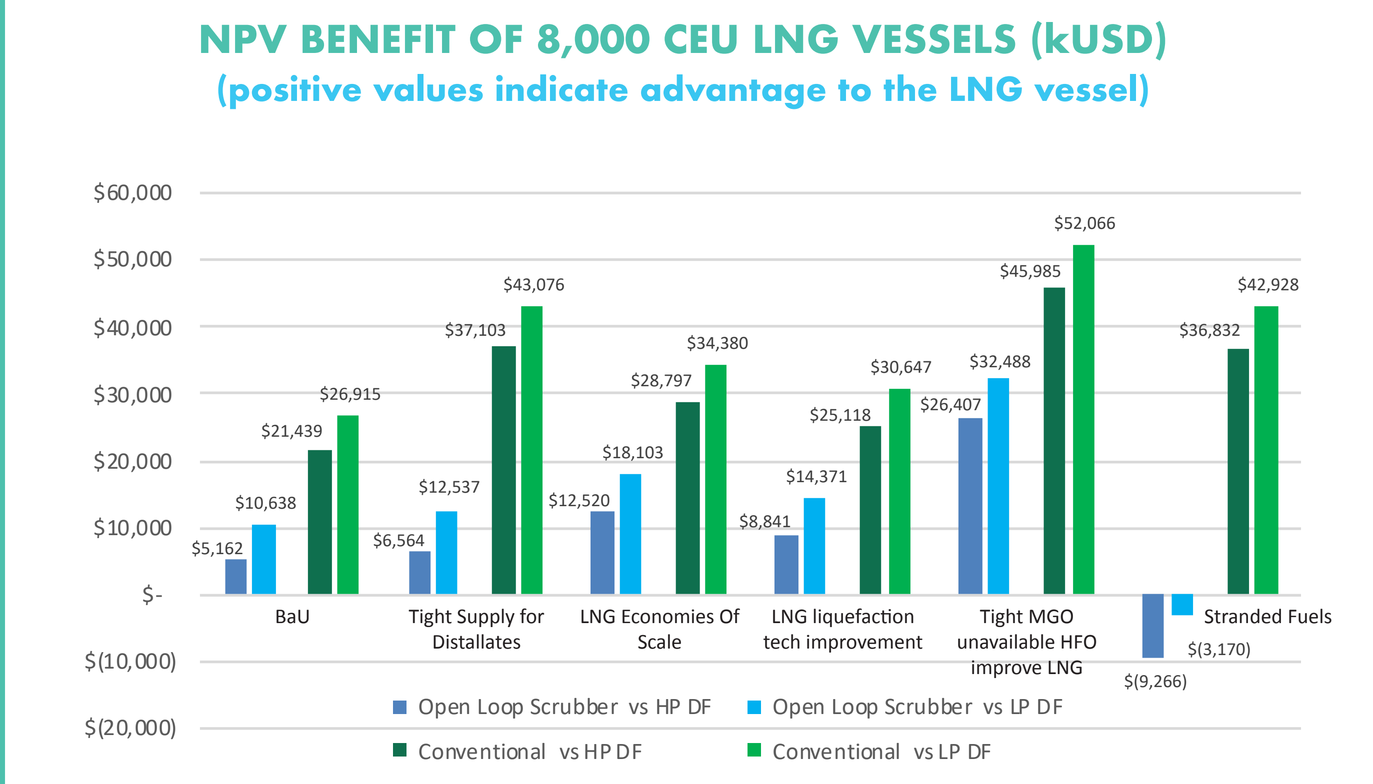
[1] Benefits gained in terms of CO_2 generated and pollutants produced per CEU transported.

Customers of major car manufacturers are demanding action to address environmental sustainability goals.

This study provides greater certainty for those investing in LNG as well as highlighting seven key findings surrounding the use of LNG as a marine fuel:

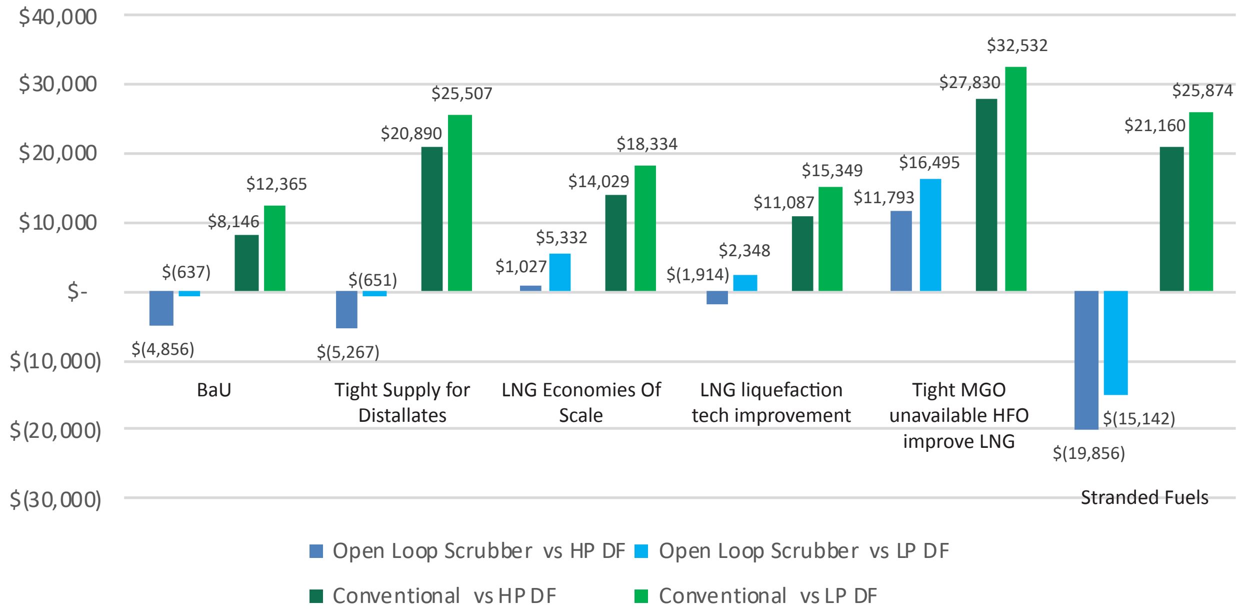
1. BETTER RETURN ON INVESTMENT

LNG delivers a greater return on investment than open loop scrubbers in all scenarios, except stranded fuels for the 8,000 CEU vessel on the Pacific Trade, and in the majority of scenarios for the 6,500 CEU vessel on the Atlantic Trade. Although to achieve the returns illustrated in the stranded fuel example, shipowners would be required to have scrubbers installed and operational at the start of 2020.



This study provides certainty for those investing in LNG as a marine fuel.

NPV BENEFIT OF 6,500 CEU LNG VESSELS (kUSD)
(positive values indicate advantage to the LNG vessel)



The results for the Pacific Trade 8,000 CEU vessel show that LNG fuel employing DF engines provide a compelling NPV savings versus a scrubber ranging from $5.1M to $32.5M across the majority of 5 of 6 fuel scenarios. LNG fuel delivers less value than scrubbers for the Pacific Trade in only one case: the Stranded Fuels scenario which results in negative savings of ($3.1M) to ($9.3M). The NPV savings for LNG DF alternatives overwhelm conventional low sulphur fuels and surges across all 6 fuel forecasts toward tens of millions NPV saving ranging from $21.4M to $52.1M.

The Atlantic Trade 6,500 CEU vessel returns also demonstrate strong NPV savings with ranges from negative ($5.3M) to plus $16.5M for LNG engines vs scrubbers. The stranded fuels scenario results in negative savings of ($15.1M) to ($19.9M). Compared with very low sulphur conventional fuels this Atlantic Trade vessel delivers robust NPV savings of $8.1M to $32.5M.

It should be noted that the stranded fuel scenario is predicated on the assumption that the price of HFO will be substantially

discounted after January 2020. If this occurs, it is only likely to be until existing stocks of HFO are exhausted, at which point the price will normalize at a level not yet known, due to the low level of demand (+/-5% of global fuel requirements to service vessels with scrubbers) and the added costs for bunker suppliers to support the product.

2. DIMINISHING CAPEX HURDLE

Historically, the high capital expenditure (CAPEX) for LNG engines and fuel tanks was a barrier to adoption. However, recent shipyard prices demonstrate substantially smaller LNG premiums above traditional vessels. LNG newbuilding experience and technology improvements have led to shipyard and other efficiency gains. This together with current shipyard market conditions continues to favour buyers of newbuildings. Recent changes in manufacturing policy to focus on LP DF technology is likely to lead to increased competition reducing LNG engine CAPEX further as well as improving GHG emissions performance.

3. COMPETITIVE ENERGY COSTS

Fuel is traditionally purchased on a dollar per ton basis; however, the transaction is really about buying energy. LNG offers a lower energy cost per ton. When priced against Heavy Fuel Oil (HFO) the differential is nearly 22% because LNG contains more energy for a given mass. LNG as a marine fuel provides 49.32GJ of energy per ton, whereas HFO only provides 40.5GJ/ton on a Lower Heating Value (LHV) basis. 2,000 tons of LNG therefore provides the same amount of energy as 2,436 tons HFO. This study highlights the positive effect this additional energy availability from LNG has on investment.

LNG newbuilding experience and technology improvements have reduced the historically high CAPEX for LNG engines and fuel tanks.

4. ENHANCED ENVIRONMENTAL PERFORMANCE

Increasingly, major global car manufacturers are demanding cleaner logistics chains in reaction to tighter regulations and elevated environmental consciousness of the car-buying public. Environmental impacts are known to be of growing importance amongst leading shippers, who contract for greater cargo volumes to environmentally conscious transport providers. These customer demands create a strong competitive advantage for shipowners who embrace LNG as a maritime fuel.

LNG meets and exceeds all current marine fuel compliance requirements for content and emissions, local and GHG. A recent independent study[2] showed GHG reductions of up to 21% are achievable now from LNG as a marine fuel, compared with current oil-based marine fuels over the entire life-cycle from Well-to-Wake (WtW). Fossil-fuel LNG is a future bridging fuel towards bioLNG or synthetic LNG, all of which are fully interchangeable. This also serves to protect current investments in LNG and LNG infrastructure. Further, blends also provide a pathway forward. For example, a blend of only 20% bioLNG can reduces CO2 emissions by a further 13% compared with 100% fossil fuel LNG.

This study confirmed that emissions of other local air pollutants, such as sulphur oxides (SOx) and particulate matter (PM), are close to zero when using LNG compared with current conventional oil-based marine fuels. Additionally, nitrogen oxides (NOx) can be reduced by 95% with LNG fuel.

Improving regional air quality and human health is particularly important in busy ports and coastal areas with high population concentrations where these PCTC vessels spend a significant number of operating days each month. Increased societal and regulatory focus on reducing GHG emissions should be expected and planned for when investing in new vessels. As the cleanest fuel available in quantity around the globe, LNG provides a “future proof” compliance choice for shipowners with present and future emission requirements.

[2] Thinkstep’s 11 April 2019 report – “Life Cycle GHG Emission Study on the use of LNG as Marine Fuel”

Fuel use monitoring regulations may mean that reducing pollution and GHG emissions is looming with the IMO goals to reach 50% reduction by 2050. This study considers the additional impact of an imposed carbon assessment. If $40[3] per ton of CO_2 emitted is assumed, the net investment gains[4] for the 8,000 CEU PCTC increase to $5.2M for LNG versus the open loop scrubber (up to $4.7M versus compliant conventional fuel) and slightly less for the 6,500 CEU vessel ($4.3M and $3.8M respectively).

5. MOST FINANCIALLY EFFECTIVE LONG-TERM MEANS OF COMPLYING WITH 2020 SULPHUR CAP

This study shows LNG as a marine fuel provides a greater return on investment for newbuild PCTCs than installation of Advanced Air Quality Systems (more commonly known as Exhaust Gas Cleaning Systems (EGCS) or Scrubbers) across a majority (5 out of 6) of the fuel scenarios; the exception being a stranded fuel forecast with plunging HFO pricing[5]. Although this stranded scenario is possible and analysed as such, it is deemed unlikely due to the growing, but small, number of scrubbers currently ordered in time to take advantage of the expected drop in HFO pricing from 2020. The stranded fuel benefit window is likely to close within a few years as the fuels market rebalances with refineries making the transition to new market demands. Additionally, unlike LNG CAPEX, which is falling, the CAPEX costs for scrubbers are expected to escalate as surging market demand outstrips supply and available slots for timely shipyard installation are disappearing. The advantageous business window for scrubbers to capture savings is rapidly closing for late adopters.

[3] This figure was chosen as it is the same one used by Shell on 19 May 2015 in their 2015 “Response to Shareholder Resolution on Climate Change” document.

[4] Although the HP “diesel-cycle” engine consumes less LNG, due to its higher diesel pilot fuel consumption than the LP “Otto-cycle” engine, it produces more CO_2.

[5] The Stranded Fuel scenario envisages HFO initially plummeting towards $200 /mt beginning in 2020.

6. SCRUBBER OPERATION IS SIGNIFICANTLY MORE EXPENSIVE THAN WIDELY REPORTED

Despite the total CAPEX premium for LNG over an Open Loop Scrubber solution of $7.6M (6,500 CEU) to $8.1M (8,000 CEU), LNG fuel's operational expenditure (OPEX) provides sufficient cost savings to far outweigh the CAPEX difference.

Although the study assumed a conservative parasitic fuel penalty of only 1% for the supplementary power requirements to run scrubbers, there is considerable extra onboard ship management and onshore record-keeping required to operate scrubber-fitted vessels and ensure compliance with environmental legislation. Further restrictions prohibiting open loop scrubber operations in various port jurisdictions are being debated and, in some cases, imposed. Where open loop scrubbers are restricted, the additional cost for consumption of costly Marine Gas Oil or the increased CAPEX for more complex Hybrid/Closed Loop Scrubbers must be added to the scrubber investment analysis.

As the cleanest fuel available in quantity around the globe, LNG provides a "future proof" compliance choice for shipowners with present and future fuel requirements.

7. THE COST OF LNG IS STABLE

LNG marine fuel is less price volatile than traditional oil based marine fuels. The cost of LNG is comprised of the natural gas (about 25%), which has fluctuated little in recent history, together with a generally fixed liquefaction fee to cool the natural gas to a liquid state and the transportation costs which can be contracted on a long term basis (about 75%). Consequently, LNG pricing is much more stable than traditional maritime fuels which reflect the volatility of crude oil prices. This principal difference is why the underlying commodity element for LNG forms a small portion of its price structure and refining and distribution plays a disproportionately large portion. LNG is therefore relatively insulated against sharp commodity swings. This relationship directly contrasts with HFO or diesel where the underlying commodity dominates costs. A century of infrastructure and refining improvements has driven these incremental costs downward. Therefore, the cost of LNG marine fuel bunkers continues to remain less volatile than traditional oil based marine fuels.

For shipowners and operators, the notion that fuel pricing is relatively stable creates a huge positive budget and business advantage. Given the high percentage of OPEX that fuel commands, having this pricing relatively stable over a long term is a strategic advantage for the shipping company as well as the underlying ultimate consumer of the service. With more stable fuel costs, fuel surcharges paid by the customer of shipping service will also be far less volatile over time.

The cost of LNG marine fuel bunkers is less volatile than traditional oil based marine fuels.

CONTEXT

The International Maritime Organisation (IMO) global cap on marine fuel (bunkers) of 0.5% sulphur content (S) which comes into force from 1st January 2020 will affect an estimated 300 million metric tons (MMT) of bunkers. This landmark legislation will have wide-ranging ramifications beyond shipping as the new distillate diesel fuels demanded by shipping are the same ones used by other modes of transport including trains and trucks, as well as domestic heating.

Today, as in the past most ocean vessels rely on Heavy Fuel Oil (HFO) which globally averages 2.5% Sulphur. Of the total marine fuel demand of 680K metric tons of oil per day, 477K metric tons is high sulphur HFO. As the residual fuel left from the crude oil refining process, HFO is the least environmentally friendly fuel when used without abatement.

The main marine fuel options for shipowners beyond 2020 are:

- LNG fuel for newbuildings
- Use existing engines burning 0.5% Low Sulphur Fuel Oil (LSFO) or a blend of existing sulphurous Heavy Fuel Oils (HFO) with no or low sulphur fuels such as 0.1% Low-Sulphur Marine Gas Oil (LS-MGO[6]).
- Continue consuming HFO and employ scrubbers to achieve alternative compliance.

The global shipping industry did experience imposition of global sulphur limits only a few years ago. The introduction of restrictive ECAs in 2015 caused 250-300 thousand barrels of oil per day to shift from high sulphur to 0.1% S representing a modest step change. However, the impact of the IMO's global 2020 0.5% S limit is a dramatic leap in comparison being ten times greater and impacting 3 million barrels of oil per day. Where the former caused a "tiger yawn" in 2015 global fuel markets, this much larger change could result in a "lion roar" during 2020.

[6] LS-MGO has a sulphur content of less than 0.1%. This marine fuel can be used in Emission Control Areas (ECAs), which among other things impose a sulphur emissions limit corresponding to that of LS-MGO.

Shipowners are now challenged with making significant investment decisions in an unprecedented dramatic fashion under a range of uncertainties. Many have chosen the LSFO route. Over 95% of ships will likely be running on LSFO based on the relatively low level of orders for exhaust gas cleaning systems and LNG fuelled vessels. This raises a number of questions: Will that prove to be the best solution? Can the higher fuel cost be recovered from customers? Will the quality, consistency and compatibility of future LSFO blends be available where and when it is needed?

Is there an opportunity to take advantage of the environmental and operational benefits of LNG and its ability to scale to meet the industry's needs? Will it be cost competitive? Are scrubbers a viable long-term cost-effective solution? Will open loop scrubber waste-water discharge be accepted in the trading regions the vessels operate? What if GHG emissions or PM are taken into consideration, which option is best? Which option offers the most competitive advantage?

The huge variation in global shipping types, ages and the trading patterns of vessels adds to the complexity. For many shipowners and operators, it will necessitate a portfolio approach[7] to achieve compliance with the IMO 2020 global sulphur cap legislation and continue profitable trading for any given vessel.

To support shipowners and operators in analysing options in an informed way, while simultaneously providing deeper analysis of the assumptions that go into the 2020 decision process, SEA\LNG commissioned this independent study by simulation and analytics experts *Opsiana*. To insure the best possible data was available to *Opsiana*, SEA\LNG members contributed maritime expertise and current, timely background information and data to insure a high level of creditability in the study and results. The study is based on a newbuild 6,500 CEU PCTC plying its trade on the Atlantic and a newbuild 8,000 CEU PCTC plying its trade on the Pacific. Investment performance was measured utilising traditional NPV

[7] Where specific fuel solutions will be chosen to suit individual vessels depending upon their classification, age and trading pattern.

calculations as well as Payback. NPV carries the time value of money (TVM) and provides a strong measure of wealth gain. Payback ignores TVM but provides a valued liquidity measure of risk: "how long before I get my money back."

The study was undertaken to make sense of the investment case based upon six different fuel-pricing scenarios that – at the time of writing – are based on assumptions that are likely and reasonable. The exercise is not meant to endorse any specific fuel price forecast. While great care has been taken in building these forecasts, it is up to each individual to decide how they see the future, and place the corresponding weight on each forecast. In the majority (5 out of 6) fuels scenarios, all except the Stranded Fuels forecast, LNG delivered the greatest return to shipowners and operators on a net present value (NPV) basis over a conservative 10-year horizon, with fast payback periods ranging from under-one year to three years.

The Stranded Fuels scenario predicts a plunge in HFO with implementation of the 2020 IMO global sulphur cap and slow pricing recovery thereafter, as market forces and global oil refining capacity switch toward higher demand and margin low sulphur fuels. As that occurs, supply will likely balance demand within a few years of implementation in early 2020. Therefore, most saving benefits, if any, will accrue to the early adopters and late adopters may find this window quickly closing.

LSFO

The vast majority of vessels are expected to fuel with LSFO, a straight low sulphur fuel oil, or – more typically – a blended fuel consisting of HFO and distillates. Some shipowners have even indicated that they will, during the initial phase after 1st January, 2020, look to purchase only MGO and thus avoid the potential risk of availability, and fuel quality issues such as stability and compatibility. There is also the risk of taking onboard non-compliant fuel and being penalized by State Port compliance authorities.

SCRUBBERS

Scrubber uptake, according to classification society DNV-GL, will 'be over' 3,000 vessels[8] by 2020. However, this only represents around 5% of the world trading fleet of 59,700 vessels. The technology, which in 2019 has seen an upsurge in uptake, does not offer any GHG reduction benefits and may be viewed as a short-term solution. Those opting for open loop scrubbers may not be able to take full advantage of these systems due to recent legislative changes. Several nation states, including Singapore and China have restricted the discharge of waste-water from open loop scrubbers in their territorial waters.

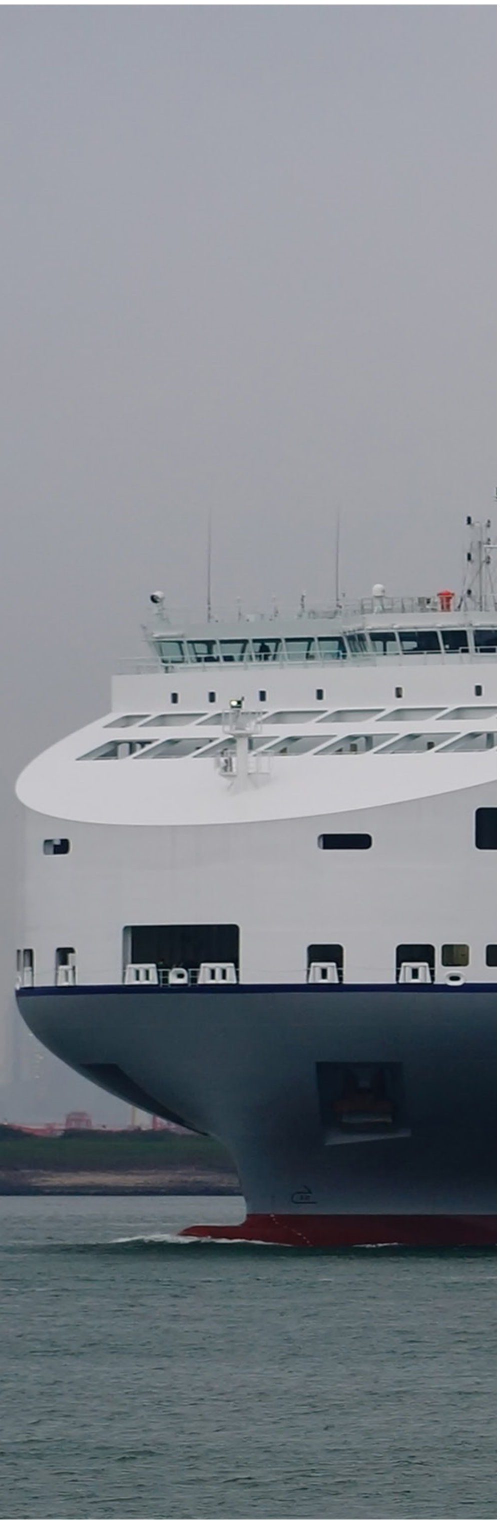
Environmental and operational challenges aside, the commercial case for scrubbers remains competitive. Although it may be the least predictable of the three main options for a vessel of this type, scrubbers do offer a short-term financial gain, provided the unit is operational and able to capture the benefits window commencing 1st January 2020.

LNG

When analysing investment options for 2020, it is important to contextualise and recall why the 2020 rules were implemented. Although shipping has demonstrated that its focus is very much on the bottom line when analysing 2020 options, the 2020 legislation was devised to dramatically improve the environmental performance of the industry. Regional air quality, especially around major maritime ports, has been a concern for decades and continues to be a key health issue around the world. LNG provides significant air quality improvements over traditional fuels.

[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/785497/shipping-fleet-statistics-2018.pdf

This study clearly indicates that LNG delivers the best return on investment on a net present value (NPV) basis over a conservative 10-year horizon.



In terms of environmental impact LNG performs well from an emissions perspective; LNG emits zero sulphur oxides (SOx) and virtually zero particulate matter (PM). Compared to existing heavy marine fuel oils, LNG emits 90% less nitrogen oxides (NOx) and through the use of best practices and appropriate technologies to minimise methane leakage, reductions of GHG by up to 21% on a WtW basis, (28% on Tank-to-Wake) are achievable[9]. These benefits can and will see increases with a potential for up to 30% or more as technology develops, compared with conventional oil-based fuels. A blend of 20% bioLNG as a drop-in fuel can reduce GHG emissions by a further 13% when compared to 100% fossil fuel LNG. LNG is a cleaner fuel and a clear winner when it comes to local emissions and contributes measurably to world health goals. LNG represents a significant step forward in the reduction of GHGs and meeting future carbon-related emissions targets.

This SEA\LNG Business Case study is intended to help the shipowning / operating community to analyse options in an informed way. The study simultaneously provides a deeper analysis of the assumptions that go into the 2020 decision process. Compared to many other case studies on this topic, this one spells out CAPEX and OPEX assumptions in detail, providing a level of insight thus far not communicated for an investment case in LNG from a newbuild perspective. While this study focuses specifically on the liner trade, SEA\LNG members are working on additional studies that analyse the investment case for a number of other ship types and routes.

[9] Thinkstep's 11 April 2019 report – "Life Cycle GHG Emission Study on the use of LNG as Marine Fuel"

LNG is a cleaner fuel and a clear winner when it comes to local emissions and contributes measurably to world health goals.

MAIN ASSUMPTIONS

Sailing speed is assumed at 19kts throughout. The North Atlantic Trade chosen covers Northern Europe and the US East Coast and is shown in the diagram below. The total sailing distance is 9,291nm of which 3,024nm (32.5%) is spent in the SECA[10] and 1,585nm (17.1%) is spent in the NECA[11] with no discharge zones in Zeebrugge and Bremerhaven.

NORTH ATLANTIC TRADE ROUTE

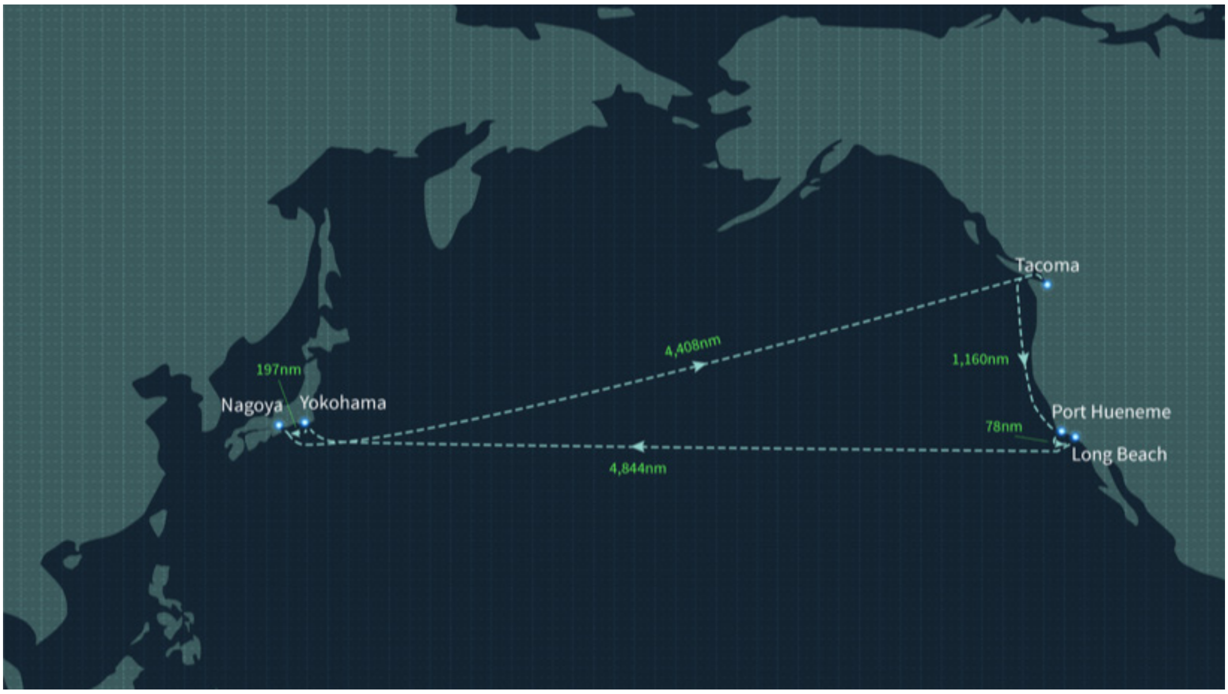
[10] Sulphur Emission Control Areas

[11] Nitrogen Emission Control Areas

SEA\LNG members contributed maritime expertise and current, timely background information to ensure a high level of creditability in the study and results.

The Pacific Trade chosen is shown in the diagram below. The total sailing distance is 10,687nm of which 2,469nm (23.1%) is spent in the SECA and 2,469nm (23.1%) is spent in the NECA[12] with 1,161nm (10.8%) spent in no-discharge zones including Long Beach and Port Hueneme.

PACIFIC TRADE ROUTE



[12] IMO Emission Control Areas designated under regulation 13 of MARPOL Annex VI for North America Pacific Coast as the same geodesic areas.

The two routes were chosen based on trading scale with approximately 3.2M vehicles shipped each year on the Pacific Trade and 1.7M on the Atlantic Trade.

FINANCIAL

a) Newbuilding LNG fuel vessel

The study utilizes a new build LNG dual fuel vessel as this is most likely to occur in the marketplace. This acknowledges that LNG retrofits often carry a premium CAPEX and also require a young candidate vessel with significant future lifetime to justify the additional CAPEX investment.

b) Investment Hurdle Rate

The study utilizes a finance investment hurdle rate traditionally known as the Weighted Average Cost of Capital (WACC) for the time value of money. The WACC value for the study of 8% was derived from these assumptions:

Debt loan rate 6% and 60% portion

Equity return rate 11% and 40% portion

Tax rate of 0%

Formula:

WACC= Loan Rate × Debt Portion × (1-tax rate) + Equity Rate × Equity Portion

Substituting in Values...

WACC= 6% ×0.60 ×(1-0)+ 11% ×0.4= 8%

c) Investment Horizon Period

The study chose a 10-year investment horizon as a very conservative timeframe understanding that the economic lifetime for PCTC vessels exceeds this substantially. The choice also recognizes that over much shorter investment horizons of only a few years an elevated CAPEX recovery charge often makes short lifetime projects not viable.

d) Terminal Recovery Value

The study ignores a salvage or recovery value at end of the investment horizon period as a very conservative condition. This avoids the risks inherent with terminal value and its presumed future cash flows or growth rates.

e) Inflation and Nominal Values
The model employs an inflation differential of 2.5% per year to maintain nominal values throughout the investment period.

f) CO2 Credits
The business model excludes any impacts of CO2 assessments to maintain a conservative approach to this investment case. However, there may be CO2 credit or debit schemes in the future. If these regimes become enacted, then the modelling should incorporate measures to show the NPV impacts.

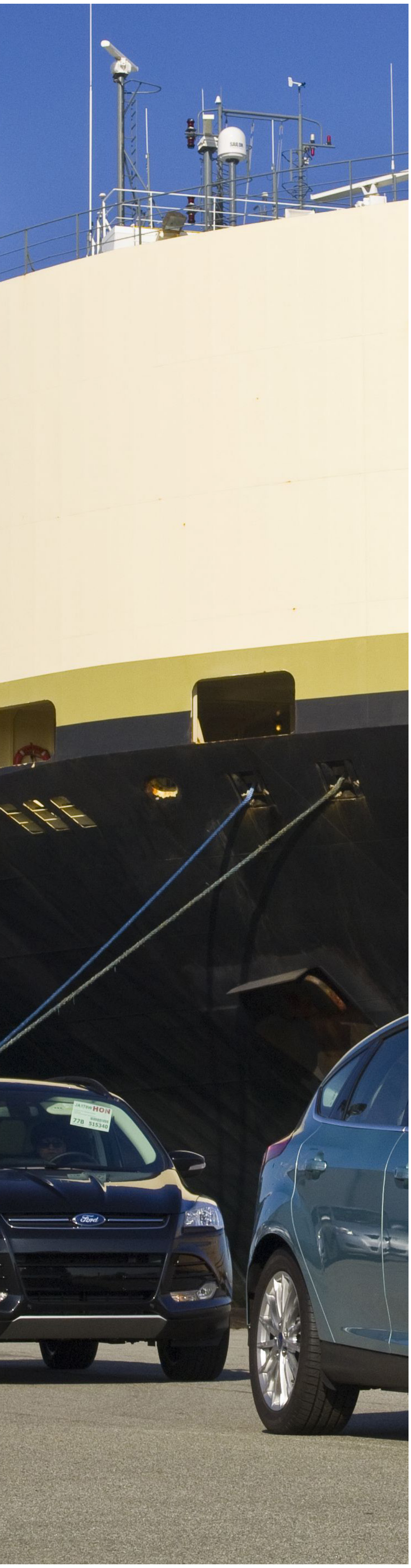
CAPITAL EXPENDITURE

Four types of main engine configurations were fully priced and compared in this study: a dual fuel HP 2-stroke LNG engine (2-s HP DF) with Tier III treatment, a dual fuel LP 2-stroke LNG engine (2-s LP DF), a conventional diesel cycle low speed engine fitted with an open loop scrubber plus SCR, and a conventional diesel cycle low speed engine fitted with SCR but without scrubber. The investment for each configuration and its components is detailed in the CAPEX summary.

4-stroke engines were not modelled as the overwhelming majority of ships of this type on these trade routes utilise 2 stroke technology. However, technology advancements and the requirement to burn higher quality fuel oils to comply with tighter environmental regulations mean that 4-stroke engine configurations may become a viable alternative for powering ocean vessels, especially in environmentally sensitive areas and within ECAs.

2-S HP DF

This configuration is modelled on a MAN 7S60ME-C8.5-GI main engine (M/E) (for the 6,500 CEU vessel) and a MAN 8S60 ME-C8.5-GI M/E (for the 8,000 CEU vessel) using 3.8% S pilot fuel with no methane slip. Although NOx Tier II compliant, both M/E require Selective Catalytic Reduction (SCR) or Exhaust Gas Recirculation (EGR) to comply with NOx Tier III. The auxiliary engines (A/E) and boilers are assumed to be gas only and do not require SCR. M/E Specific Fuel Oil Consumption



(SFOC) is 137.3g/KWh, gas is supplied at 300-350 bar to the M/E and low pressure to the A/Es. The HP gas system CAPEX is costed at $1.09M, with the LP gas system at $349K for the 6,500 CEU vessel, $1.13M and $364K restively for the 8,000 CEU vessel. There is no differential CAPEX attributed to the boilers and mechanical propulsion is assumed.

2-S LP DF

This configuration is modelled on a WinGD 7X62DF Winterthur Gas & Diesel engines (for the 6,500 CEU vessel) and a WinGD 8X62DF (for the 8,000 CEU vessel) which use lean-burn Otto-cycle combustion with approximately 1% S micro-pilot. It complies with NOx Tier III in gas mode so is modelled without an SCR. M/E SFOC is 139.5g/KWh with low-pressure gas supplied to the M/E and A/Es. Once again, the LP gas systems are priced at $349K and $364K with no differential CAPEX attributed to the boilers and mechanical propulsion assumed.

OPEN LOOP SCRUBBER VESSEL

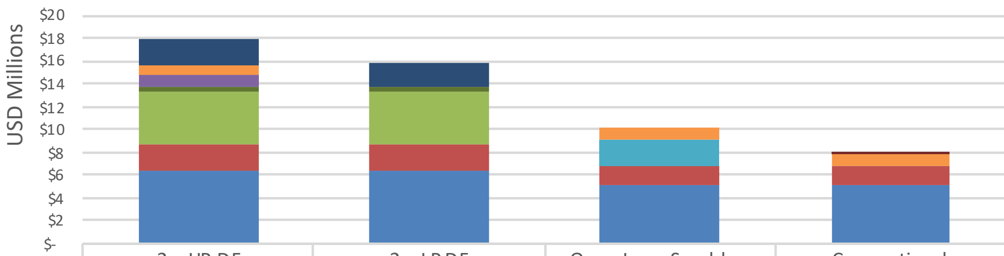
This configuration is based on a conventional diesel cycle, low speed engine, MAN 7S60ME-C8.5 (for 6,500 CEU vessel) and MAN 8S60ME-C8.5 (8,000 CEU), with a scrubber fitted to cover exhaust from the M/E, A/E and one boiler rated at 5MW. The other boiler is assumed to be powered using waste heat recovery (WHR) and is therefore not scrubbed. Although the M/E is NOx Tier II compliant, an SCR is required to comply with NOx Tier III at an approximate cost of $1.04M for the 6,500 CEU vessel and $1.18M for the 8,000 CEU vessel. M/E SFOC is 173.4g/KWh including scrubber load. The scrubber is open loop and therefore does not consume Sodium Hydroxide (NaOH).

CONVENTIONAL VESSEL

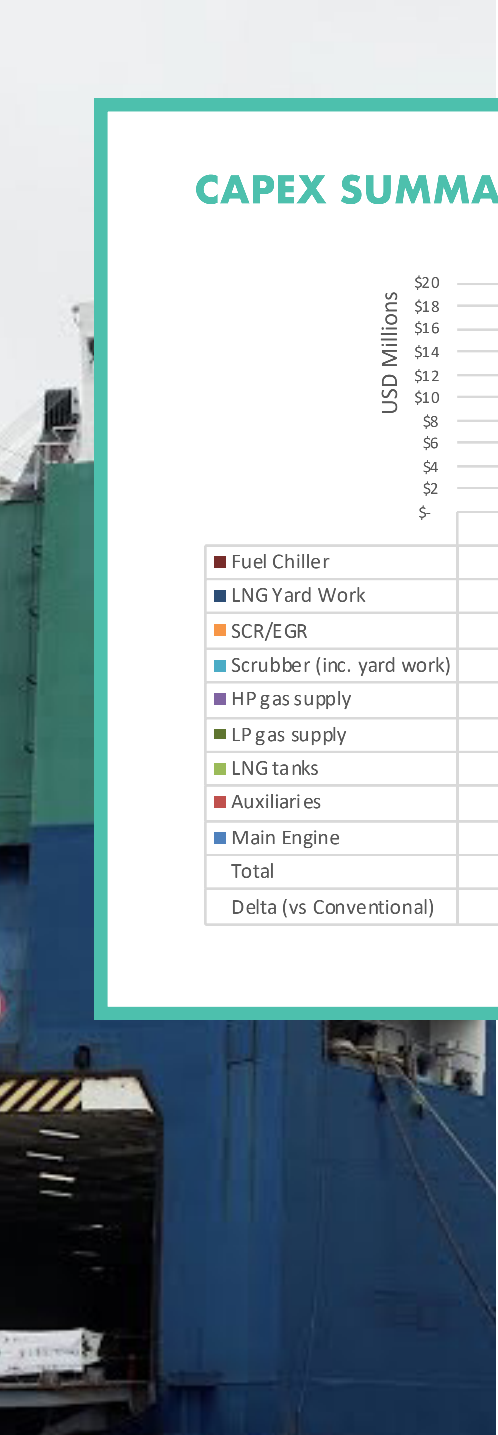
This configuration is based on the same conventional diesel cycle, low speed engines – MAN 7S60ME-C8.5 (for 6,500 CEU vessel) and MAN 8S60ME-C8.5 (8,000 CEU) whereas the M/E is NOx Tier II compliant, an SCR is required to comply with NOx Tier III. M/E SFOC is 165.7g/KWh. Additional CAPEX of $118K is assumed for a fuel chiller for both 6,500 CEU and 8,000 CEU vessels, since the M/E was designed to operate with fuels of higher viscosity relative to MGO.

CAPEX for all engine configurations is summarised below.

CAPEX SUMMARY – 6,500 CEU



	2-s HP DF	2-s LP DF	Open Loop Scrubber	Conventional
Fuel Chiller				$118,000
LNG Yard Work	$2,110,000	$2,110,000		
SCR/EGR	$884,646		$1,040,229	$1,040,229
Scrubber (inc. yard work)			$2,292,030	
HP gas supply	$1,087,241			
LP gas supply	$349,138	$349,138		
LNG tanks	$4,712,734	$4,712,734		
Auxiliaries	$2,308,800	$2,308,800	$1,776,000	$1,776,000
Main Engine	$6,397,440	$6,397,440	$5,117,952	$5,117,952
Total	$17,850,000	$15,878,112	$10,226,211	$8,052,181
Delta (vs Conventional)	$9,797,819	$7,825,931	$2,174,030	$-

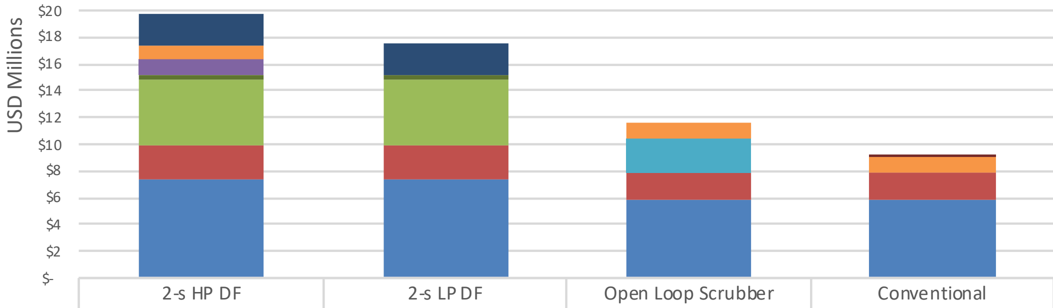


The additional CAPEX for each 6,500 CEU vessel configuration option over the conventional vessel is:

- 2-s HP DF $9.8M,
- 2-s LP DF $7.8M,
- Open Loop Scrubber $2.2M

The study chose a 10-year investment horizon as a very conservative timeframe understanding that the economic lifetime for PCTC vessels exceeds this substantially.

CAPEX SUMMARY – 8,000 CEU



	2-s HP DF	2-s LP DF	Open Loop Scrubber	Conventional
Fuel Chiller				$118,000
LNG Yard Work	$2,403,900	$2,403,900		
SCR/EGR	$1,011,024		$1,185,994	$1,185,994
Scrubber (inc. yard work)			$2,613,207	
HP gas supply	$1,128,276			
LP gas supply	$364,340	$364,340		
LNG tanks	$4,913,159	$4,913,159		
Auxiliaries	$2,599,480	$2,599,480	$1,999,600	$1,999,600
Main Engine	$7,311,360	$7,311,360	$5,849,088	$5,849,088
Total	$19,731,539	$17,592,239	$11,647,889	$9,152,682
Delta (vs Conventional)	$10,578,857	$8,439,557	$2,495,207	$-

The additional CAPEX for each 8,000 CEU vessel configuration option over the conventional vessel is:

- 2-s HP DF $10.6M,
- 2-s LP DF $8.4M,
- Open Loop Scrubber $2.5M

The CAPEX premium for LNG alternatives over a scrubber with IMO 2020 0.5% compliance is $8.1M (8,000 CEU) and $7.6M (6,500 CEU) for a 2-s HP DF M/E arrangement and $5.9M (8,000 CEU) and $5.6M (6,500 CEU) for a 2-s LP DF M/E arrangement. One note of caution, the scrubber assumption is for an open loop system. The open loop scrubber CAPEX is lower than that for a more costly complex hybrid or closed loop system and its OPEX is generally lower. This study also assumes that a vessel using an open loop system can fully operate in all waters, which is no longer be possible given recent restrictions.

FUEL CONSUMPTION

M/E fuel consumption is summarised in the table below. Scrubber consumption includes a very conservative 1% parasitic load. Energy consumption includes pilot fuels for the LNG DF engines. Indicative consumption figures in the table are for 19 knots. The table highlights the fact that LNG contains 22% more energy content for a given mass than conventional oil-based fuels.

	6500 CEU		8000 CEU		SFOC [/kWh]
Propulsion alternative	M/E archetype	MCR [MW]	M/E archetype	MCR [MW]	
LNG 2s HP DF	MAN 7S60ME-C8.5-GI	16.660	MAN 8S60ME-C8.5-GI	19.040	137.3 g LNG + 6.2 g MGO
LNG 2s LP DF	WinGD 7X62DF	16.695	WinGD 8X62DF	19.080	139.5 g LNG + 1.2 g MGO
Scrubber	MAN 7S60ME-C8.5	16.660	MAN 8S60ME-C8.5	19.040	173.4 g HFO (incl scrubber load)
Conventional					165.7 g VLSFO

FUEL TANK SIZE IMPACTS

This report models a C type LNG tank of sufficient volume for a round trip with Atlantic Trade 6,500 CEU sized at 2,700 m3 (Pacific Trade 8,000 CEU at 3,400m3) with a 15% sailing margin. The study also includes a penalty representing displaced cargo volume capacity. The annual displaced cargo loss assessment is $451K USD for Atlantic Trade and $540K for the Pacific. Other LNG storage technologies are outside the scope of this business case study, such as membrane tanks, where a different initial construction CAPEX and minimized operational impacts may provide potential benefits by reducing cargo revenue loss.

Vessel Size	Propulsion type	Tank Sizes [m3]			
		LNG	HSFO	VLSFO	MGO
6500 CEU	LNG 2s HP DF	2,700			170
	LNG 2s HP DF	2,700			170
	Scrubber		1,500		
	Conventional			1,190	500
8000 CEU	LNG 2s HP DF	3,400			170
	LNG 2s HP DF	3,400			170
	Scrubber		1,800		
	Conventional			1,600	500

LNG tanks are placed vertically to minimize volumetric loss of cargo space in lower decks and no cargo tonnage reduction is assessed due to added scrubber weight. Loss of cargo space is estimated using deck height 3.5 m, CEU area = 7.4 m2, radius of tanks = 5 m. Similarly, the bunker tanks for fuel oils are as traditionally placed and do not affect CEU capacity.

FUEL COSTS

The study considers four fuels, LNG plus three oil-derived fuels. The oil-derived fuels are:

1. A conventional high sulphur fuel oil "HSFO" with as much as 3.5% S.
2. A marine gas oil "MGO" distillate containing 0.1% S
3. A very low sulphur fuel oil "VLSFO" which complies with 0.5% S.

Although 0.5% S fuels could be achieved either through blending or directly from residual of a naturally sweet crude, it is assumed that the price of these VLSFO alternatives would converge despite differences in their chemical composition. Throughout this document we assume that VLSFO is a blend of 85% MGO and 15% HSFO[13]. The physical properties and prices for VLSFO are obtained accordingly.

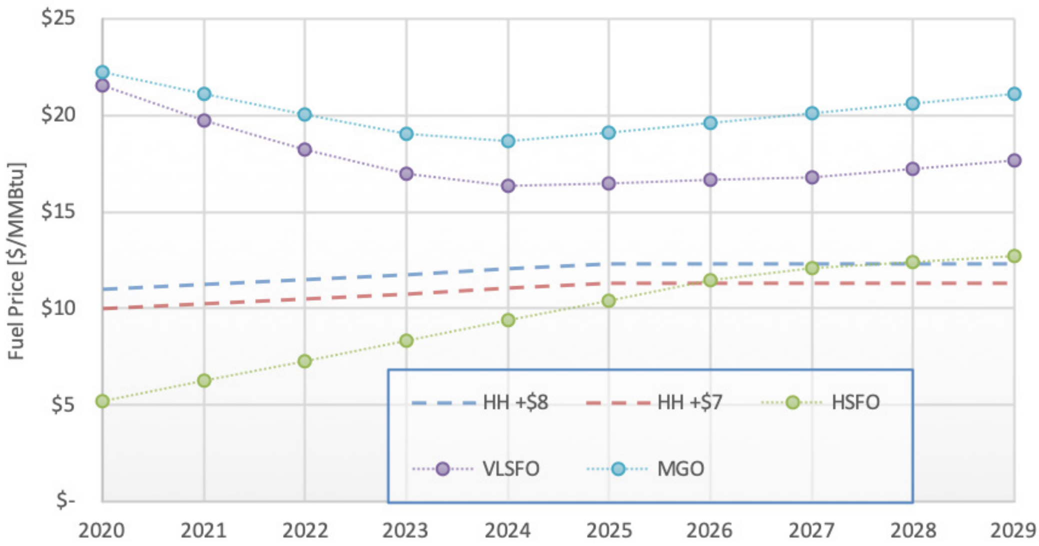
Six scenarios are modelled in the study representing fuel price forecasts from 2020 out to 2029:

[13] We assume an average sulphur content of 2.76% for HSFO. Blending of 85% MGO and 15% HSFO then leads to 0.5% sulphur content

LNG contains more energy for a given mass than traditional oil based fuels, creating a price differential of 22% when priced against Heavy Fuel OIl (HFO).

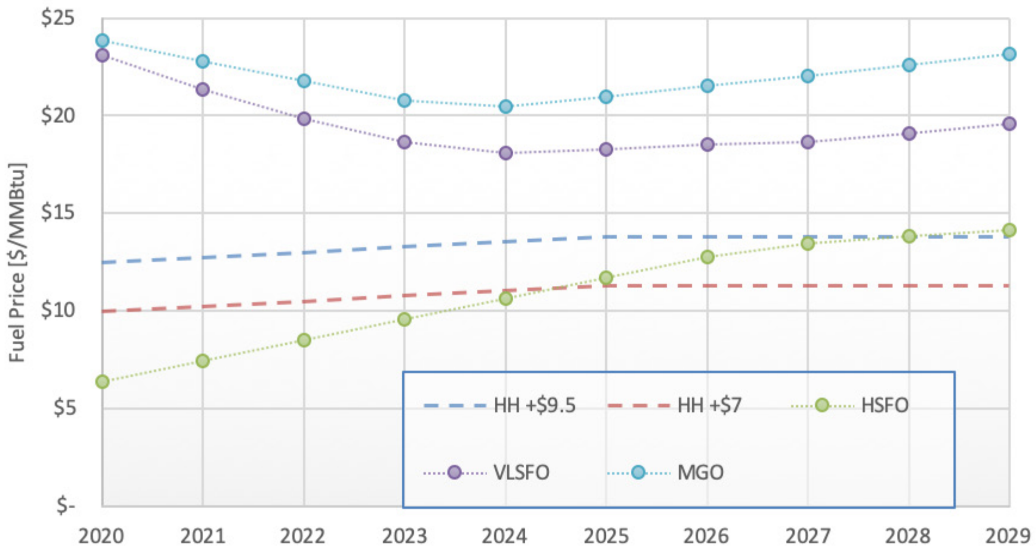
STRANDED FUELS FORECAST - ATLANTIC

Conventional fuels at ARA



STRANDED FUELS FORECAST - PACIFIC

Conventional fuels at USLGB



1. **Stranded Fuels**
   The rationale behind this forecast is that HSFO stocks will become stranded at 2020 due to low penetration of scrubbers. Penetration of scrubbers to grow gradually towards 2027, leading to a gradual recovery of HSFO prices. MGO and distillates will see very high demand in 2020 and price pressure. As LNG and scrubbers increase their penetration and additional refinement capacity comes on-line, MGO prices will level down. VLSFO is initially very tightly coupled to MGO. As new blends are tested and accepted by the market, there is a gradual decoupling. LNG prices will be as in "Liquefaction Tech Improvements" through 2025. After 2025, renewables start to displace LNG for land-based applications, and LNG prices level off.

2. Business as Usual "BAU":
   Relative prices remain as they were as of Q1 2019.

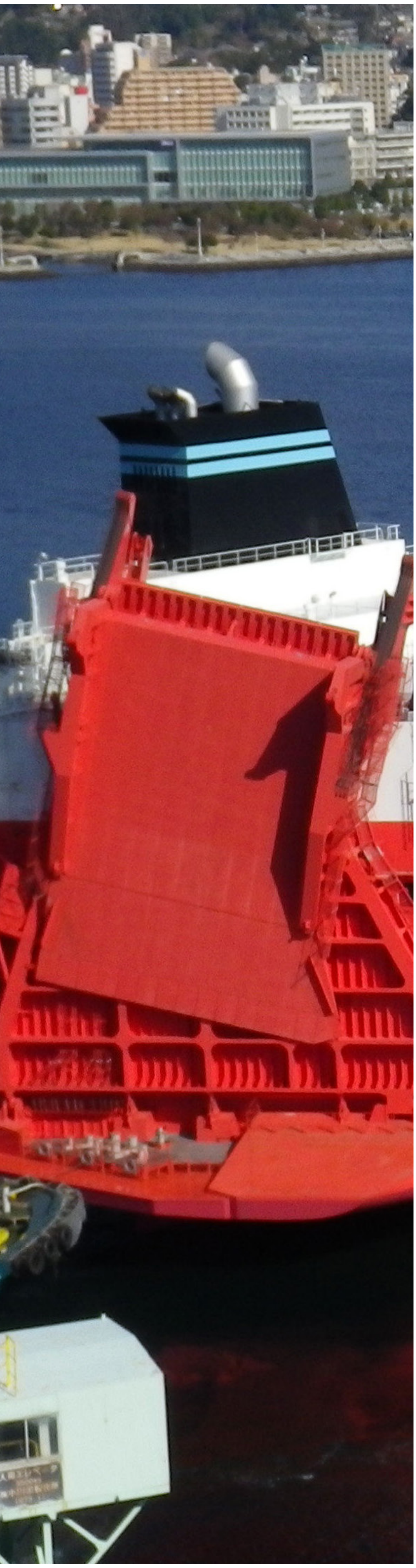
3. Tight Supply for Distillates:
   By 2020 MGO increases in price by 20% relative to Q1 2019 due to high demand for low-sulphur fuels in 2020. HSFO and LNG remain as of Q1 2019.

4. LNG Economies of Scale:
   LNG liquefaction and delivery costs reduced by 20% due to increased adoption and associated economies of scale.

5. LNG Liquefaction Technology Improvements:
   Liquefaction cost reduced by 20% due to technology improvements in small scale liquefaction.

6. Tight MGO, unavailable HSFO, improve LNG:
   MGO increases in price by 20% due to high demand for low sulphur fuels. HSFO goes up in price by 20% because it is no longer widely available. LNG liquefaction and delivery prices decrease by 20% due to economies of scale.

For the scenarios, in forecasts 2-6, prices are modelled to grow with inflation (assumed at 2.5% p.a.) after 2020. Initial oil prices are based on 15 March 2019 data from Ship & Bunker and projected to 2020 using 2.5% inflation.



a) Initial LNG pricing

The study estimates the price of LNG based on Henry Hub prices, set at $2.97/MMBtu based on historical data[14] and project to $3.04 on 1st Jan 2020. To arrive at the final price of LNG, the following additions to the Henry Hub wellhead price are performed:

1. Molecules at Henry Hub are marked up by 15% to $3.50/MMBtu following "Cheniere formula"[15] .
2. Conversion to LHV increases molecule cost by 10% to **$3.85/MMBtu**.
3. Liquefaction cost is estimated at **$3.08/MMBtu**, based on "Sabine Pass" for 2018[16]
4. LNG logistics and bunkering estimated[17] at **$3.08/MMBtu** for 2020

Based on these calculations, the initial price of LNG DES U.S. East Coast is: $3.85 + $3.08 + $3.08 =$10.01/MMBtu. For brevity, and following common practice, the study rounds this figure to $10/MMBtu and refers to this price level as "Henry Hub + $7", or HH+$7.

Opsiana research into marine LNG suppliers in the US East Coast indicated that HH+$7 is balanced, and that the price could be below HH+$6 in some locations. Their research with suppliers on the US West Coast indicated that HH+$7 is also reasonable for the west coast. For ARA (Antwerp-Rotterdam-Amsterdam range), the study set the initial LNG price at Henry Hub +$8 and for Japan, it was set at Henry Hub +$9.5, to account for additional transportation and logistics cost.

[14] Two-year historical median taken on Feb 2019 from the U.S. Energy Information Administration webpage.

[15] Using the approach from "U.S. Natural Gas (LNG) Exports: Opportunities and Challenges".

[16] Based on "LNG-fueled Shipping Outlook, Opportunities & Technologies", Braemar LNG Team. Gas Shipping America, Houston, May 14th, 2018.

[17] Due to the nature of "take or pay" LNG supply contracts in certain markets in Asia, there may be instances where LNG is sold at significantly discounted prices relative to the estimates shown. This effect was not included in the model.

b) **Initial Fuel Prices – North Atlantic Trade**

Fuel Type	ARA	Charleston /Jacksonville	New York /Baltimore
HSFO	$420.5	$483.0	$444.0
VLSFO	$560.3	$645.4	$609.7
MGO	$585.0	$674.0	$639.0

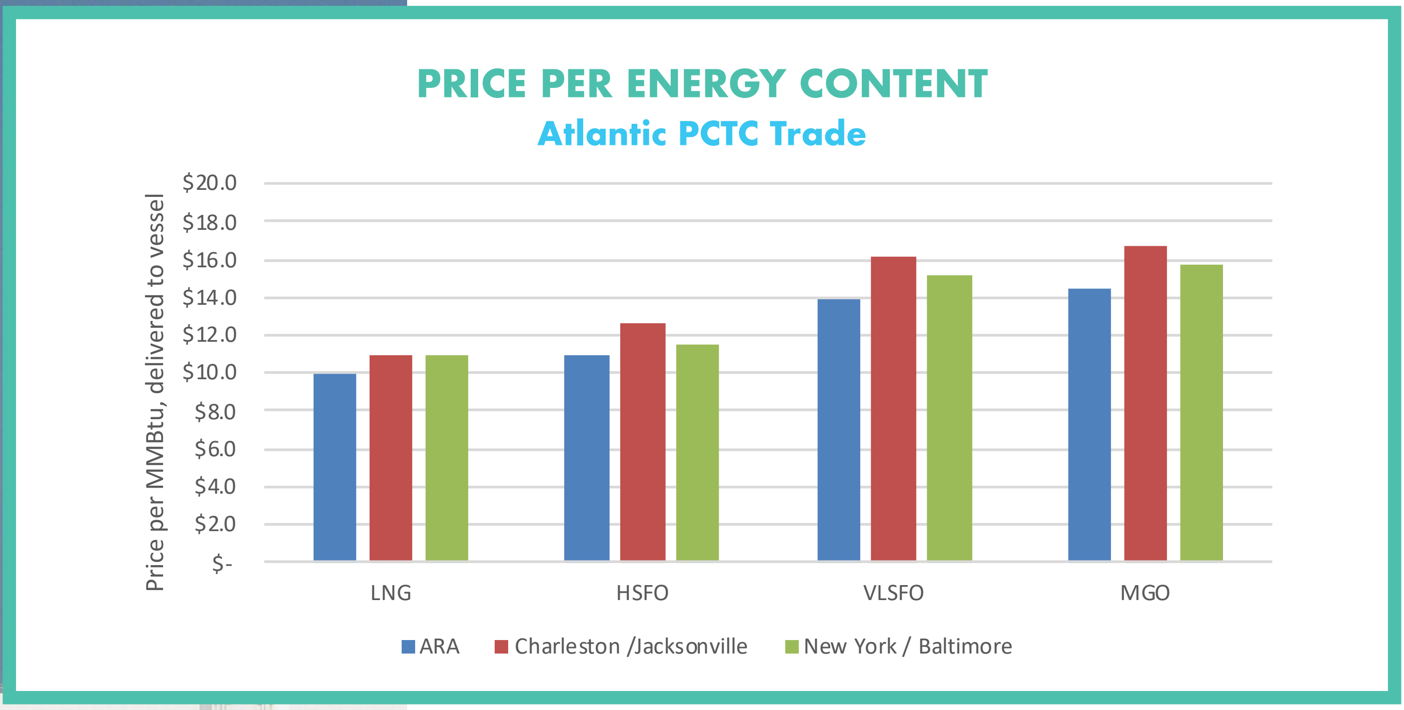
c) **Initial Fuel Prices – Pacific Trade**

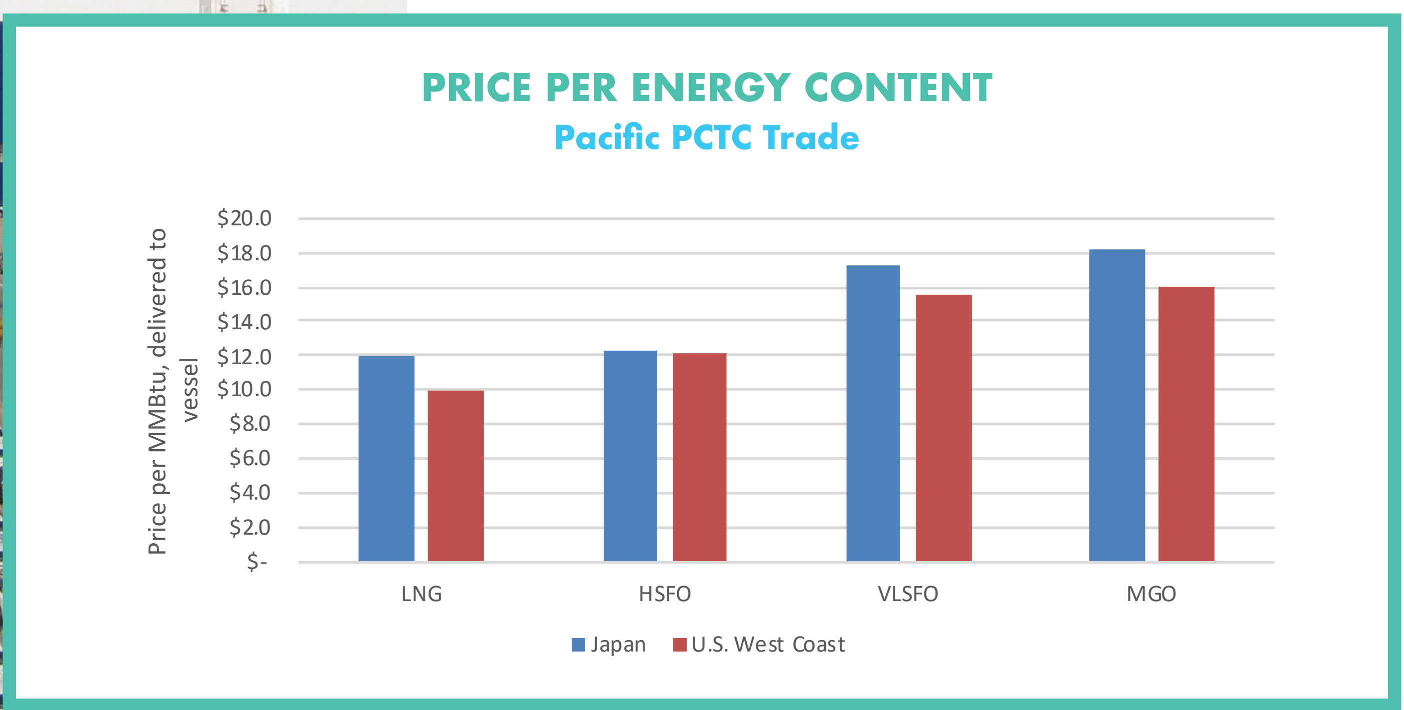
Price variations along the US West Coast are relatively minor for conventional fuels, so the study uses a single price for simplicity.

Fuel Type	Japan	U.S. West Coast
HSFO	$472.0	$464.5
VLSFO	$693.9	$623.0
MGO	$733.0	$651.0

The investment model can be adjusted for other fuel scenarios, should the basis for these forecasts change.

Taken together these fuel cost assumptions result in the following cost on an energy content basis 2020:





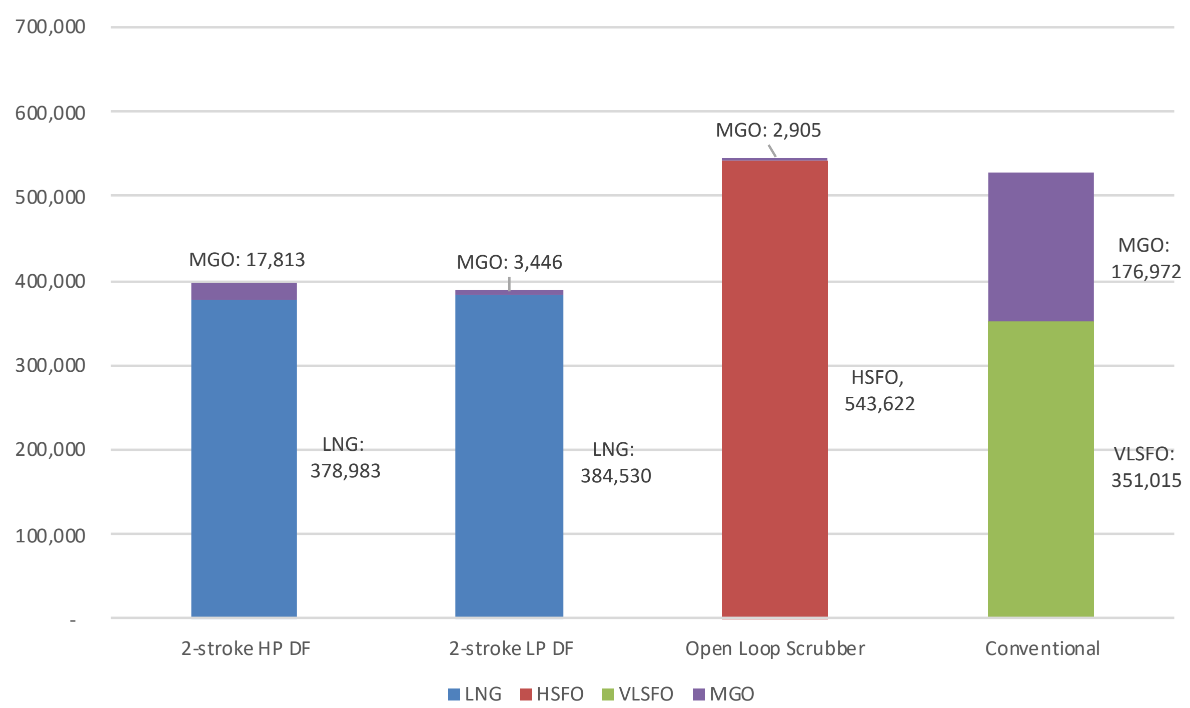
As all of the above fuel forecasts are assumptions, the investment model can be adjusted for other fuel scenarios, should the basis for these forecasts change.

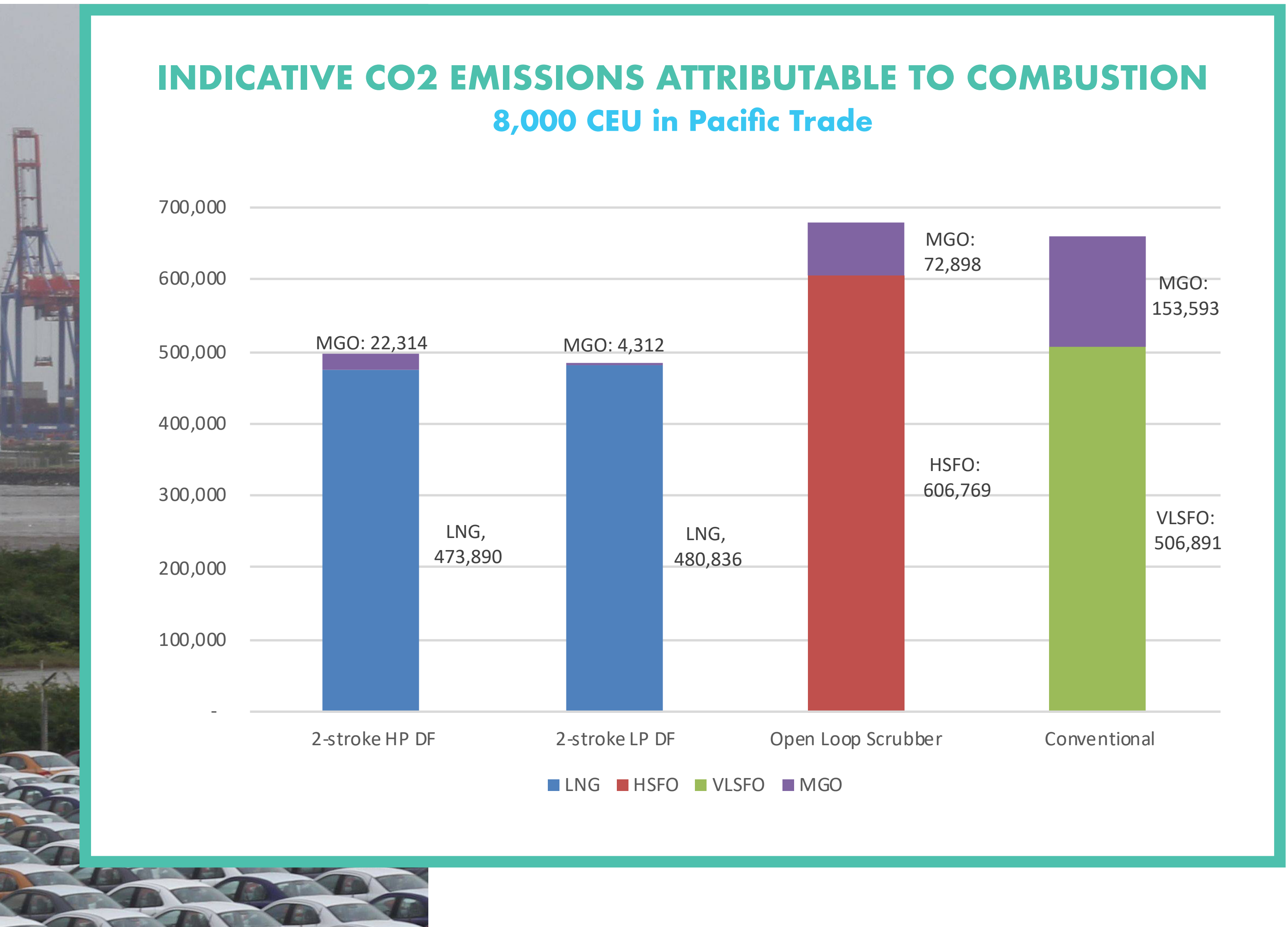
CARBON COSTS

IMO regulations mandate that all vessels record fuel consumption from 1st January 2019. This allows vessel GHG emissions to be calculated and reflects the additional regulatory focus that may follow in coming years to promote GHG emissions/efficiency. The IMO is retaining the information on a vessel type basis providing them with the opportunity to baseline performance. It is considered likely that the IMO or others will set tighter standards on GHG emissions. Such standards are in place already for NOx emissions and individual Energy Efficiency Design Index (EEDI) requirements for newbuildings. The EU has a similar program of CO2 reporting, which began on 1st January 2018 and the values are retained per vessel IMO number. This means each vessel's history is kept specific to it, not homogenised into a vessel category as per the IMO CO2 records.

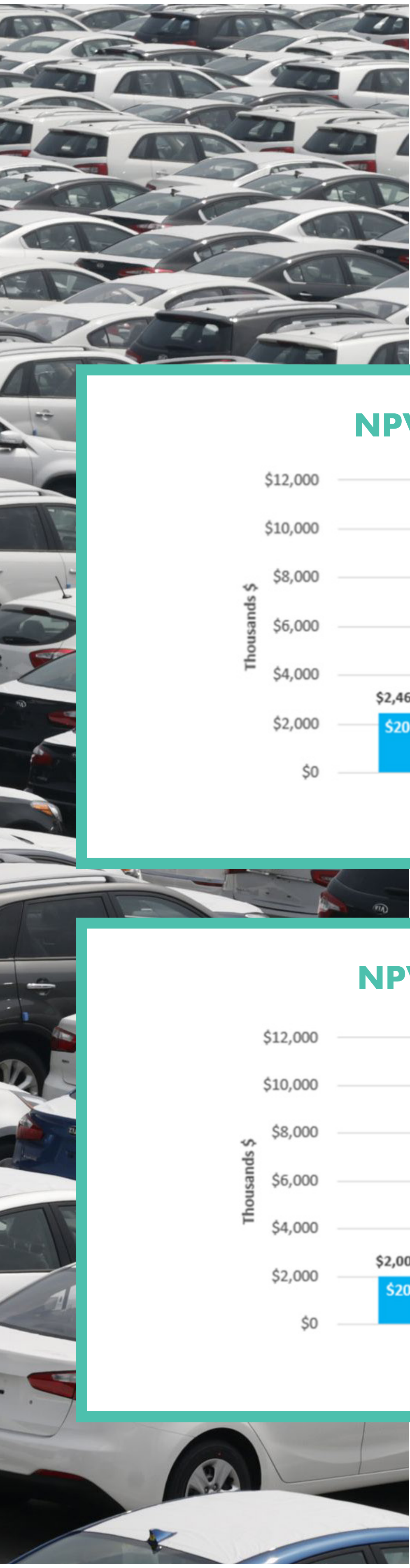
INDICATIVE CO2 EMISSIONS ATTRIBUTABLE TO COMBUSTION

6,500 CEU in Atlantic Trade



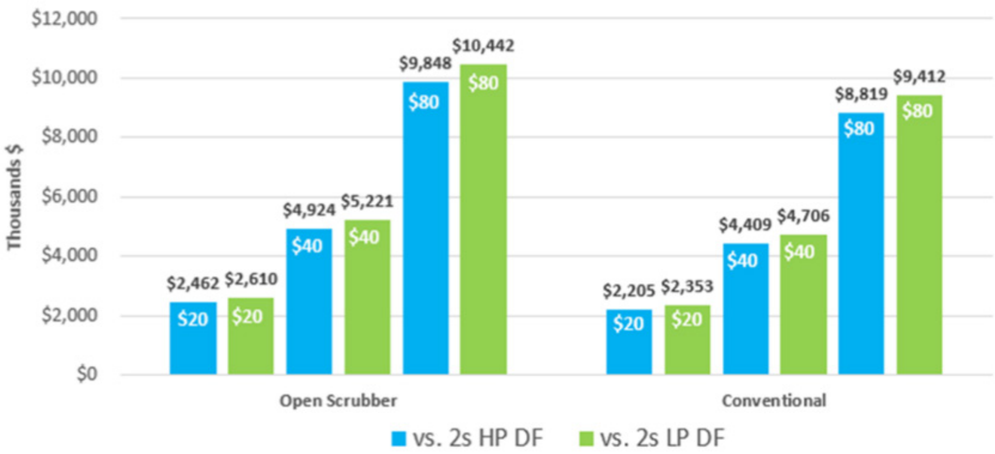


LNG meets and exceeds all current marine fuel compliance requirements for content and emissions, local and GHG - including GHG reductions up to 21% achievable now from LNG compared with current oil-based marine fuels from Well-to-Wake (WtW).

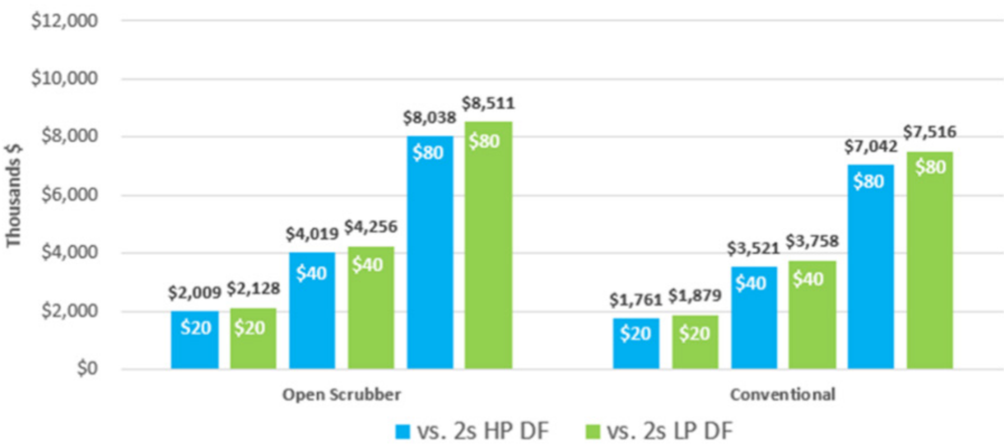


If a carbon value of $40[18] per ton of CO2 emitted is assumed, (as shown in the middle bars below), the NPV investment gains[19] for the 8,000 CEU PCTC fitted with a 2s LP DF engine increase to $5.2M for LNG versus the open loop scrubber (up to $4.7M versus compliant conventional fuel) and slightly less for the 6,500 CEU vessel ($4.3M and $3.8M respectively). The NPV investment gains double as the carbon value doubles to $80 per ton of CO2 (right-hand bars).

NPV CO2 COMPARISON - 8,000 CEU



NPV CO2 COMPARISON - 6,500 CEU



[18] This figure was chosen as it is the same one used by Shell on 19 May 2015 in their 2015 "Response to Shareholder Resolution on Climate Change" document.

[19] Although the HP "diesel-cycle" engine consumes less LNG, due to its pilot fuel consuming more diesel than the LP "Otto-cycle" engine, it produces more CO2.

RESULTS

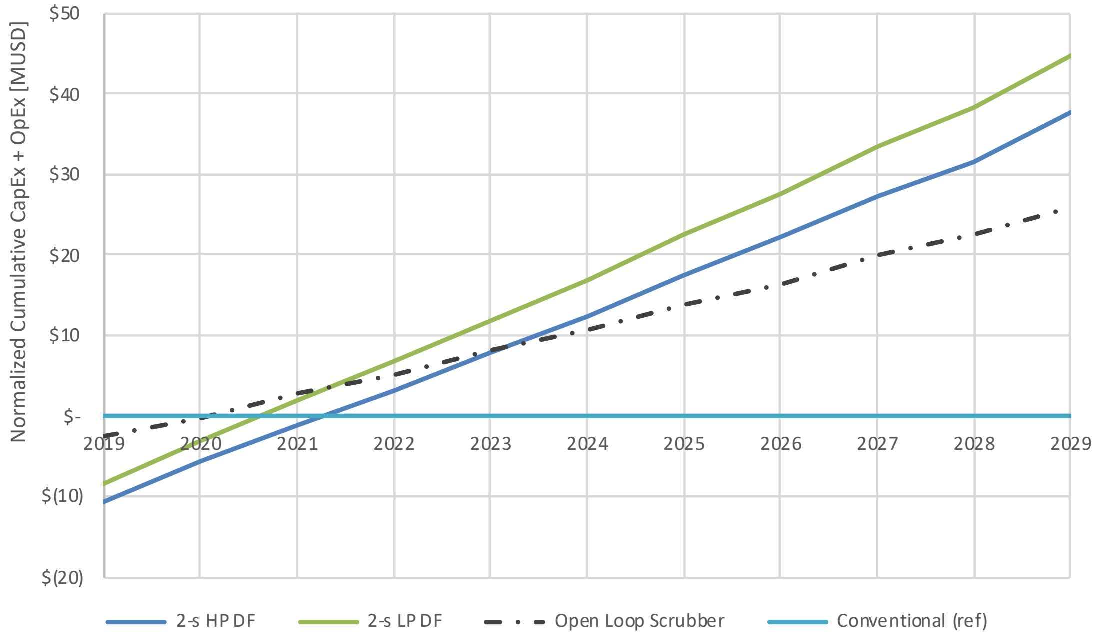
This study clearly indicates that LNG as a marine fuel delivers the best return on investment on a net present value (NPV) basis over a conservative 10-year horizon. The payback periods are fast, ranging from one to three years on the Atlantic Trade and from less-than-one year to two years on the Pacific Trade. LNG also delivers a greater return on investment than open loop scrubbers in all scenarios, except stranded fuels for the 8,000 CEU vessel on the Pacific Trade, and in the majority of scenarios for the 6,500 CEU vessel on the Atlantic Trade. It must be noted that to achieve the returns illustrated in the stranded fuel example scrubbers need to be installed and working at the start of 2020.

Current orders and shipyard capacity mean than any scrubbers ordered now will not be operational until mid-2020, at the earliest. With lower demand for HFO following implementation of the sulphur cap in 2020, the availability of HFO on a global basis is unknown. How many bunker suppliers will keep "dirty" bunker supplies and at what cost? Consequently, any investment decisions taken based on this scenario are deemed high risk.

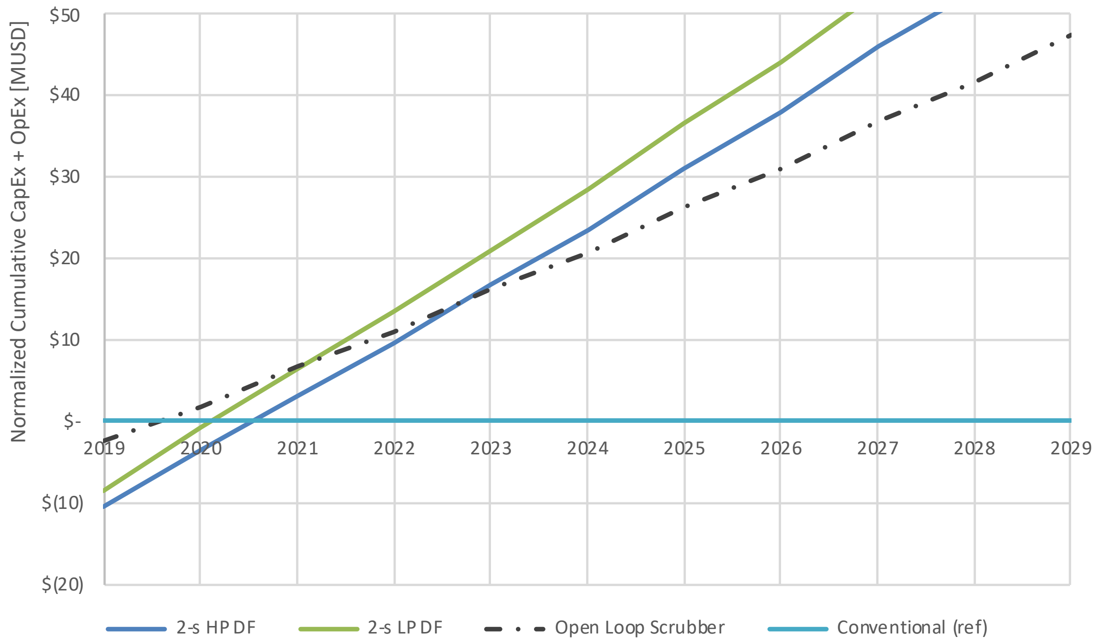
This study clearly indicates that LNG as a marine fuel delivers the best return on investment on a net present value (NPV) basis over a conservative 10-year horizon.

1) Payback scenarios for an 8,000 CEU vessel on the Pacific Trade

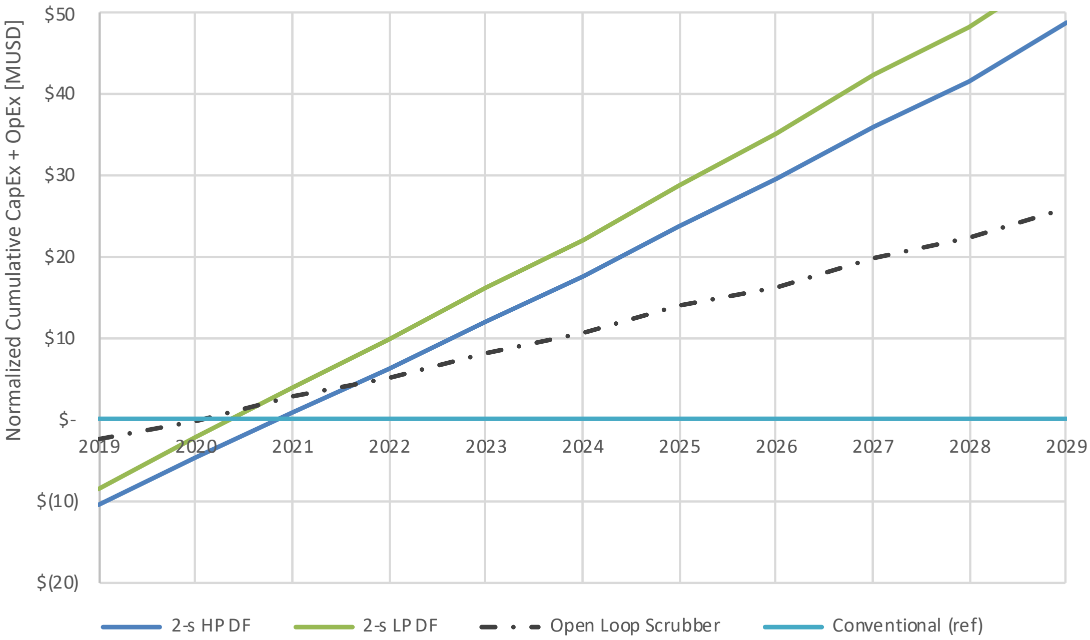
BAU



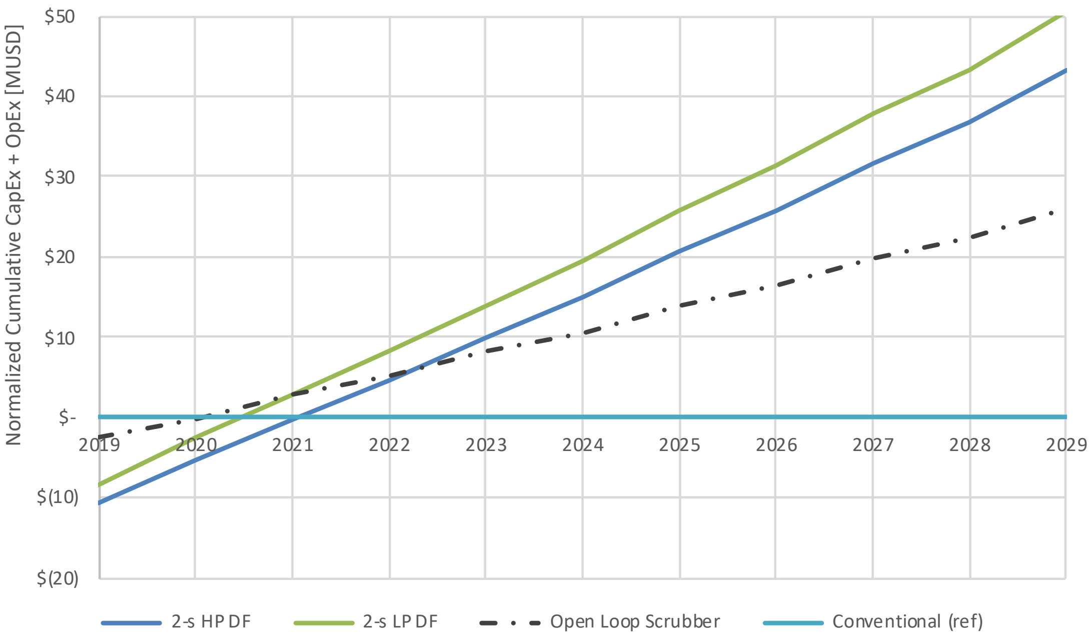
TIGHT SUPPLY FOR DISTILLATES



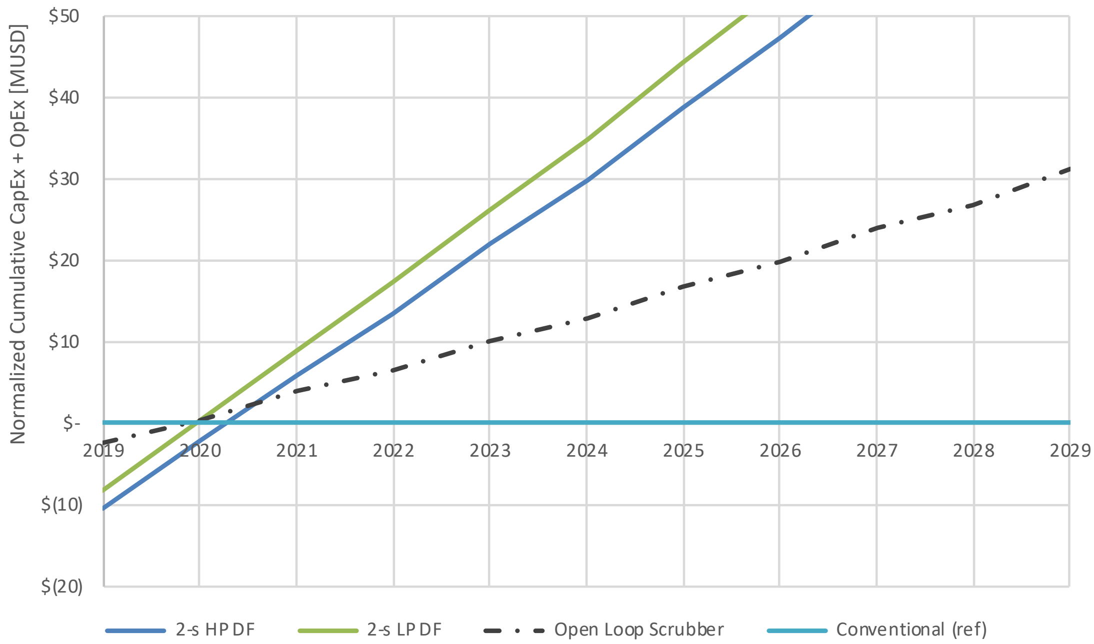
LNG ECONOMIES OF SCALE



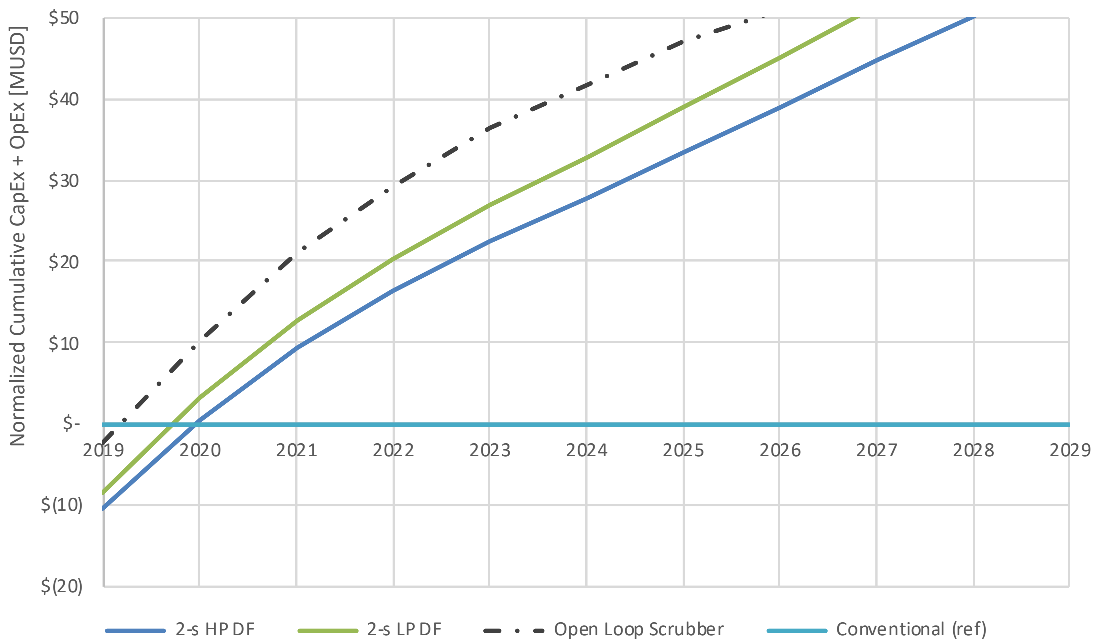
LNG LIQUEFACTION TECH IMPROVEMENTS



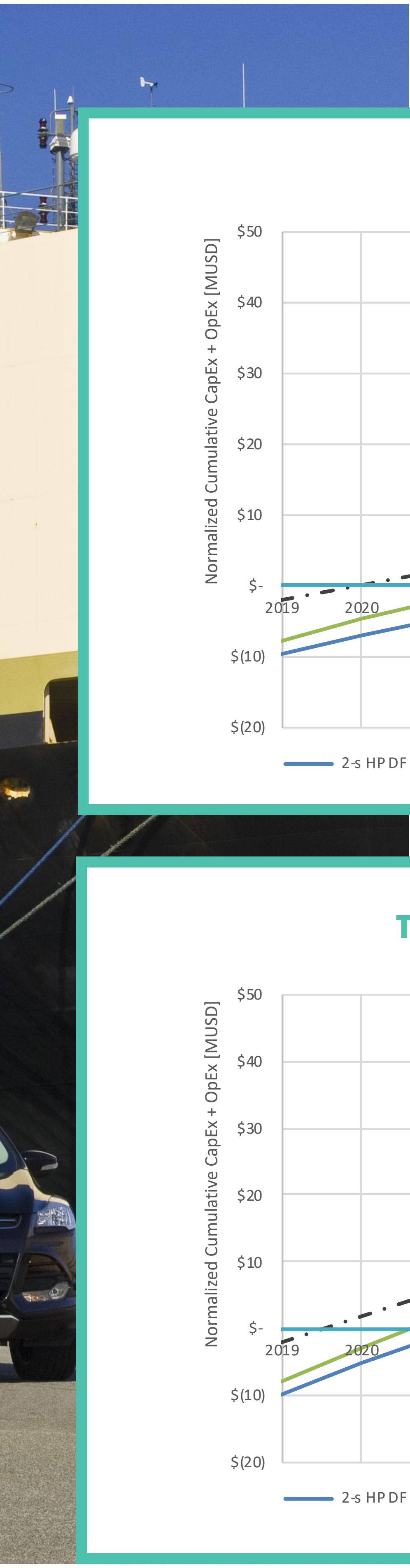
TIGHT MGO UNAVAILABLE HFO IMPROVE LNG



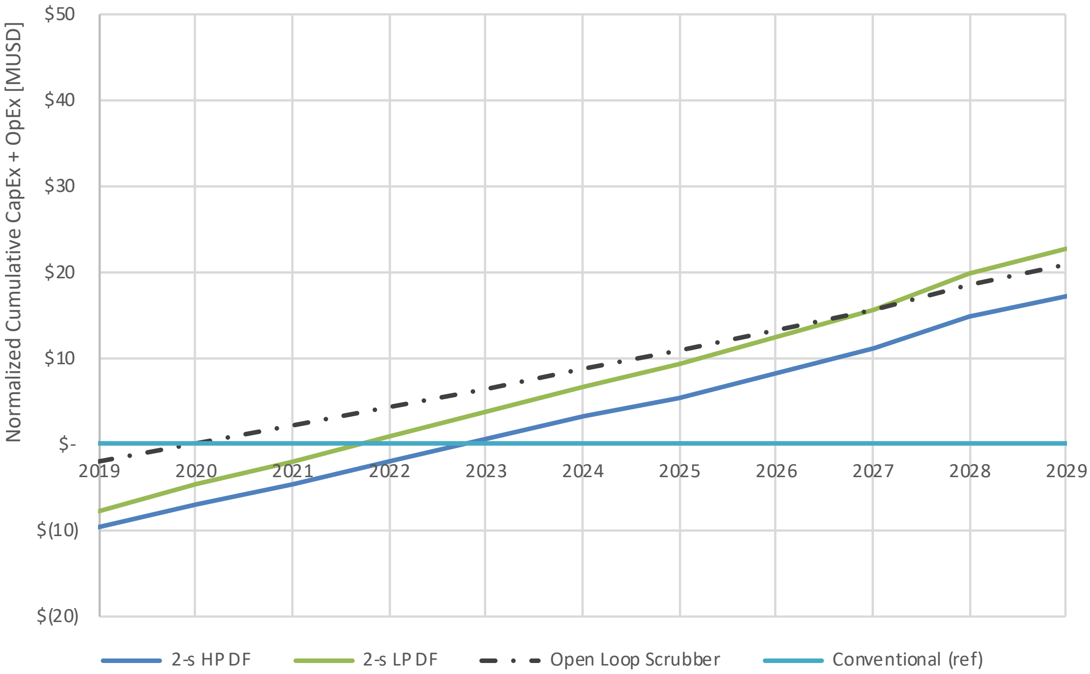
STRANDED FUELS



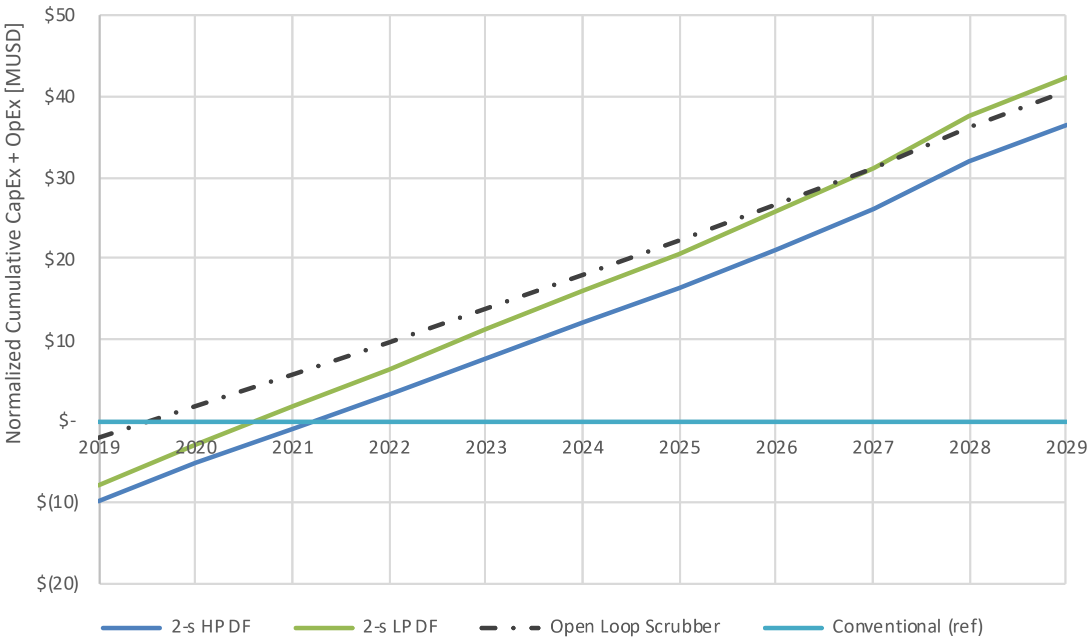
2) Payback scenarios for a 6,500 CEU vessel on the Atlantic Trade



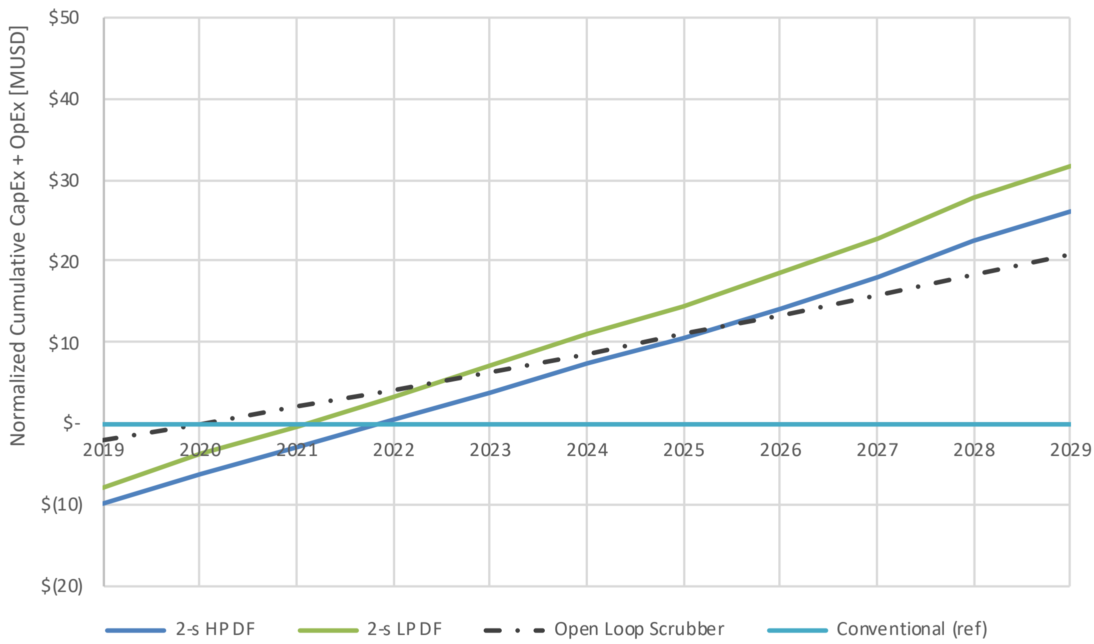
BAU



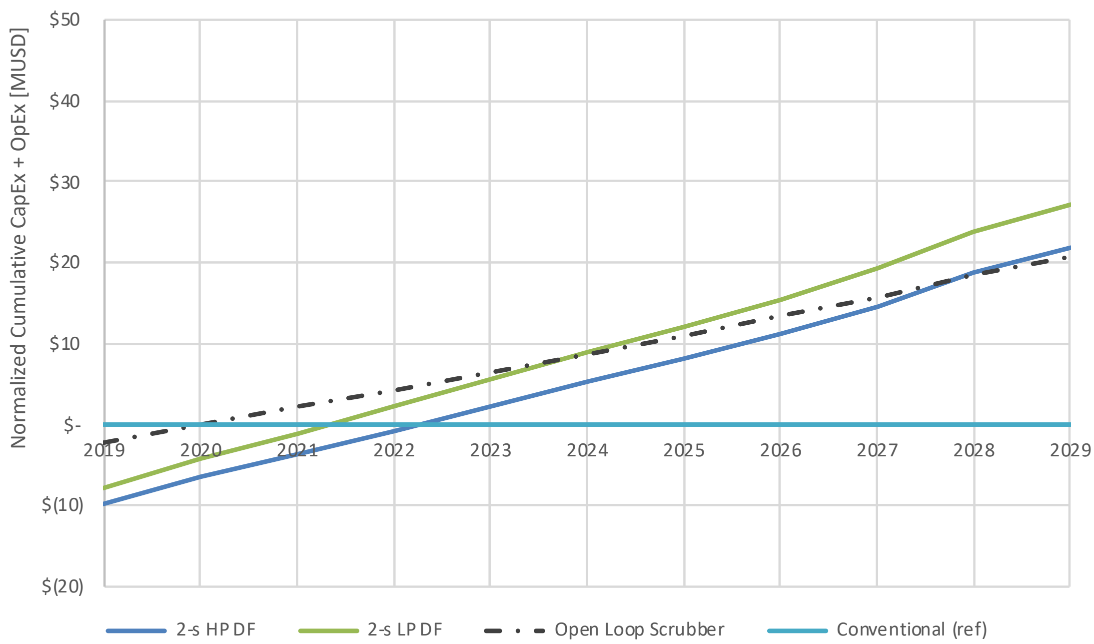
TIGHT SUPPLY FOR DISTILLATES



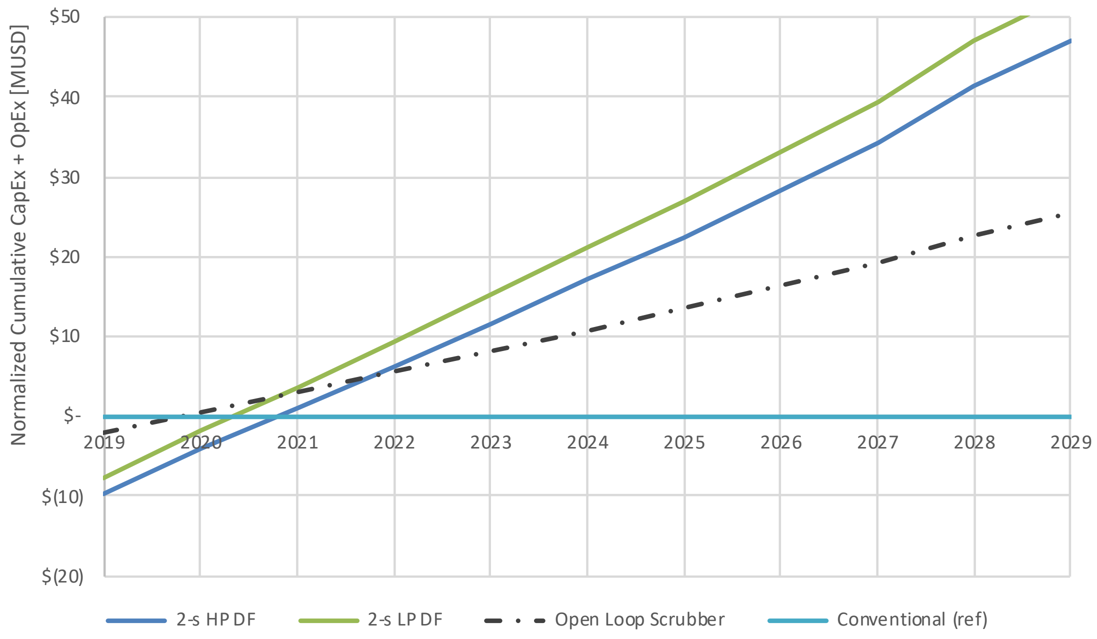
LNG ECONOMIES OF SCALE



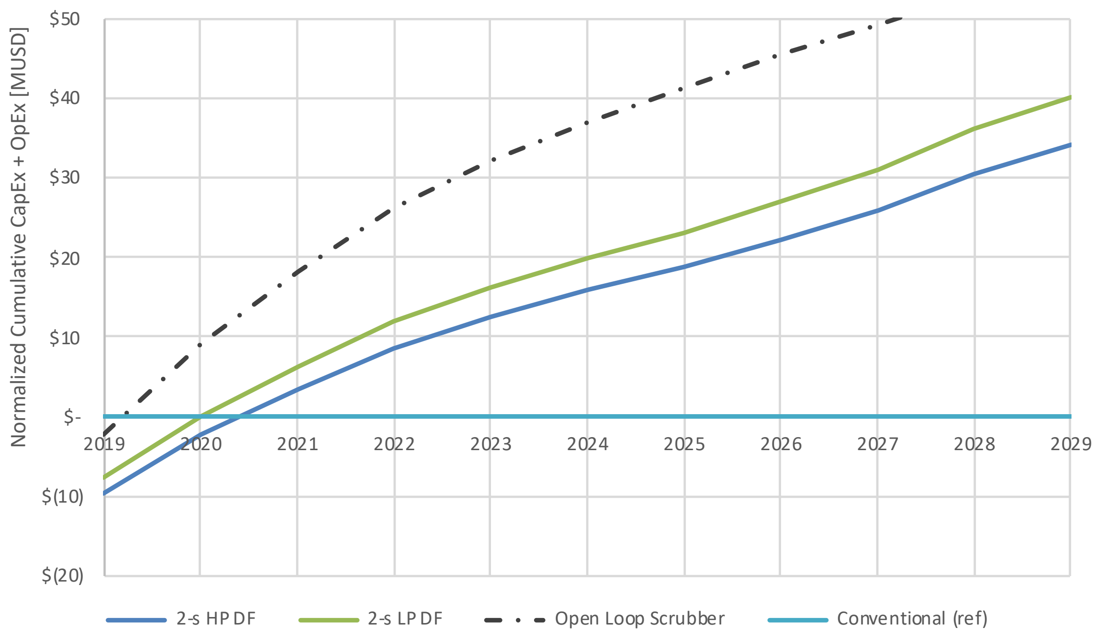
LNG LIQUEFACTION TECH IMPROVEMENTS



TIGHT MGO UNAVAILABLE HFO IMPROVE LNG

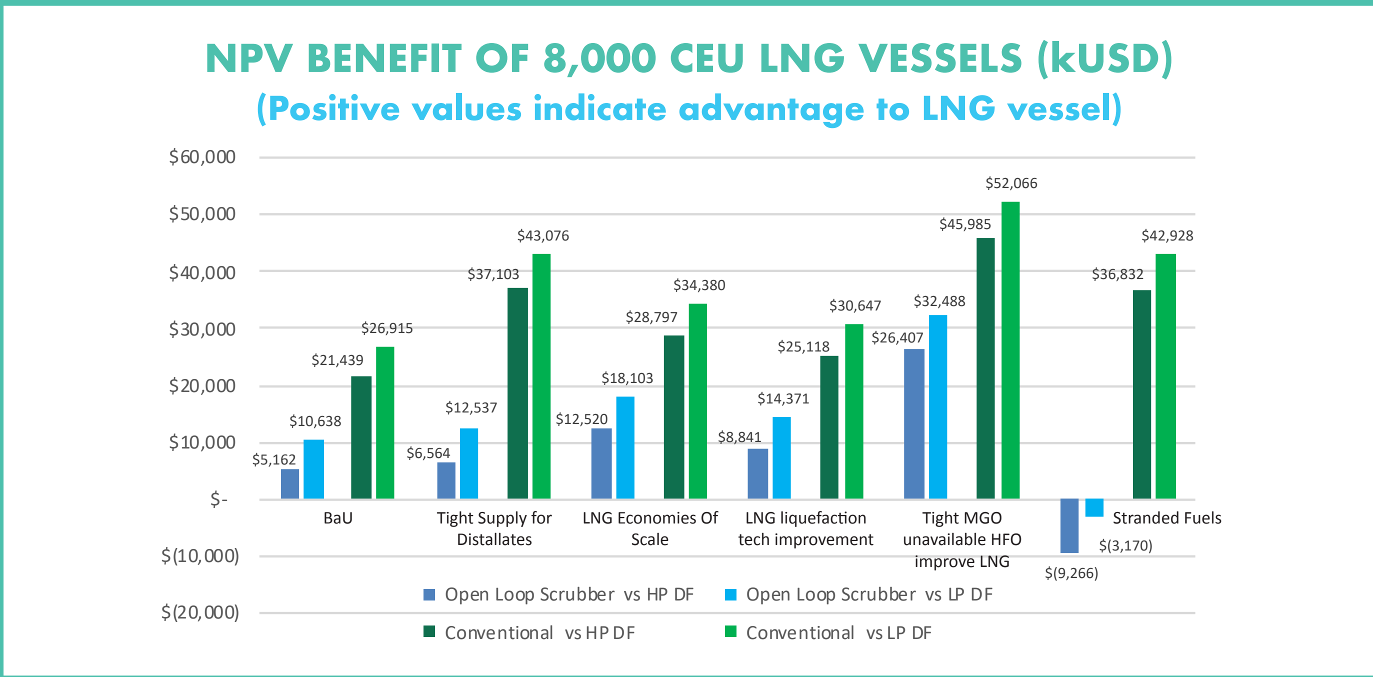


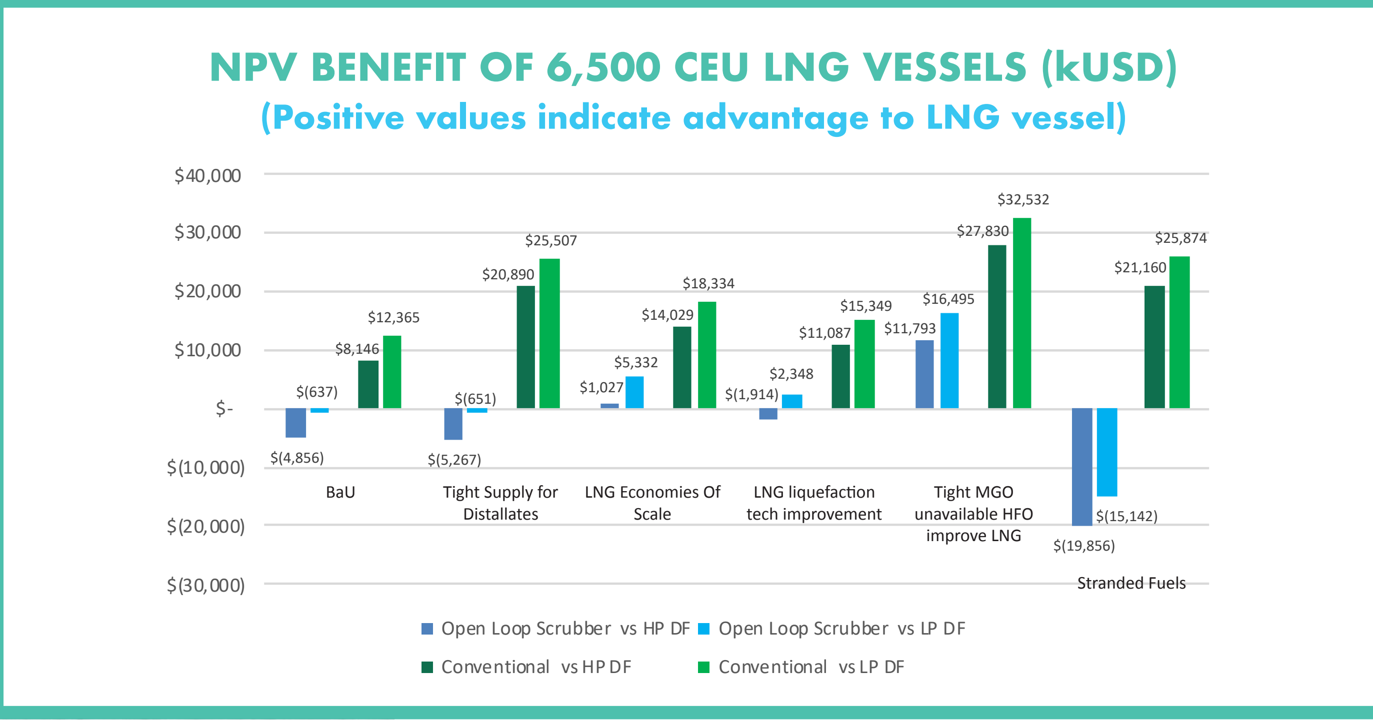
STRANDED FUELS



Net Present Value benefit for LNG on both 8,000 and 6,500 CEU vessels

Comparison of the NPV of each engine option together with their relevant fuels clearly shows the economic benefits of choosing LNG as a marine fuel. The two graphs below show the NPV benefit for the Pacific and Atlantic Trades, highlighting the fact that LNG delivers better return on both Trades. There is no consideration of carbon pricing is included in these figures.

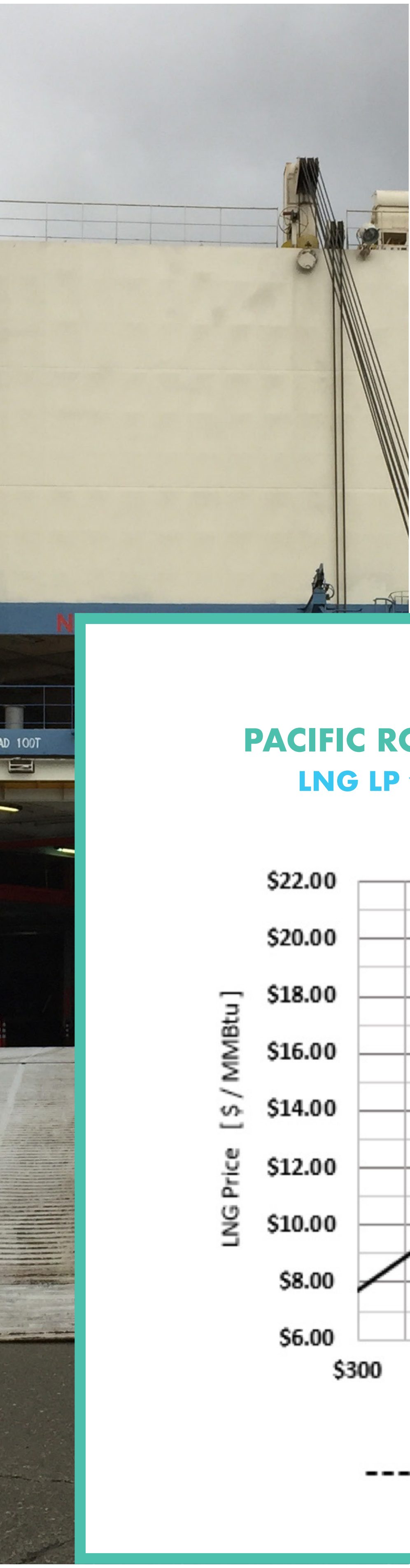




Net Present Value represents the increase in wealth accruing from an investment. The PCTC business case evaluates alternatives for the lowest out of pocket cost, while incorporating both a recapture fee for CAPEX expenditure and the discounted time value of money Present Value of OPEX. The results for the Pacific Trade 8,000 CEU vessel show LNG fuel employing Dual Fuel engines provide compelling Net Present Value Savings versus a scrubber ranging from $5.1M to $32.5M across the majority (5 of 6) fuel scenarios. LNG fuel delivers less value than scrubbers for the Pacific Trade in only one case: the Stranded Fuels scenario which results in negative savings of ($3.1M) to ($9.3M). The Net Present Value Savings for DF alternatives overwhelm conventional low sulphur fuels and surges across all 6 fuel forecasts toward tens of millions Net Present Value ranging from $21.4M to $52.1M for the 8,000 CEU vessel.

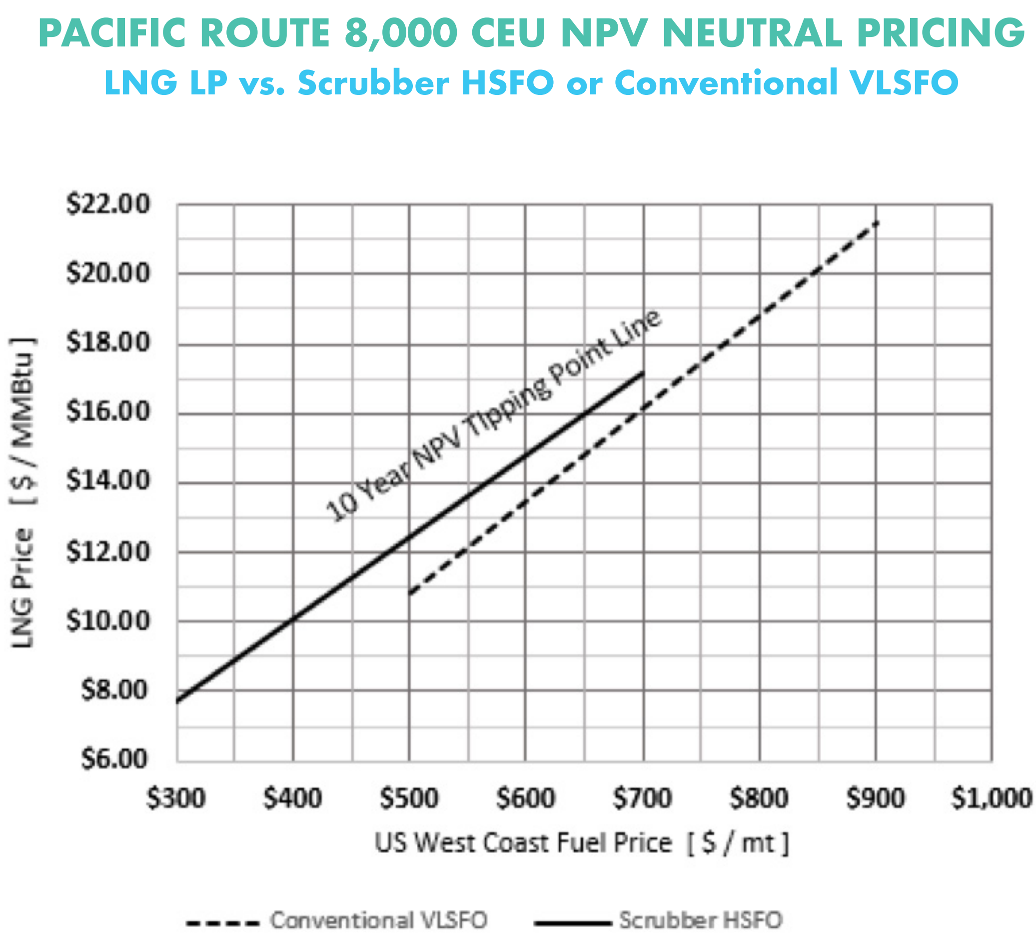
The Atlantic Trade 6,500 CEU vessel returns also demonstrate strong Net Present Value savings with ranges from negative ($5.3M) to plus $16.5M for LNG engines vs scrubbers. The stranded fuels scenario results in negative savings of ($15.1M) to ($19.9M). Compared with very low sulphur conventional fuels this Atlantic Trade vessel delivers robust Net Present Value savings of $8.1M to $32.5M. It is interesting to note that LNG alternatives win big as expected on the Pacific Trade with a large vessel and high fuel consumption yet sustain a substantial win on the Atlantic Trade with a smaller vessel consuming less fuel.

LNG alternatives win big on the Pacific Trade with a large vessel and high fuel consumption, and sustain a substantial win on the Atlantic Trade with a smaller vessel consuming less fuel.



Readers Choice Fuel Forecasts for 8,000 and 6,500 CEU vessels

For a given vessel on a trade route, a perspective-seeking reader may ask: "If one fuel price is X what is the tipping point for the alternative fuel price Y for the business case to be neutral on NPV?" The "reader's choice" sensitivity plot for the Business as Usual "BAU" case provides additional insights. The chart below illustrates the fuel price tipping points resulting in the same business case outcomes for the 8,000 CEU vessel on the Pacific trade bunkering US West Coast. The tipping point is represented by the straight diagonal line labelled "10-year NPV Tipping Point Line" with a solid-line for LNG 2s LP DF versus conventional HSFO + scrubber, and the dotted-line for LNG 2s LP DF versus conventional LSFO.



Example: For an assumed scrubber vessel consuming HSFO priced at 500$/mt, what is the LNG tipping point price that produces matching NPV outcomes (with all Business Case parameters: 10-year horizon, WACC 8%, etc...), or more formally stated where the alternatives become investment neutral? For the 8,000 CEU vessel on the Pacific route – LNG versus scrubber fitted vessel: entering the graph on the horizontal axis for US West Coast bunkers provided @$500/mt HSFO, this route achieves the same business NPV result (a neutral outcome) at an LNG price of $12.40 /MMBtu as shown on the vertical axis. The LNG vessel outperforms the vessel sailing with a scrubber on HSFO when LNG prices are below $12.40/MMBtu and vice versa: it underperforms when LNG is above this break-even price indication.

Utilizing the same vessel-route-bunkering point, it is possible to compare the tipping-point the LNG versus conventional vessel consuming VLSFO. The reader may proceed as in the above example beginning with VLSFO on the horizontal axis or utilizing the graph in reverse starting with LNG price on the vertical axis. Assuming the LNG price of 14.00 $/MMBtu; the reader enters the chart vertical axis, finding VLSFO @ 619$/mt is the tipping point where the business case is the same "neutral investment decision outcome". As before, VLSFO is the preferred investment option when priced below 619 $/mt for the assumed LNG price and conversely falls out of investment favour when above this point. Note, the neutrality line for the conventional alternative can be seen to have shifted and has a different slope to that of the scrubber business case owing to a different mix of CAPEX and OPEX values.

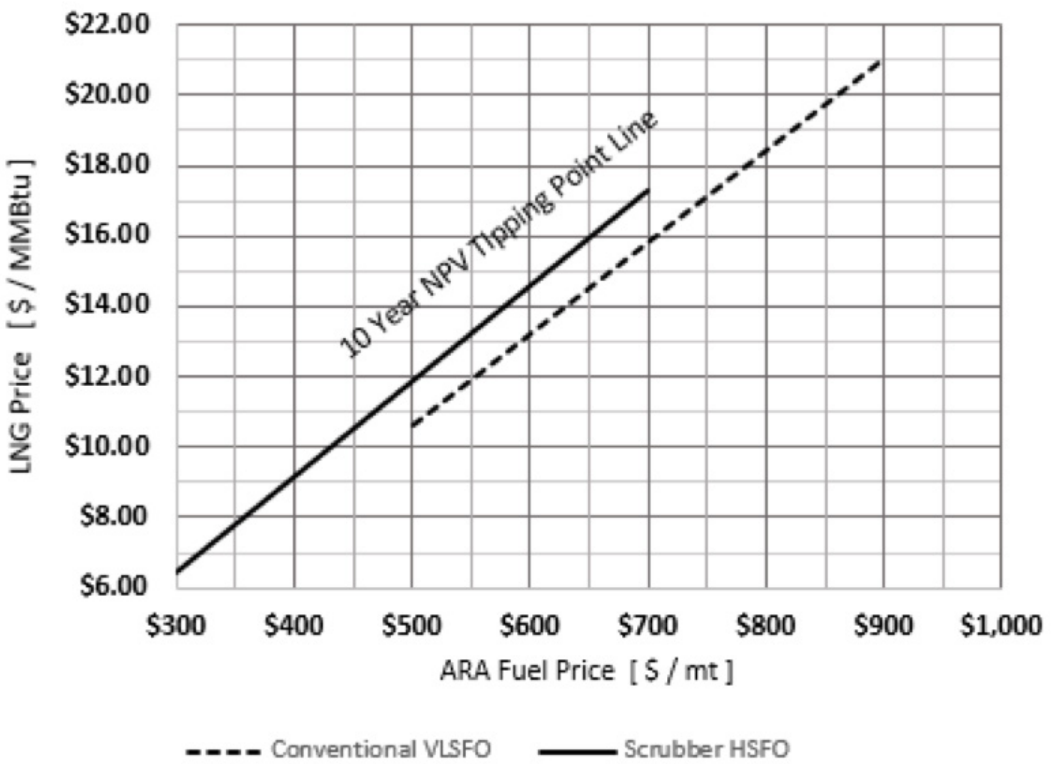
The results are intuitive when examining the two alternatives against the LNG fuel vessel. For a given LNG fuel price point, the incremental added CAPEX required for the scrubber fitted HSFO vessel as compared to the minimal CAPEX VLSFO alternative, requires the scrubber vessel fuel price tipping point be lower than VLSFO. Atop this fundamental is the general consensus that the scrubber fitted vessel burns a lower cost HSFO whereas the conventional vessel consuming VLSFO encounters a fuel price

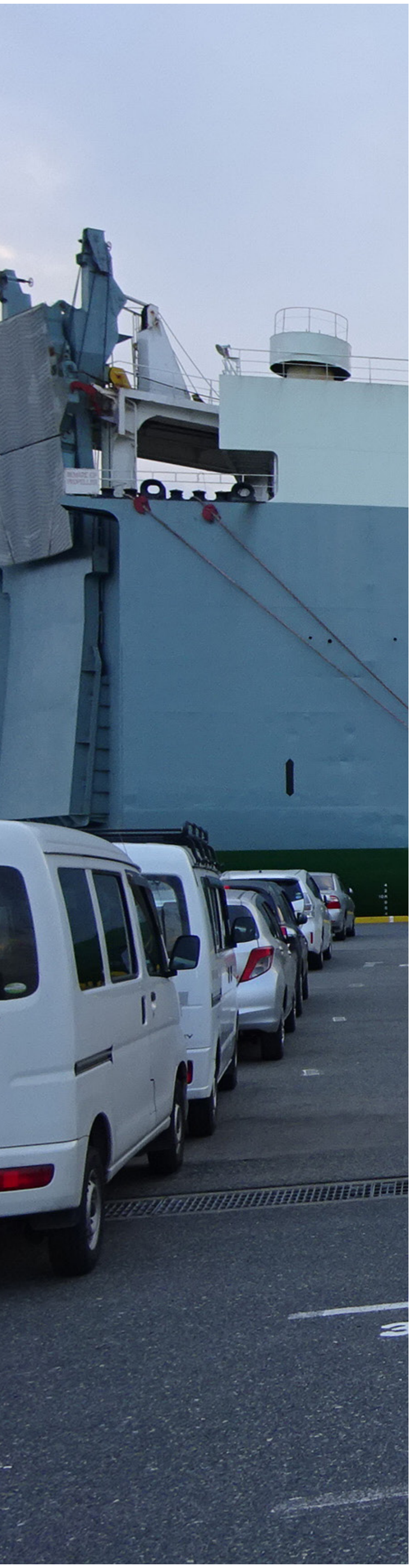
premium. The reader can judge for themselves which pricing level and forecast suits their view of the future. In both cases, the neutral line provides insights as to relationships amongst alternatives for the 8,000 CEU vessel on the Pacific route.

The next chart illustrates the fuel price tipping points resulting in neutral business case outcomes for the 6,500 CEU vessel on the North Atlantic bunkering in ARA. As before, the tipping point provides a "reader's choice" generating perspectives about business case sensitivity to fuel pricing. Note that the business case Pacific plots are slightly different than that of the North Atlantic trade whose smaller vessel and route profiles encountered a different mix of CAPEX and OPEX values.

NORTH ATLANTIC ROUTE 6,500 CEU NPV NEUTRAL PRICING

LNG LP vs. Scrubber HSFO or Conventional VLSFO





WAY FORWARD

With the IMO's 1st January 2020 0.5% global cap on heavy fuel sulphur content around six months away, the shipping industry's focus this year will continue to be on marine fuel. As 2020 looms, there is growing consensus that LNG is the best solution for today and into the future, certainly towards 2050. There are no real viable alternative safe solutions that can match LNG's emissions profile and scalability. Further, because of the growth of LNG infrastructure worldwide, the concerns about supply of LNG to the maritime community are being effectively addressed.

While there remain many unanswered questions about the choice and prices of marine fuels going into 2020, SEA\LNG will continue its commercially focused studies to provide authoritative intelligence regarding the investment case for LNG as a marine fuel for shipowners, shipyards, ports and wider stakeholders. SEA\LNG is repeating this independent research modelling to study the investment cases for common ships in typical trades. These will include:

- dry bulk Capesize vessel,
- very large crude carrier (VLCC) and
- companion to supplement SEA\LNG's first 14,000 TEU Containership study for Asia-USWC first published in January 2019 and available at www.sea-lng.org here: https://sea-lng.org/wp-content/uploads/2019/01/190123_SEALNG_InvestmentCase_DESIGN_FINAL.pdf

As the months progress we expect to see an acceleration in decision making in favour of LNG due to three key factors: economics, environmental pressures and evolution.

Economically, this study has shown LNG as a marine fuel to be the best option for a large 8,000 CEU PCTC vessel in the Pacific Trade as well as a 6,500 CEU vessel on the Atlantic Trade. While there will need to be a portfolio of marine fuel options for existing vessels within a corporate fleet, the direction of legislation affecting marine fuel and the advancement of technology and expanding infrastructure to support LNG mean the advantages of

LNG will increase significantly over time.

Environmentally, LNG is the only practical industry wide marine fuel readily available today and in the foreseeable future that provides a positive and compelling solution to power ocean shipping and advance the environmental standards - reducing pollutant particulates, noxious nitrogen and sulphur oxides and GHG emissions. So, while IMO 2030 and IMO 2050 seek reductions in carbon intensity of at least 40% by 2030 and towards 70% by 2050 necessitating a move in marine fuel to non-fossil fuels, LNG will be a long-term solution for multiple vessel life cycles.

Additionally, the climate effects of GHG emissions are cumulative - **CO2 is not simply a flow problem but it is also a stock problem.** Therefore, the CO2 challenge becomes much greater as accruals continue with today's carbon intensive fuels. If no action is taken NOW while some await future carbon-free alternative fuels, the problem only intensifies. Inaction today will result in an even greater reduction challenge to overcome tomorrow. Moving aggressively towards LNG today reduces the magnitude of future challenges and is the right thing to do now for air quality, global health plus GHG concerns.

Evolutionary, The world continues to evolve, and environmental consciousness is now no longer a movement, but instead a reality. There is growing demand from the ultimate customers for shipping goods, the consumers of the world, that products are not only sourced but also transported in more environmentally sustainable ways. LNG as a marine fuel provides a positive choice for shipowners, not just in terms of reducing pollution but also in demonstrating to their customers that they are continuing to make positive strategic changes in business practices which match the demands of the world's consumers.

The economic, environmental and evolutionary realities of global transportation are demanding changes and LNG can and does satisfy the demand for cleaner air and GHG reductions.

LNG is the only commercially viable marine fuel alternative available at scale today which is successfully able to address the shipping industry's air quality and greenhouse gas (GHG) emissions reduction objectives.

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