SEA\LNG

LNG AS A MARINE FUEL – THE INVESTMENT OPPORTUNITY

SEA-LNG STUDY - NEWBUILD 210K DWT ORE CARRIER (CAPESIZE) SAILING FROM AUSTRALIA TO CHINA

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 pragmatic pathway to a zero-emissions shipping industry.

To support shipowners and operators in analysing options in an informed way and providing a deeper analysis of the assumptions that go into the 2020 decision process, SEA-LNG is commissioning a series of independent studies by simulation and analytics experts Opsiana. This CAPESIZE study is the fourth in a series preceded by a 14,000 TEU container vessel operating on the Asia-US West Coast liner route, a dual study examining an 8,000 CEU Pure Car and Truck Carrier (PCTC) on the Pacific and smaller 6,500 CEU on the Atlantic Trade Lanes, and a 300K DWT VLCC running Arabian Gulf to Asia. To ensure the best possible data was available to Opsiana, SEA-LNG members contributed maritime expertise and timely background information to ensure a high level of creditability in the study and results. The business case compares the relative investment performance of four propulsion alternatives for a CAPESIZE: a conventional sailing with Very Low Sulphur Fuel Oil (VLSFO); a conventional equipped with Advanced Air Quality Systems (more commonly known as Exhaust Gas Cleaning Systems (EGCS) or scrubbers) sailing mostly with Heavy Fuel Oil (HSFO); and two LNG powered vessels, including high-pressure (HP) and low-pressure (LP) 2-stroke (2s) engine variants.

This CAPESIZE study clearly indicates that LNG as a marine fuel delivers a strong return on investment on a net present value (NPV) basis over a conservative 10-year horizon. The analysis is bolstered by compelling paybacks from two to four years for the 210K DWT CAPESIZE trading from Australia to China.

This route was chosen because it is the major ore trade corridor from Australia to China. 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, the potential characteristic advantages in operations and technology between differing LNG engines are not explored in this study.

The investment returns were calculated within traditional frameworks without including the significant extra benefits and branding value gained by choosing LNG as a more environmentally friendly marine

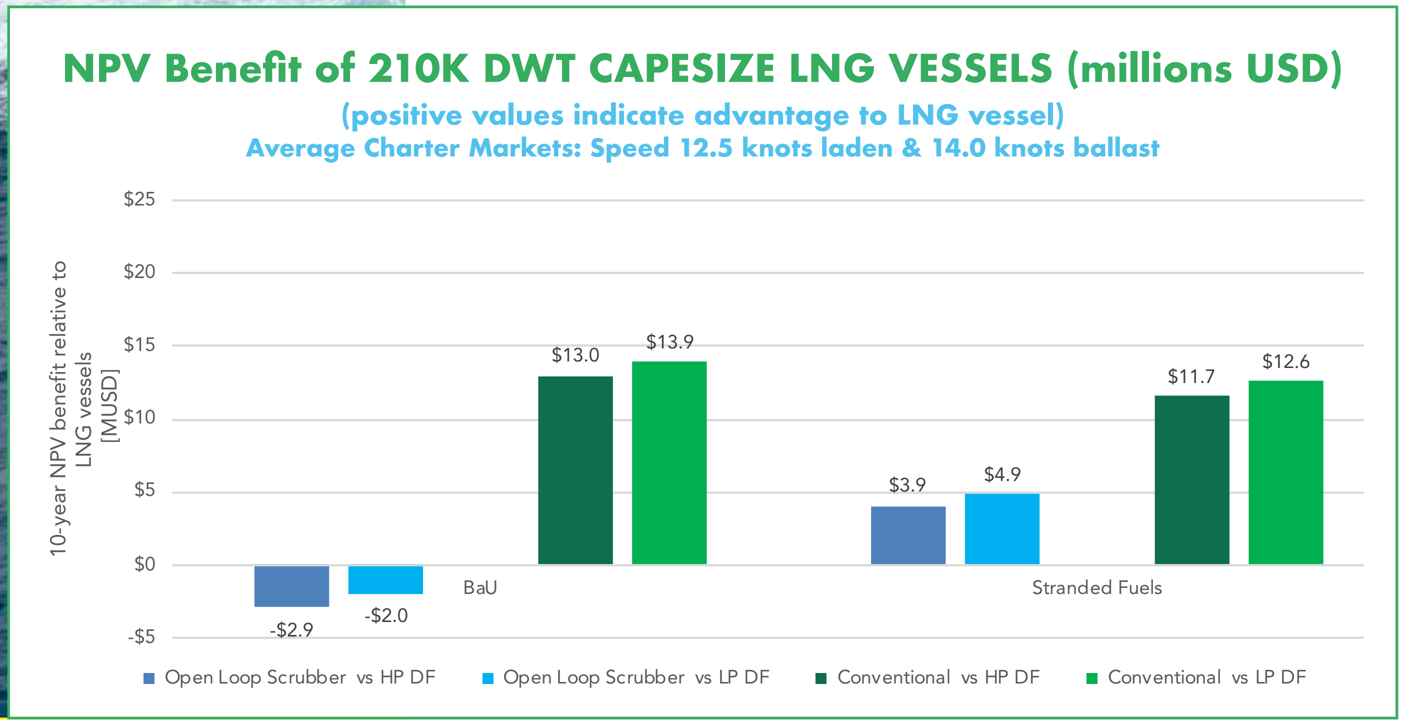
[1] This is derived from the NPV gain of millions of dollars for one vessel being multiplied up for the global fleet.

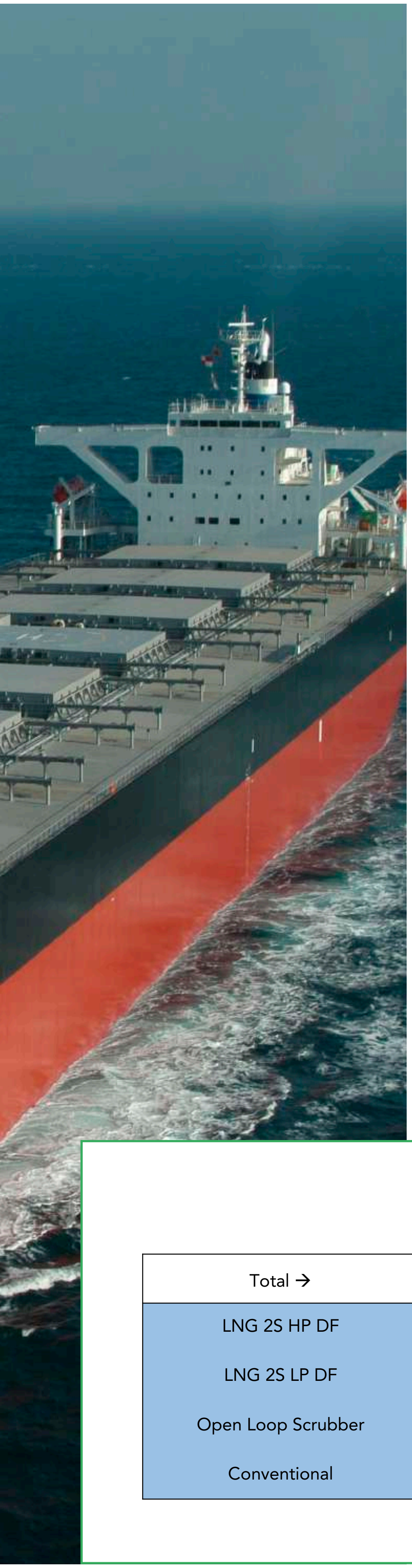
fuel, which could be worth hundreds of millions of dollars[1] across the global CAPESIZE fleet. Consumers and industrial firms are demanding action from energy suppliers to address environmental sustainability goals. Recent actions by the European Union (EU) and International Maritime Organization (IMO) demonstrate the implementation of these goals with requirements for monitoring, reporting and verification of vessel fuel consumption which allows tracking of CO2 emissions. Should CO2 emission levels be assessed to have a financial value in the future, then LNG's low carbon footprint compared to traditional fuels will enhance its competitive financial advantage.

Overall, 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 superior return of several million dollars on investment than conventional compliant fuels across all fuel scenarios investigated; business as usual (BaU), plus stranded fuels, for three time charter markets (ECO, Average, Strong). LNG only trails behind the open-loop scrubber in the BaU cases while providing strong wealth gains for stranded fuels in all charter markets. Although to achieve the returns illustrated for the scrubber in business as usual or stranded fuels forecasts, shipowners would take on several risks surrounding HSFO future availability, pricing savings, future regulatory restrictions, and additional potential technical performance plus operational responsibilities.





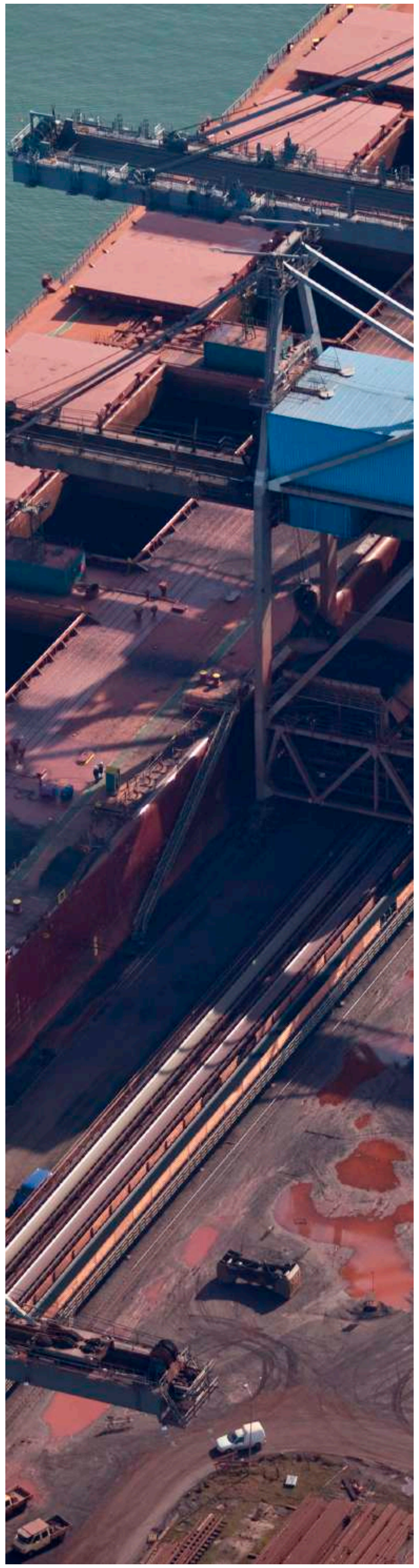
The results for the 210K DWT CAPESIZE show that LNG fuel employing DF engines provide compelling NPV savings for average charter market speeds versus compliant fuel ranging from $11.7 million(M) to $13.9M across the fuel scenarios. LNG fuel investment results show mixed outcomes versus scrubbers. For the BaU forecasts LNG trails behind scrubbers with a negative result ($2.0M to $2.9M) and conversely generates strong positive investment gains ($3.9M to $4.9M) for Stranded Fuels forecasts. The BaU forecast has HSFO beginning 2020 with a slow inflationary rise over the next decade whereas the Stranded fuels has HSFO rising more rapidly as the refinery supply and market demand rebalances. (see sections on Stranded Fuels and BaU forecast for details.)

The stranded fuel scenario A assumes that the price of HSFO as demonstrated during January 2020 will remain discounted and rise over the coming years. If this occurs, it is only likely to be until existing stocks of HSFO are exhausted, at which point the price will normalise at a level not yet known, due to the low level of demand from vessels with scrubbers across the global fleet and the added costs for bunker suppli-ers 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, recently reported shipyard prices signal substantially smaller LNG premiums above traditional vessels. LNG newbuilding experience and technology improvements have led to shipyard and other efficiency gains. These, together with current shipyard market conditions, continue to favour buyers of newbuildings. Competition between LNG DF technology solutions is likely to reduce CAPEX further as well as improving GHG emissions performance.

	LNG 2S HP DF	LNG 2S LP DF	Open Loop Scrubber	Conventional
Total →	$ 20,614,364	$ 18,132,200	$ 11,794,225	$ 9,093,921
LNG 2S HP DF	$ -	$ (2,482,165)	$ (8,820,139)	$ (11,520,443)
LNG 2S LP DF	$ 2,482,165	$ -	$ (6,337,975)	$ (9,038,278)
Open Loop Scrubber	$ 8,820,139	$ 6,337,975	$ -	$ (2,700,304)
Conventional	$ 11,520,443	$ 9,038,278	$ 2,700,304	$ -



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 HSFO 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 HSFO only provides 40.5GJ/ton on a Lower Heating Value (LHV) basis. Therefore, 2,000 tons of LNG provides the same amount of energy as 2,436 tonnes HSFO. This study highlights the positive effect this additional energy availability from LNG has on investment.

4. Enhanced Environmental Performance

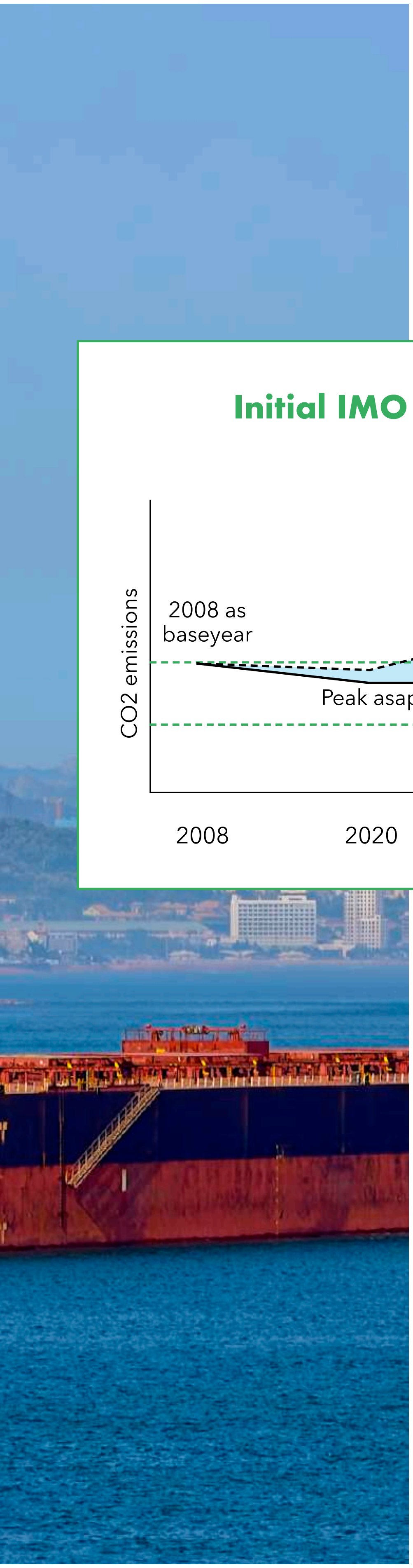
Energy suppliers are paying increasing attention to reducing their carbon footprint, demanding cleaner logistics chains in reaction to both tighter regulations, and the environmental climate. Environmental impacts are known to be of growing importance amongst leading charterers who as beneficial cargo owners give greater cargo volume preference 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 compliance requirements for marine fuel content and emissions, which includes local and GHG. A recent independent study[2] by thinkstep showed GHG reductions of up to 21% are achievable now from LNG as a marine fuel, compared with current heavy oil-based marine fuels over the entire life-cycle from Well-to-Wake (WtW). Fossil fuel LNG is a bridging fuel towards bio or synthetic methane, all of which are fully interchangeable and would utilise existing investments in LNG and LNG infrastructure. Further, blends of fossil-fuel LNG with bio or synthetic methane provide improved environmental performance today. For example, a blend of only 20% biomethane can reduce CO2 emissions by a further 13% compared with 100% fossil fuel LNG.

The thinkstep 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, emissions of nitrogen oxides (NOx) are reduced by 85% with LNG fuel.

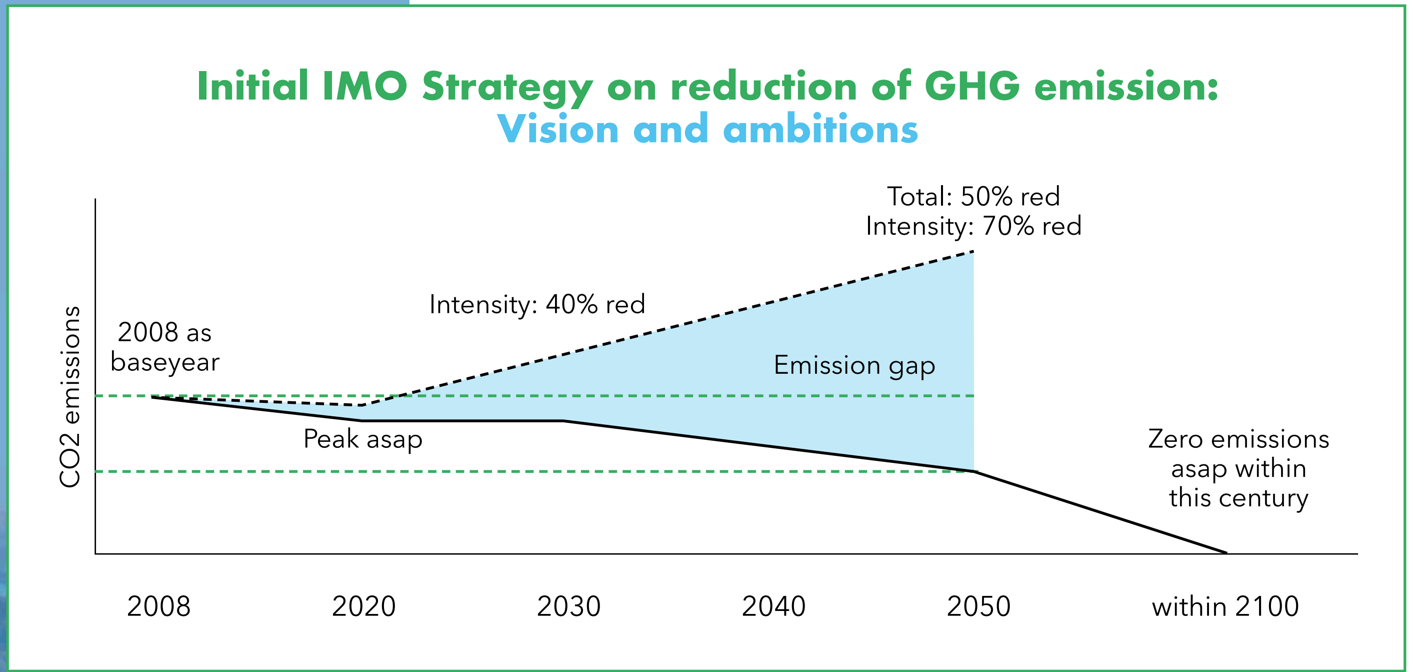
Improving regional air quality and human health is particularly important in busy ports and coastal areas where high population concentrations exist. There is increased societal and regulatory focus on reducing GHG emissions, and this should be planned for when investing in new vessels.

[2] thinkstep's 11 April 19 report - "Life Cycle GHG Emission Study on the use of LNG as Marine Fuel" https://www.thinkstep.com/content/life-cycle-ghg-emission-study-use-lng-marine-fuel-1



As the cleanest fuel available in the quantities currently required by shipping around the globe, LNG provides a "future proof" compliance choice for shipowners with present and planned emission requirements.

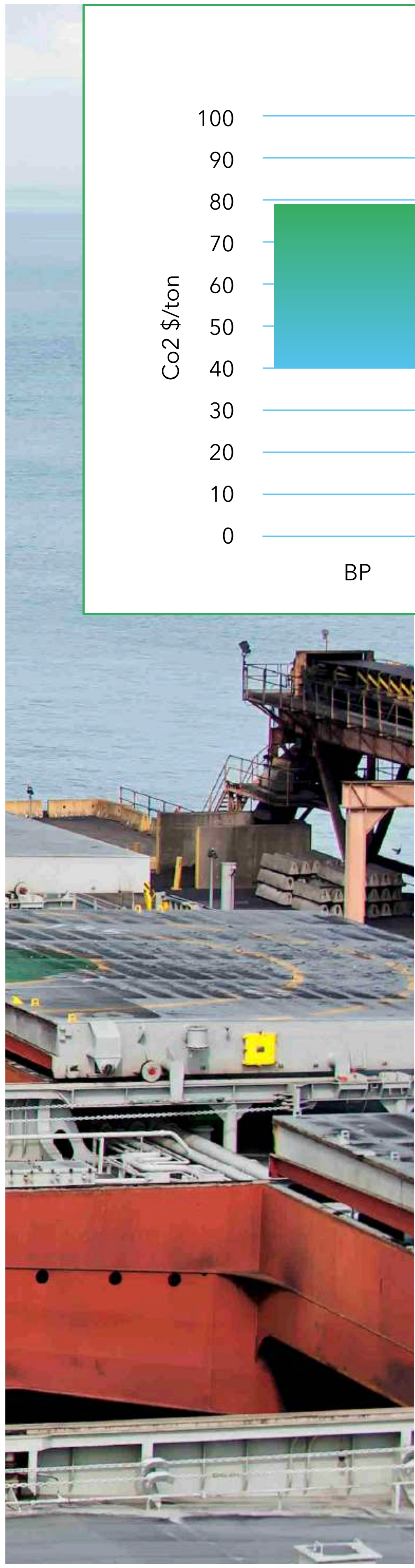
Current fuel use monitoring regulations facilitate measurement of emissions and the means to enforce reductions in local air pollution and GHG emissions towards the IMO goals of total fleetwide 50% GHG reduction by 2050 compared to 2008 base year.

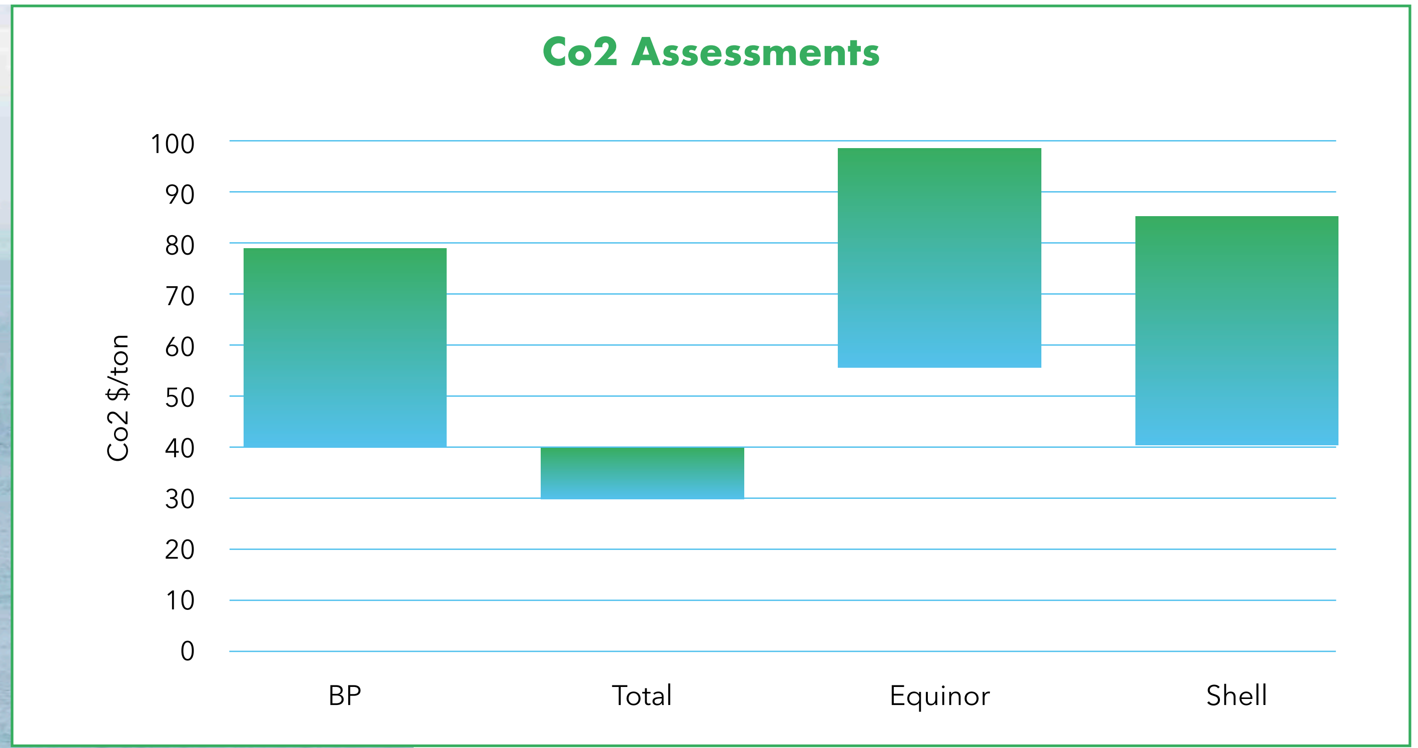


This study highlights the additional impact of imposed carbon emissions assessments. If $40[3] per tonne of CO2 emitted is assumed, the net investment benefit for the 210K DWT CAPESIZE fitted with a 2s LP DF engine provides a NPV wealth increase for LNG of $3.4M[4] versus the open-loop scrubber and $2.9M versus compliant conventional fuel. These Net Present Value (NPV) investment gains will double as the carbon value doubles to $80 per ton of CO2.

Several leading energy companies have established within sustainability regimes a carbon price value assessment. A representative sample of these firms demonstrate a range of values for each from $30 per CO2 ton to more than $85.

[3] This figure was chosen as it is the same one used for investment analysis by BP (https://www.bp.com/content/dam/bp-country/fr_ch/PDF/bp-sustainability-report-2018.pdf)
Total uses $30-$40 (https://www.total.com/sites/default/files/atoms/files/total_rapport_climat_2019_en.pdf)
Equinor at least $50 (https://www.equinor.com/content/dam/statoil/image/how-and-why/climate/climate-roadmap-2018-digital.pdf)
Shell up to $85 (https://reports.shell.com/sustainability-report/2018/servicepages/downloads/files/shell_sustainability_report_2018.pdf).
[4] NPV of the annual CO2 savings occurring over the 10 year investment horizon discounted at WACC less 2% reflects environmental benefit requirements (8% - 2% = 6%).





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 than conventional compliant fuels across Strong, Average, and ECO charter markets with NPV wealth gains of several million dollars. This study shows LNG fuel provides a lower return on investment for CAPESIZEs than the installation of scrubbers in the BaU fuel forecast with plunging HSFO pricing[5] that with assumed prices exhibiting a slow inflationary recovery LNG generates strong returns against the scrubber in the stranded fuels scenario where the rebalancing of HSFO demand with refinery supply forecast has prices recovering quickly during the decade. Indeed, as demand for HSFO has dropped substantially since January with advent of 2020, the BaU price levels fell during 2020 Q1, approaching that of the 2020 stranded fuel forecast plunge levels.

While the case for scrubbers may appear marginally more favourable, the traditional business model excludes any impacts of CO2 assessments, perhaps a risky approach considering the drive to reduce GHG in shipping. There may be CO2 credit or debit schemes in the future. If these CO2 regimes are enacted, then the LNG business return for NPV improves favourably by several million dollars. This scenario is explored by the model in later sections.

Although this stranded fuels scenario is possible and analysed as such, it is deemed unlikely due to the growing, but relatively modest number of scrubbers ordered and contracted for fitting (upwards of 3,898 vessels)

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

in time to take advantage of the expected initial 2020 plunge in HSFO pricing[6]. Some tankers have deferred scheduled scrubber installations to capture strong spot market opportunities during Q4 of 2019 and other owners are finding scrubber schedules slipping due to cornonavirus disruptions at Chinese shipyards[7]. The business case anticipates a CAPESIZE ordered now is delivered in 2022 which will miss the first two years of favourable low HSFO prices. A shorter opportunity window conveys much greater risk for the scrubber alternative dependent on sustained low HSFO pricing as the energy market and refineries make adjustments toward substantially lower volumes as Total announced mid- February 2020[8]. This market realignment imposes greater price, quantity, and availability risks borne by the scrubber alternative that likely erase initial price benefits over the long term.

6. Scrubber Operation is Significantly More Expensive than Widely Reported

Despite the additional CAPEX for LNG over an open-loop scrubber solution of $8.8M, LNG fuel's OPEX cost savings balance out the CAPEX premium. Although the study assumed a conservative scrubber parasitic fuel penalty of only 1% for supplementary operations, 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 a growing number of areas have imposed restrictions on discharge into the sea[9]. Where open-loop scrubbers are restricted, the additional OPEX cost for consuming costly Marine Gas Oil or the increased CAPEX for more complex hybrid/closed-loop Scrubbers must be added to the scrubber investment analysis.

7. The Cost of LNG is Stable

LNG marine fuel exhibits lower price volatility than traditional oil-based marine fuels because of the contribution difference from the underlying commodity to the total overall cost. The LNG cost structure is insulated from wild swings since the underlying commodity - natural gas, as variable cost represents a minor contribution (about 25%) in stark contrast to traditional marine fuels where total cost reflects the heavy dominance of fluctuating energy prices. Consequently, LNG pricing is much more stable than traditional maritime fuels which reflect the volatility of crude oil prices. Natural gas commodity prices have exhibited little fluctuation over recent history due to the steadily expanding global supply, which when combined with stable fixed costs for liquefaction and transportation allows LNG fuel to be contracted on a long term basis. Long term LNG fuel price certainty provides a competitive advantage to those

[6] "IMO 2020 Update, Successes, and Challenges" Quaim Choudhury Sr. Principal Engineer ABS, SNAME Great Lakes and Great Rivers Section Meeting 13 February 2020.
[7] "China virus may cause delays of anti-pollution equipment retrofits on ships" Reuters, 31 January, 2020; https://www.reuters.com/article/us-shipping-outlook-imo/china-virus-may-cause-delays-of-anti-pollution-equipment-retrofits-on-ships-idUSKBN1ZU1VV
[8] "Totals Move Away from Fuel Oil May Unnerve Shipowners With Scrubbers" Ship and Bunker, 19 February 2020; https://shipandbunker.com/news/world/142790-viewpoint-totals-move-away-from-fuel-oil-may-unnerve-shipowners-with-scrubbers
[9] "IMO 2020: Worldwide Scrubber washwater restrictions (update Jan. 2020)" Maritime Cyprus February 3, 2020; https://maritimecyprus.com/2020/02/03/imo-2020-worldwide-scrubber-washwater-restrictions-update-jan-2020/

responsible for fuel payments. Vessel owner gains accrue for liner service or charters under voyage or contract of affreightment; charterers secure these benefits under bareboat or time charters. This relationship directly contrasts with HSFO or diesel, where the underlying commodity dominates costs, and a century of infrastructure and refining improvements have driven these incremental costs downward. Hence, the cost of LNG marine fuel bunkers continues to remain less volatile than traditional oil-based marine fuels. While this may currently make the business case for LNG look slightly softer, it also underlines the cost volatility and instability risks inherent with HFO post-2020. At the time of writing this business case immediately following the 2020 Sulphur Cap introduction at the beginning of the year, several questions remain unresolved. Will there be sufficient availability? What will the price be? When taking these risk factors into consideration, the investment case for LNG is bolstered.

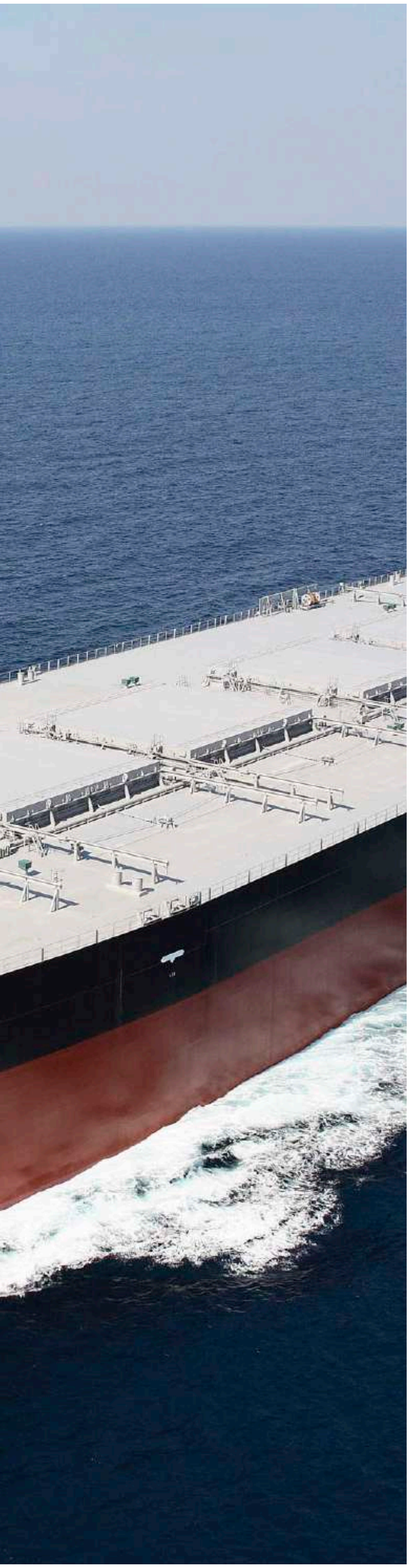
For shipowners and operators, the notion that fuel pricing is relatively stable creates a huge positive budget and business advantage. Given the high percentage of OPEX that marine fuel commands, having this pricing relatively stable over a long term is a strategic advantage for the shipping company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

Reader's Choice – whether Shipyard, Energy Supplier, Ship Owner or Charterer...

The four major stakeholders - shipyard, energy supplier, shipowner and charterer will benefit from insights and key perspectives obtained by utilising the "Readers' Choice" function to examine what makes the business-case work for all parties to achieve reasonable returns.

While the results of this study are based on a set of fuel forecast assumptions, through "Readers' Choice" (see end of this report), provision has also been made for each reader to impose their crystal ball on future costs and graphically determine quickly corresponding values that preserve the investment case wealth gain. Not only can the reader's assumed decade average fuel prices for HSFO, LNG, and or VLSFO be assessed, the stakeholder may also wish to understand first cost CAPEX impacts whose premiums may grow or shrink as a result of differences across three principal categories; market signals, technology choices, and/or physical differences such as vessel range.

Through exploring the reader's combination amongst key attributers; fuel prices and CAPEX variations, the four stakeholders can gain valuable understanding of the robustness or fragility for the overall business case that otherwise may be obscure.



CONTEXT

The International Maritime Organisation's (IMO) global cap on marine fuel (bunkers) of 0.5% sulphur content (S) recently came into force from 1st January 2020, which affects an estimated 210 million metric tonnes (MMT) of bunkers. This landmark legislation step change on allowable sulphur content imposes 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, most ocean vessels rely on Heavy Sulphur Fuel Oil (HSFO) which globally averages 2.5% sulphur. Of the total marine fuel demand of 680K metric tonnes of oil per day, 477K metric tonnes is high sulphur HSFO. As the residual fuel left from the crude oil refining process, HSFO is the cheapest and very often the most polluting fuel for a given energy output.

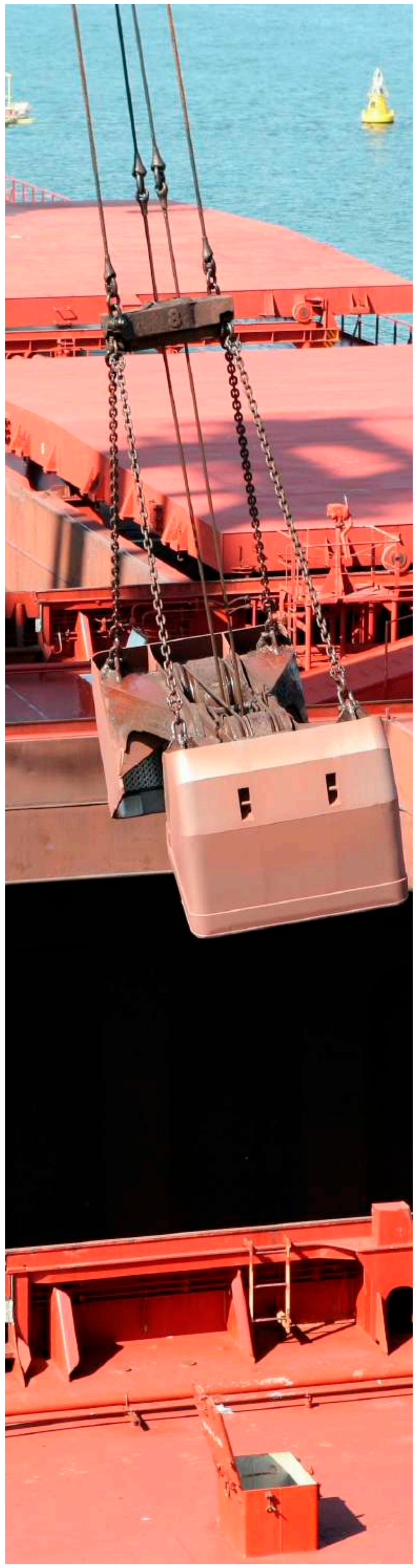
The main marine fuel options for shipowners beyond 2020 are:

- LNG fuel for newbuildings
- Use existing engines burning 0.5% sulphur fuel-oil either by:
  - Low Sulphur Fuel Oil (LSFO) or a blend of existing sulphurous Heavy Fuel Oils (HSFO) with no or low sulphur fuels such as 0.1% Low-Sulphur Marine Gas Oil (LS-MGO[10]) LS-MGO.
  - Continue consuming HSFO and employ scrubbers to achieve alternative compliance.

The global shipping industry had to implement initial global sulphur limits only a few years ago. The introduction of restrictive Emission Control Areas (ECA)s in 2015 caused 210-250 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 much greater with impacts on 3 million barrels of oil per day and bunker prices now demonstrate added volatility.

Shipowners are challenged with making significant investment decisions in an unprecedented dramatic fashion under a range of uncertainties. Many have chosen the LSFO route. Around 94% of ships will likely be running on LSFO based on the relatively low level of orders for scrubbers and LNG fuelled vessels. This decision raises several post 2020 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?

[10] 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.



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?

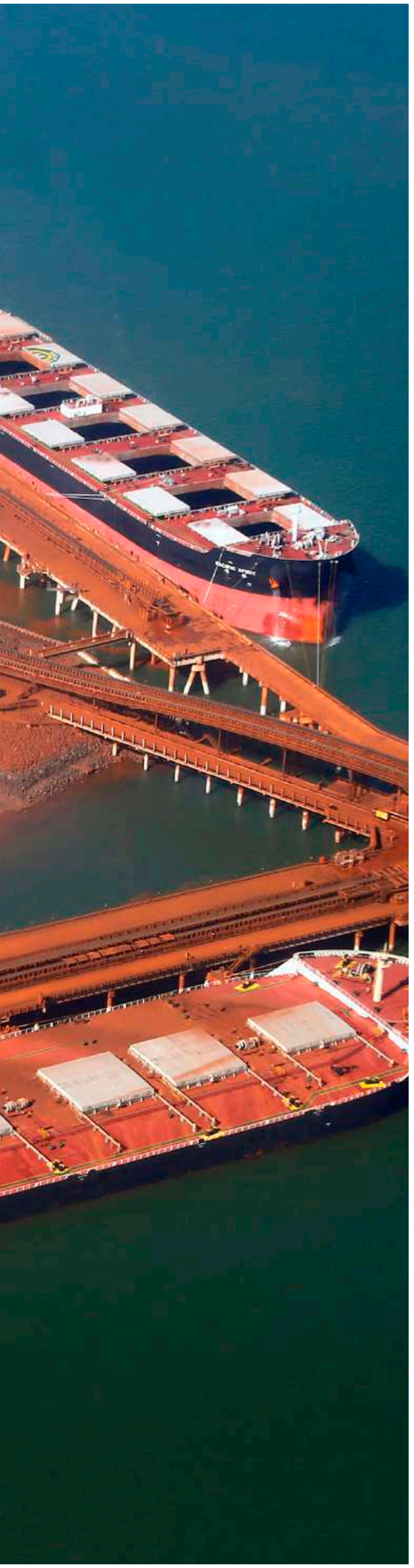
The huge variation in global shipping types, ages and the trading patterns of vessels adds to the complexity of decision-making. For many shipowners and operators, it will necessitate a portfolio approach[11] to achieve ongoing compliance with the IMO 2020 global sulphur cap legislation and continue 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 ensure the best possible data was available to Opsiana, SEA-LNG members contributed maritime expertise and current, timely background information and data to ensure a high level of creditability in the study and results. The study is based on a newbuild 210K DWT CAPESIZE sailing from the Australia to China. Investment performance was measured utilising traditional NPV 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 three different fuel-pricing scenarios (Business as Usual, Stranded Fuels, and Reader's Choice) 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 Business as Usual and Stranded Fuels forecasts, LNG against compliant fuels delivered the greatest return to shipowners and operators on an NPV basis over a conservative 10-year horizon, with compelling payback periods ranging from two to four years. This return excludes the NPV of the environmental benefits that LNG delivers.

The Stranded Fuels scenario captures the plunge in HSFO toward $320/ton after implementation of the 2020 IMO global sulphur cap and a modest price recovery thereafter, as market forces and global oil refining

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



capacity switch toward higher demand for greater margin low sulphur fuels. As that occurs, supply will likely balance demand within a few years around 2027 and thereafter HFO prices decelerate to match predicted 2.5% inflation. Therefore, most saving benefits, if any, will accrue to the early adopters and late adopters may find this window quickly closing. As this CAPESIZE enters into service in 2022, it misses the advantage of the initial HSFO plunge captured by the early adopters and will also have to cope with the price volatility of HSFO at that point in time, which remains unclear.

LSFO

The vast majority of vessels are nominated to consume LSFO, a straight low sulphur fuel oil, or – more typically – a blended fuel consisting of HSFO and distillates. Some shipowners have even indicated that they will, after the initial January 2020 phase, 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 penalised by State Port compliance authorities.

Scrubbers

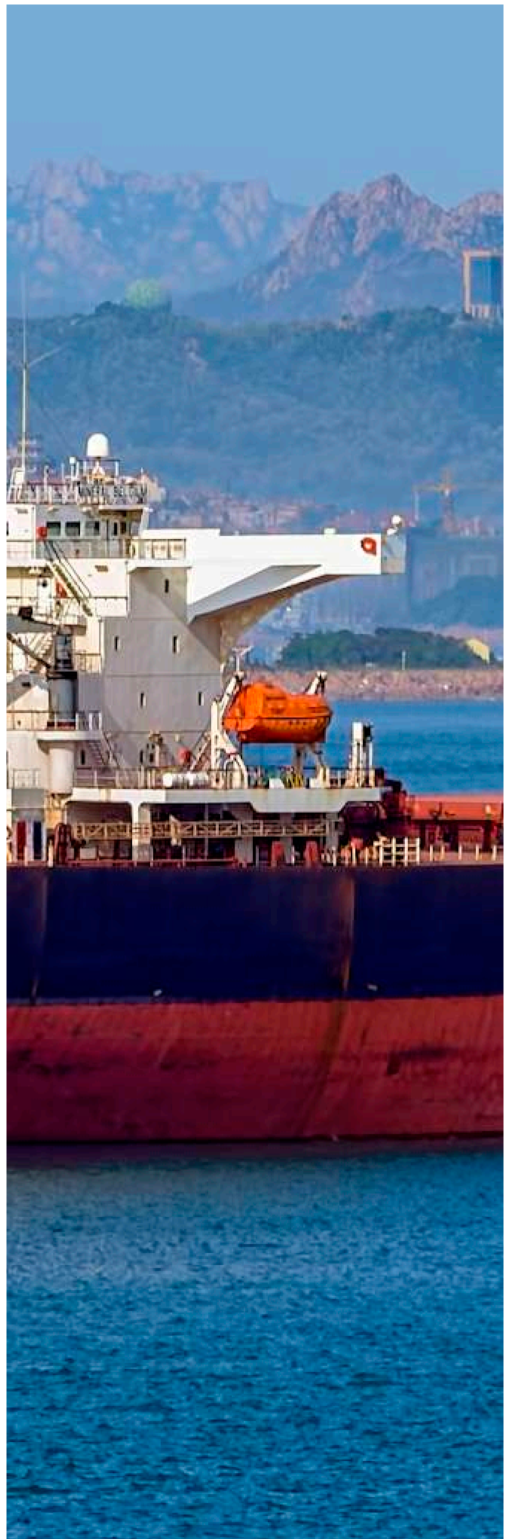
Scrubber uptake, according to classification society DNV-GL, will 'be over' 3,500 vessels by 2020[12]. However, this only represents around 6% of the world trading fleet of 58,500 vessels. The technology, which in 2019 witnessed an upsurge in uptake, does not offer any GHG reduction benefits and may 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 nations, including Singapore, China, and others, 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 price spread benefits window beginning January 2020. As mentioned though, as this CAPESIZE will not come into service until 2022, it misses this early window of opportunity. It must also contend with the, as yet, unknown availability and cost of HSFO. As the recent HSFO price volatility demonstrates, this creates significant risks.

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 improve the environmental performance of the industry dramatically. Regional air quality, especially around major maritime ports, has been a concern for decades and continues to be a key human health issue around the world. LNG provides significant air quality improvements over traditional fuels which provides better human health for longer life.

[12] https://www.hellenicshippingnews.com/sulfur-limit-debate-continues-scrubbers-seeing-a-faster-pace-of-adoption/



In terms of environmental impact, LNG performs very 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 85% fewer 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[13]. 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% biomethane 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. It also represents a significant step forward in the reduction of GHGs and a potential pathway to meeting future carbon-related emissions targets.

This SEA-LNG Business Case study is intended to help the ship owning/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 sets 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 CAPESIZEs, SEA-LNG has also produced similar studies for container, PCTC vessels, and VLCC, and are working on additional studies that analyse the investment case for other typical ships and common trades.

[13] *thinkstep's* 11 April 19 report – "Life Cycle GHG Emission Study on the use of LNG as Marine Fuel" https://www.thinkstep.com/content/life-cycle-ghg-emission-study-use-lng-marine-fuel-1

LNG is a safe, mature, commercially viable marine fuel offering superior local emissions performance, significant GHG reduction benefits and a pragmatic pathway to a zero-emissions shipping industry.

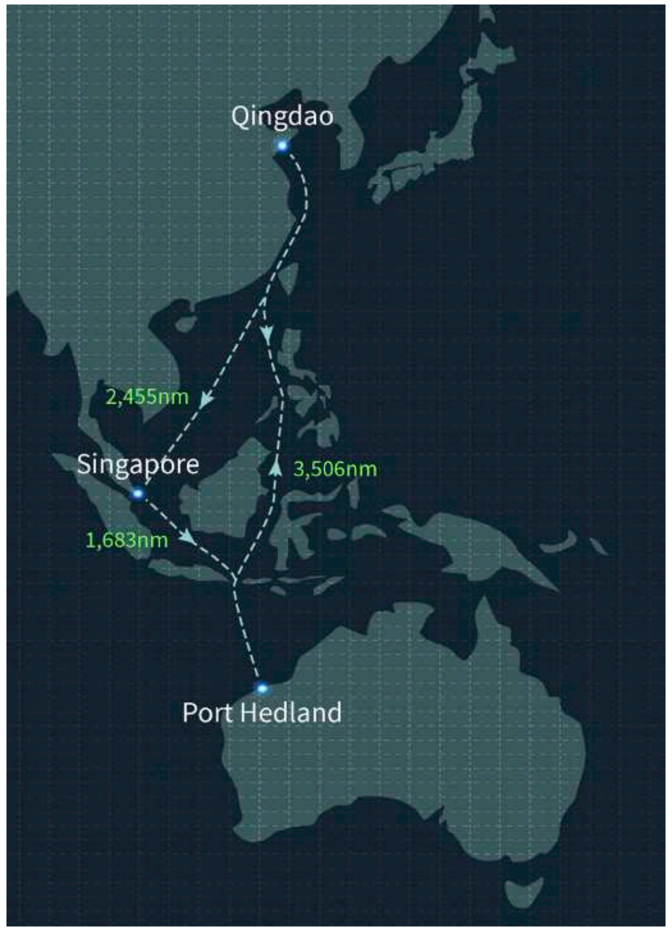
MAIN ASSUMPTIONS

The main assumptions include the following:

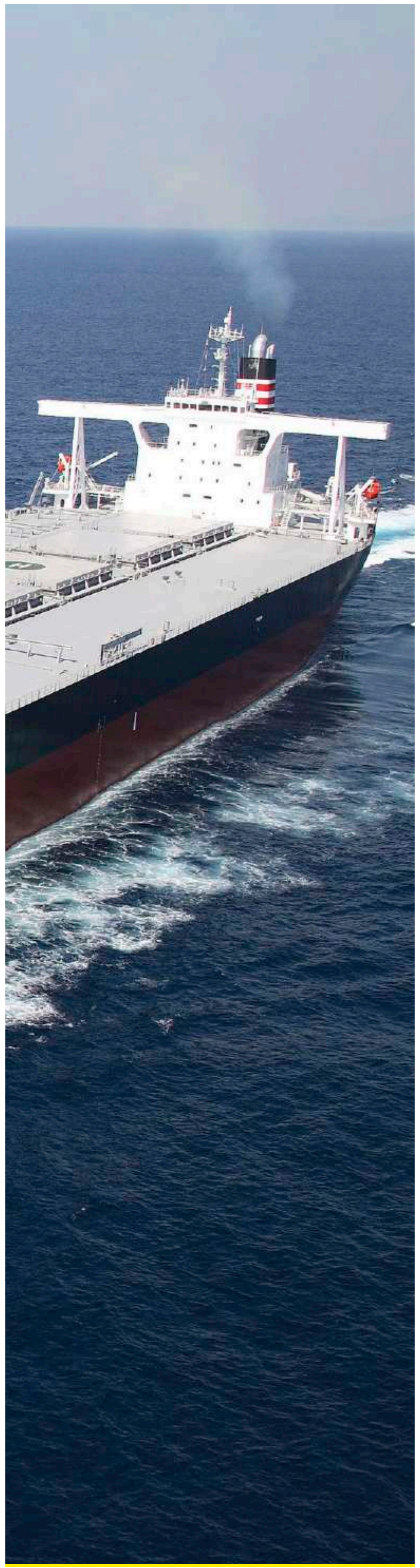
- The business case envisions three market phases; Strong Charter Markets with sailing speed at 14.0 knots laden and 15.2 knots ballast; base case Average markets at 12.5 knots laden and 14.0 ballast; and ECO markets at 11.0 knots laden and 12.5 knots ballast.

- The CAPESIZE Australia-China route runs between Port Hedland / Qingdao with fuelling every second round trip while in ballast at Port Singapore. The total sailing distance is 14,656nm. No distance is spent in the SECA or NECA, but there is no scrubber discharge for 42nm (0.3% of route) at Qingdao.

Australia - China Trade



[10] Trade Winds "Costco Tanker Outfit makes first move for VLCC fuelled by LNG" Irene Ang 14 November 2019.
[11] Trade Winds "Capital Maritime grabs first-mover role on LNG fueled VLCCs" Irene Ang and Lucy Hine 5 September 2019.



- The CAPESIZE enters into service beginning year 2022 as the initiation date in fuel forecast, which means it misses the lowest and most favourable HSFO pricing point commencing 2020.

- The case assumes the CAPESIZE is contracted in 2020 and therefore is subject to IMO EEDI Phase 2. The CAPESIZE with LNG will meet the 2022 IMO EEDI Phase 3 requirements.

- The CAPESIZE is fitted with a pair of on deck LNG bunker tanks which hold a combined total of 6,000 m^3 of fuel. This fuel quantity provides a range exceeding 20,000 nautical miles, which is sufficient to allow trading over most of the envisioned cargo routes for the vessel.

Speed

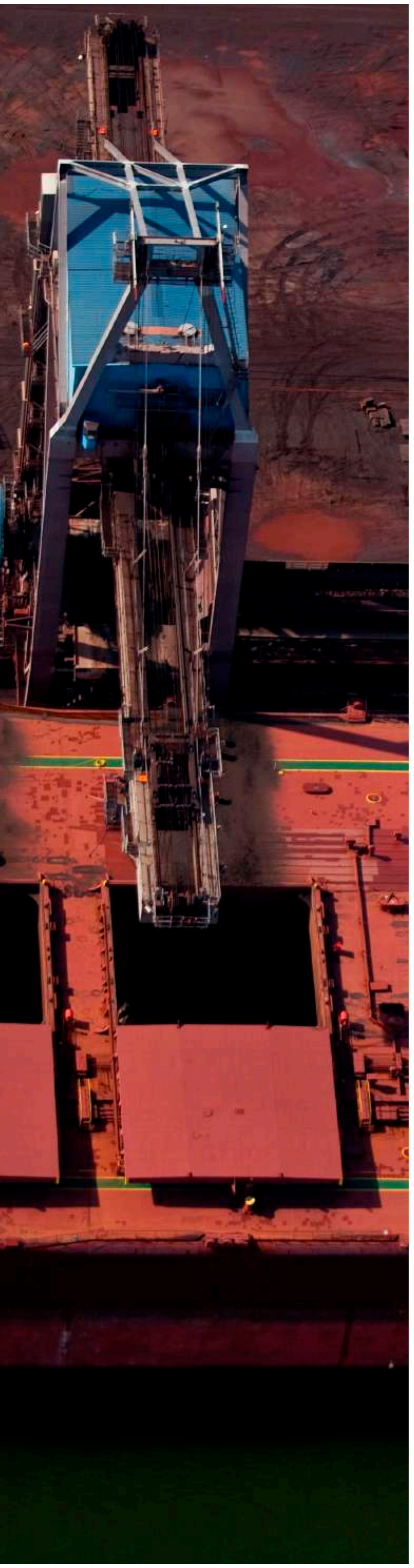
The speed of a CAPESIZE varies dramatically in ballast and less when laden as market conditions change. With so many influencing factors affecting both the laden and ballast legs, it is challenging to choose only one voyage scenario of laden and ballast speeds. The markets have a substantial influence on the ballast speeds, which impact the supply of tonne-miles available for a route. Spot markets reflect a shift amongst laden speeds and ballast speeds as the charterer or vessel owner respectively dictates vessel speeds where the greatest span reflects the extremes of strong or weak markets. Strong spot markets exhibit naturally higher speeds (shipowners race back to fix another profitable spot cargo); and slower ballast return speeds (at lower fuel consumption costs to the shipowner's account) during ECO freight markets.

This model emphasis however is for a long time charter where a charterer favours speeds for laden and ballast that possess similar power demands on the engine for levelling fuel consumption rate. As a beneficial cargo owner, the charterer seeks similar laden and ballast engine power to mimimise fuel consumption for a given freight transport demand.

While ore carrier speed selection was difficult, reasonable, realistic laden and ballast speed choices were made representing the historical ranges for strong, base case normal, and ECO time charter markets.

Financial

a) **Newbuilding LNG-fuelled vessel.**
The study utilises 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 a significant future lifetime to justify the additional CAPEX investment.

b) **Investment Hurdle Rate**

The study utilises 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:

$$WACC = Loan\ Rate \times Debt\ Portion \times (1\text{-}tax\ rate) + Equity\ Rate \times Equity\ Portion$$

Substituting in Values…

$$WACC = 6\% \times 0.60 \times (1-0) + 11\% \times 0.4 = 8\%$$

c) **Investment Horizon Period**

The study chose a 10-year investment horizon as a very conservative timeframe understanding that the economic life for CAPESIZE vessels exceeds this substantially. The choice also recognises 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 the end of the investment horizon period as a very conservative condition. This assumption 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 traditional 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 CO2 regimes are enacted, the business return on an NPV basis in favour of LNG improves by several million dollars. This scenario is explored by the model in later sections.

Capital Expenditure

Four types of main engine (M/E) configurations were fully priced and compared in this study: a dual fuel HP 2-stroke LNG engine (2s HP DF) with Tier III treatment; a dual fuel LP 2-stroke LNG engine (2s 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 Selective Catalytic Reduction (SCR) but without scrubber. The investment required for each engine configuration, including key 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.

2s HP DF

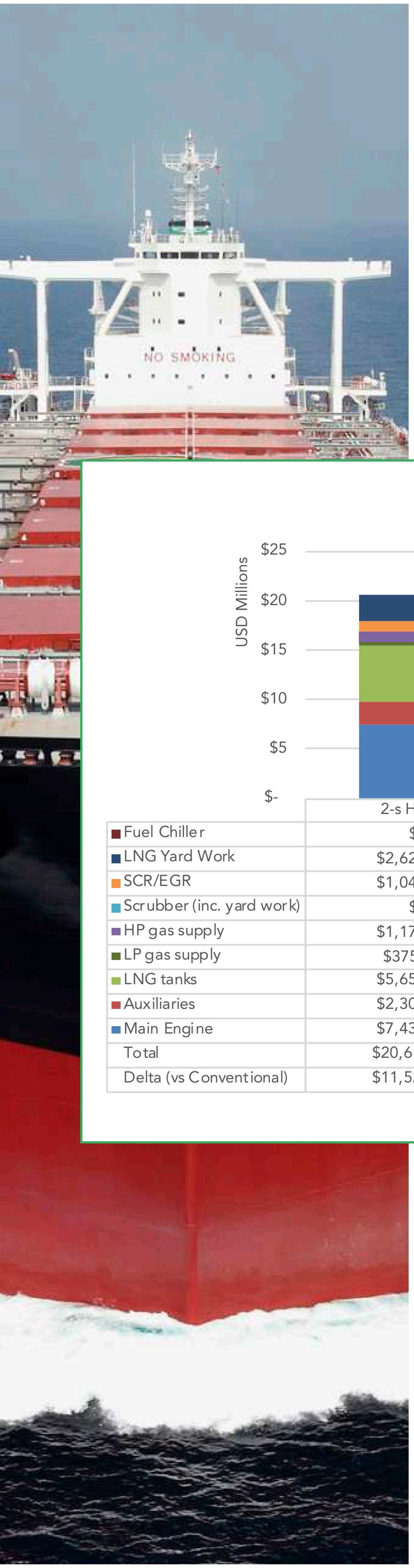
This configuration is modelled on a MAN 6G70ME-C9.5-GI for the 210K DWT CAPESIZE using approximately 1% MGO pilot fuel with no methane slip. Although NOx Tier II compliant, the M/E requires Selective Catalytic Reduction (SCR) or Exhaust Gas Recirculation (EGR) to comply with NOx Tier III. The auxiliary engines (A/E) and boilers are assumed to be gas-only and do not require SCR. M/E Specific Gas Consumption (SGC) is 139.6 g/KWh: gas is supplied at 210-350 bar to the M/E and low pressure to the A/Es. The HP gas system CAPEX is costed at $1.18M, with the LP gas system at $376K for the vessel. There is no differential CAPEX attributed to the boilers and mechanical propulsion is assumed.

2s LP DF

This configuration is modelled on a WinGD 6X72DF Winterthur Gas & Diesel engine for the CAPESIZE which uses a lean-burn Otto-cycle combustion with MGO pilot. It complies with NOx Tier III in gas mode so is modelled without an SCR. M/E SGC is 149.2 g/KWh and 0.9 g/KWh MGO pilot fuel with low-pressure gas supplied to the M/E and A/Es. The LP gas systems are priced at $363K 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 6G70ME-C9.5, 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

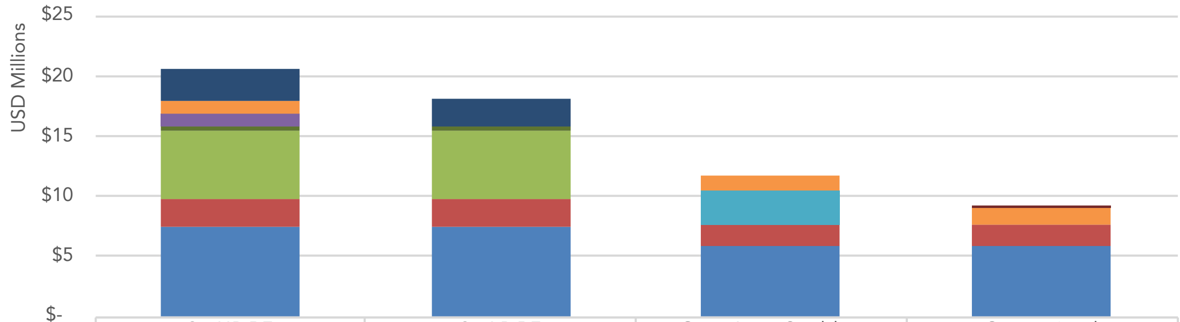


to comply with NOx Tier III at an approximate cost of $1.26M for the vessel. M/E Specific Fuel Oil Consumption SFOC is 175.9 g/KWh on HSFO, including scrubber load. The scrubber is costed at $2.8M and being open-loop does not consume Sodium Hydroxide (NaOH).

Conventional Vessel

This configuration is based on the same conventional diesel cycle, low-speed engines – MAN 6G70ME-C9.5. Whereas the M/E is NOx Tier II compliant, an SCR is required to comply with NOx Tier III. M/E SFOC is 167.1 g/KWh using VLSFO. Additional CAPEX of $118K is assumed for a fuel chiller for the vessel since the M/E was designed to operate with fuels of higher viscosity relative to MGO.

CAPEX summary - CAPESIZE

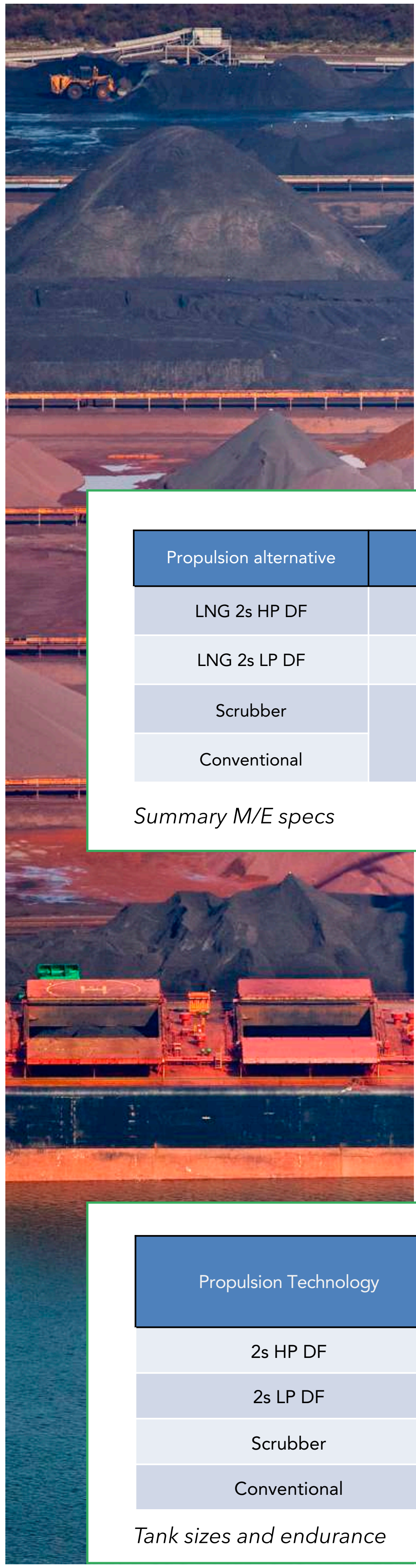


	2-s HP DF	2-s LP DF	Open Loop Scrubber	Conventional
Fuel Chiller	$-	$-	$-	$118,000
LNG Yard Work	$2,628,000	$2,379,000	$-	$-
SCR/EGR	$1,043,734		$1,255,921	$1,255,921
Scrubber (inc. yard work)	$-	$-	$2,818,304	$-
HP gas supply	$1,176,552	$-	$-	$-
LP gas supply	$375,931	$363,052	$-	$-
LNG tanks	$5,651,348	$5,651,348	$-	$-
Auxiliaries	$2,308,800	$2,308,800	$1,776,000	$1,776,000
Main Engine	$7,430,000	$7,430,000	$5,944,000	$5,944,000
Total	$20,614,364	$18,132,200	$11,794,225	$9,093,921
Delta (vs Conventional)	$11,520,443	$9,038,278	$2,700,304	$-

The additional CAPEX for each CAPESIZE vessel configuration option over the conventional vessel is:

- 2s HP DF $11.5M
- 2s LP DF $9.0M
- Open-Loop Scrubber $2.7M

The CAPEX premium for LNG alternatives over a scrubber with IMO 2020 0.5% compliance is $8.8 M for a 2s HP DF M/E arrangement and $6.3M for a 2s 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 throughout the investment timeframe, however this may be curtailed if regional port restrictions are implemented along the trade route.

Fuel Consumption

M/E fuel consumption is summarised in the table below. Scrubber consumption includes a very conservative 1% parasitic load as a lower range value. Energy consumption includes pilot fuels for the LNG DF engines. Indicative consumption figures in the table are for 13.0 knots. The table highlights the fact that LNG contains 22% more energy content for a given mass than conventional oil-based fuels.

Propulsion alternative	M/E archetype	MCR [MW]	SFOC [/kWh]
LNG 2s HP DF	MAN 6G70ME-C9.5-GI	21.84	139.6 g LNG + 1.3 g MGO [1]
LNG 2s LP DF	WinGD 6X72DF	19.35	149.2 g LNG + 0.9 g MGO [2]
Scrubber	MAN 6G70ME-C9.5	21.84	175.9 g HFO [1] (incl scrubber load)
Conventional			167.1 g VLSFO [1]

Summary M/E specs

Fuel tank size impacts

The report models a C type LNG tank of sufficient volume for the CAPESIZE to achieve a range near 20,000 nautical miles with a 15% sailing margin. The study considers displaced cargo loss assessment when appropriate. As the LNG tanks are located above deck for the CAPESIZE, there is no cargo displacement loss and insignificant impact on weight or stability. The 6,000m3 LNG tanks' CAPEX is evaluated at $5.7M.

Propulsion Technology	Tank Sizes [m3]				Endurance [nm]
	LNG	HSFO	VLSFO	MGO	
2s HP DF	6,000	-	-	200	21,300+
2s LP DF	6,000	-	-	200	
Scrubber	-	3,400	100	100	
Conventional	-	-	3,200	200	

Tank sizes and endurance

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 can be achieved either through blending oils of different sulphur content or directly from the residual of a single 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 physical blend of 85% MGO and 15% HSFO[14]. The physical properties and prices for VLSFO are obtained accordingly. The initial 2020 observed VLSFO prices appear close to MGO and therefore the VLSFO pricing formula reflects a cost weighting of 5% HSFO plus 95% MGO.

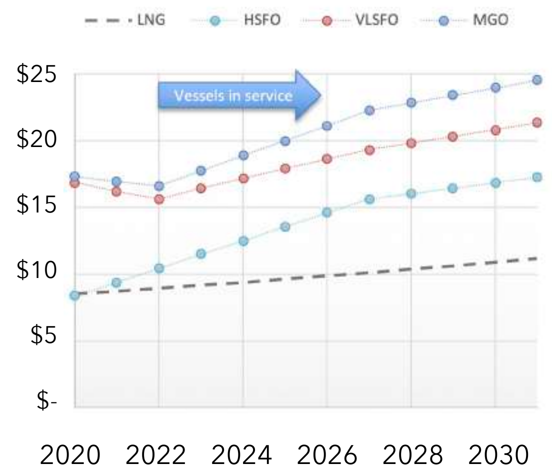
Three scenarios are modelled in the study representing fuel price forecasts beginning in 2020 with the vessel entering into service from 2022 for an investment horizon extending out ten years:

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 at $600/mt by 2027. MGO and distillates will see very high demand in 2020 and price escalation pressure. As LNG and scrubbers increase their penetration and additional refinery capacity comes on-line, MGO prices will level down, slowing to match inflation increases. The initial MGO price for 2020 is estimated at $700/mt for Singapore. VLSFO is initially very tightly coupled to MGO. As new blends are tested and accepted by the market, there is a gradual decoupling mid-decade. LNG prices are modeled similar to those found in the BaU and rise gently along with inflation through 2030.

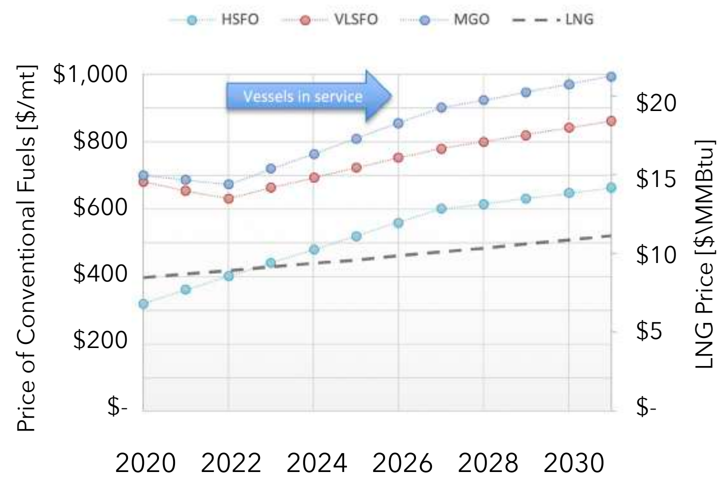
[14] We assume an average sulphur content of 2.76% for HSFO. Blending of 85% MGO and 15% HSFO then leads to 0.5% sulphur content

LNG meets and exceeds all current compliance requirements for marine fuel content and emissions, which includes local and GHG.

Stranded Fuels: Normalized Prices
All fuels lifted at Singapore



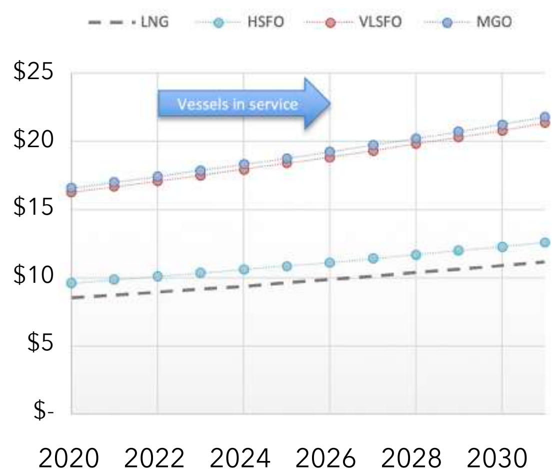
Stranded Fuels: Prices in Native Units
All fuels lifted at Singapore



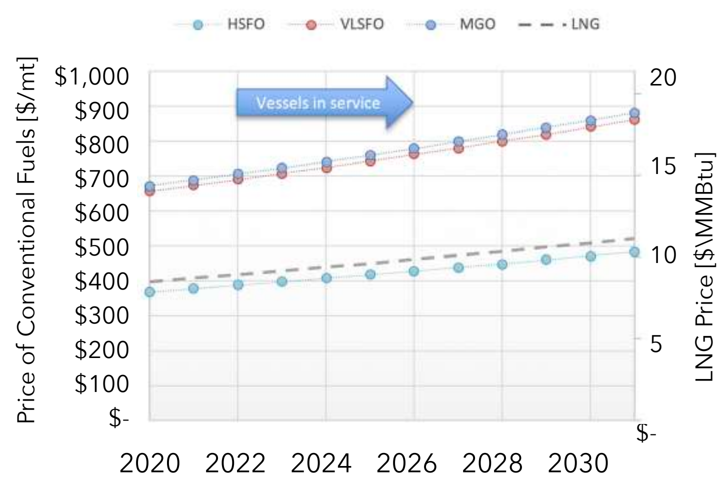
Notes: The price of LNG can be read from either axis (based on LHV = 46.748 MMBTU/mt). The price of conventional fuels must be taken from the left vertical axis.

2. **Business as Usual "BaU":**
   Conventional fuel prices were established from median prices during January 2020 to acknowledge influences imposed by the IMO 2020 Sulphur Cap step change. Each year the increase matches inflation modelled at 2.5%.

BaU: Normalized Prices
All fuels lifted at Singapore



BaU: Prices in Native Units
All fuels lifted at Singapore



Notes: The price of LNG can be read from either axis (based on LHV = 46.748 MMBTU/mt). The price of conventional fuels must be taken from the left vertical axis.

3. **Reader's Choice**
For a given vessel on a trade route, a fresh 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.

Initial LNG Pricing

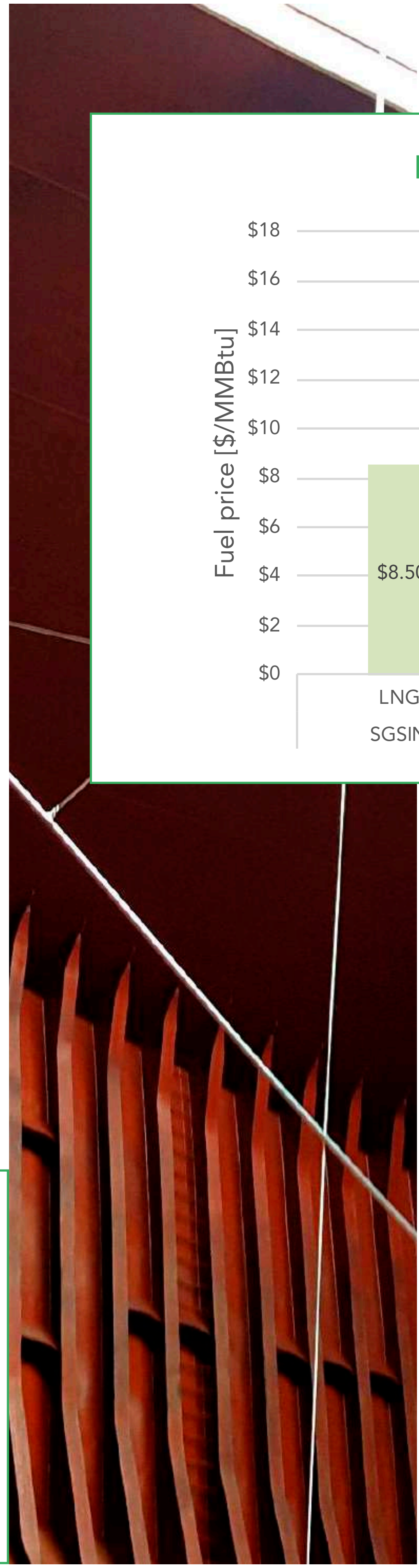
It is assumed that all vessels will divert upon second unloading in China on the ballast leg into Singapore to take all fuels. LNG is provided at Singapore by a bunkering vessel for vessel-to-vessel transfer to the CAPESIZE. LNG cost is estimated by the study as; $5.0/mmBTU bulk shipment basis, plus storage at $1.5/mmBTU, plus LNG logistics and bunkering at $2.0/mmBTU. With this, the price of LNG delivered onboard the vessel is $8.50 / MMBtu for January 2020.

Base prices for conventional fuels are based on historical data for the period between January 2nd and January 24th, 2020 to reflect the impacts of IMO 2020 Sulfur Cap.

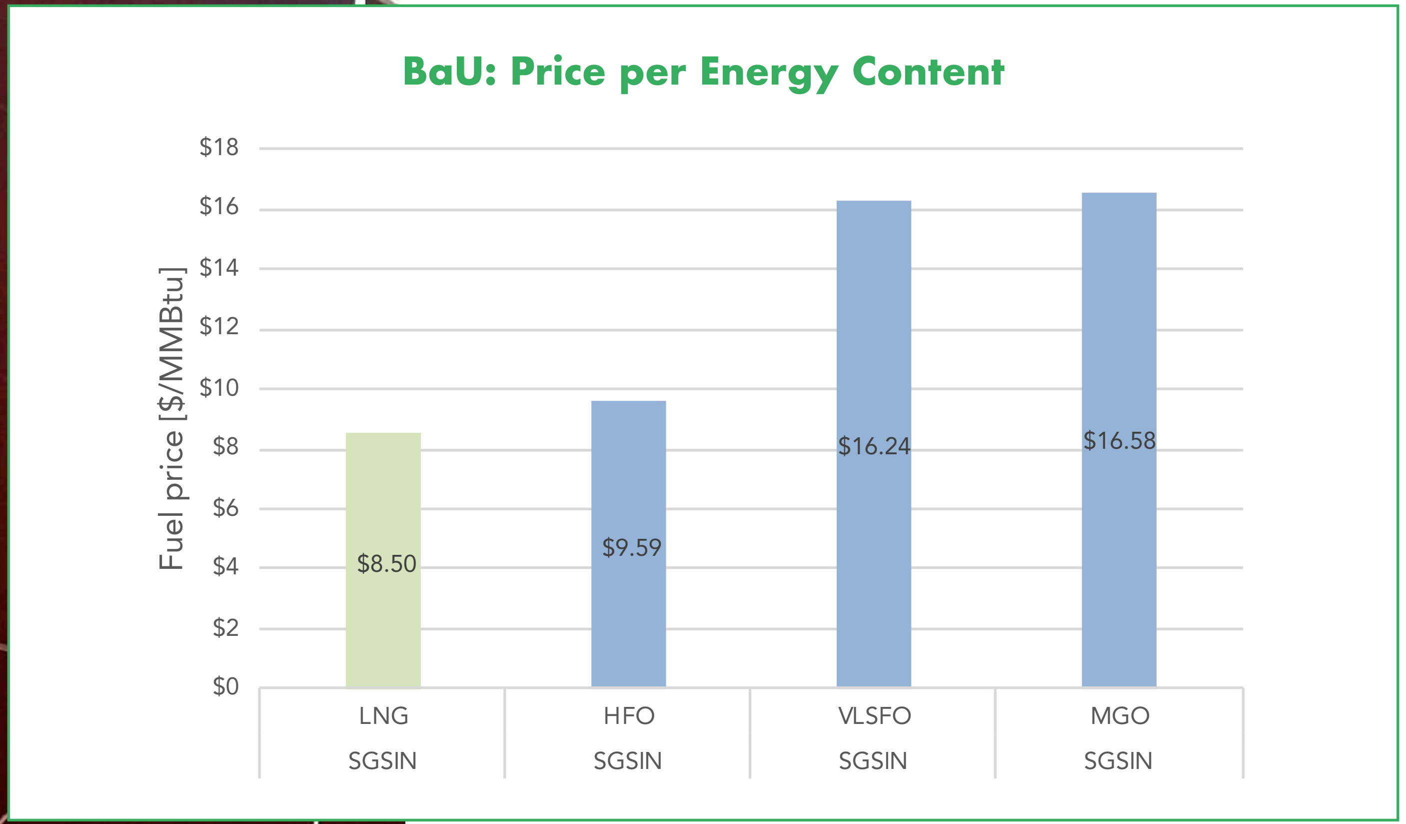
Fuel Type	Port	Median Price [USD/mt]
HSFO	SGSIN	$368.0
VLSFO	SGSIN	$655.0
MGO	SGSIN	$671.0

Initial prices for conventional fuels

Fossil fuel LNG is a bridging fuel towards bio or synthetic methane, all of which are fully interchangeable and would utilise existing investments in LNG and LNG infrastructure.



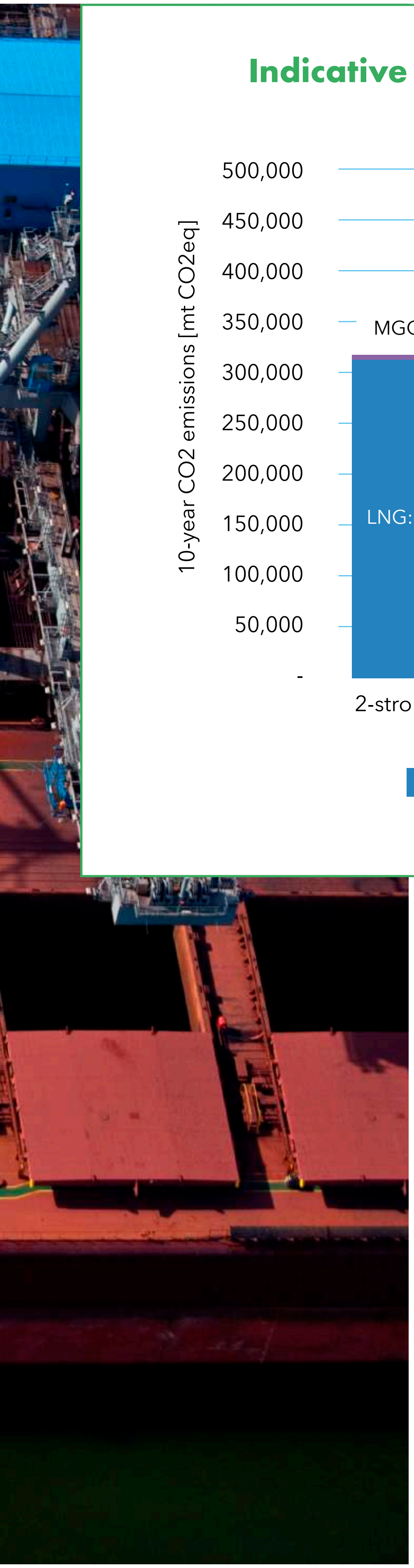
Taken together these fuel cost assumptions result in the following Singapore estimated costs on an energy basis for 2020:



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

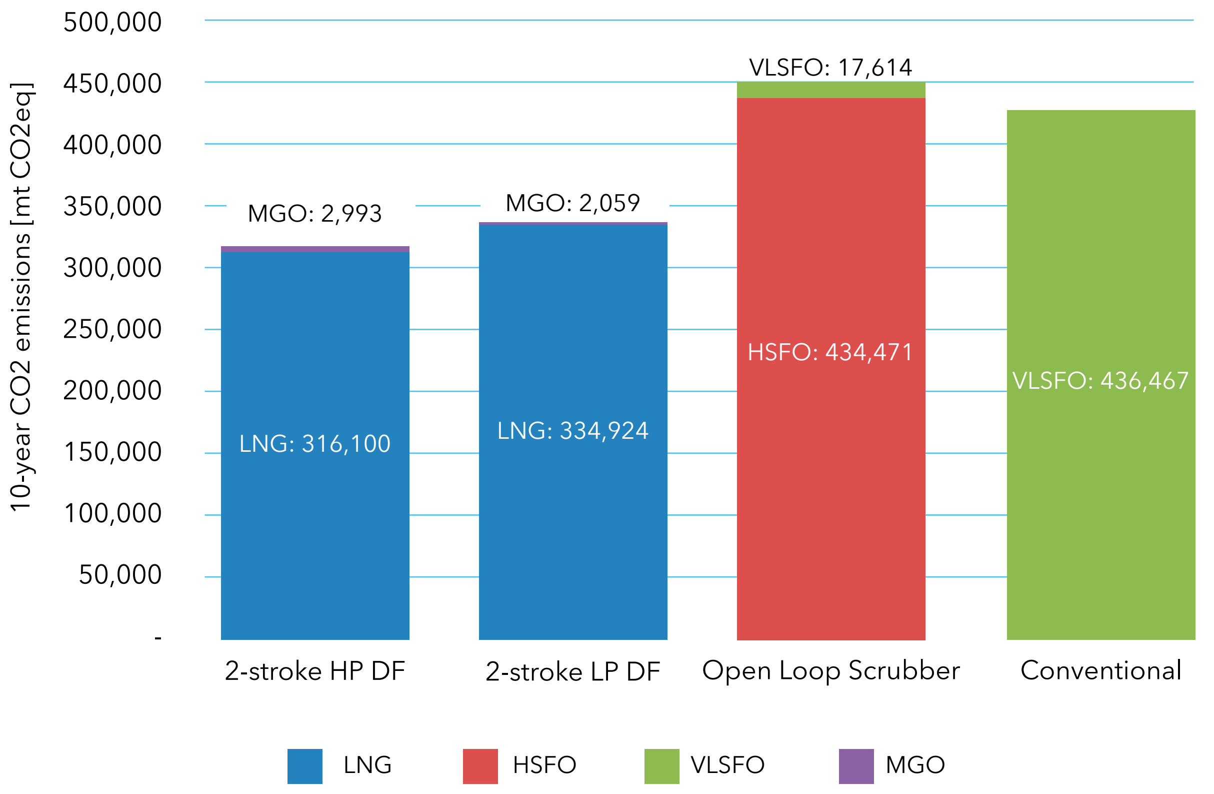
Carbon Costs Reader's

IMO regulations, introduced on 1st January 2019, mandate that all vessels record fuel consumption. These records allow 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, but 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

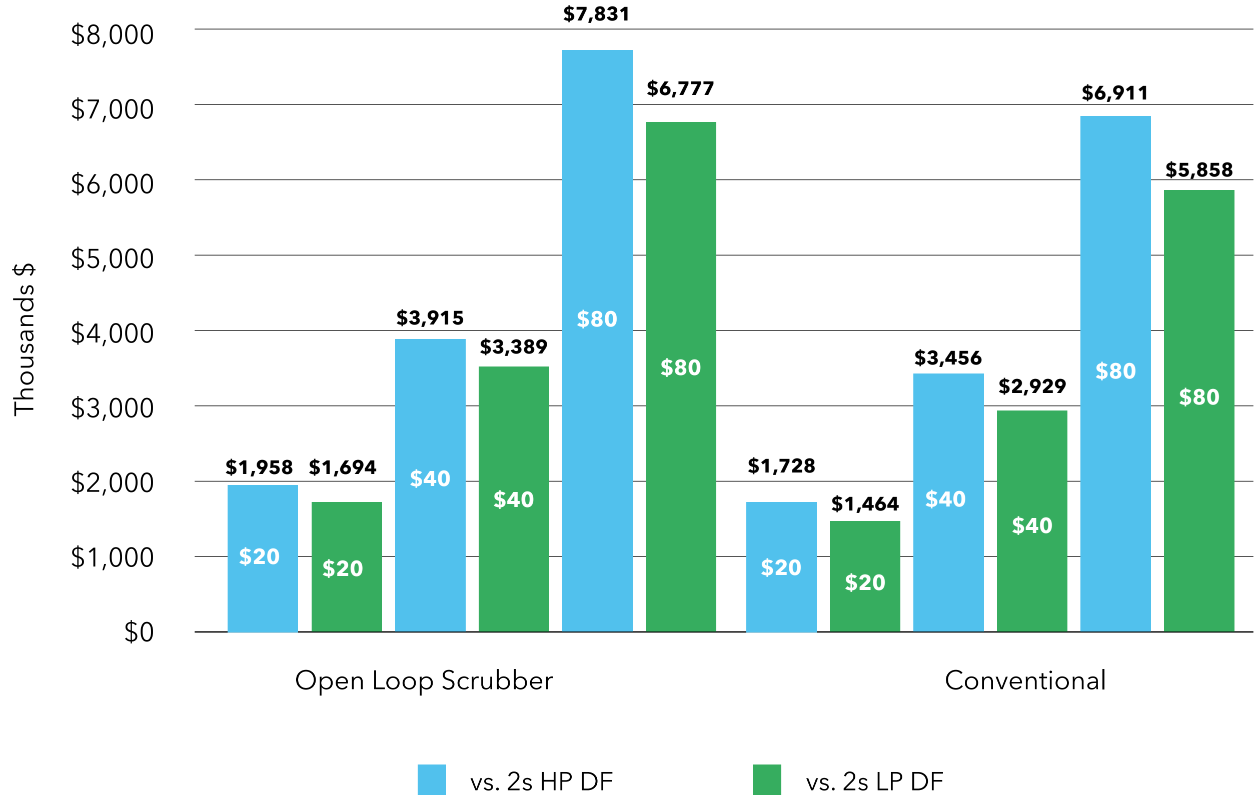
210K DWT CAPESIZE Austraila - China Trade



If a carbon value of $40 per ton of CO2 emitted is assumed, (as shown in the middle bars below), the NPV gains for the 210K DWT CAPESIZE fitted with 2s LP DF engine increase to $3.4M[15] for LNG versus the open-loop scrubber (up to $2.9M versus compliant conventional fuel). The NPV investment gains double as the carbon value doubles to $80 per ton of CO2 (right-hand bars). In effect, an additional $7M can be achieved in wealth gain if CO2 consumption is factored in at the higher per tonne rate. While this is not yet included in the normal investment profile of CAPEX dollars for fuel savings or money spent, it ought to be considered as environmental factors increasingly become a benefit rather than a cost. Taking carbon pricing into account, any benefits currently achieved through scrubbers will retreat further and, with the inclusion of drop-in fuels, the NPV for LNG- fuelled vessels will improve substantially.

[15] NPV of the annual CO2 savings occurring over the 10 year investment horizon discounted at WACC less 2% reflects environmental benefit requirements (8% - 2% = 6%).

LNG NPV Benefit at CO2 Price Points – 210K DWT Capesize



Taking carbon pricing into account, any benefits currently achieved through scrubbers will retreat further and, with the inclusion of drop-in fuels, the NPV for LNG-fuelled vessels will improve substantially.

RESULTS

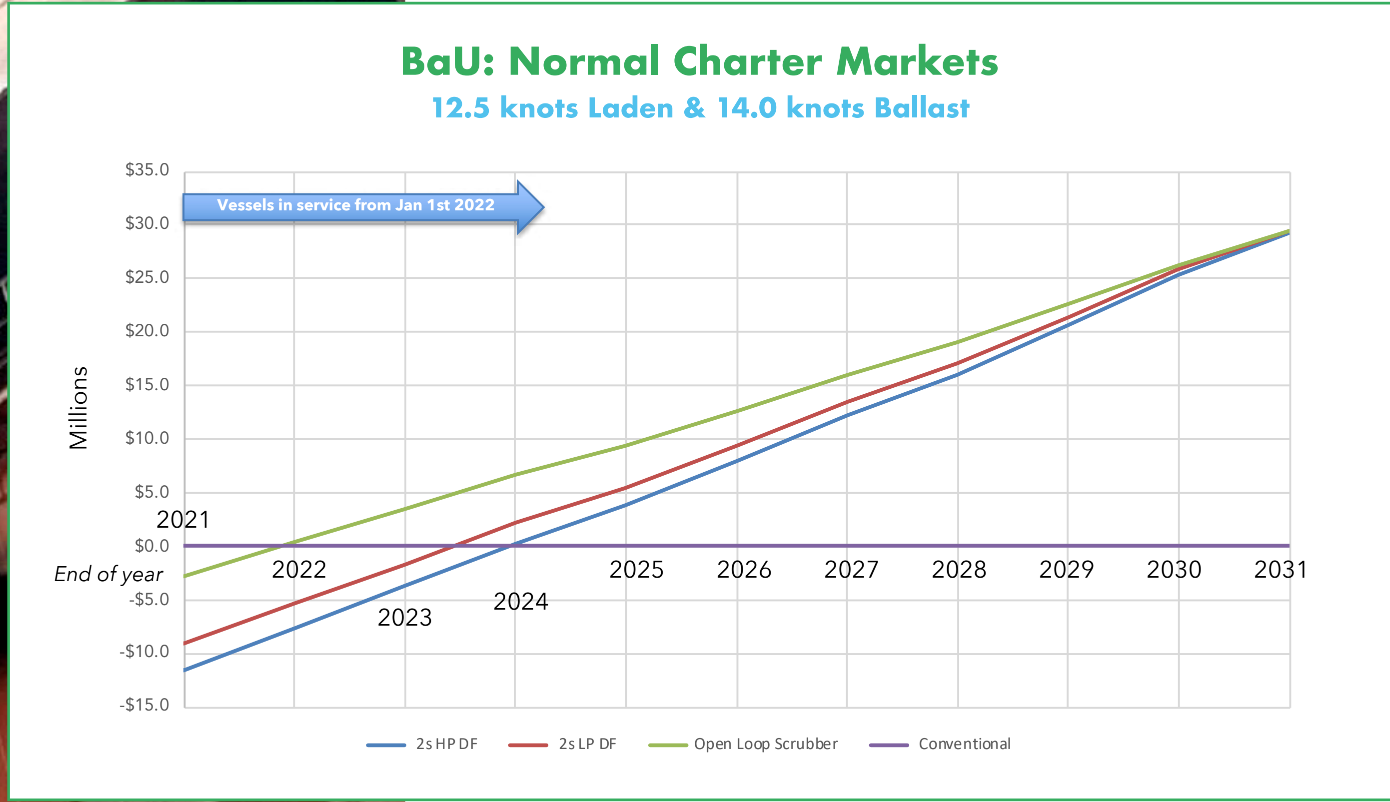
This study clearly indicates that LNG as a marine fuel delivers the best return on investment on an NPV basis over a conservative 10-year horizon against conventional compliant fuels and perform well, although mixed, against scrubbers. The LNG payback periods are compelling, ranging from two to four years. While LNG delivers a marginally less favourable return on investment than open-loop scrubbers in the BaU scenario it does deliver wealth gains against scrubbers for the stranded fuel scenario. To achieve the returns illustrated in the BaU forecast HSFO prices need to behave as modelled along with scrubbers operational starting 2022 throughout the 10 year investment horizon despite growing port exceptions. Current orders and shipyard capacity mean than any scrubbers ordered now will not be operational until 2022, at the earliest. It is also important to reiterate that open-loop scrubbers deliver no CO2 benefits, which, if carbon emissions attract a financial value through regulation, would improve the NPV several million dollars for LNG fuel, and even more so with the addition of drop-in fuels.

With lower demand for HSFO evident post 2020 sulphur cap, the availability of HSFO 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.

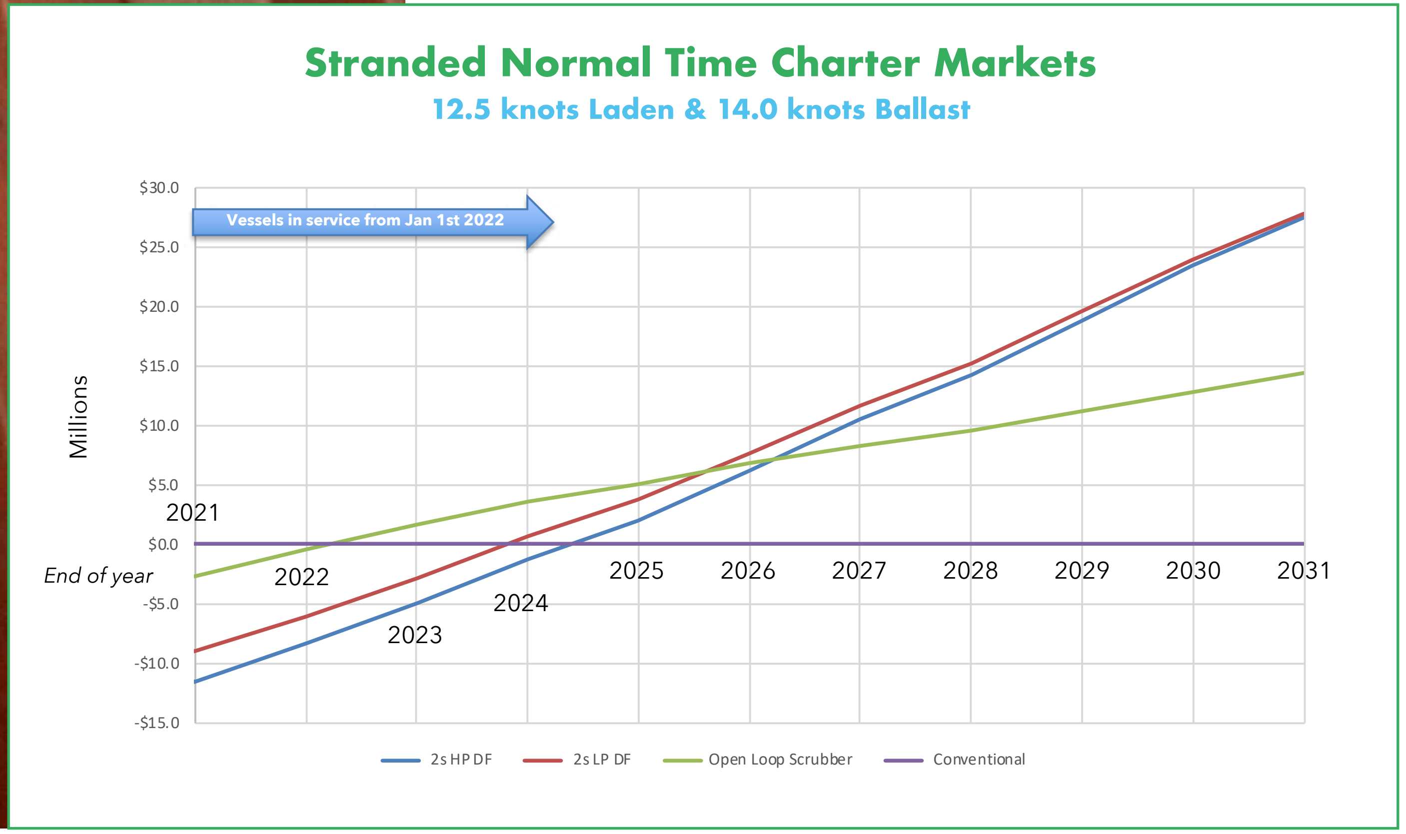
This study clearly indicates that LNG as a marine fuel delivers a strong return on investment on a NPV basis over a conservative 10-year horizon with fast payback periods ranging from two to four years.

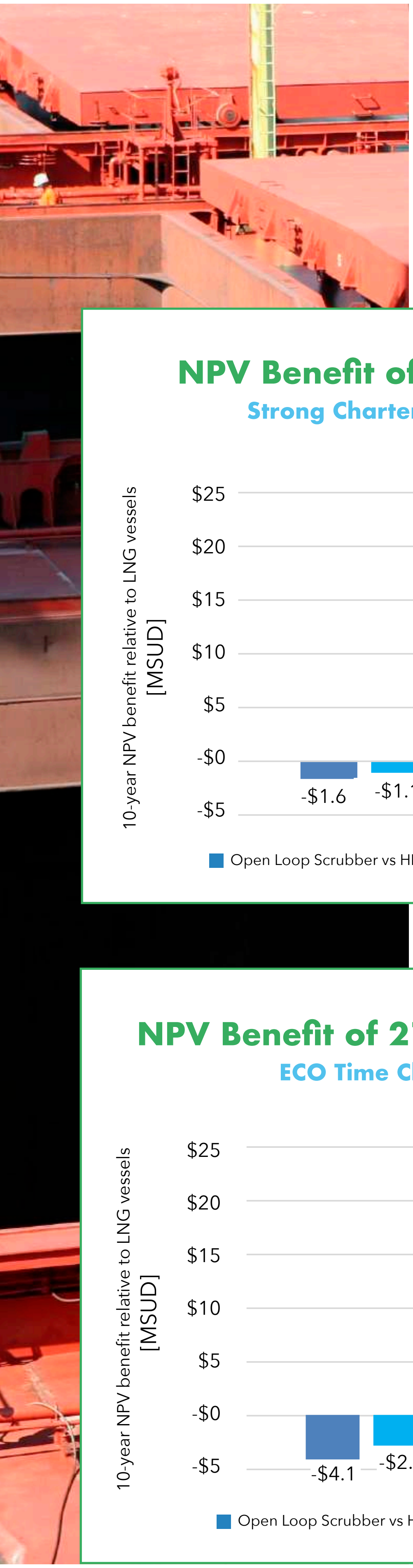
Payback scenarios for VLCC

a) BaU



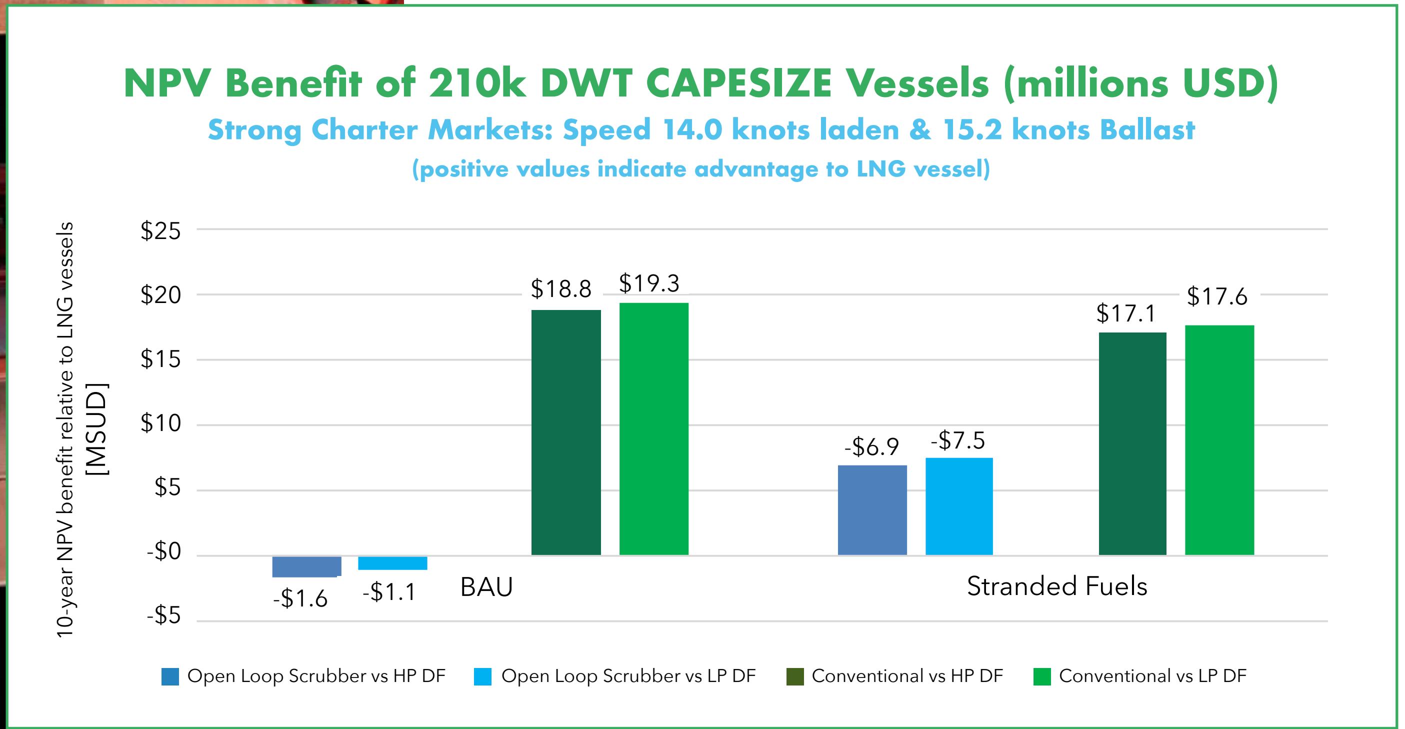
b) Stranded Fuels

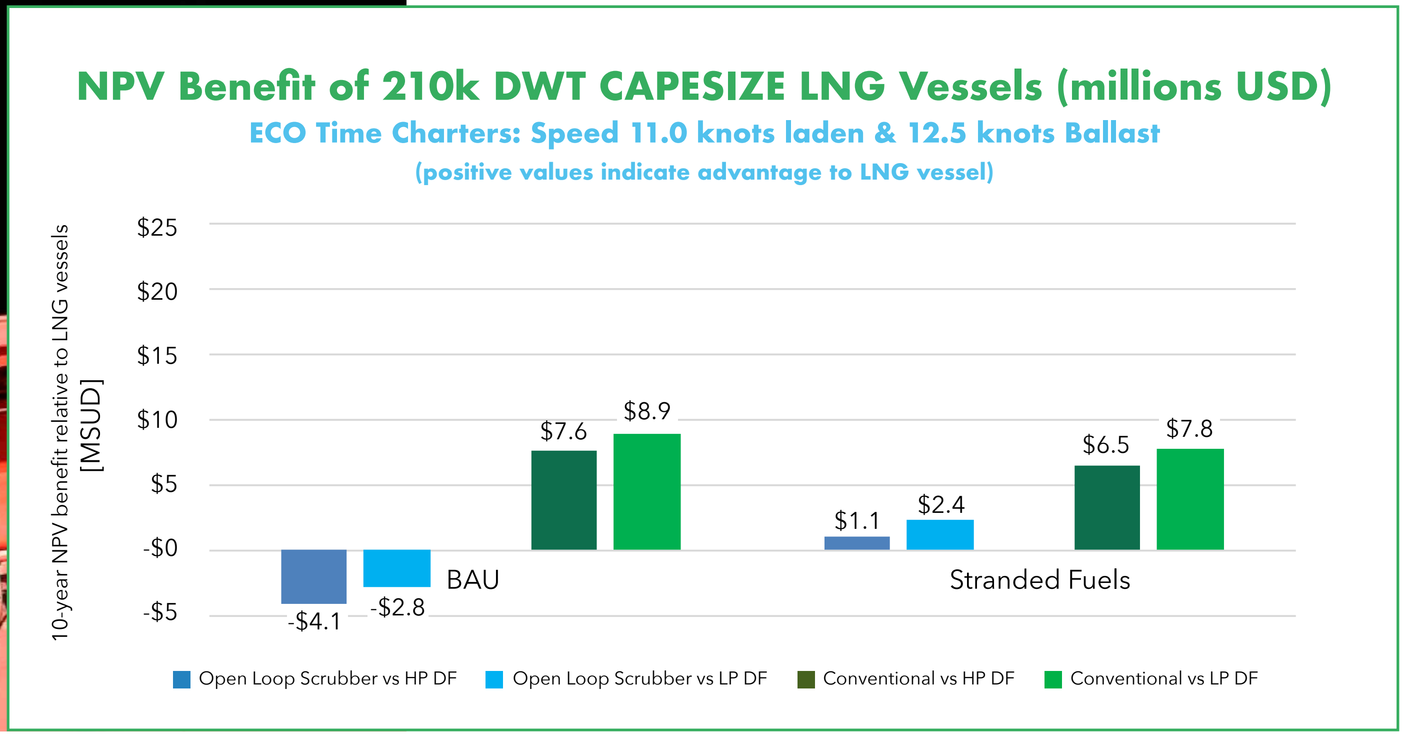




Net Present Value benefit for LNG on 210K DWT CAPESIZE

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 graphs below show the NPV benefit for the CAPESIZE, highlighting the fact that LNG delivers a better return on this trade against a vessel using low sulphur fuel oil. There is no consideration of carbon pricing included in these figures.





Net Present Value represents the increase in wealth accruing from an investment. The CAPESIZE vessel returns demonstrate superior NPV savings versus conventional compliant fuels for the BaU scenarios of Strong Time Charters ($18.8M to $19.3M) and ECO Time Charters ($7.6M to $8.9M). The NPV LNG advantage against conventional compliant fuel remains robust in the Stranded Fuel Scenarios under Strong ($17.1 to $17.6M) and ECO ($6.5M to $7.8M) respectively. The LNG fuel case against the scrubber with results in the negative range across BaU and positive ranges for Stranded Fuels forecast. However, the NPV calculations are based on a vessel trading from 2022 and take no account of potential financial values being applied to carbon emissions. Any newbuild vessel ordered today, would not be trading until 2022. The NPV for Average Charter Markets for vessel speeds of 12.5 knots Laden and 14.0 knots Ballast are illustrated in the executive summary.

Reader's Choice Fuel Forecasts

While the results of this study are based on a set of assumptions, through the "Reader's Choice" modelling, provision has also been made for each reader to select their variables in line with personal projections. The "Reader's Choice" sensitivity plot for the Business as Usual (BaU) case provides additional insights, plotting higher and lower CAPEX options. 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.

CAPEX premiums may change as a result of differences across three principal categories; market, technology, and/or physical. A market signal CAPEX change arises where a tough business climate forces shipyards to take contracts at historically low prices, or the reverse under expansionary periods. Similarly, market elements may also alter prices as a result of lower risk due to experience and/or cost advantages shared from long-running vessel series. On the technical side, a shipowner may decide to use another approach for his CAPESIZE, such as manganese material in C type tanks, or the installation of a membrane design. Physical differences that impact CAPEX arise when an owner prefers a different vessel trading range and thus a smaller or larger LNG tank capacity or other vessel characteristic change with resulting price reduction or additional cost.

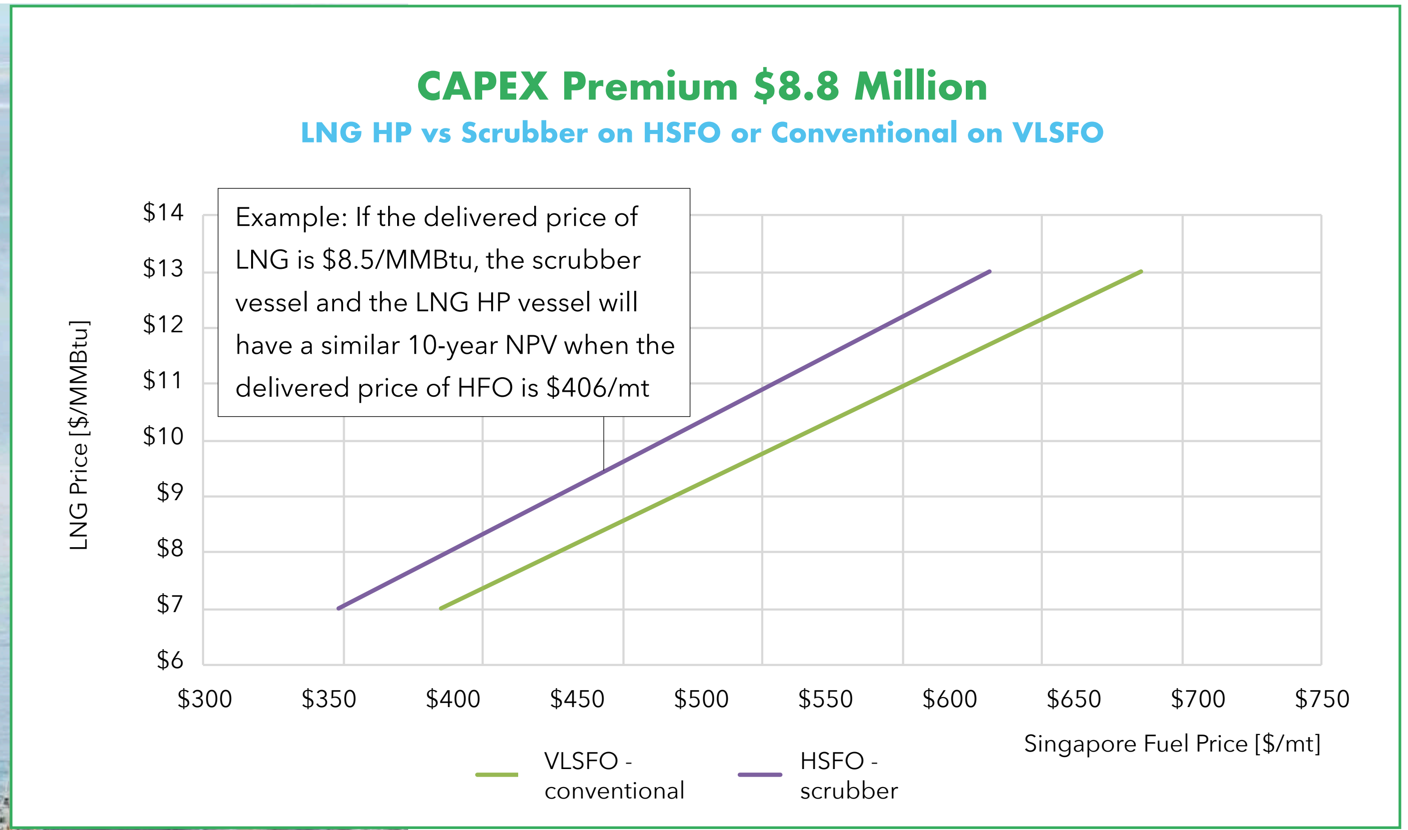
Key stakeholders, such as shipyards, vessel owners, energy providers, and charterers, can utilise the "Reader's Choice" to gain perspective on what key attributes balancing CAPEX and OPEX make the business-case work for all parties. If any combination of major stakeholders take monetary

positions outside accommodative ranges, then the business case fails for the remaining parties. Ideally these stakeholders will obtain valuable guidance from their interpretation of "Reader's Choice" about positions where business opportunities yield returns sufficient for all to engage. For example:

- **Shipyards** - insight into what LNG CAPEX premium yields reasonable returns for the other principal stakeholders
- **Vessel owners** - gain informative guidance on the relative price balance amongst energy alternatives, while achieving competitive returns satisfying the additional LNG CAPEX burden.
- **Energy suppliers** - understand the competitive positioning of different fuel alternatives OPEX positioning across various CAPEX values
- **Charterers** - determine whether a satisfactory charter hire premium is sufficient and justifies obtaining reduced supply chain CO_2 emissions.

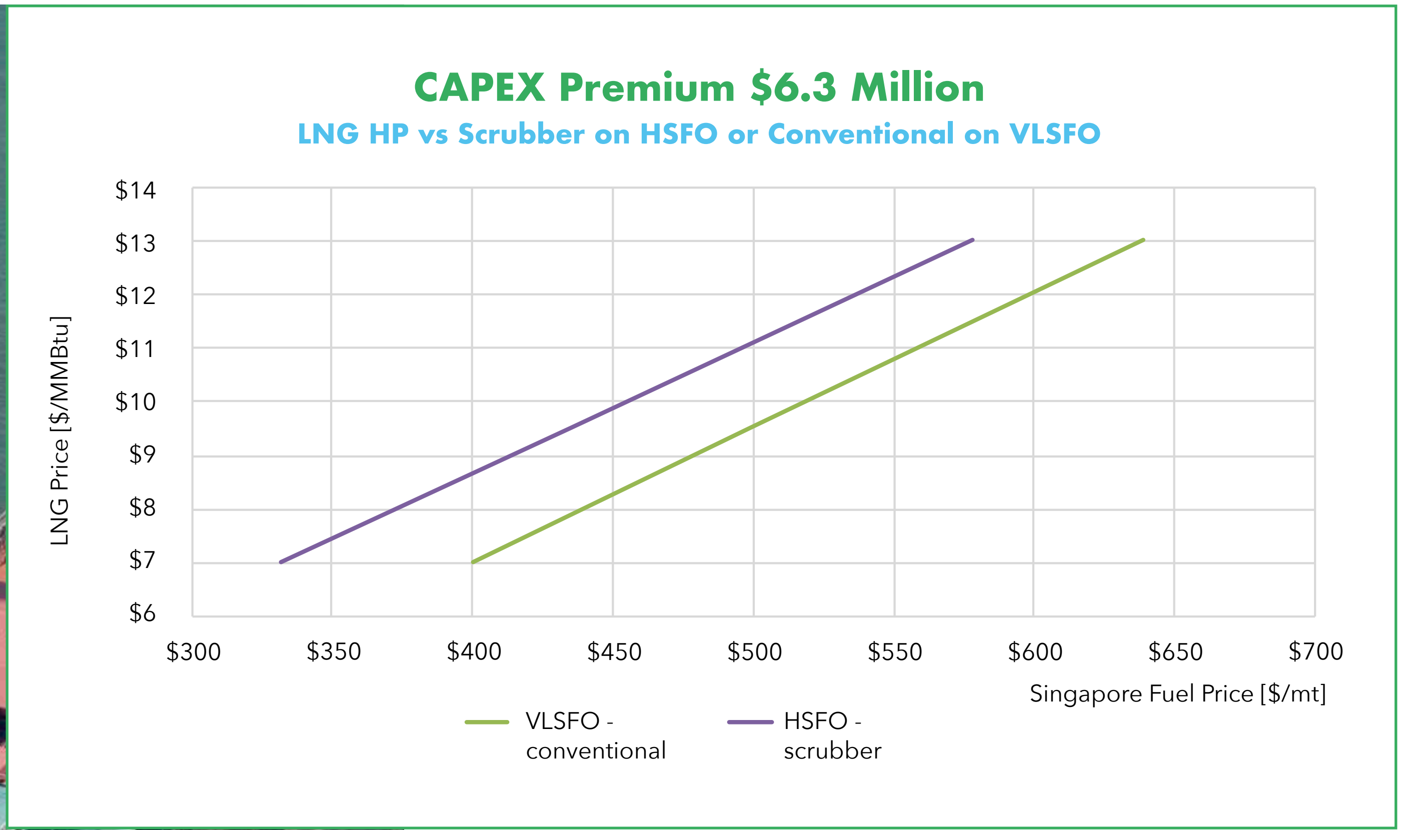
The next chart illustrates the fuel price tipping points resulting in the same business case outcomes for the 210K DWT tanker on the Australia-China trade when the HIGH CAPEX premium for LNG over a scrubber vessel is $8.8 million or conventional compliant $11.5M. The tipping point is illustrated by the straight diagonal line labelled "10-year NPV Tipping Point Line", with a purple solid-line for the LNG 2s versus conventional HSFO with a scrubber, and the light green solid line for the LNG 2s versus conventional LSFO.

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

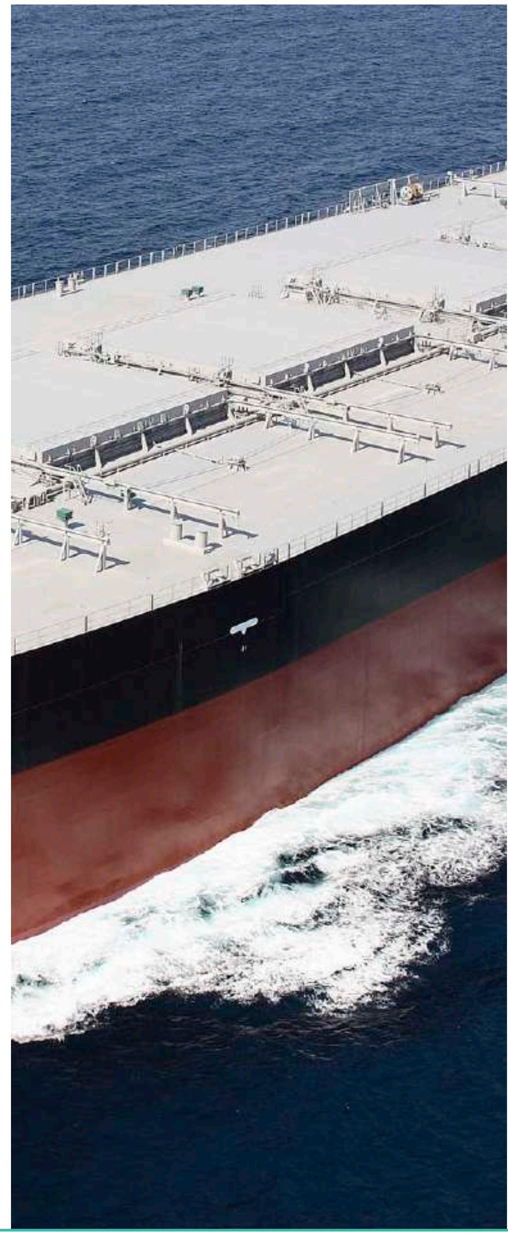


A second "Reader's Choice" plot provides this additional 'LOW' CAPEX perspective. This chart below illustrates the fuel price tipping points resulting in the same business case outcomes for the 300K DWT tanker on the Arabian Gulf-China trade when the CAPEX premium for LNG over a scrubber vessel is only $13.2 million or versus the conventional compliant of $16.5M. The tipping points are illustrated as before, but have now shifted due to the lower CAPEX premium for LNG over the scrubber fitted VLCC.

The choice also recognises that over much shorter investment horizons of only a few years, an elevated CAPEX recovery charge often makes short lifetime projects not viable.



The CAPEX High and Low Readers' Choice charts provide valuable business case insights amongst the principal four stakeholders: shipyard, energy provider, shipowner, and charterer. Each stakeholder can model how their cost basis for the business case impacts other participants' investment viability, given the need to accommodate reasonable return risk profiles for success under the business case assumptions.



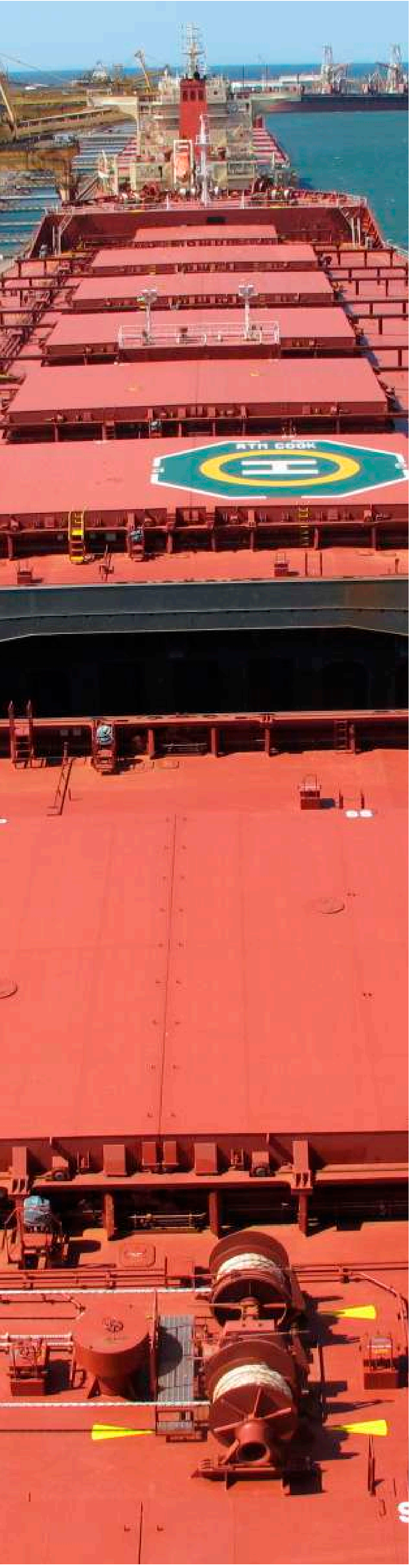
The impact of CAPEX premium for LNG fuel alternative can be obtained by interpreting the "Readers' Choice" charts. For example, consider HSFO plus scrubber with an assumed BaU fuel price of $400 per ton: for the High CAPEX chart we find the same business NPV outcome for LNG when priced $8.33 /mmBTU. A check on the Low CAPEX readers choice finds for the same BaU fuel price the LNG tipping point value rises to about $8.66 /mmBTU. This is understandable since a Low CAPEX upfront cost when considering the overall business case investment horizon allows the recurring annual OPEX fuel cost to rise while resulting in the same result for the time value of money analysis.

Interpretation of the combined charts provides a valuable perspective, a $2.5M CAPEX premium reduction results in an LNG tipping point price escalation of nearly $0.33 /mmBTU to provide the same NPV investment return. The linkage between initial capital cost and annual OPEX energy prices is revealed as for every $1 million CAPEX reduction the price of LNG may rise 0.13 $/MMBtu[16]. Note that these charts relate to the quantity of fuel consumed on this cargo route by a modern CAPESIZE of 210K DWT under the model assumptions. Other ships and trades will have different values. Note that the trends will be similar; a higher CAPEX premium for LNG then must find a reduction in LNG fuel price so that the recurring annual OPEX costs generate the same investment return.

[16] The ratio 0.33 $/MMBTU divided by $2.54 million CAPEX = 0.13 $/MMBtu LNG rise per Million CAPEX reduction.

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

It also represents a significant step forward in the reduction of GHGs and a potential pathway to meeting future carbon-related emissions targets.



WAY FORWARD

With the implementation of the IMO's 1st January 2020 0.5% global sulphur cap on marine fuel comprising both an economic and operational issue, owners' attention is increasingly focused on the IMO emissions reduction targets for 2030 and 2050. Environmental consciousness is the new normal. Demand is growing for goods that are both sourced and transported in more sustainable ways and marine LNG is set to play a central role.

While there are a variety of lower or zero-carbon alternative fuels that could help to meet these future GHG reduction targets and current air quality legislation, most of these alternatives are immature, require significant development for safe use onboard vessels and lack any meaningful infrastructure to meet the shipping industry's needs. None are available now at scale to meet the quantity required for shipping, nor expected to be for decades into the foreseeable future.

However, LNG is a solution – available now - that could move the industry forward, on a pragmatic pathway towards carbon-neutral bio and synthetic methane produced from renewable energy. With unrivalled emissions credentials, LNG cuts SOx and particulate emissions to negligible amounts, reduces NOx by around 85% and reduces CO2 emissions by up to between 21% on a well-to-wake basis today.

Shipping represents one element of an inter-twined, highly efficient, international multimodal logistics chain. Recent efforts to curb CO2 emissions have included advocates pressing for speed restrictions to reduce global warming. While mandatory speed reduction may seem appealing, it is not a good answer to the decarbonization question on multiple fronts. First this may have unintended consequences as older inefficient vessels may find a longer lifetime and remain active thereby generating higher emissions that add to the pollution problem rather than being phased out by more efficient vessels. Slower delivery by sea means time-sensitive cargoes may miss efficient stack train land channels and opt for direct faster trucking with elevated emissions. Secondly innovation on several technical fronts including prime movers, emissions management, and or vessel efficiency may lose momentum. Third a speed reduction may reduce otherwise fast-paced implementation of alternative fuel programs or other advances that are needed to achieve the IMO targets.

While there remain many unanswered questions about the choice and prices of marine fuels going into 2020 and beyond, SEA\LNG remains committed to working with independent consultants to bring factual, evidenced information to the market. In addition to recent research, for example the Life Cycle Greenhouse Gas Emissions Study, conducted by Thinkstep, the Alternative Marine Fuels Study undertaken by DNV GL, and previous investment studies from Opsiana, 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. This independent research modelling will be repeated to study the investment cases for common ships in typical trades, and a study which explores the potential availability of bio and synthetic methane, undertaken by Delft, will also be imminently released.

The investment case for LNG as a marine fuel is compelling. The direction of emissions legislation, the advancement of technology, and continuously expanding infrastructure to support LNG all mean the commercial advantages of LNG are increasing. It is the only practical option that meets today's emissions challenges and provides a pragmatic pathway to future decarbonisation goals while safeguarding a competitive advantage for the shipowners and operators who facilitate global trade.

LNG is a solution – available now - that could move the industry forward, on a pragmatic pathway towards carbon-neutral bio and synthetic methane produced from renewable energy. With unrivalled emissions credentials, LNG cuts SOx and particulate emissions to negligible amounts, reduces NOx by around 85% and reduces CO2 emissions by up to between 21% on a well-to-wake basis today.

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