Quadrise Fuels International

Alternative energy

30 November 2021

Cleaner fuel, cleaner planet

Quadrise has developed a synthetic heavy fuel oil (HFO) technology that potentially reduces costs and polluting emissions for HFO users in the industrial, marine bunker and power markets, as well as improving the profitability of upstream operations and of refineries producing HFO. Recent third-party tests on Quadrise's new biofuel, bioMSAR, show reductions in CO2 emissions that are materially ahead of existing biofuels at a lower cost.

Making progress on three customer programmes

Following the signing of a joint development agreement (JDA) in January 2021, Quadrise and MSC Shipmanagement, part of the world's second largest shipping line, could potentially start on-vessel, commercial-scale trials in mid-CY22. If successful, the trials may be followed by commercial roll-out of bioMSAR and/or MSAR across MSC's global fleet. Tests on samples from Greenfield Energy, a subsidiary of TomCo Energy, have confirmed that heavy sweet oil from the Tar Sands site in Utah is suitable for conversion to both MSAR and bioMSAR for potential power and marine applications, potentially leading to on-site production in mid-CY22. Quadrise and its customer in Morocco are preparing for an industrial trial in Q1 CY22 to be followed by a commercial trial later in H1 CY22.

Cash runway to Q1 CY23

Quadrise is still pre-revenue. Stripping out share option and exceptional charges, operating losses narrowed by £0.3m y-o-y in FY21 to £2.9m, reflecting lower administrative costs. Free cash outflow decreased by £0.6m to £2.4m. Following a placing and oversubscribed open offer in March, raising £6.5m (net), the group had £7.0m cash, no debt or convertible securities at end FY21. Management notes that this balance represents 2½ years of fixed costs, giving a cash runway to progress the ongoing trial programmes into Q1 CY23, by which time, if one or more of these programmes is successful, it believes the company should be generating commercial revenues and sustainable cash flows.

Valuation: Modest adoption transformational

We are not presenting forecasts at this stage. However, as a rough guide, based on data from the company, our scenario analysis calculates that even modest adoption of MSAR could generate material revenues and take the company to sustainable profitability. For example, adoption across only 9% of MSC's global fleet could generate around $80m in licence revenues and require minimal capex.

Historical performance

Year end	Revenue (£m)	EBITDA (£m)	PBT* (£m)	EPS* (p)	DPS (p)	P/E (x)	Yield (%)
06/18	0.0	(3.3)	(3.5)	(0.37)	0.00	N/A	N/A
06/19	0.0	(2.8)	(3.0)	(0.32)	0.00	N/A	N/A
06/20	0.0	(3.0)	(3.3)	(0.32)	0.00	N/A	N/A
06/21	0.0	(2.8)	(2.8)	(0.23)	0.00	N/A	N/A

Source: Company accounts

Price	2.39p
Market cap	£34m

Share price graph

Share details

Code	QFI
Listing	AIM
Shares in issue	1,406.9m
Net cash at end June 2021	£7.0m

Business description

Quadrise is the innovator, supplier and global licensor of disruptive oil technology that produces a synthetic, enhanced heavy fuel oil called MSAR and a biofuel called bioMSAR. The technology provides a low cost and cleaner fuel for marine, power and industrial applications.

Bull

- bioMSAR gives better CO_2 and cost savings than existing biofuels.
- Adoption of MSAR improves economics of refinery production and upstream operations.
- Adoption of MSAR improves profitability of upstream operations and reduces costs and emissions in industrial, marine bunker and power markets.

Bear

- Economics of adoption dependent on oil product spreads.
- Ability to progress trials adversely affected by COVID-19-related travel restrictions.
- Target markets slow to adopt new technologies.

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Company description: Lower-cost fuel oil solution

Economic and environmental benefits

Quadrise is the innovator, supplier and global licensor of a disruptive residual oil technology for producing an enhanced, emulsified synthetic heavy fuel oil called MSAR (multiphase superfine atomised residue) and a biofuel called bioMSAR. Installing MSAR production technology increases profitability for oil refiners without incurring the significant expenditure typically associated with infrastructure upgrades. This is because MSAR production frees up valuable distillates traditionally used for HFO manufacture. The savings achieved enable refineries to price MSAR at a discount to conventional HFO, resulting in cost savings for existing HFO users. A switch to MSAR can also improve the profitability of a refinery's upstream operations. MSAR and its biofuel variant, bioMSAR, can be used for the same applications as conventional HFO which, based on data from the International Energy Agency, is a market worth around $170bn/year. These economic benefits depend on the differential in price between diesel and HFO rather than the price of crude oil.

Although MSAR was originally promoted primarily for its economic benefits, there are environmental benefits too as it produces less NOx (nitrogen oxide) and soot than HFO and 5% less CO_2 than diesel fuel, giving a route to reducing greenhouse gas emissions. bioMSAR reduces greenhouse gases even further, by over 20%, and the company is working towards having a net-zero solution by 2030.

Quadrise is focusing on four significant market segments. These are as a replacement for fuel oil, biofuels or crude oil in industrial processes such as cement manufacture and in power generation, as a marine bunker fuel and in upstream oil production operations where MSAR may be used either as an alternative fuel source for on-site utilities or to produce a low-viscosity finished fuel product that significantly reduces pipeline transport costs.

Fuel proven in power and marine fuel markets

The market for MSAR is already proven because more than 60Mt of a first-generation oil-in-water emulsion fuel, BP and PDVSA's Orimulsion, was supplied to the global market for power generation between 1993 and 2006, at which point Orimulsion production in Venezuela was discontinued because of issues in the wider Venezuelan economy. Key members of Quadrise's management, including CEO Jason Miles, were instrumental in the development and commercialisation of Orimulsion. They have since continued this work in developing a technically improved, second-generation emulsion fuel, MSAR. This was proven as a substitute for marine bunker fuel through extended sea-based trials with Maersk and commercial-scale trials at Lithuania's main electrical generation plant, although neither of these projects proceeded to commercialisation for reasons outside Quadrise's control.

Focus on three customer programmes

Quadrise is currently focused on three customer programmes: (1) a JDA with MSC Shipmanagement, part of the world's second largest shipping line, leading to potential on-vessel trials of bioMSAR and/or MSAR as bunker fuel; (2) commercial- and industrial-scale trials with a chemicals and mining group in Morocco using MSAR to heat kilns; and (3) discussions with Greenfield Energy regarding the commercial production of bioMSAR and MSAR adjacent to proposed oil wells in Utah. The earliest that any of these projects may proceed to commercial supply is mid-CY22.

Quadrise was admitted to AIM in April 2006 and its headquarters are in London. It also has an R&D facility in the UK where it develops bespoke MSAR solutions for refinery residual oils, some of

which activity is paid for by the potential customer. It currently employs nine staff excluding non-executive directors and consultants.

MSAR: Proven, established technology

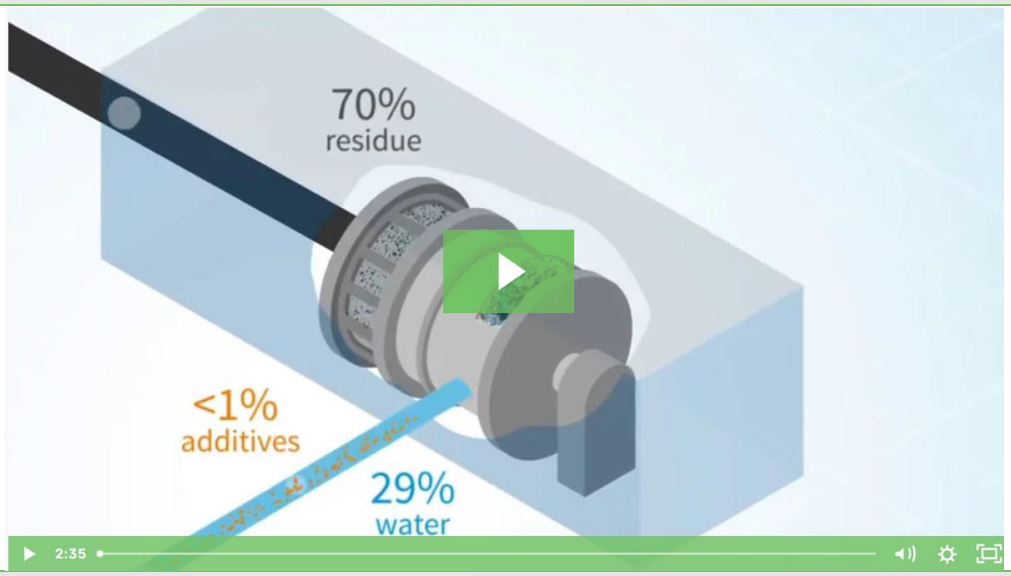
Traditional refining and MSAR process compared

After refining, around 70% of the output from a typical semi-complex refinery is high-value transportation fuel and 30% low-value residue. The residue is solid at room temperature and, if not processed further, can only be used for limited volume applications such as road surfacing material. Refineries widen the market for this residue by blending it with some of the high-value transportation fuel to create HFO in a mix that is 60–80% low-value residue and 20–40% valuable distillate. HFO is sold at a discount (c 7% as of October 2021) to crude oil, resulting in a loss for the producer.

The MSAR process significantly improves refinery yields by eliminating the need to blend the heavy residues with distillates to make HFO. Instead, MSAR is made by mixing the hydrocarbon residue (c 70%) with water (c 30%) and small amounts (<1%) of specialised surfactants and emulsifiers from long-term partner Nouryon. This means that the refiner can sell the high-value distillates, which would otherwise be required for manufacturing HFO, improving profitability.

MSAR manufacturing process

Exhibit 1: Introduction to MSAR



Source: Quadrise Fuels International

Residue is converted to MSAR using a proprietary process in which the hydrocarbon residue is reduced to particles of approximately 5–10 microns in diameter. The surfactant chemicals ensure that the resultant emulsion is stable throughout transportation, storage, fuel handling and consumption. Quadrise is able to tailor the MSAR production process to suit different residue types and applications, broadening its applicability. The key steps in the manufacturing process are:

- Stage one: oil residues are taken direct from refinery rundown lines and cooled to achieve the required viscosity for the colloid mill. This is a machine used to reduce the particle size of a solid in suspension in a liquid, or to reduce the droplet size in emulsions.
- Stage two: water, which can be derived from several waste-water utility sources, is added to the residue.
- Stage three: special additives are included in the water phase to stabilise the emulsion for long-term storage and conventional transport, and to promote complete combustion.

- Stage four: the mixture is processed in a proprietary MSAR manufacturing module to a high hydrocarbon content (typically 70%) oil-in-water emulsion with enhanced fuel properties.

MSAR's environmental credentials

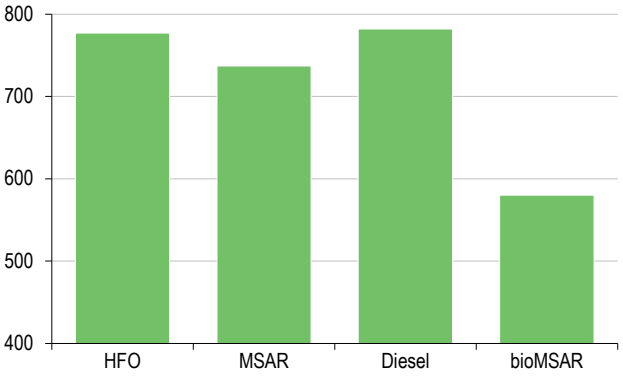
As the oil phase in MSAR is pre-atomised to very small sizes (5–10 microns) compared with atomised HFO droplets (100 microns), the increased surface area enables almost complete combustion, leaving virtually no carbon particulates in the exhaust gases. This makes MSAR more environmentally friendly than HFO. In addition, the water in MSAR reduces the temperature of combustion; tests carried out by Wärtsilä have shown this reduces NOx (nitrogen oxide) emissions by 20–50%. Since the MSAR production process uses less energy than other techniques for refining residue, which may involve cracking at high temperatures or the use of solvents, it can be considered a more environmentally beneficial process in this regard as well. As the amount of sulphur in MSAR depends on the composition of the residue, MSAR is potentially available in both high and low sulphur variants.

Quadrise currently supplies two proven lower-cost synthetic fuel solutions: power MSAR for use in stationary applications such as boilers and kilns; and marine MSAR for use as a bunker fuel by shipping companies. A third fuel, bioMSAR (see below), is currently undergoing final testing for marine and power applications, and currently offers 20–30% reductions in CO_2 compared with conventional oil-based fuels

bioMSAR – biofuel variant of MSAR

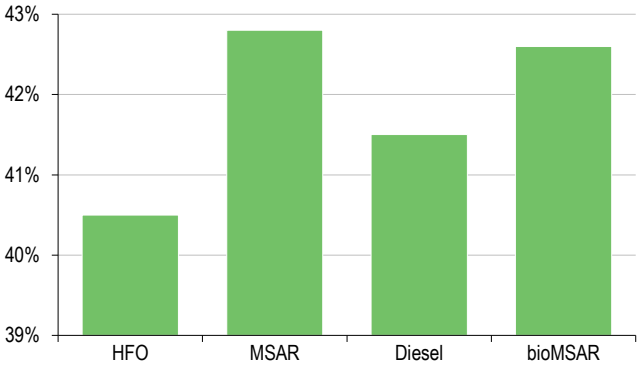
While the original MSAR is more environmentally friendly than HFO, Quadrise went a step further with the launch of bioMSAR in December 2020. bioMSAR is manufactured in the same way as conventional MSAR using a mixture of bioglycerine (40–50%), refinery residue (40–50%), water (c 10%) and small amounts (<1%) of specialised surfactants and emulsifiers from long-term partner Nouryon. Glycerine is a biodegradable, non-toxic liquid derived from plant and animal sources which is a waste product from the manufacture of biodiesel. The proportion of glycerine in bioMSAR can be adjusted to potentially give a range of CO_2 savings of 10–50% depending on a customer's requirements.

Exhibit 2: Well-to-wake CO_2 emissions (g/kWh) – 75% load



Source: Quadrise Fuels International

Exhibit 3: Efficiency* of four-stroke Wärtsilä engine – 75% load



Source: Quadrise Fuels International. Note: *Amount of energy in fuel realised as useful energy in the engine.

Results from tests on five tonnes of bioMSAR using a medium speed four-stroke Wärtsilä diesel engine by VTT in Finland, which were announced in August, gave average CO_2 savings of 26% on a well-to-wake basis compared with conventional diesel. Part of the CO_2 reduction was attributable to an increase in engine efficiency of up to 7%. This result is better than the CO_2 savings achieved with existing biofuels, which are typically in the region of 10–15%. NOx emissions were lower than for HFO and comparable to diesel, with further NOx optimisation possible. Smoke and particulate levels were very low, as were unburned hydrocarbons emissions, due to efficient fuel combustion.

The next stage of bioMSAR testing will involve commercial 2-stroke and 4-stroke engine testing at OEM testing facilities, as well as testing on combustion applications.

Importantly, MSAR and bioMSAR fuels are fully interchangeable with each other. bioMSAR thus provides a potential route for MSAR adopters to reduce their CO_2 emissions. In our opinion, this should both help increase Quadrise's market opportunity and the speed and scale of market penetration. For example, we note that the rapid progress made developing bioMSAR was instrumental in securing the JDA with MSC Shipmanagement, which intends to trial bioMSAR ahead of MSAR.

Given the magnitude of the potential demand for bioMSAR, Quadrise is engaged in discussions with crude glycerine suppliers and is conducting joint research with the University of Greenwich and Algae UK on the production of glycerine and other products from algae. Algae could potentially provide new sources of feedstock for renewable fuels based on the MSAR technology, as well as further reducing the CO_2 emissions of bioMSAR to net zero in future. The company is also in the early stages of investigating the use of other renewable fuels such as lignin, which is a renewable, wood-derived fuel source, to produce a net-zero fuel.

Adoption by oil refineries

Adoption of the MSAR process means all of the high-value middle distillate can be sold as transportation fuel, enabling the refinery to offer MSAR at a discount to HFO and still improve overall profitability. This potential discount encourages the refineries' customers in power generation and shipping to adopt the fuel. Quadrise has carried out extensive assessment work for a wide variety of refineries. This has included detailed front-end engineering design studies and determination of MSAR formulation costs for residues from individual refineries. It also has data from the installation, commissioning and operation of a 1,000t/d (6,000bpd) MSAR manufacturing unit at the Cepsa refinery in Gibraltar (see below).

The value generated by the refinery is not linked directly to the price of crude oil but is a function of the pricing spread between diesel and residue-based fuel oil. Based on the Futures pricing for 2022 in November 2021 which indicates a spread of US$241/tonne, Quadrise calculates that if a 100kbpd semi-complex refinery producing 15kbpd of residue switched to MSAR production it would save 10kbpd of middle distillate and produce output c 22kbpd of MSAR, giving an additional gross profit of £53m each year for the refinery.

Exhibit 4: MSAR production plant at the Cepsa Refinery Gibraltar-San Roque

Source: Quadrise Fuels International

The studies also show that a refinery can switch to MSAR relatively swiftly and inexpensively because the production technology is modular and can be integrated into an oil refinery's existing operations in less than 12 months. Quadrise calculates that the total capital expenditure required for full conversion of the 100kbd refinery in the example above would be around $20m. The alternative approach for this type of refinery to achieve a comparable increase in crude 'yield' would be to undertake a substantial facility upgrade costing c $1.1bn and taking four to six years. In

addition, MSAR is a low-viscosity liquid at room temperature so it can be stored and transported at ambient temperatures (c 20–30°C), while HFO must be heated to much higher temperatures (60–100°C). Consequently, less energy is required to handle and transport MSAR, generating further savings.

Adoption in the power industry

As noted above, refineries can potentially offer MSAR at a discount to HFO, making it an attractive proposition for power generation. In 2008, Quadrise successfully completed a commercial demonstration of MSAR as boiler fuel in Lithuania. Over 22,000 tonnes of MSAR were produced at ORLEN Lietuva's 200,000bpd (10Mt/year) refinery from Urals crude-based residues. The MSAR was transported c 300km by rail to the 1,800MWe (megawatt electrical) Elektrėnai power plant in Lithuania. This plant is operated by Lietuvos Elektrinė, a former Orimulsion customer, and is the primary source of Lithuania's electrical power. Lietuvos Elektrinė concluded that the performance of MSAR was similar to or better than Orimulsion. The trial results were independently verified by consultants from the European Bank for Reconstruction and Development (EBRD), but the project did not proceed to commercialisation because of the financial crash in 2009. The project has not been revived since, because Lithuania now has a liquefied natural gas (LNG) terminal at Klaipeda so security of fuel supply is less of an issue than when it was dependent on Russian gas.

Based on the studies carried out for utility companies and using the spread value given above, Quadrise calculates that the cost of converting a 400MWe boiler to MSAR would be $2.5m, generating fuel savings of $20m/year compared with HFO costs of c $280m pa at current prices. This represents a payback time of only a few months. Quadrise estimates that over 80% of the running costs for a boiler are related to fuel costs.

Exhibit 5: Elektrėnai power plant

Source: Quadrise Fuels International

Adoption in the shipping industry

bioMSAR potentially helps shipping lines meet carbon reduction targets

According to the International Maritime Organization (IMO), maritime transport emits c 940m tonnes of CO_2 annually and is responsible for c 2.5% of global greenhouse gas emissions. The organisation estimates that under a 'business-as-usual' scenario, shipping emissions could increase between 50% and 250% by 2050. To combat this situation, in April 2018 the IMO set out a policy framework, which aimed to cut greenhouse gas emissions from international shipping by at least half by 2050 compared with the level in 2008, and reduce the carbon intensity of international shipping by at least 40% by 2030 compared to 2008. (Carbon intensity is defined as either the

amount of CO_2 emitted per tonne of cargo transported a nautical mile or the amount emitted by a vessel in a year divided by its cargo-carrying capacity and the number of nautical miles travelled.) In June 2021, the IMO adopted some short-term measures aimed at achieving its target. These measures combine technical and operational approaches to improve the energy efficiency of ships and will require all ships to obtain a rating of their energy efficiency and ships over 5,000 gross tonnage to determine their annual operational carbon intensity indicator (CII) and CII rating. This is the first time the IMO has established a formal rating system for ships, sending a strong signal to the market. The IMO notes that shipping will need new technologies, new fuels and innovation to meet the greenhouse gas targets.

Based on recent results from VTT (see above), Quadrise calculates that bioMSAR could reduce emissions of CO_2 from a large vessel consuming 25,000 tons of HFO annually by over 25%. This equates to 23,000 tons of CO_2, ie equivalent to the annual emissions from 11,000 petrol cars. Adoption of bioMSAR thus potentially presents a mechanism for shipping lines to reduce carbon dioxide emissions from existing vessels without incurring substantial investment in new systems.

Using MSAR to offset the cost of installing scrubbers for use with high sulphur fuel

Fuel accounts for the largest proportion of a fleet's operating costs, typically over 50% for container ships, so switching from HFO to a lower-cost fuel such as MSAR is an attractive option. Management estimates that, based on the spread value stated earlier, which determines the level of discount to HFO that refineries can offer, converting a very large container ship consuming 25,000 tonnes of fuel annually to MSAR would cost c $400k and save up to $1,210k/year. The savings arising from switching from HFO to MSAR are a potential way of offsetting the cost of installing scrubbers, estimated at around $2m per large vessel, which enable a vessel to continue to use heavy sulphur fuel while meeting the tightened IMO sulphur emission requirements introduced at the start of 2020. The heavy sulphur fuel could be either a high sulphur fuel oil (HSFO) or high sulphur MSAR variant. The main alternative to scrubbers for a shipping line is to switch to very low sulphur fuel oil (VLSFO), which is more expensive than HSFO.

When the tightened sulphur emissions requirements initially came into force, the price difference between VLSFO and HSFO was over $300 per tonne, resulting in payback times of less than a year for installing scrubbers on a very large crude carrier and just over a year for a capesize bulk carrier. However when the difference in price between HSFO and the compliant fuel oil narrowed to only $52 per tonne in north-west Europe in the middle of CY20, the payback period for a scrubber on a capesize bulk carrier extended beyond five years, and beyond three years for a very large crude carrier. This deterred shipowners from installing scrubbers. In recent months the spread between VLSO and HSFO has widened to a point where the economics are in favour of scrubber installation again. In August 2021, Lloyd's List noted that the total number of container ships globally fitted with scrubbers was 816, representing just under one-third of the total fleet by capacity. The rate of installation had dropped year-on-year, with 85 scrubber-fitted vessels added to the fleet during H121 compared to 250 ships in H120. However, part of the slowdown in installations may be attributable to very strong demand for containership capacity during the pandemic which is discouraging owners and operators from taking tonnage out of service for retrofitting while those ships could be earning at record high freight and charter rates.

We note that the potential switch to marine MSAR is relatively straightforward because it can be transported to end-users in the same way as HFO and may be used in conventional electronically controlled two-stroke and four-stroke diesel engines without the need for major modification or retuning. This compares favourably with LNG, which is often cited as an alternative marine fuel but has specialised and expensive storage and handling requirements. A switch from HFO to marine MSAR would also give a reduction in both NOx and black soot emissions. This may help drive demand for marine MSAR in the longer term because the IMO has imposed an 80% reduction in

NOx emissions for the North American and US Caribbean emission control areas, the Baltic Sea and the North Sea, applicable to ships whose keels are laid from January 2016.

MSAR proven for use in marine sector

Shipping giant Maersk invested seven years in a programme that conclusively proved that MSAR was a viable marine bunker fuel in both two- and four-stroke engines. The programme culminated in an operational trial during 2016 and 2017 on the Seago Istanbul container vessel. The vessel completed c 1,500 MSAR running hours following its normal route, using a total of 7,000 tonnes of MSAR produced at Cepsa's Refinery Gibraltar-San Roque in Spain. The MSAR fuel performed well and feedback from engine manufacturer Wärtsilä and from Maersk was very positive. As a result, Quadrise received an interim letter of no objection (LONO) for MSAR for Wärtsilä RT-flex96C-B engines. Despite this successful outcome, in 2017 Maersk decided not to install scrubbers on the majority of its fleet and to use VLSFO instead, possibly because the IMO decided to bring forward implementation of the low sulphur legislation from 2025 to 2020, requiring a massive investment in scrubbers over a much-shortened timescale.

Exhibit 6: Seago Istanbul sailing its normal route during the marine MSAR trial

Source: Quadrise Fuels International

The world's second largest shipping line, MSC, has taken an alternative approach to Maersk. It has already equipped over 40% of its 560 container ships with scrubbers so it can continue to burn high-sulphur fuel while being compliant with the IMO's tightened sulphur cap. MSC is interested in using Quadrise's fuels to offset the costs of installing and operating scrubbers. In January 2021, MSC Shipmanagement signed a JDA with Quadrise (see below) for bioMSAR and MSAR.

Active projects

Marine programme with MSC Shipmanagement

Under the JDA with Quadrise, MSC Shipmanagement is to carry out a LONO trial of MSAR on representative commercial vessels in MSC's global fleet deploying either large MAN ME and/or Wärtsilä/WinGD Flex two-stroke engines. Originally, Quadrise expected that the two parties would carry out high-level scoping and feasibility activities and define a project roadmap during H1 CY21 ahead of one or more on-vessel trials commencing in Q4 CY21. However, the shipping line is an early adopter of environmental technology and currently uses 850,000 tonnes of biofuel annually, making it one of the largest consumers of biofuel in the marine sector. Consequently, as more details of bioMSAR's performance were released, which was after the original agreement had been signed, MSC decided it wanted to fast-track Quadrise's biofuel option. This decision delayed the preparatory phase until VTT had conducted independent tests on bioMSAR (see above) and Quadrise had advised on how the performance achieved during tests with a four-stroke Wärtsilä stroke engine would translate to two-stroke engine performance. The preparatory phase has also been held up by lack of availability of MSC, engine manufacturer and Classification Society

personnel because of coronavirus issues and challenges such as the Suez Canal blockage and testing of new low-carbon fuels. These delays mean that the earliest the 4,000-hour LONO trial will start is mid-CY22. If successful, the trial may potentially be followed by commercial roll-out of bioMSAR and MSAR across MSC's global fleet commencing in CY23. We note that the average consumption per ship burning MSAR/bioMSAR would be 600bpd.

Industrial applications with partner in Morocco

Exhibit 7: Testing burner tip for Morocco pilot trial

Source: Quadrise Fuels International

Since November 2021, Quadrise has been working with an international chemicals and mining group headquartered in Morocco, which is considering using MSAR as a substitute for HFO in some of its kilns. Quadrise had hoped to conduct a pilot trial at one of its partner's sites (site A) in Morocco in March 2020, but COVID-19 restrictions meant that Quadrise's personnel were not able to gain access to the site and successfully complete the trial until October 2020. An industrial-scale trial at a different site (site B) owned by the same partner has been delayed from early Q1 CY21 to Q1 CY22 because of a combination of site access restrictions and a recent internal management reorganisation at the client, which is currently holding up the approval to proceed with the site B trial. This industrial-scale trial, which will consume 60Mt of MSAR, extends the potential for deployment across the client's facilities. As the industrial-scale trial is a precursor to a larger, commercial-scale trial on site A, the commercial-scale trial has been delayed to later in Q1 CY22 or Q2 CY22. These project timelines may be subject to delays due to ongoing and future COVID-related travel restrictions in Morocco. Assuming that the trials complete successfully, management intends to conclude a commercial supply agreement covering one or more of the client's sites in Morocco around during in Q2 CY22, potentially leading to commercial deliveries equivalent to 2–5kbpd from H2 CY22 onwards.

Upstream potential with Greenfield Energy

Greenfield Energy is a wholly owned subsidiary of TomCo Energy, an oil development group using innovative technology to exploit oil sands in Utah. Greenfield temporarily took over the management and operations of Petroteq Energy's oil sands plant in Utah between June 2020 and June 2021 to assess whether Petroteq's patented solvent extraction technology was an economic option for extracting crude oil from oil sands at scale. The programme showed that the technology was viable, so Greenfield intends to purchase a different oil sands site in Utah, the Tar Sands II site, which has higher levels of oil saturation than the Petroteq site, and to place a commercial-scale (up to 10,000 barrels of oil per day) oil extraction facility there. In August 2020, Greenfield signed a commercial trial agreement with Quadrise with the intention of converting crude oil into a diesel replacement for medium speed engines, boilers and other heavy machinery or bunker fuel. Since the bituminous sands in Utah have a relatively low sulphur content, the crude oil from the Tar Sands II site could be converted via the MSAR process into a bunker fuel that is compliant with the latest regulations from the IMO.

Originally, Greenfield had hoped to reactivate production at the Petroteq site in November 2020 so it could send oil samples to Quadrise for checking on the appropriate MSAR formulation by the end of CY20. Reactivation of the extraction process was delayed by coronavirus-related restrictions and bad weather, so Quadrise did not receive crude oil samples from the Tar Sands II site until August 2021. The subsequent tests confirmed that the sample could be converted to both standard MSAR and the bioMSAR variant for potential use in power and marine end-user applications domestically and internationally. TomCo is currently reviewing the report on the test programme and expects that Greenfield and Quadrise will enter into discussions regarding potential future trials and deployment of Quadrise's technology to produce MSAR and/or bioMSAR fuel at a commercial scale. Greenfield has purchased an initial 10% stake in the Tar Sands II site and, subject to securing the required permits, intends to drill up to five wells on it. These wells could potentially start production mid-CY22. Greenfield could potentially convert crude oil extracted from the wells to MSAR and/or bioMSAR for sale as low sulphur fuel to the power and marine markets. Subject to financing, Greenfield intends to deploy an oil sands extraction plant at the Tar Sands site and potentially produce bioMSAR/MSAR from the output. TomCo estimates that it would take just over a year to construct an extraction plant which would cost around US$185m to build. Quadrise is also engaged in discussions regarding MSAR and bioMSAR production at other upstream facilities in Utah and elsewhere in the United States.

Power

Quadrise continues to work with its regional agent network on projects in Panama, Mexico and Ecuador which involve the use of MSAR to generate power for use within refineries. However, at present it is prioritising work on the three projects discussed in detail above.

Management

Quadrise's management has the breadth and depth of experience required to commercialise the MSAR technology. CEO Jason Miles spent the first 12 years of his career developing emulsified fuel projects, initially as a process engineer for BP and subsequently as business development manager for PDVSA, where he implemented numerous Orimulsion power projects globally. He now has around 30 years' technical and commercial experience in emulsion fuels. He joined Quadrise in 2006 and was promoted from COO to CEO in February 2020.

Executive chairman Michael Kirk retired at the group's AGM in November 2021. Non-executive director Laurie Mutch has become interim chairman while the group looks for Michael's successor. Following the resignation of former COO Mark Whittle in July 2021 the company expects to appoint a replacement by the end of CY21.

Sensitivities

Customer acceptance: Quadrise's MSAR has been proven both in extensive marine trials with Maersk and in a commercial and technical demonstration in Lithuania. However, MSAR still needs to be adopted as a marketable, environmentally friendly and economic substitute for HFO by the power and marine bunker sectors, which are inherently conservative. Moreover, unless refineries intend to use the MSAR they produce within their own operations, there need to be enough customers using MSAR for power generation, providing heat for industrial processes or marine transport for refineries to start manufacturing the fuel.

Fuel oil spreads: the refinery price 'spread' between diesel and HFO determines the economic attractiveness of a switch in converting heavy residue to MSAR, rather than HFO, and thus the

amount by which MSAR may be discounted with respect to HFO. In addition, depressed oil prices tend to extend decision-making cycles.

Not applicable to all refineries: only one-third of refineries globally are suitable for producing MSAR because some do not produce any liquid residue and some inland refineries would have logistics issues. However, this still offers substantial scope for MSAR uptake.

Environmental: the IMO 2020 increases in environmental restrictions on marine engine emission characteristics play to the advantage of MSAR as a more efficient marine fuel. However, environmental and supply concerns, as well as the availability of cheap gas in certain regions, may lead to a number of oil-consuming power stations converting to gas where they can.

Partner risk: Quadrise has been working with Nouryon since 2004. It currently has a three-year contract with Nouryon for the exclusive global collaboration and supply of goods and services for future MSAR projects to October 2022.

Financial: in early October management stated that it expects the group to have the cash resources to progress the ongoing trial programmes to commercial revenues and positive sustainable cash flows by Q1 CY23. However, there is no certainty on the likely timing of any material commercial agreements or the progression to break-even.

Financials: Cash runway to sustainability

Quadrise is still pre-revenue. Stripping out share option and exceptional charges, which included £1.3m in fair value adjustments relating to convertible securities, operating losses narrowed by £0.3m y-o-y in FY21 to £2.9m. The reduction reflected lower administrative costs. Production and development costs were at similar levels to the prior year.

Free cash outflow decreased by £0.6m during FY21 to £2.4m. £0.2m of the reduction was attributable to favourable working capital movements. Capital expenditure was minimal, the same as in FY20, and all research and development was expensed. In March 2021, the group completed a placing and oversubscribed open offer, raising £6.5m (net) at 2.7p/share. The group also raised £0.5m (net) through the issue of a second tranche of convertible securities to Bergen Global Opportunity Fund in February 2021. This tranche was fully converted at the end of April 2021, leaving the group with £7.0m cash, no debt and no convertible securities at end FY21 (June 2021). Management notes that this cash balance represents 2½ years of fixed costs. These are running at c £230k/month excluding project costs, which are typically subsidised by partners. Management expects that the company has the cash resources to progress the ongoing trial programmes to commercial revenues and positive sustainable cash flows by Q1 CY23.

Valuation: Modest adoption transformational

As Quadrise has yet to generate commercial revenues, its value resides in the potential future cash flows generated from volume production of MSAR and bioMSAR. Since there is substantial uncertainty on when the various projects Quadrise is working on with its partners will progress to commercialisation, precluding the preparation of estimates, we present a high-level scenario analysis based on data from the company, which we understand is derived from the numerous detailed case studies it has carried out for prospective clients. This shows potential revenues, EBITDA and capex requirements attributable to projects (ie before deducting costs not related to projects) for various levels of adoption by global refineries and penetration of MSC's shipping fleet. We note that minimal capex is required for projects where MSAR technology is installed on a licensing basis, although the potential profit and risk is substantially less than if Quadrise were manufacturing fuel on a toll basis, ie charging a fee per tonne of MSAR and bioMSAR

manufactured as it did for the production of fuel for the Maersk trials. We expect that Quadrise will form a separately financed JV with a partner for projects involving production on a tolling basis, thus avoiding substantial investment in capex and minimising shareholder dilution.

Exhibit 8: Possible financial implications for Quadrise from different MSAR adoption scenarios

Power market				
Number of MSAR manufacturing units	2	3	4	6
Production capacity (HFO equivalents Mtpa)	0.5	0.7	0.9	1.4
Production capacity (HFO equivalents kpbd)	8.8	13.2	17.5	26.3
% global HFO market	0.1%	0.2%	0.3%	0.4%
Revenues - licence model (US$m)	18.6	27.1	35.6	54.2
EBITDA attributable to projects - licence model (US$m)	4.4	6.4	8.4	12.8
Revenues - tolling model (US$m)	30.0	46.6	63.3	94.5
EBITDA attributable to projects - tolling model (US$m)	1.9	8.0	14.2	17.3
Capex - tolling model (US$m)	(9.8)	(16.8)	(23.8)	(37.8)
Marine market				
Number of vessels using MSAR	18	27	36	54
% MSC fleet	2.9%	4.3%	5.8%	8.6%
Revenues - licence model (US$m)	28.6	42.0	55.5	84.1
EBITDA attributable to projects- licence model (US$m)	4.7	6.9	9.1	13.8
Revenues - tolling model (US$m)	38.5	59.4	80.3	120.1
EBITDA attributable to projects - tolling model (US$m)	0.8	6.4	11.9	14.0
Capex - tolling model (US$m)	(9.8)	(16.8)	(23.8)	(37.8)

Source: Edison Investment Research based on company data

Adoption across only 9% of MSC's global fleet could generate around $84m in licence revenues and $13.8m EBITDA and be transformational for Quadrise. The other two projects closest to commercialisation are smaller. Commercial adoption by the Moroccan partner would require the output from two MSAR manufacturing units (MMUs), ie. c 9kbpd. This would be only part of the output from a single refinery such as the Cepsa site, which produced MSAR for the Maersk trial and has an output of 240kpd. The projected output from Greenfield Energy's oil sands extraction plant is 5–10kbpd. In our opinion, adoption of MSAR in any one of the projects closest to commercialisation would encourage multiple customers to use the fuel, which could potentially support profits beyond the upper range of our analysis.

Exhibit 9: Financial summary

£000s	2018	2019	2020	2021
30-June	IFRS	IFRS	IFRS	IFRS
INCOME STATEMENT				
Revenue	9	22	0	17
EBITDA	(3,284)	(2,780)	(3,006)	(2,752)
Operating Profit (before amort. and except.)	(3,514)	(3,010)	(3,178)	(2,887)
Amortisation of acquired intangibles	0	0	0	0
Exceptionals	0	0	(1,199)	(1,266)
Share-based payments	(53)	(154)	(474)	(303)
Reported operating profit	(3,567)	(3,164)	(4,851)	(4,456)
Net Interest	11	(3)	(139)	46
Profit Before Tax (norm)	(3,503)	(3,013)	(3,317)	(2,841)
Profit Before Tax (reported)	(3,556)	(3,167)	(4,990)	(4,410)
Reported tax	294	184	147	150
Profit After Tax (norm)	(3,209)	(2,829)	(3,170)	(2,691)
Profit After Tax (reported)	(3,262)	(2,983)	(4,843)	(4,260)
Minority interests	0	0	0	0
Discontinued operations	0	0	0	0
Net income (normalised)	(3,209)	(2,829)	(3,170)	(2,691)
Net income (reported)	(3,262)	(2,983)	(4,843)	(4,260)
Average Number of Shares Outstanding (m)	862.2	888.7	982.8	1,175.4
EPS - normalised (p)	(0.37)	(0.32)	(0.32)	(0.23)
EPS - diluted normalised (c)	(0.37)	(0.32)	(0.32)	(0.23)
EPS - basic reported (c)	(0.38)	(0.34)	(0.49)	(0.36)
Dividend per share (p)	0.00	0.00	0.00	0.00
BALANCE SHEET				
Fixed Assets	3,885	3,654	3,506	3,384
Intangible Assets	2,924	2,924	2,924	2,924
Tangible Assets	961	730	582	460
Investments & other	0	0	0	0
Current Assets	2,600	1,396	2,766	7,279
Stocks	61	61	61	61
Debtors	188	169	213	117
Cash & cash equivalents	2,229	1,060	2,380	7,006
Other	122	106	112	95
Current Liabilities	(400)	(288)	(2,243)	(276)
Creditors	(400)	(288)	(198)	(276)
Tax and social security	0	0	0	0
Short term borrowings	0	0	0	0
Convertible securities	0	0	(2,045)	0
Long Term Liabilities	0	0	0	0
Long term borrowings	0	0	0	0
Other long-term liabilities	0	0	0	0
Net Assets	6,085	4,762	4,029	10,387
Minority interests	0	0	0	0
Shareholders' equity	6,085	4,762	4,029	10,387
CASH FLOW				
Op Cash Flow before WC and tax	(3,284)	(2,780)	(3,072)	(2,752)
Working capital	298	(77)	(140)	191
Exceptional & other	0	130	65	7
Tax	294	184	147	150
Net operating cash flow	(2,692)	(2,543)	(3,000)	(2,404)
Capex	(135)	(24)	(24)	(29)
Acquisitions/disposals	0	0	0	0
Net interest	11	(3)	1	46
Equity financing	0	1,401	2,343	6,513
Dividends	0	0	0	0
Other	0	0	0	0
Net Cash Flow	(2,816)	(1,169)	(680)	4,126
Opening net debt/(cash)	(5,045)	(2,229)	(1,060)	(2,380)
FX	0	0	0	0
Other non-cash movements	0	0	2,000	500
Closing net debt/(cash)	(2,229)	(1,060)	(2,380)	(7,006)

Source: Company accounts

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