

Quadrise Fuels International

Alternative energy

25 November 2019

Value from the bottom of the barrel

Quadrise's MSAR fuel has been proven as a low-cost substitute for heavy fuel oil (HFO) in the marine and power generation markets through extensive commercial scale trials. Management estimates that the recent fundraise totalling £4.5m gives sufficient cash to pursue commercial opportunities through to end calendar year 2020 with a further draw-down of £2m potentially available. Given the lack of visibility on the timing of commercialisation, we have not issued estimates or an indicative valuation.

MSAR: The lower-cost fuel solution

Quadrise's MSAR process mixes heavy oil residues with water and speciality chemicals to produce MSAR fuel. This is a cost-effective, environmentally cleaner substitute for HFO, proven to have enhanced performance characteristics. Refineries produce HFO by mixing residues with valuable middle distillates, so manufacturing MSAR would allow them to sell all their middle distillate as a premium product, enabling MSAR to be sold as a lower-cost synthetic HFO. About 60% of the c 370Mt of HFO used each year is consumed by marine fleet operators. Quadrise believes that switching to MSAR plus scrubbers is the lowest cost way for refineries to meet the International Maritime Organisation regulations on sulphur emissions being introduced in January 2020.

Commercial potential demonstrated

MSAR has been proven as an alternative marine bunker fuel through extensive land and sea-based trials with Maersk. 60m tonnes of Orimulsion (a precursor to MSAR) was consumed in the global power generation market, while MSAR was proven in use at Lithuania's main electrical generation plant. Although these trials demonstrated the technical and economic case for MSAR adoption, they did not proceed to commercialisation because of external factors outside Quadrise's control. Quadrise now has a broad opportunity pipeline of MSAR projects that it has the funding capacity to progress through to calendar 2021.

Valuation: Modest adoption transformational

Based on data from the company, our scenario analysis calculates that even modest adoption of MSAR would generate material profits. Just one refinery producing MSAR equivalent to 1.9Mtpa HFO under a licensing model would generate \$15.6m annual EBITDA, or adoption by 1% of the world's shipping fleet would generate \$16.7m annual EBITDA.

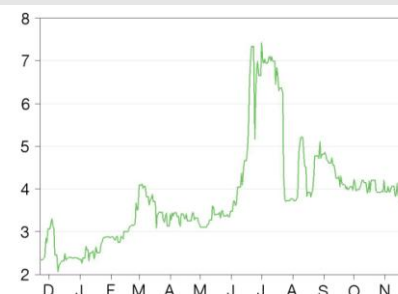
Historical financials

Year end	Revenue (£m)	EBITDA (£m)	PBT* (£m)	EPS* (p)	DPS (p)	P/E (x)
06/16	0.0	(4.0)	(4.1)	(0.49)	0.0	N/A
06/17	0.1	(3.9)	(4.1)	(0.45)	0.0	N/A
06/18	0.0	(3.3)	(3.5)	(0.37)	0.0	N/A
06/19	0.0	(2.8)	(3.0)	(0.32)	0.0	N/A

Note: *PBT and EPS are normalised, excluding amortisation of acquired intangibles, exceptional items and share-based payments.

Price 4p
Market cap £40m

Share price graph



Share details

Code	QFI
Listing	AIM
Shares in issue	995.8m
Net cash (£m) at end June 2019 (prior to fund-raising of £4.5m gross)	1.1

Business description

Quadrise Fuels International is the innovator, supplier and global licensor of disruptive residual oil technology that produces a synthetic, enhanced heavy fuel oil called MSAR. The technology enables refiners to produce MSAR for use as a low-cost substitute for heavy fuel oil.

Bull

- Adoption of MSAR would enable oil-based economies to reduce the volumes of expensive middle distillate used to make HFO.
- Adoption of MSAR would enable shipping fleets to offset cost of meeting low-sulphur regulations.
- MSAR potential replacement for HFO in power generation and industrial applications.

Bear

- Previous projects have demonstrated efficacy of MSAR but not proceeded to commercialisation because of industry conservatism.
- No visibility of when Quadrise will become profitable.
- Potentially dilutive impact of convertible loan note with Bergen Global Opportunity Fund.

Analyst

Anne Margaret Crow +44 (0)20 3077 5700

industrials@edisongroup.com

[Edison profile page](#)

Quadrise Fuels International is a research client of Edison Investment Research Limited

Investment summary

Company description: Low-cost HFO substitute

Quadrise has developed an enhanced, emulsified synthetic heavy fuel oil called MSAR. This is offered as a low-cost substitute for conventional HFO for use in land-based thermal and diesel power generation plants, in industrial applications and in marine diesel engines. The opportunity addressed is substantial given the global HFO market currently is around 370Mt/year (source JODI-Oil database). MSAR has been proven as a fuel for power generation in commercial-scale trials at Lithuania's main electrical generation plant and as an alternative marine bunker fuel through extended sea-based trials with Maersk. Adoption by shipping companies would offset the cost of installing scrubbers to meet IMO regulations being imposed in 2020 to limit sulphur emissions. Over the last two years, Quadrise has reduced its reliance on the commercialisation of individual projects by establishing a global network of partner companies, each of which are identifying and progressing commercial opportunities involving the production and supply of MSAR.

Financials: Still at the pre-revenue stage

Quadrise recorded an operating loss (adjusted for share-based payments) of £3.0m for FY19, compared with a £3.5m loss in FY18. This included production and development costs of £1.5m (FY18: £2.0m). Administration expenses were tightly controlled at £1.5m, 4% lower than the prior year. The group commenced FY19 with £2.2m in cash (there was no debt) and finished with £1.1m, as a free cash outflow of £2.6m, which included a £0.8m increase in working capital, was partly offset by an open offer in January 2019 raising £1.5m (gross). Since the end of FY19, Quadrise has raised £2.0m through the issue of convertible securities to Bergen Global Opportunity Fund, £1.8m (gross) from an open offer and £0.7m (gross) from a subscription. It has the option to raise a further £2.0m through the issue of additional convertible securities to Bergen in FY20.

Valuation: Licensing model reduces cash requirement

Based on data from the company, our scenario analysis presents potential revenues, EBITDA and capex requirements for various levels of adoption by global refineries and penetration of the marine transportation market. We note that minimal capex is required for projects where MSAR is produced on a licensing basis, although the potential profit is substantially less than if Quadrise was manufacturing the MSAR itself. Even a single refinery producing, for example, MSAR equivalent to 1.9Mtpa HFO (32.4k barrels/day) under a licence arrangement would generate \$15.6m annual EBITDA, or adoption by 1% of the global shipping fleet would generate \$16.7m annual EBITDA.

Sensitivities: MSAR still to gain customer acceptance

The key sensitivity in our opinion is customer acceptance, because although MSAR has been proven in extensive field trials, it still needs to be accepted as a marketable, environmentally friendly and economic substitute for HFO by the power and marine bunker sectors, which are inherently conservative. The economic attractiveness of MSAR adoption is driven by the refinery price 'spread' between diesel and HFO, which has widened ahead of the introduction of regulations on maritime sulphur emissions. Tightening of environmental regulations on marine engine emissions is supportive of MSAR adoption in shipping but environmental concerns may lead to some HFO-consuming power stations switching to gas rather than MSAR. Only one-third of refineries globally are suitable for producing MSAR. We note the dilutive impact of the £2.0m convertible security issued to Bergen Opportunity Fund and that while management estimates that the recent financing activities (excluding potential £2.0m draw-down in FY20) should provide sufficient funding through to end calendar 2020, depending on project requirements, there is no clarity on the likely timing of any material commercial agreements or the progression to break-even.

Company description: Disruptive residual oil technology

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). Installing MSAR production technology increases profitability for oil refiners without incurring the significant expenditure typically associated with infrastructure upgrades because it frees up valuable distillates traditionally used for HFO manufacture. MSAR can therefore be offered as a low-cost alternative to conventional HFO for use in thermal and diesel power generation plants, industrial applications and marine diesel engines. The opportunity addressed is substantial since the global HFO market is around 370Mt/year. Quadrise is focusing on four significant market segments: a replacement for fuel oil or crude oil in base-load utility generation applications or industrial applications; as marine bunker fuel; and as an alternative fuel in upstream heavy oil production operations. Here, MSAR may be used to generate power or steam for assisted gravity drainage.

The market for MSAR is proven because more than 60Mt of a first-generation oil-on-water emulsion fuel, BP and PDVSA's Orimulsion, was supplied to the global market for power generation between 1993 and 2006, when production in Venezuela was discontinued because of issues in the wider economy. Key members of Quadrise's senior management team, including Chief Operating Officer 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 has been 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. As neither of these projects proceeded to commercialisation, Quadrise has reduced dependence on individual projects by building up a global network of partner companies in the refining, shipping, power generation and trading markets, with each partner identifying and progressing potential commercial opportunities involving the production and supply of MSAR.

Quadrise was admitted to AIM in April 2006 and its headquarters are in London. In order to promote adoption of MSAR technology, it is developing bespoke MSAR solutions for refinery residual oils at its R&D facility in the UK, some of which activity is paid for by the potential customer, and project managing MSAR conversion projects at major refineries, marine vessels and power plants from feasibility studies through to commercial fuel production and consumption. There are three basic business models post-commercialisation. The first is for Quadrise to sell the production equipment to a refiner at a margin and grant a licence for its operation and the provision of additives. The refiner is responsible for selling the MSAR produced to its customers in the power, marine bunkering or industrial markets. In the second option, toll-processing, Quadrise manufactures MSAR on behalf of the refiner, charging a fee per tonne of fuel produced, with the refiner still being responsible for the sale of MSAR to its end-customers. The third option is for Quadrise to undertake a project on a build-own operate basis, with Quadrise purchasing suitable residue and taking responsibility for the manufacture and sale of MSAR to its own end customers. In these latter two scenarios, it is likely that Quadrise would form a JV with a local partner and seek finance specifically for that project, minimising shareholder dilution.

MSAR: Proven, established technology

Traditional refining and MSAR process compared

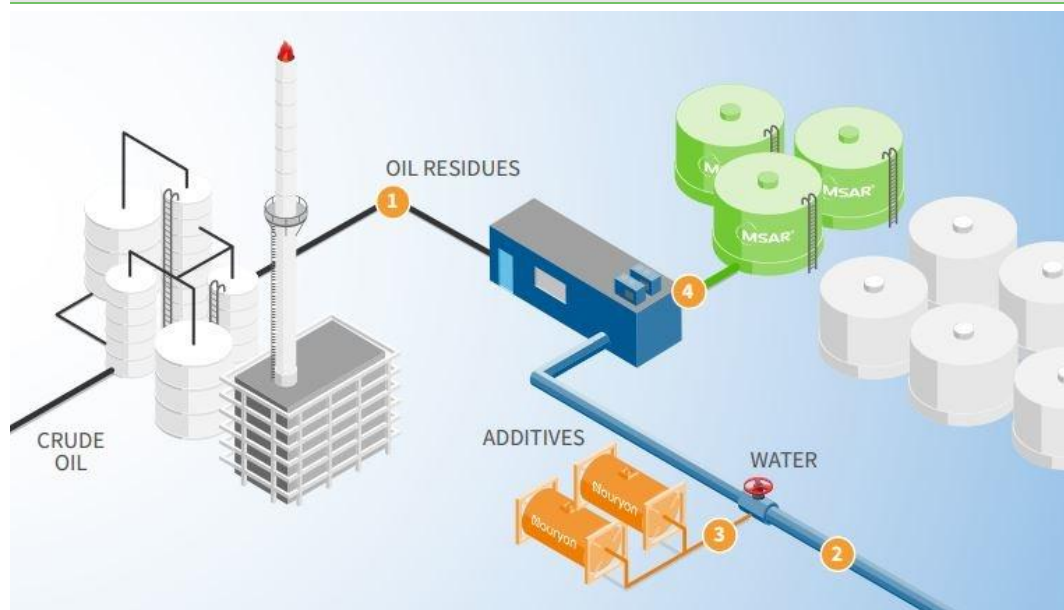
After refining, 70% of the output from a typical semi-complex refinery is high-value transportation fuel and 30% low-value residue. The residue is solid at room temperature and, if not processed

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.

The MSAR process significantly improves refinery yields by eliminating the need to blend the heavy residues with distillates to make HFO. MSAR is made by mixing the hydrocarbon residue (70%) with water (30%) and small amounts (<1%) of specialised surfactants and emulsifiers. This is done through a proprietary process whereby the hydrocarbon residue is reduced to particles of approximately five to 10 microns in diameter.

- Stage One: Oil residues are taken direct from refinery rundown lines and cooled to achieve the required viscosity (c 350–500 centistoke at 100–200°C) 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.

Exhibit 1: Introduction to MSAR



Source: Quadrise Fuels International

The surfactant chemicals, which are supplied by long-term partner Nouryon (formerly AkzoNobel Specialty 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.

As the oil phase in MSAR is pre-atomised to very small sizes (5–10 microns) compared with atomised HFO droplets (100 microns), this increased surface area enables almost complete combustion, leaving virtually no carbon particulates in the exhaust gases. This makes MSAR more environmentally friendly. In addition, the water in MSAR reduces the temperature of combustion, which tests carried out by Wärtsilä have shown reduces nitrogen oxide emissions by 20–50%.

Quadrise currently supplies two lower-cost synthetic fuel solutions: marine MSAR for shipping companies, and power MSAR for use in stationary applications such as boilers and kilns.

Adoption by oil refineries

Adoption of the MSAR process means all of the high-value middle distillate can now be sold as transportation 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 the 1000t/d (6,000bbpd) MSAR manufacturing unit at the CEPESA refinery (see below). This work shows that for a 250kbd semi-complex refinery which produces 50kbpd of residue, a switch to MSAR would generate additional middle distillate sales of c 20kbd as well as 70kbd of MSAR. The value generated 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. Using the Cal 2021 spread value of \$285/ton as at 12 November 2019, Quadrise calculates that this additional distillate represents \$195m/year net of all variable costs, which can be shared between the oil refiner, Quadrise and its partners, primarily Nouryon. The studies 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 250kbd refinery in our example would be around \$90m. 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 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.

IMO 2020 could spur adoption of MSAR in the shipping industry

Since it is potentially highly cost-effective for refineries to convert heavy residue into MSAR rather than HFO, they will be able to offer MSAR at a discount to HFO, creating interest in a novel fuel. This potential discount is attractive to fleet operators, which face intense competition over freight rates, because fuel accounts for the largest proportion of a fleet's operating costs. Importantly, switching to MSAR presents a cost-effective way to meet new legislation from the International Maritime Organisation (IMO), which has reduced the global sulphur cap outside emission control areas from 3.5% to 0.5%, effective from 1 January 2020. The potential switch to 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 liquefied natural gas (LNG), which is often cited as an alternative marine fuel, but has specialised and expensive storage and handling requirements.

Exhibit 2: MSAR bunkering at the Port of Klaipeda



Source: Quadrise Fuels International

Exhibit 3: Ship-to-ship MSAR transfer at Bremerhaven



Source: Quadrise Fuels International

Shipping giant Maersk considered addressing the IMO legislation by switching from HFO to MSAR, with the lower cost of MSAR offsetting the cost of installing scrubbers to remove sulphur from exhaust fumes. It spent seven years on a programme that [conclusively proved](#) that MSAR was a viable marine bunker fuel in both two- and four-stroke engines. The proof of concept trials took

place during 2014. 1,000 tonnes of MSAR were manufactured at ORLEN Lietuva’s refinery in Lithuania, loaded on to a bunker barge at the Port of Klaipėda and transferred at Bremerhaven in Germany to the Maersk containerships by ship-to-ship transfer. These vessels, the Seago Istanbul with a two-stroke Wärtsilä engine and the Bogor with a two-stroke MAN engine, completed hundreds of hours running on MSAR. During 2016 and 2017 Maersk conducted an operational trial on its 52,000DWT/4,300TEU container vessel, the Seago Istanbul. 7,000 tonnes of MSAR was produced at Cepsa’s Refinery Gibraltar-San Roque in Spain over an eight-month period to fuel the Seago Istanbul’s 68MW main engine. The vessel completed c 1,500 MSAR running hours following its normal route and re-fuelling with MSAR at Algeciras in Spain approximately every six weeks. The MSAR fuel performed well and feedback from Wärtsilä and Maersk was very positive. As a result, Quadrise received an interim letter of no objection (LONO) for MSAR for Wärtsilä RT-flex96C-B engines.

The decision by the IMO to bring forward implementation of the low sulphur legislation from 2025 to 2020 appears to have influenced Maersk in its decision to end the trial at the interim stage in 2017. At the time it stated that it would not be installing any scrubbers because, we believe, of the capital investment required, which is around US\$2m/large vessel. This implied that Maersk would be wholly reliant on sourcing low sulphur compliant fuels. For example, it has signed long-term agreements with PBF Logistics’ terminal facility in New Jersey and with Koole Terminals in Rotterdam to produce sufficient low sulphur fuel to cover 10% and 5–10%, respectively, of its annual fuel requirements. Maersk plans to pass on the increased costs to customers on 80–90% of its contracts, which represent around half of its volumes.

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



Source: Quadrise Fuels International

Exhibit 5: Seago Istanbul sailing its normal route during the marine MSAR trial



Source: Quadrise Fuels International

There is some debate as to whether this approach is workable in the longer term. Firstly, since the marine sector has been responsible for around half of global fuel oil consumption in recent years, there are concerns that oil refineries may not have the capacity to produce the quantity of low sulphur oil fuels required to support such a shift in fuel oil consumption patterns. Secondly, increased demand for low sulphur variants is likely to widen the price differential between low and high sulphur fuel oils. In May 2019 the spread between IFO 380 (the high sulphur fuel oil most commonly used by ships) and marine gas oil (the low sulphur fuel most commonly used by ships) was \$261.5/tonne. Energy and shipping consultancy Wood Mackenzie estimates that this will increase to closer to \$350/tonne in 2020. For owners of large ships that consume 60 to 70 tonnes of fuel per day, such a price jump would significantly increase operating costs, making it more difficult to pass on the increased cost in full to clients chartering their ships. Thirdly, there are known issues with the use of very low sulphur fuel oils. They have a high risk of instability and can be hypersensitive to mixing with other fuels on board resulting in the precipitation of particles, which can block filters and fuel injection systems, potentially causing loss of power. In autumn 2018

Maersk altered its position on scrubbers, installing them on an estimated 15% of its fleet after seeing some of their main competitors installing scrubbers.

The potential switch to MSAR brings other environmental benefits. The International Maritime Organisation has imposed an 80% reduction in NOx emissions for the North American and US Caribbean emission control areas, applicable for ships whose keels are laid from January 2016. It is considering regulating particulate (soot) emissions. A switch from HFO to MSAR would give a reduction in both NOx and black soot emissions. This may drive demand for MSAR in the longer term.

Quadrise estimates that, based on data from the Maersk trial and using Mitsui futures prices for 2021 as of November 2019, converting a very large container ship with 30,000kW of installed engine power to MSAR would cost c \$400k and save \$400k/year.

Adoption in the power industry

In 2008 Quadrise successfully completed a commercial demonstration of MSAR as boiler fuel in Lithuania. Over 22,000 tonnes of MSAR was produced at ORLEN Lietuva's 200,000bpd refinery from Urals crude-based residues. The MSAR was transported c 300km by rail to the 1,800MWe Elektrėnai power plant in Lithuania. This is operated by Lietuvos Elektrinė, a former Orimulsion customer, and is the primary source of Lithuania's electrical power. The systems for loading and offloading HFO were used at either end. MSAR was fired on the 2 x 150MWe Unit 7, confirming Alstom APC operational viability. Lietuvos Elektrinė concluded that the performance of MSAR was similar to, or better than, Orimulsion and 'suitable for long-term operation in those of our units installed with our new air pollution control equipment.' 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.

Exhibit 6: Elektrėnai power plant



Source: Quadrise Fuels International

Based on the studies discussed earlier, Quadrise calculates that, using the Mitsui oil futures prices for 2021 as of November 2019, the cost of converting a 400MWe boiler to MSAR would be \$2.5m, generating fuel savings of \$15m/year. This represents a payback time of only a couple of months, longer if scrubbers are required to remove sulphur from the flue gases. The introduction of more stringent regulations on sulphur emissions from shipping in 2020 (see above) is already having a

favourable impact on the economics of adopting MSAR for power generation because it is reducing the value of high sulphur residues, making MSAR more attractive for power generation.

Route to commercialisation

Broadening the project pipeline

The termination of the programme with Maersk in CY17 and protracted delays in setting up a trial linking an oil refinery and power station in the Kingdom of Saudi Arabia (KSA) highlighted the risk of over-reliance on a very small number of potential projects. Over the last two years therefore Quadrise has reduced dependence on individual projects by building up a global network of partner companies, each of which are identifying and progressing commercial opportunities involving the production and supply of MSAR (see Exhibit 7). In most cases, eg Aleph or Younes Maamar, the partner is effectively a sales agent and paid only on success. For others, including Al Khafrah and Freepoint, in addition to the sales agent role there is opportunity for Quadrise and the partner to form a JV to license or manufacture MSAR.

Exhibit 7: Alliances

Partner	Details	Date	Geographies	Initial focus
Aleph Commodities	UK company. Small group of commodities traders with significant experience in the Middle East.	Service agreement February 2019 (Kuwait) Service agreement June 2019 (Kingdom of Saudi Arabia)	Kingdom of Saudi Arabia, Kuwait	Power and Marine
Al Khafrah Holding Group	Portfolio of 42 industrial companies employing around 45,000 people, with partners in the oil, gas and petrochemical sectors that include Air Liquide and Gulf Chemicals & Industrial Oils. Replaces partnership with Rafid Group, which terminated in May 2019.	Memorandum of agreement May 2019	Kingdom of Saudi Arabia	Power
API POLY-GCL	Project origination and development company in the downstream oil, gas and power sectors both in China and globally. Energy conglomerate Golden Concord Holdings is an indirect shareholder.	Memorandum of understanding May 2019	China	Power and Marine
Bitumina	Global producer, trader and supplier of bitumen products for road construction. Also manufactures colloidal mills for bituminous products. MSAR adds value to its terminal assets and technology.	Memorandum of understanding March 2019	CIS, Poland, Romania, Vietnam	Power and Marine
Freepoint Commodities	Global merchant of physical commodities and financier of upper- and mid-stream commodity-producing assets.	Co-marketing and project development agreement November 2018	Americas, Middle East, Asia	Power
Hawazin Regional Trading Company	Investor and provider of expert services to the oil and gas industry in Kuwait. Major shareholder of Petroleum Dynamics Oil & Gas.	Agency agreement May 2019 Memorandum of understanding with Quadrise and Aleph May 2019	Kuwait	Power and Marine
Japan Gas Corp	Largest engineering contractor in Japan. Offers engineering, procurement, construction, operation and maintenance, and planning and investment services to major corporate and governmental customers globally.	Memorandum of agreement November 2017	Japan, Columbia, Peru	Power and Marine
Merlin Energy Resources	Upstream oil and gas consultancy specialising in geological and geophysical exploration and production-related services.	Memorandum of understanding August 2019	Not specific to geography	Upstream heavy oil
Redliner	Industrial infrastructure rehabilitation in Mexico for the oil and gas, water and chemical industries. Has worked in PEMEX- (Petróleos Mexicanos) owned refineries.	Agency agreement June 2019	Mexico	Power
Younes Maamar	Former CEO of Moroccan state electricity company.	March 2019	Morocco	Power and Industrial

Source: Quadrise Fuels International

Active projects

Marine

Quadrise is in discussion with a number of marine market participants regarding work to progress MSAR trials alongside the adoption of exhaust gas-cleaning systems. At present, the shipping lines are focused on addressing the immediate challenges created by the introduction of the IMO 2020 legislation in January. Nevertheless, ideally Quadrise needs to initiate at least one Letter of No

Objection (LONO) project with a shipping line operator in the near term as these trials are lengthy, typically involving 4,000 operating hours and lasting six to nine months.

Power

Quadrise demonstrated its technology to key participants in the Kuwaiti refining market during CY18, testing small volumes of residues for the suitability of conversion to MSAR and showing them the MSAR manufacturing facility at the Cepsa refinery. During CY19 this opportunity has been progressed through its partner, Aleph Commodities. Aleph signed-up a local partner, Hawazin, for Quadrise in May 2019, triggering a milestone payment of 5m warrants. Aleph will receive another 10m warrants if one of the potential customers in Kuwait commences a formal trial study by the end of CY19 and a further 25m warrants on the signature of a contract for a commercial project. There is no formal deadline for achieving this final milestone. Similarly, Younes Maamar will receive 3m warrants if he secures a trial MSAR project by the end of CY19 and 10m warrants on signature of a contract for a commercial project.

Although the work carried out by Quadrise and its former partner Rafid in the Kingdom of Saudi Arabia did not proceed to a full-scale trial in early CY18 because of issues between the oil company and the power company in KSA, unrelated to the MSAR project, the approvals regarding use of MSAR in KSA are still valid. Three contracts regarding commercialisation of MSAR in KSA were signed, while a further two contracts reached their final form. This means that the new partner in KSA, Aleph, should have less work to do in facilitating commercialisation of MSAR in the kingdom. We note that the economic benefits of MSAR in reducing the volume diesel and HFO imports to KSA, which management estimates to be \$500–1,000m annually, remain valid.

In November 2018 Quadrise signed a memorandum of understanding with a European oil major under which the two parties will work together to identify potential MSAR clients for one of the oil major's European refineries and then undertake a feasibility study for a potential MSAR fuel client. Management originally hoped that the feasibility study would be carried out during CY19. However, it is highly likely that Quadrise will need to have a reference project in either the power or industrial sector (see below) to attract potential MSAR clients for introduction to the European oil major.

Industrial

In August 2019 Quadrise announced that it had signed a memorandum of agreement with an oil refiner that is part of a European integrated oil and gas company. Quadrise and the oil refiner will work together to evaluate and develop a potential MSAR project using residue to make MSAR for producing steam and power for use at one of the latter's refineries. Quadrise has begun to test specific refinery residue samples ahead of a potential trial in CY20. Management has also identified opportunities in Morocco.

Upstream

Merlin is a consultant to the upstream oil and gas industry with a remit to identify potential projects using MSAR to generate steam for encouraging oil to flow out of underground reservoirs or for producing heat to help viscous oils flow in pipelines. Management recently noted that its stated objective of initiating at least one MSAR project with Merlin during CY19 remains feasible.

Management

Quadrise's management has the breadth and depth of experience required to commercialise the MSAR technology. Collectively the team has over 70 years' experience of commercial emulsion fuels supply, having been instrumental in the Orimulsion business with BP and PDVSA. For example, Chief Operating Officer 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 joined Quadrise in 2006 and now has around 25 years' technical and commercial experience in the emulsion fuels industry. The management team has been expanded to include experts from refining, power, trading and engineering backgrounds. This enables Quadrise to develop bespoke solutions for residual oils from different refineries and for different applications and to project manage MSAR conversion projects from feasibility studies to commercial fuel production and consumption.

These skills are complemented by significant downstream oil, financial and capital markets experience. For example, Michael Kirk became a non-executive director in December 2015, stepping up to the executive chairman's role in April 2016 on the retirement of Ian Williams. He served as a corporate finance partner at Cazenove providing advisory services to a number of clients in the utilities, oil and gas and oilfield service sectors. While at Cazenove, Mike led the flotation of Wood Group, Expro International and KBC Advanced Technologies, where he also served as a non-executive director for nine years. Since leaving the City, Mike has held a portfolio of non-executive directorships for a variety of companies and is currently chairman of Portsmouth Water and of Vivid Homes. Prior to working in the City, Mike worked in the chemical and nuclear industries.

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 and for which the imminent IMO 2020 requirements may make adoption of low sulphur fuels an easier, more familiar, albeit pricier, option.

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. However, depressed oil prices tend to extend decision-making cycles. The diesel/high sulphur heavy fuel oil spread and the relativity to low sulphur fuel oil is widening ahead of introduction of the IMO low sulphur regulations.

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 marine fuel. However, for power generation, 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 has recently signed 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: The convertible security issued to Bergen Opportunity Fund in August 2019 (see below), is dilutive. Management estimates that, together with the open offer and subscription in September 2019, this convertible should provide sufficient funding through to end calendar 2020 (with a potential £2.0m additional draw-down in FY20 available), there is no clarity on the likely timing of any material commercial agreements or the progression to break-even.

Financials

Still at a pre-revenue stage

Quadrise is still at a pre-revenue stage and recorded an operating loss (adjusted for share-based payments) of £3.0m for FY19, compared with a loss of £3.5m in FY18. This included production and development costs of £1.5m (FY18: £2.0m) as work continued to further develop testing and research facilities to handle more challenging residues that require much higher working temperatures and pressure to convert to MSAR. Administration expenses were tightly controlled at £1.5m, 4% lower than the prior year.

Conserving cash

The group commenced FY19 with £2.2m in cash (there was no debt) and finished with £1.1m cash. Working capital increased by £0.8m. Capital expenditure was minimal. Free cash outflow of £2.6m was partly offset by an open offer in January 2019 raising £1.5m (gross) at 2.5p/share, which provided financing to October 2019. Net assets totalled £4.8m at the period end compared with £6.1m at the start. The period end total included £0.7m fixed tangible assets, mainly plant and equipment in the R&D facility, and £2.9m intangibles associated with the MSAR trade name.

Recent financing activity provides cash for the coming year

On 30 August 2019 Quadrise issued a convertible security of £2.0m, which is the first tranche of zero coupon convertible securities of up to £4.0m to Bergen Global Opportunity Fund. The second tranche of £2.0m will be issued in August 2020 provided the aggregate nominal value (up to £2.15m) does not exceed 3.5% of the company's market capitalisation on issue and the share price has not remained below 3p for 60 days. Both the initial tranche and the second tranche have 24-month maturity dates from the dates of their respective issuance. Any convertible securities not converted prior to the maturity dates will automatically convert into ordinary shares at that point. Up to £0.8m of the convertibles may be converted at 5.78p/share, the conversion price of the remainder will be the average of five daily volume-weighted average prices during a specified period before the conversion date. Bergen is contractually precluded from short selling Quadrise shares. Quadrise is precluded from entering into certain prohibited transactions that would adversely affect Bergen's position for a period of 120 days after all the convertibles have converted. Quadrise has also issued 4.9m 36-month warrants to Bergen, initially exercisable at 5.78p/share.

The cash from the first tranche of convertibles was supplemented by an open offer raising £1.8m (gross) at 3.96p/share with warrants attached and a subscription raising £0.7m (gross), also at 3.96p/share with warrants attached. 46.6m new shares and 23.3m warrants were issued in connection with the open offer. Management estimates that collectively these activities should provide sufficient funding through to end calendar 2020, depending on project requirements, with a further £2.0m draw-down potentially available.

Valuation

As Quadrise has yet to generate commercial revenues, its value resides in the potential future cash flow generated from volume production of MSAR. Since there is little visibility on when any of the projects Quadrise is working on with its partners will progress to commercialisation, precluding the preparation of estimates, we present a scenario analysis based on data from the company. This shows potential revenues, EBITDA and capex requirements for various levels of adoption by global refineries and penetration of the marine transportation market. We note that minimal capex is required for projects where MSAR is produced on a licensing basis, although the potential profit is

substantially less than if Quadrise was manufacturing the MSAR itself on either a toll or merchant basis. We expect that Quadrise will form a separately financed JV with a partner for projects involving production on a tolling or merchant basis, thus avoiding substantial investment in capex and minimising shareholder dilution. Even a single refinery producing MSAR equivalent to 1.9m tonnes of HFO annually (32.4kbd), or adoption by 1% of the world's shipping fleet, would make the group materially cash generative. In our opinion, adoption of MSAR by one refinery or shipping line would encourage competitors to deploy the technology, supporting the upper range of the analysis.

Exhibit 8: Scenario analysis

Power market				
Number of MSAR manufacturing units	6	30	60	150
Production capacity (HFO equivalents mtpa)	1.9	9.3	18.6	46.6
% global HFO market	0.5%	2.5%	5.0%	12.6%
Revenues – licence model (US\$m)	60.9	304.6	609.3	1,523.2
EBITDA – licence model (US\$m)	15.6	77.8	155.7	389.2
Capex – licence model (US\$m)	(9.9)	(49.5)	(99.0)	(247.5)
Revenues – tolling model (US\$m)	120.0	600.1	1,200.1	3,000.3
EBITDA – tolling model (US\$m)	41.2	205.8	411.6	1,029.1
Capex – tolling model (US\$m)	(53.6)	(267.8)	(535.6)	(1,339.0)
Revenues – merchant model (US\$m)	419.2	2,095.9	4,191.8	10,479.4
EBITDA – merchant model (US\$m)	66.9	334.4	668.8	1,672.0
Capex – merchant model (US\$m)	(68.1)	(340.6)	(681.2)	(1,703.0)
Marine market				
Number of vessels using MSAR	75	375	750	1875
% global fleet	1.3%	6.3%	12.6%	31.5%
Revenues – licence model (US\$m)	95.6	478.2	956.3	2,390.8
EBITDA – licence model (US\$m)	16.7	83.7	167.3	418.3
Capex – licence model (US\$m)	(9.9)	(49.5)	(99.0)	(247.5)
Revenues – tolling model (US\$m)	149.7	748.4	1,496.9	3,742.2
EBITDA – tolling model (US\$m)	37.3	186.5	372.9	932.3
Capex – tolling model (US\$m)	(53.6)	(267.8)	(535.6)	(1,339.0)
Revenues – merchant model (US\$m)	419.2	2,095.9	4,191.8	10,479.4
EBITDA – merchant model (US\$m)	33.3	166.7	333.3	833.3
Capex – merchant model (US\$m)	(68.1)	(340.6)	(681.2)	(1,703.0)

Source: Edison Investment Research based on company data

Exhibit 9: Financial summary

	£000s	2016	2017	2018	2019
Year end 30 June		IFRS	IFRS	IFRS	IFRS
INCOME STATEMENT					
Revenue		2	126	9	22
EBITDA		(3,989)	(3,858)	(3,284)	(2,780)
Normalised operating profit		(4,137)	(4,069)	(3,514)	(3,010)
Amortisation of acquired intangibles		0	0	0	0
Exceptionals		0	0	0	0
Share-based payments		(802)	(242)	(53)	(154)
Reported operating profit		(4,939)	(4,311)	(3,567)	(3,164)
Net Interest		33	9	11	(3)
Profit Before Tax (norm)		(4,104)	(4,060)	(3,503)	(3,013)
Profit Before Tax (reported)		(4,906)	(4,302)	(3,556)	(3,167)
Reported tax		149	213	294	184
Profit After Tax (norm)		(3,955)	(3,847)	(3,209)	(2,829)
Profit After Tax (reported)		(4,757)	(4,089)	(3,262)	(2,983)
Minority interests		0	0	0	0
Discontinued operations		0	0	0	0
Net income (normalised)		(3,955)	(3,847)	(3,209)	(2,829)
Net income (reported)		(4,757)	(4,089)	(3,262)	(2,983)
Basic average number of shares outstanding (m)		809.6	846.1	862.2	888.7
EPS – basic normalised (p)		(0.49)	(0.45)	(0.37)	(0.32)
EPS – diluted normalised (p)		(0.49)	(0.45)	(0.37)	(0.32)
EPS – basic reported (p)		(0.59)	(0.48)	(0.38)	(0.34)
Dividend (p)		0.00	0.00	0.00	0.00
BALANCE SHEET					
Fixed Assets		4,080	3,980	3,885	3,654
Intangible Assets		2,924	2,924	2,924	2,924
Tangible Assets		1,156	1,056	961	730
Investments & other		0	0	0	0
Current Assets		4,685	5,561	2,600	1,396
Stocks		0	61	61	61
Debtors		297	302	188	169
Cash & cash equivalents		4,268	5,045	2,229	1,060
Other		120	153	122	106
Current Liabilities		(576)	(247)	(400)	(288)
Creditors		(576)	(247)	(400)	(288)
Tax and social security		0	0	0	0
Short term borrowings		0	0	0	0
Other		0	0	0	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		8,189	9,294	6,085	4,762
Minority interests		0	0	0	0
Shareholders' equity		8,189	9,294	6,085	4,762
CASH FLOW					
Op Cash Flow before WC and tax		(3,989)	(3,858)	(3,284)	(2,780)
Working capital		308	(428)	298	(77)
Exceptional & other		2	0	0	130
Tax		149	213	294	184
Net operating cash flow		(3,530)	(4,073)	(2,692)	(2,543)
Capex		(596)	(111)	(135)	(24)
Acquisitions/disposals		0	0	0	0
Net interest		33	9	11	(3)
Equity financing		0	4,952	0	1,401
Dividends		0	0	0	0
Other		0	0	0	0
Net Cash Flow		(4,093)	777	(2,816)	(1,169)
Opening net debt/(cash)		(8,361)	(4,268)	(5,045)	(2,229)
FX		0	0	0	0
Other non-cash movements		0	0	0	0
Closing net debt/(cash)		(4,268)	(5,045)	(2,229)	(1,060)

Source: Company data

Contact details		Revenue by geography	
Gillingham House 38-44 Gillingham Street London, SW1V 1HU, UK +44 20 7031 7321 www.quadrisefuels.com		N/A	
Management team			
Executive chairman: Mike Kirk		Chief operating officer: Jason Miles	
Mike Kirk was managing director of Weber Shandwick Square Mile until 2005. Prior to that he worked in the corporate finance department of Cazenove for over 13 years, advising on the demerger of Centrica from British Gas and the UK listings of John Wood Group and KBC Advanced Technologies. He is currently non-executive chairman of Portsmouth Water and Vivid Homes.		Jason Miles spent 12 years developing emulsion fuel projects, initially as a process engineer with BP and subsequently as business development manager for PDVSA, where he implemented various Orimulsion projects globally. He joined Quadrise in 2006 and now has some 25 years' technical and commercial experience in the emulsion fuels industry.	
Principal shareholders			(%)
Ruudowen Limited			6.1%
Phibatec Limited			5.2%
Intertrust Trustees Limited			4.6%
Anthony Lowrie			3.2%
Vistra Trustees (Mauritius) Limited			3.0%
Hemant Thanawala (Non-executive director)			2.9%
Companies named in this report			
A.P. Moeller-Maersk (MAERSK:DC), KBC Advanced Technologies (KBC:LN).			

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Frankfurt +49 (0)69 78 8076 960
Schumannstrasse 34b
60325 Frankfurt
Germany

London +44 (0)20 3077 5700
280 High Holborn
London, WC1V 7EE
United Kingdom

New York +1 646 653 7026
1,185 Avenue of the Americas
3rd Floor, New York, NY 10036
United States of America

Sydney +61 (0)2 8249 8342
Level 4, Office 1205
95 Pitt Street, Sydney
NSW 2000, Australia