

MSAR® - Synthetic Fuel Oil

November 2017



Quadrise ("QFI") is a UK-listed company with world-leading expertise and technology for producing a synthetic fuel oil (an oil-in-water emulsion fuel branded as MSAR®) directly from extra-heavy oil residuals, using technology deployed at the oil refinery.

The Quadrise team were previously responsible for commercialising the 60 million tonne Orimulsion® business for power generation, along with downstream specialists from oil companies (ExxonMobil, Shell, ConocoPhillips), power utilities and marine (GE Alstom, Maersk, DNV-GL & VPS).

Proprietary chemicals and associated RD&I support for MSAR® are supplied exclusively by AkzoNobel Surface Chemistry globally, with dedicated RDI facilities in the UK (QRF and University of Surrey).

MSAR® has been successfully used in major oil-fired power plants, boilers and diesel engines (2-stroke and 4-stroke) for marine and stationary power applications as a lower cost HFO alternative.

MSAR® Technology – Driving Value Delivery:

Quadrise licenses & supplies MSAR® technology, additives & services to produce a stable 'Oil-in-Water' emulsion fuel from the heaviest oil residuals.



How it works:

Tiny droplets of extra-viscous heavy hydrocarbons are dispersed in water & chemicals in a modular in-line blending unit using proven proprietary processes and additives. MSAR® systems can be installed in <12months.



MSAR® provides refiners with low-cost, rapidly deployed upgrading solutions for residuals blended to HFO.



Key benefits:

- ✓ Water & chemicals replace premium diluents in the fuel oil pool.
- ✓ Significant value is added at the refinery.
- ✓ MSAR® viscosity is lower than HFO.
- ✓ MSAR® can be handled & transported using existing HFO infrastructure.

MSAR® delivers HFO consumers tangible cost savings & environmental benefits.



Key benefits:

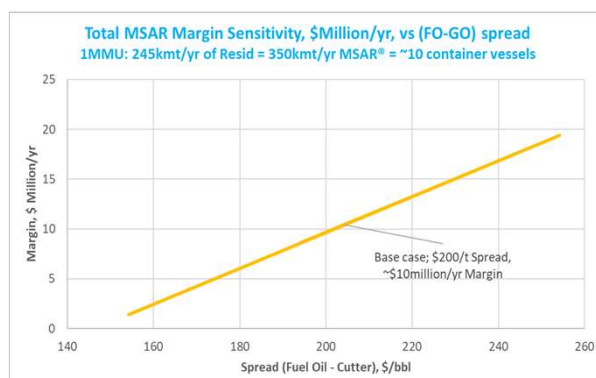
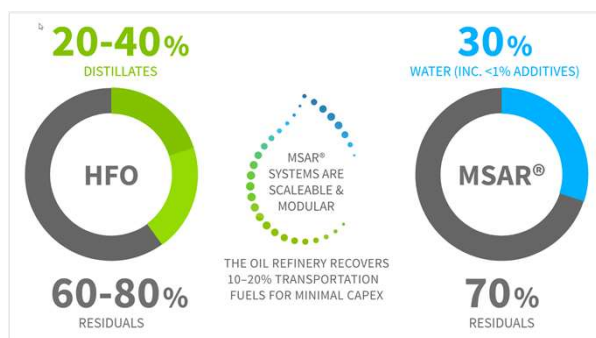
- ✓ Provides a stable, lower cost synthetic HFO.
- ✓ MSAR® provides enhanced combustion:
 - ✓ High carbon conversion = lower PM/Soot.
 - ✓ Water reduces NOx by 20-50%.



MSAR® = Multiphase Superfine Atomised Residue
70% of extra-viscous heavy residue droplets (5-10 microns) dispersed in ~29% water and <1% stabilising chemicals.

Oil Refineries – Economic Value Added:

- When a refinery produces heavy fuel oil (HFO), middle distillates are downgraded to the fuel oil pool to dilute residues mainly to control viscosity.
- MSAR® technology significantly improves the refinery middle distillate yield/margin by releasing high value distillates from the fuel oil pool, as they are no longer required as cutter stock to control viscosity.
- Budget Capex for implementing a modular, 1,000tpd MSAR® Unit into a refinery is ~\$5M, with payback of ~12 months, even if only half of the Margin generated was retained by the refinery.
- The MSAR® margin is a function of the Gasoil / Fuel Oil spread, which is forecast to significantly widen prior to 2020, as a result of the IMO Marpol decision, further strengthening MSAR® economics:
 - The margin increases as the spreads increase (as shown in the adjacent graph).



Proven Refinery Technology – MSAR® in Spain:

A 6KBPD MSAR® system is installed within a Cepsa 240KBPD refinery in Spain. Project completion was <9 months from agreement sign-off to commissioning.

The system can supply cargoes of MSAR® made from low sulphur or high sulphur residues to power and marine fuel users.



Key outlets are marine bunkers and oil power generation...

Key benefits of MSAR® to heavy fuel oil consumers:

- ✓ It is a lower cost synthetic HFO (per unit energy).
- ✓ MSAR® is formulated to meet end-user requirements.
- ✓ Fuel specifications are similar to HFO (ISO8217).
- ✓ With MSAR®, there are no asphaltene precipitation issues during blending.
- ✓ MSAR® results in enhanced combustion vs. HFO:
 - ✓ High carbon conversion = **less ash & soot**.
 - ✓ The added water **reduces NOx by 20-50%**.
 - ✓ MSAR® performance is similar to burning gas.
 - ✓ Compatible with exhaust gas cleaning systems.

Marine MSAR® has been successfully tested in Wärtsilä 4-stroke engines and electronic 2-stroke engines (MAN & Wärtsilä) through joint development with Maersk Line leading to the recent issue of an Interim LONO. MSAR® is compatible with exhaust gas cleaning systems and can improve vessel economics.



Power MSAR® is an enhanced version of Orimulsion®, where over 60 million tonnes was consumed globally for base-load power generation and is fully tested in boilers. We are working with an oil major and utilities in the Kingdom of Saudi Arabia (oil demand >50Mtpa), as well as other oil-based territories.



GE Power & Water



MSAR® - Synthetic Fuel Oil

November 2017