

DISRUPTIVE TECHNOLOGY

MSAR[®] as an alternative to Heavy Fuel Oil

MSAR[®] (Multiphase Superfine Atomised Residue)

quadrise



7TH ANNUAL

**EUROPEAN BUNKER FUEL
CONFERENCE**



PLATTS

McGRAW HILL FINANCIAL

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Rotterdam



Mark Whittle

General Manager Refining




MSAR® - low cost synthetic fuel oil

for Power generation, Marine fuels, Refinery & Oilfield refuelling

- **About Quadrise & MSAR®**
- Benefits of emulsion fuels
- Marine MSAR® & Project Update



Quadrise:

- UK Listed plc with ~€140 Million market cap
- Experienced team – ex BP/PDVSA/Shell/Conoco
- Global alliance with **AkzoNobel** 
- Comprehensive project implementation capability



MSAR®:

- A proprietary oil-in-water emulsion technology & fuel
- Converts refinery residues into stable synthetic fuel oil
- Low capex method of improving refinery margins
- Implemented in typically <12 months
- Technology proven and verified at commercial scale



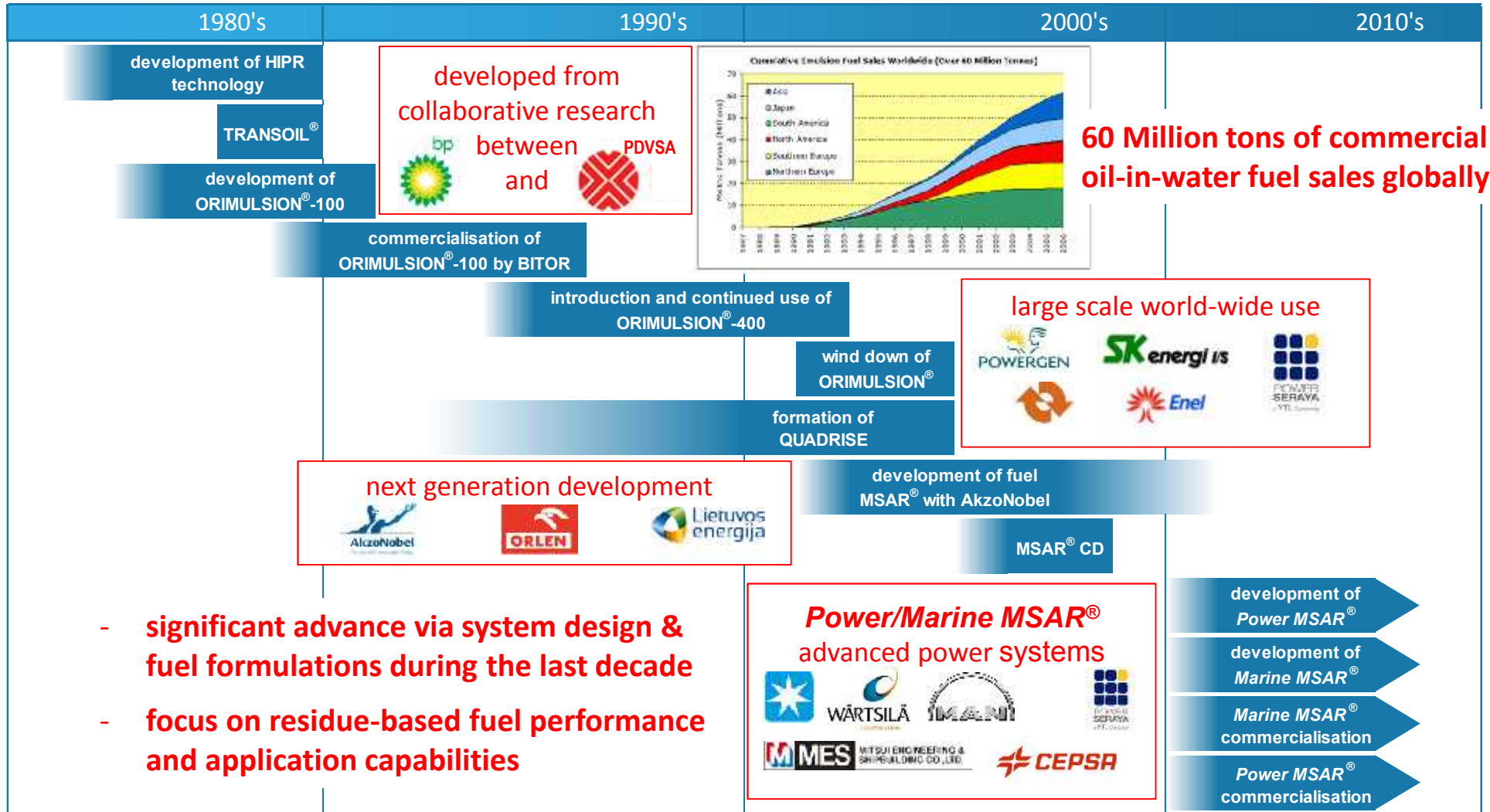
Projects:

- Marine MSAR® with Maersk Line & Cepsa
- Power MSAR® for the Kingdom of Saudi Arabia
- Other projects with select Oil Majors (Marine & Power)



MSAR® stands for **M**ultiphase **S**uperfine **A**tomised **R**esidue

Oil-in-water emulsion fuel technology and Quadrise



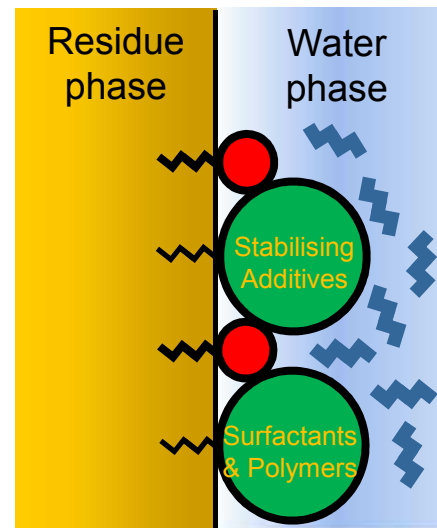
What is MSAR[®] fuel?

MSAR[®] is an **'Oil-in-Water'** emulsion system consisting of tiny droplets of heavy hydrocarbons (asphaltenic residuals) dispersed in water using proprietary additives and a colloid mill.

"Typically": **~70% Residue +**



<1% Additives +



~29% Water

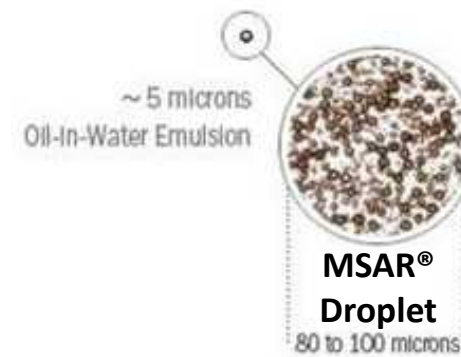


MSAR[®] technology produces a low viscosity fuel from high viscosity residuals using water and additives, instead of expensive oil diluents...



MSAR[®] is a **stable and superior** pre-atomised fuel with enhanced combustion features...

- High Carbon Conversion
- Up to 50% reduction in NOx



MSAR[®] formulation and performance testing



Lab test facilities



Key to the application of emulsion fuel is the required functionality. MSAR[®] as an end product is primarily a fuel oil substitute, not a standard emulsion

Research & Development is focused on producing a fuel that is ‘fit for purpose’, not just meeting a prerequisite set of specifications at the point of production

Through an iterative process of fuel formulation and extensive testing at laboratory, pilot and field scale, the key performance parameters are evaluated and optimised

Pilot test facilities



Investment in MSAR[®] RD&I and Service Centres



- **Quadrise Research Facility (QRF) UK – Recently Expanded**
 - ❖ Product development to enhance economics & efficiency
 - ❖ Fuel emulsion testing from lab to industrial scale
 - ❖ Central service centre for operations support
- **University of Surrey – Research Collaboration**
 - ❖ Centre for Petroleum & Surface Chemistry, formerly with BP
 - ❖ 1st class facilities – ideally equipped (\$7m hardware + expertise)
 - ❖ Primary research aligned to business needs
- **AkzoNobel**  **Stenungsund – Joint R&D and IP**



AkzoNobel Stenungsund, Sweden



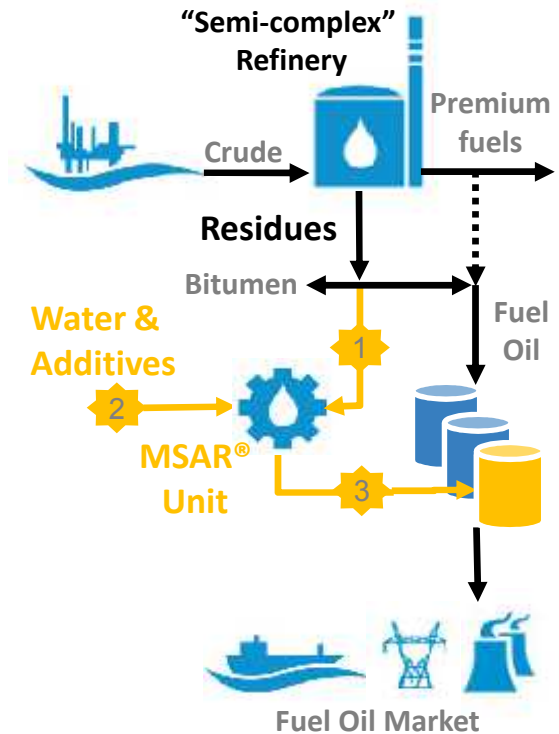
Quadrise Research Facility (QRF) UK

MSAR[®] Technology : “Plug & Play” Integration



Refinery integration of the MSAR[®] blending system:

- 1) Oil residues are taken direct from refinery rundown lines and cooled to achieve the required viscosity (~200-400cSt @ 100-200°C typically) for the colloid mill.
- 2) Water, which can be derived from several utility or wastewater sources, together with proprietary additives are added to the residue in a high-speed colloid mill under pressure.
- 3) The mixture is processed in the mill and cooled to provide highly stable oil-in-water fuel oil equivalent (~200cSt at 50°C) that can be run down to existing fuel oil tanks.





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- **Benefits of emulsion fuels**
- Marine MSAR[®] & Project Update



MSAR[®] Refinery Economics : Overview

Example semi-complex refinery...

- 1 **The refined barrel:**
Premium fuels, sold at a premium to crude, i.e. crude+



- 2 **Residue:**
- Viscous
 - Low value

- 3 **To monetise the Residue:**
Premium fuels / Distillates blended with residue to make HFO



- Heavy Fuel Oil:**
- Market: \$100 billion
 - Sold at crude-

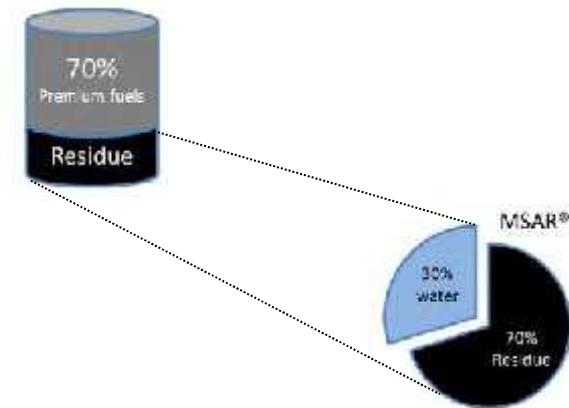
Loss of high value product to HFO

Residue + Distillates => HFO

In this refinery using MSAR[®] technology...

The pure residue is emulsified using water & chemicals to create MSAR[®]

Potentially all Premium fuels can be sold at premium prices



- ✓ Fast implementation
- ✓ Low capital cost, rapid pay-back
- ✓ Modular plant enables easy scale-up

Residue + Water + Additives => MSAR[®]

In simple terms, MSAR[®] works where: HFO Distillates Value > Water + Additives...

1 For the Refinery:

- Premium fuel output + profit increases
- Low capex: <<\$10 Million
- Fast payback (<12 months) and high IRRs

2 For the End User:

- Lower fuel costs
- Lower NOx / ash



3 For Quadrise and AkzoNobel:

- Quadrise is the project “Integrator” (Refinery and End User)
- Sales of Licenses, Additives & Services

MSAR[®] Refinery Economics : Example



Generic Case Study; Residue cut with LCO to make 380cSt HFO			
Percentage of Resid in MSAR	70%		
Resid consumed by MSAR production	245,000	mt/yr	
MSAR MMU daily production	1,000	mt/d (single unit)	
MSAR annual production	350,000	mt/yr	
Stream Values & Properties	\$/mt	Viscosity cSt @ 50°C	NCV GJ/mt
Heavy Fuel Oil, 3.5wt% S	150	380	40.5
Cutter Stock (LCO)	300	6.5	42.0
Refinery Residue	35	890,001	39.0
Refinery Fuel Oil Blend	wt %	mt/yr	\$/mt
Cutter Stock (LCO)	43.4%	187,544	300
Refinery Residue	56.6%	245,000	35
Refinery Fuel Oil blend	100.0%	432,544	150
MSAR Blend Economics	\$/mt	Ratio (wt %)	\$/mt MSAR
Refinery Residue	35	70%	(25)
OPEX (Water 29%, Chems 1%, etc)		30%	(35)
Variable cost of MSAR Production			(\$60/mt)
MSAR Net Calorific Value (NCV, GJ/mt)	27.3		
NCV adjustment factor, HFO:MSAR =	1.48		
MSAR equivalent value vs HFO (normalised for NCV) =			\$101/mt

Assumptions:

Dec-15 market / assessment prices
 Refinery Residue netback as per HFO blending pool for 380cSt viscosity spec
 OPEX for Marine application

Example retrofit of 1xMSAR[®] module:

HFO blend today to make 380cSt:
 57%w Residue + 43%w LCO => HFO380

Calculated Residue “netback” = \$35/mt
 based on HFO value less LCO distillates...

MSAR production cost (Opex only):
 = Residue + Additives + Water
 = 70% x \$35/mt + \$35/mt (Additives etc)
 = \$60/mt MSAR[®]

Energy equivalent cost of HFO vs MSAR[®] (NCV):
 = \$150 / 40.5 * 27.3 GJ/mt = \$101/mt

Potential savings for Stakeholders:
 = \$41/mt x 350,000mt/a MSAR[®]
 = up to \$14.5M/a

**NB. Excludes additional capex (~\$5M),
 fixed opex, logistics, etc.**

Medium Term View – next 18 months

- Crude prices directionally increase with supply / demand rebalancing.
- European refining margins return to historical norms despite low crude prices. Diesel / Fuel oil spreads return to historical levels or widen.
 - Europe is expected to increase its middle distillate deficit but this will be met by imports from refineries outside of the region.
- Uncertainty around the Global marine bunker fuel oil spec change in 2020/25 is leading to a lack of action on investment:
 - Traditional refinery based residue upgrade options take significant Capex and require several years to implement.
 - Vessel based scrubbing is compatible with MSAR.



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- About Quadrise & MSAR[®]
- Benefits of emulsion fuels
- **Marine MSAR[®] & Project Update**



Projects: Marine MSAR® Background



Commercial experience with Orimulsion® Diesel Engine refuelling:

- Orimulsion® tested in 1990's with MAN Diesel, Mitsui and Wärtsilä
- Established a requirement to “break” Orimulsion® before combustion
- Subsequent Wärtsilä 4-stroke testing on V32/46/64 engines for LONO*
- 160MWe designed for HFO/Orimulsion® successfully operated (>150,000h)



MSAR®:

- MSAR® successfully tested on Wärtsilä 4-stroke V32, no need to “break” fuel
- LONO/operating experience for Orimulsion® also applicable for MSAR®
- JDA commenced with Mærsk in 2010, focussing on possible 2-stroke applications:

JDA testing undertaken to evaluate Marine MSAR®:

- ✓ Fuel stability during 6+ months marine storage
- ✓ Sufficiently robust when in contact with conventional fuels
- ✓ Generic formulation suitable for blending of various refinery residues / MSAR®'s
- ✓ Stability within centrifugal separators (up to 18,000 times gravity) if required
- ✓ Low pressure fuel rail recirculation at 10 bar
- ✓ High pressure injector spill-back at 800-1500 bar

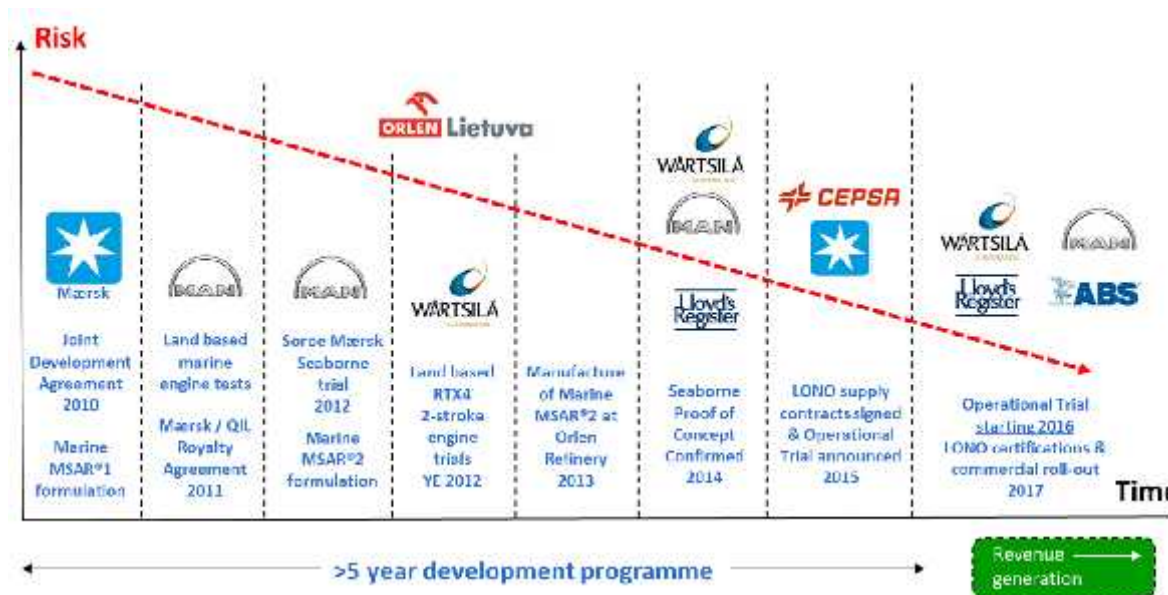


* LONO = Letter Of No Objection from OEM

Projects: Marine MSAR® with Mærsk

Milestones:

- Land-based 2-stroke engine tests at MAN/Mitsui & Wärtsilä
- First seaborne vessel test on residue OIW emulsion fuel (MSAR®)
- “Proof Of Concept” completed in 2014 (MAN / Wärtsilä) on operational Mærsk vessels
- Operational trial approved by Mærsk and Cepsa end 3Q 2015



Projects: Marine MSAR[®] - Current Status



Operational Trial (Mærsk & Cepsa):

- Cepsa (Compañía Española de Petróleos, S.A.U.), an integrated energy company 100% owned by IPIC (the Abu Dhabi sovereign wealth fund)
- One 6,000 BPD MSAR[®] system is being installed at the 240,000 BPD Refinery Gibraltar San Roque (RGSR, Cepsa's largest oil refinery)
- "Fast-track" Timetable:
 - Triparty agreement to proceed Q4 2015, site permitting initiated
 - FEED and Detailed Engineering completed Q1 2016, civils started
 - Mechanical and E&I works completed end Q2 2016
 - LONO volumes commencing summer 2016 for ~4,000 hours of testing
 - Commercial MSAR[®] volumes post-LONO early 2017, subject to results



Projects: Marine MSAR[®] - Implementation Case Study



Tie-ins and lines for residue supply/return to the Visbreaker

New buffer tanks for VB residue & MSAR[®]

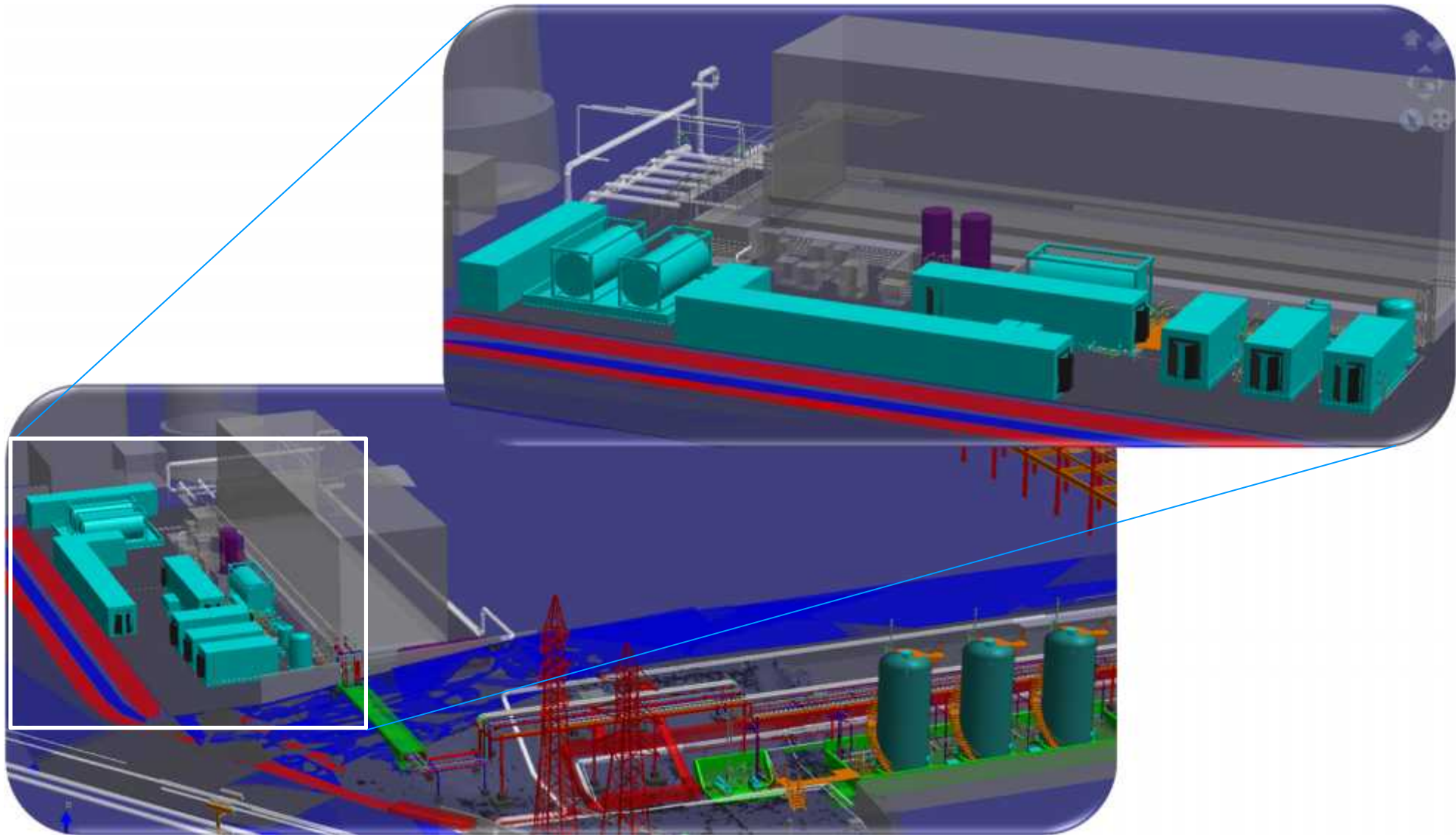
New MSAR[®] unit & support infrastructure

New tie-ins to existing pipework

Cleaning & preparation of 14,000m³ tank

Use of existing oil jetty

Projects: Marine MSAR[®] - Implementation Case Study



Projects: Marine MSAR[®] - Implementation Case Study

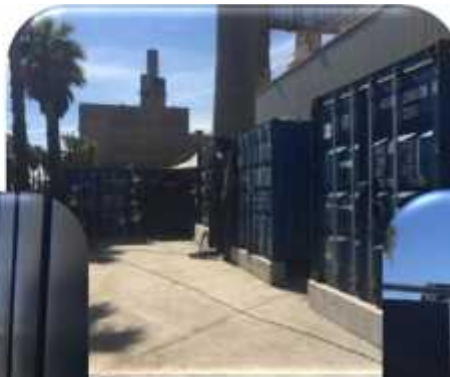


Site available, Civils started Mar'16



MSAR unit & equipment delivered Apr'16

Mechanical and E&I erection & integration Apr-May'16



Projects: Power MSAR[®] in the Kingdom of Saudi Arabia

The Market:

- Very high energy consumer per capita, subsidised for the domestic market.
- Fuel mix for power: 56% Oil-based (43M t/a), 44% Gas

For MSAR[®]:

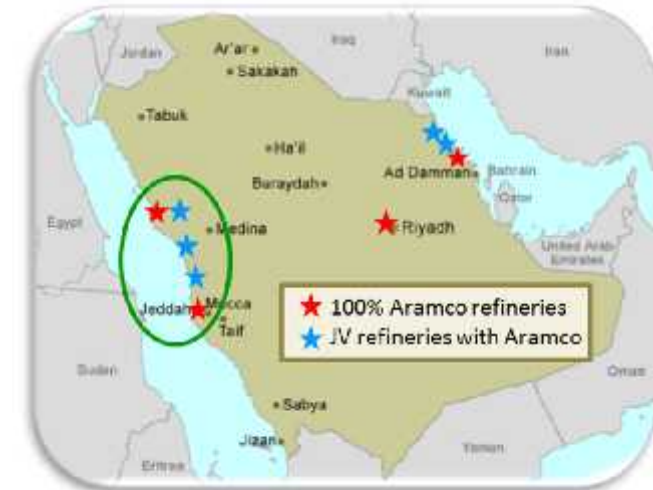
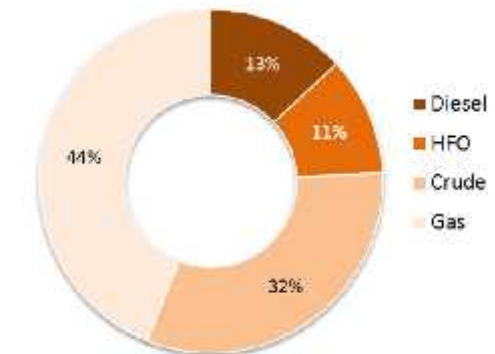
- Scope: Replace crude oil / HFO use for power with MSAR[®]
- Working through local partner and KSA majors

400MWe Demonstration Trial (Refinery – Power MSAR[®] - Major Utility):

- West coast candidates established, integrated 400KB/D refinery
- Refinery production of MSAR[®] & coastal supply to modern 400MWe baseload Power unit for commercial trial, plus potential follow-on.
- Preliminary client approvals and refinery tie-ins completed & Trial agreements in negotiation

Fuel Consumption for Electricity

43M t/a KSA Oil Consumed Annually
ECRA 2014



Location of NOC & JV Refineries

Projects: Pipeline (Others)

Quadrise has a targeted business development programme to build awareness and interest with both potential producers & consumers.

Marine MSAR with Cepsa & Maersk as above.

Global oil majors at multiple sites for MSAR[®] production

- Laboratory & plant scale tests of residues continuing
- Candidates for expanding marine MSAR[®] to additional bunker hubs & associated power opportunities.

YTL PowerSeraya refuelling (Singapore)


- Former Orimulsion[®] consumer – 750MWe = 1.8M mt/a
- MOU to supply MSAR[®] supply candidates



Refinery Refuelling

- Working with a number of refiners to explore opportunities



- Quadrise:**
- UK Listed plc with ~€140 Million market cap
 - Experienced internal team – ex BP/PDVSA/Shell/Conoco, supported by a Global alliance with **AkzoNobel** 
 - Project evaluation & implementation capabilities, covering all phases from feasibility through production to end use, across all applications

- MSAR®:**
- A proven, proprietary oil-in-water 2nd generation emulsion fuel
 - Converts low value refinery residues into a lower cost synthetic fuel oil
 - Low capex, low risk, fast payback method of improving refinery margins
 - Applications in Marine, Power, Refinery & Oilfield refuelling

- Projects:**
- Well developed project pipeline with stakeholders
 - Marine MSAR® with Maersk Line & Cepsa
 - Power MSAR® for the Kingdom of Saudi Arabia
 - Other projects with select Oil Majors (Marine, Power & Refuelling)



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Thank You



Mark Whittle
GM Refining
Tel: +44 20 7031 7321
info@quadrisefuels.com
www.quadrisefuels.com



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