TFG marine

Modernising marine fuel delivery

Transparency, digitalisation and decarbonisation – the case for standards-compliant mass flow metering

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This industry-sponsored paper was written by Adrian Tolson, an independent consultant at 2050 Marine Energy with more than three decades' experience in the marine fuel supply industry. Its conclusions and recommendations are endorsed by key stakeholders in the bunker supply chain, including those named at the end of this document.

This paper argues that the global adoption of calibrated mass flow meters (MFMs) will bring much-needed transparency to bunkering by generating accurate, real-time data for all stakeholders along the marine fuel supply chain. It describes the problems for the industry caused by inaccurate quantity measurement and sets out a number of remedial actions. It recognises the success of Singapore's MFM-based bunker licensing system and proposes this as a template for regulators in other regions across the world. It calls on all supply chain participants to actively support MFM-based deliveries, promote transparency and encourage digitalisation in the long-term interests of the bunker industry and to help further the decarbonisation goals of the shipping industry.

Executive summary

The bunker industry urgently needs to modernise and embrace transparency. The traditional practices that persist across its supply chain limit efficiency, constrain growth, hamper industry-wide efforts to reduce GHG emissions, and increase the cost of international trade.

Over the years, bunkering has evolved as a highly competitive, low-margin industry where the lowest headline price wins the business. Counterparties have been less exercised by the quantity or quality of fuel delivered, its energy content and the service levels they experience. In an intensely competitive market the focus on headline pricing creates the risk of a race to the bottom. When suppliers get rewarded for low prices but not the value they deliver they have an economic incentive to cut corners.

Over time, this structural bias has encouraged opaque, sometimes questionable, working practices to develop that have now become a systemic issue for the industry. A key root cause is the absence of transactional transparency. Many transactions are measured volumetrically, with their mass-equivalent value calculated indirectly. This creates a layer of uncertainty that invites differing interpretations between suppliers and buyers.

Migrating the industry to MFM-based delivery can transform how transactions are processed. Calibrated mass flow meters (MFMs) measure mass directly. They can provide transactional transparency, with data available to all parties in real time.

This would significantly improve industry efficiency. Shared access to agreed data would end the vast majority of quantity disputes, many of which spring from intentional short-delivery.

The International Bunker Industry Association (IBIA) supports the introduction of MFM-based delivery to improve transparency between suppliers and buyers. It recommends the adoption of the ISO 22192 international standard which specifies best practice across the supply chain.

The global adoption of standard-compliant MFMs can help to modernise the bunker industry by simplifying data sharing. Shipowners will gain accurate, real-time fuel data which they can use for reporting purposes and to assist in decarbonisation.

Digitalised bunkering is an important building block for blockchain-based shipping and trade finance. MFM-based delivery can help to create a digitally driven bunker industry that will be better able to innovate.

But more needs to be done to reach this goal. Entrenched interests in shipping and bunkering stand in the way. The major supply chain participants and regulators need to work together to make change happen in the long-term interests of the bunker industry and the global economy.

The global bunker industry: An overview

The bunker industry plays a critical role in society as the engine for global maritime trade. It is ultimately responsible for providing the energy that moves billions of tonnes of cargo across the world's oceans.

Maritime transport connects the global economy. Around 90 percent of the world's internationally traded goods are carried by sea. In 2021, 11 billion tonnes[1] of maritime cargo were delivered worldwide, equivalent to an estimated 58,988 billion tonne-miles[2] of maritime distance.

The fuel for all these journeys contributes significant CO_2 emissions. Without appropriate action, as shipping activity increases in response to global growth, the industry's CO_2 emissions will continue to grow. Recognising this, the International Maritime Organization (IMO) has been ratcheting up its carbon reduction ambitions. Its 2023 GHG strategy calls for an up to 80 percent reduction in maritime emissions by 2040 (versus 2008). It is targeting net zero by around 2050.

These decarbonisation efforts depend on a modernised bunker industry and the transaction transparency provided by MFMs is a pre-requisite for that. Widespread MFM adoption marks the first step towards a fully digitalised bunker industry that opens the door to all types of electronic data exchange possibilities.

1. UNCTAD secretariat
2. Clarksons, quoted in UNCTAD report

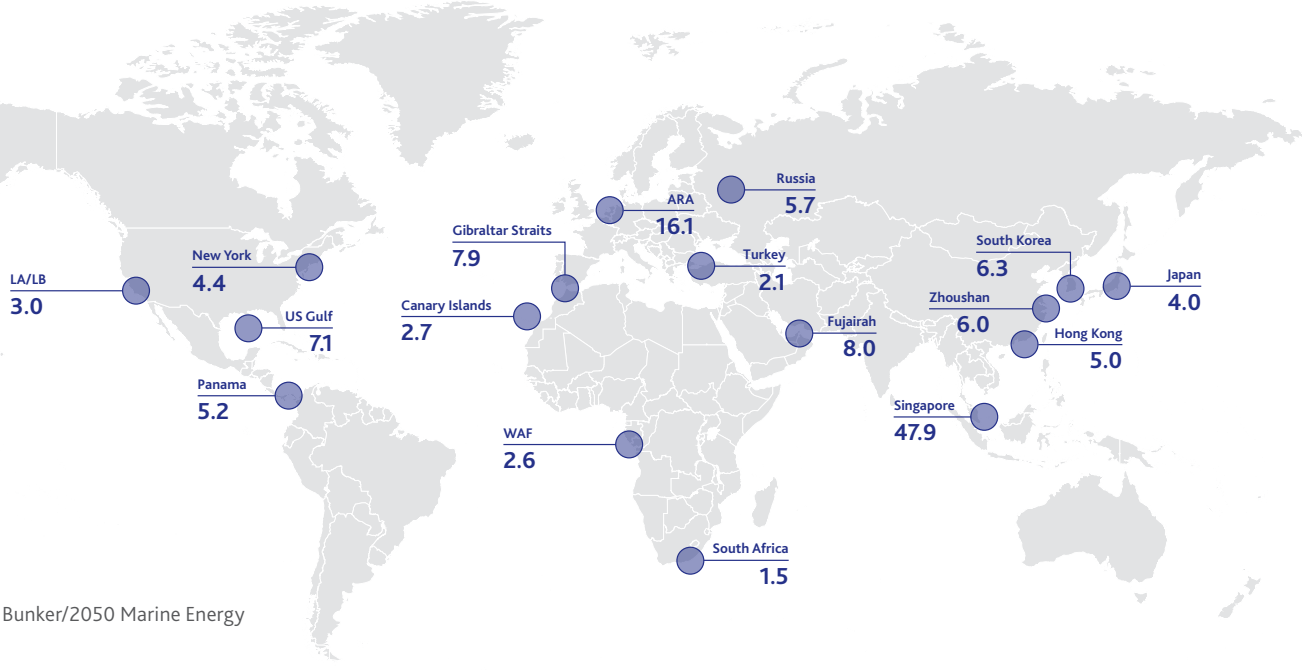
Market volume

The global scale of the bunker fuel market is hard to determine with any precision. The IMO publishes estimates based on consumption figures from vessel owners but, as explained later in this paper, there is a lot of uncertainty about industry reporting. Many vessel owners receive incorrect delivery quantities from their suppliers at various ports around the world. Their reported figures are therefore likely to overstate consumption.

However, fuel consumption estimates do give a broad sense of the scale of the industry. The IMO requires all international vessels over 5,000 metric tonnes in gross tonnage to report their fuel consumption. Over 94 percent of vessels did so in 2021. From this, can be extrapolated (IMO didn't extrapolate) global bunker demand of approximately 225 million metric tonnes for the year. The standard industry assumption is that 30 million metric tonnes is consumed annually by smaller boats and on domestic, non-trade and freshwater journeys. Our best approximation therefore is that the global bunker market was around 255 million metric tonnes in 2021, equivalent to over USD200 billion in total market value (2021 prices), with container ships, bulk carriers and tankers accounting for around 80 percent of that.

The bunker fuel business involves many hundreds of entities at hundreds of ports around the world. Singapore, strategically located on a crucial shipping lane, is by a distance the world's largest marine fuel destination, followed by ARA (Amsterdam, Rotterdam and Antwerp) and Fujairah.

Global main bunker supply ports in 2022 (mmt)[3]



3. Ship & Bunker/2050 Marine Energy

The bunker supply chain

The bunker supply chain is highly complex, with many different types of companies involved in the bunker ecosystem. These include state-controlled companies, oil majors, oil independents, commodity trading houses, oil traders, storage terminals, international bunker traders, online procurement platforms, brokers, smaller regional bunker traders, bunkering pools servicing shipping fleets and bunker buying alliances. They are involved at different stages – from production, transportation and storage through to procurement, sales and delivery to various end users – as set out in the diagram below.

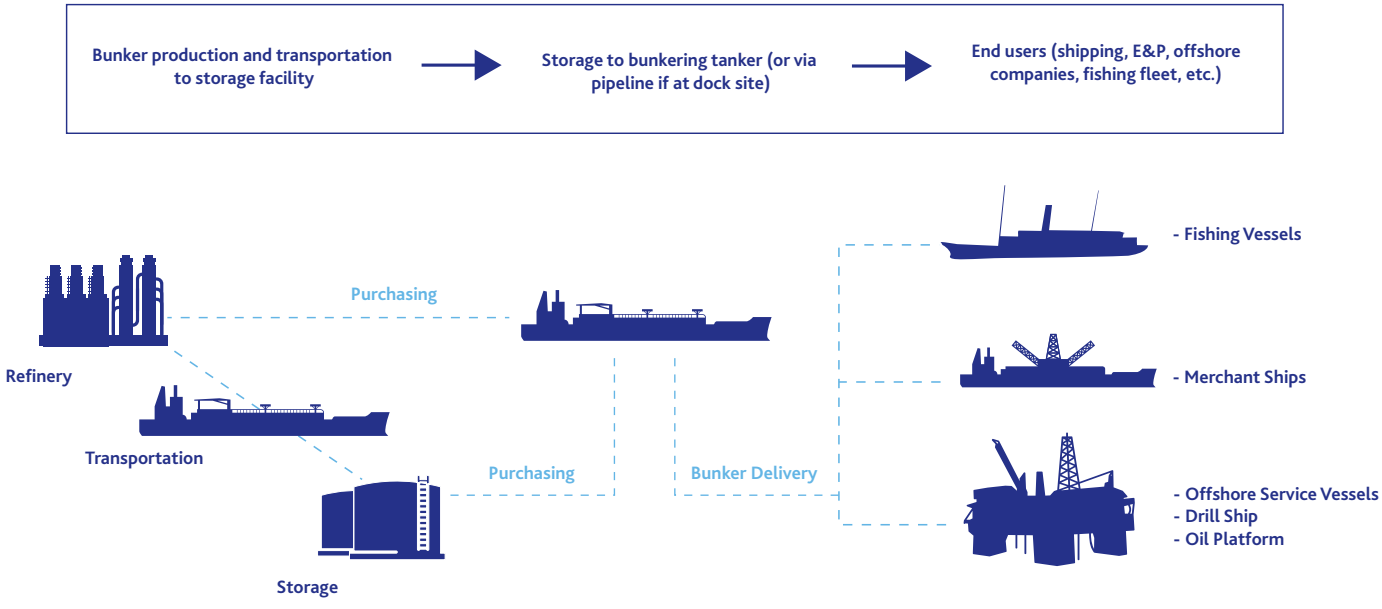
The table to the right ranks Ship & Bunker's top ten bunker selling companies by sales volume. The global marine fuel-focused publication identified its industry leaders based on sales volume, global reach and their overall potential to impact the supply chain.

Top ten bunker companies in 2022[4]

Bunker Holding Group	**World Fuel Services**	**Minerva**
30.0mmt	19.1mmt	16.5mmt
Peninsula	**TFG Marine**	**Vitol Bunkers**
14.5mmt	10.0mmt	7.5mmt
Monjasa	**Integr8 Fuels**	**Fratelli Cosulich**
6.4mmt	6.8mmt	6.0mmt
Alpha Trading		
3.5mmt		

4. As compiled by Ship & Bunker

Global bunker supply chain



History and development

For much of the twentieth century, the bunkering industry was dominated by the oil majors. In the early days, this was not considered by them to be a priority market, it was seen more as a useful mechanism for disposing of residual, lower quality fuels. With fuel supplies readily available internationally at low prices, the business was not intensely competitive. Shipowners too prioritised convenience over price.

This all changed with the 1970s oil crisis. Supply shortages, escalating prices and diminishing trade put international shipping under pressure. The risk-averse oil majors began retreating from the bunker industry to focus on their core businesses.

The bunker industry as it exists today was born out of these dynamics. Stressed market conditions during the oil crisis offered independent suppliers and smaller refiners with access to oil and a higher credit risk tolerance the perfect opportunity to build market presence.

During this period, many of the barging and delivery companies that had previously serviced bunker supply for the majors began sourcing directly and, initially at least, their business model proved very profitable. But this didn't last. By the 1980s, the oil majors and big refiners were returning to the market. They were able to grow market share with aggressive pricing strategies and global supply chains. The independents, unable to match their firepower and financial muscle, were quickly pushed into survival mode.

As competition intensified and margins fell, the bunker barrel became increasingly commoditised. For many smaller companies, survival was dependent on creating margin where none existed.

Some cut costs by blending their supply with lower quality fuels. Others resorted to misstating quantities – initially by taking advantage of volume-to-mass conversion factors and later on, when that was no longer possible, through inaccurate barge and ship-side measurements.

Shipping's relationship with bunkering facilitated such tactics. Historically, easy availability and low prices had meant that shipowners paid scant attention to bunkers, which were often procured by local agents. When independent suppliers arrived on the scene, most shipowners lacked any real capacity to assess supplier quality and service levels. The buyers focused mainly on headline prices rather than the quantity and quality of the fuel they were getting.

This price-led approach became the industry norm. It has promoted a market environment where suppliers have no tangible incentive to differentiate themselves in terms of better-quality fuels, full-quantity delivery or good service. Even today, after many problem years, buyers' purchasing decisions focus significantly on price without much regard to fuel specifications, full-quantity delivery or service.

The need for transparency

An outdated, undercapitalised industry

These decades of wafer-thin margins and chronic commoditisation imposed a high price on the bunker industry. It has resulted in an undercapitalised industry that remains steeped in outdated practices, some of them unethical.

Industry participants incur significant additional costs both in terms of time and money. Precise numbers are, by definition, hard to come by, but one recent estimate by Minerva highlights the scale of the problem. By extrapolating reported data globally, they have estimated that customers lose USD2.6-5.2 billion every year in quantity shortages, while the time lost from delays, disputes and arbitration is put at a further USD2.2 billion annually.

The cost and risks of physical documentation

The industry's continued reliance on physical documentation has imposed unnecessary costs and restrictions. In many places, multiple pieces of paperwork (bills of lading, ullage reports, warrants, BDNs etc.) are still required. These documents are often filled out in triplicate or quadruplicate, passed from barge to ship and back, then to the supplier and after that to the buyers' and the suppliers' banks. They are easily lost or damaged and prone to forgery.

Document forgery has been a major problem in bunkering for many years, but until very recently there was no real desire for change. Industry regulators were accepting of inaccuracies. Market participants were accustomed to the process. Many saw it as a cost of doing business.

Regulators and the financial community recognise the risk of relying on manual systems. Most now insist on the adoption of secure digital documents, a critical component in the move towards digitalisation. The IMO has responded by approving electronic bunker receipts, which are readily available using MFMs.

Quality concerns are being addressed

Outdated industry practices persist that compromise the accuracy of both delivery quantities and qualities. On quality, some progress has been made. The financial impact (especially in terms of claims) of quality control issues in the bunker industry has spurred the development of widespread and generally accurate bunker quality testing. This has been spearheaded by increasingly sophisticated international fuel testing laboratories in conjunction with multiple revisions of the ISO 8217 bunker specifications. While bunker quality control is not perfect and there are still occasions when claims outbreaks go undetected prior to fuel reaching vessels, the knowledge and understanding of fuel quality has improved considerably.

In addition, while not as yet mandated on a global basis, it is now common for vessels and their owners to receive Certificates of Quality for fuel prior to bunkering. Even so, there are still locations where this does not happen or where the quality and accuracy of these certificates are dubious.

Inaccurate quantity measurement remains endemic

Unfortunately, outdated quantity measurement practices are still widespread. The most common way of measuring fuel delivery to a ship is by gauging the volume supplied. This is typically done by sounding tanks before and after bunkering with the aid of ullage tables. Taking accurate soundings can be challenging in real-world conditions and the accuracy of the ullage tables is also debatable. These same flawed methods are frequently used to gauge the receiving vessel's tanks. As a result, measurement inaccuracies from either side may trigger disputes.

Once a figure for the volume of fuel provided has been agreed between the delivery barge and the receiving ship, this then has to be converted into its equivalent mass. A volume-to-mass conversion factor is used to derive the metric tonne equivalent, the relevant measure for sales. This varies according to the density and temperature of the fuel.

This combination of analogue measurement, unreliable tables and complex conversion factors will almost by definition create disputes that cannot easily be resolved. Inaccuracy is baked into the process and there are ample opportunities for cheating on quantities. These mechanisms are clearly sub-optimal, yet they are still widely viewed as acceptable and an unavoidable cost of doing business.

There are effective alternatives out there, but the industry has – so far – failed to adopt them. In particular, the widespread adoption of calibrated mass flow meters (MFMs) would be transformative. Most market participants understand that this would bring precision to quantity measurement. Ninety percent of respondents to a CE Delft 2022 study[5] for the Port of Rotterdam agreed that MFMs could solve quantity problems.

Not all measurement issues are intentional. When fuels are pumped from a barge to a receiving vessel the flow may not be consistent, there may be fuels of different densities involved in deliveries, fuels of different temperature, fuels with greater water content and fuels with entrapped air, particularly when stripping tanks. In fact, many of the techniques that have reportedly been used by some suppliers to falsify quantities, which would be eradicated by MFMs, can and do occur by accident.

5. Summary of CE Delft Study for Port of Rotterdam – CE Delft, 2022

Lost volumes and missing metric tonnes

Simply put, in many supply ports around the world, bunker buyers do not receive the full quantity of the fuel they have contracted for or the amount of fuel that appears on the bunker delivery note (BDN). In July 2020, VPS[6] estimated that, based on a sample of over 10,000 vessels bunkering using the VPS Bunker Quantity Survey (BQS) service in 2019, quantity shortages cost the average vessel USD96,200 annually. Minerva[7] estimates that more than three percent of volume is lost in many ports. In April 2022, marine and energy consultancy Blue Insight calculated[8] that volume shortages had cost USD100 million in Rotterdam and USD150 million in Fujairah during 2021. These dollar figures were arrived at by looking at the cost of bunker fuel in the daily bulk market, factoring in added expenses, including barge operation and financing in each port, and comparing that with the actual sales prices seen by shipowners. These calculations indicated consistent negative margins. Since suppliers could not consistently sell at below cost, the report concluded that these losses were likely offset by unregistered supply chain gains.

Short-loading is hampering market development

The VPS report placed the responsibility for the shortages it identified on fuel suppliers, but the actual situation is more nuanced. CE Delft's Study for the Port of Rotterdam states "…it is impossible to clearly identify a single type of stakeholder or cause as a reason behind these bunker quantity problems"[9].

Blue Insight highlighted the negative economic consequences of supply shortages in the supply chain, but stopped short of assigning blame entirely to any specific sector. Instead, it presented a range of explanations for quantity discrepancies, leaving open the possibility that cargo suppliers and buyers, owners and charterers might sometimes be originators and/or co-participants in these activities. There are economic motivations for cargo suppliers to short-load barges and for buyers and vessels to overstate consumption so they can accumulate inventory off the books and sell it on later with or without any actual physical transfer.

Ultimately, fuel has an intrinsic commodity value and that can turn an unprofitable voyage into a profitable one or incentivise a poorly paid crew. The bunker supply industry reflects its customers and while we have a better understanding of how and why suppliers might try to gain volumes, we have limited insight into what goes on on board.

Having said that, the body of evidence tends to support the view that the overwhelming majority of those benefiting from quantity gains are on the supply side. Their actions distort the market and are reputationally damaging for the industry.

Quantity disputes cost time and money

Quite apart from the direct dollar losses from missing quantities, there are significant associated costs in dealing with a quantity dispute. Once a quantity claim is placed, there is immediate pressure on one or both sides to compromise. Whenever a dispute is raised additional administrative costs become inevitable. Independent surveyors need to be commissioned and dispatched to vessels. Both the receiving vessel and the delivering barge may lose time while their differences are settled.

These delays cost money and they can also put a vessel at critical risk of missing a cargo loading or discharge date. Suppliers have been known to raise the spectre of operational delays to force compromise from buyers or their on-board representatives. Buyers' vessels too have been known to use this tactic. They understand that disruption to tanker barge scheduling can be costly for suppliers.

6. Quantity Shortage Prevention for Marine Fuels – Captain Rahul Choudhuri & Renze Vonk, 2020
7. https://www.minervabunkering.com/advanced-delivery-platform/
8. Fuel Buyers Losing Millions a Year as Bunker Industry's Shame Continues Unabated – Adrian Tolson, 2022
9. Summary of CE Delft Study for Port of Rotterdam – CE Delft, 2022

Short delivery: twelve tricks that inflate bunker quantities

Misreporting mass-equivalence

- **Density misstatement:** Reporting the supplied fuel as being heavier than it actually is overstates its mass in metric tonnes.
- **Temperature misstatement:** Since fluids expand with increasing temperature, understating the temperature at which a given volume of fuel is supplied overstates its mass.
- **Suspect calibration tables:** Using old and non-class-certified tables to compute mass incorrectly.

Increasing volumes

- **Cappuccino effect:** Releasing compressed air into fuel before, during and after bunkering increases its volume – tank gauging and ordinary flow meters will not detect this.
- **High water content:** Adding fresh water or sea water to fuel expands the delivery volume.
- **Adding slops:** Pumping/mixing slops into delivery both impacts the quality of the fuel and increases the volume delivered.

Manipulating volumetric flow meters

- **Lack of certification:** Uncertified meters may have broken seals and include return pipes after the meter.
- **Enforced metering:** Customs sealing of ullage ports/sounding pipes and the enforced use of a specific flow meter by the barge master stop buyers and shipowners from ratifying their bunker deliveries.

Distorting soundings and tampering with gauging equipment

- **Doctoring sounding pipes:** Adding oil to the sounding pipe alters the recorded level.
- **Altering sounding tapes**
- **Miscalibration:** Registering gauging tanks at zero when these contain unpumpable fuel or gravitating fuel through inter-tank transfers after gauging has been completed.

Unethical operations

- **Joint enterprise:** The receiving vessel may join forces with the supplier or the supplier's crew to understate its Bunker Survey (ROB) and agree to short-delivery in return for a financial benefit.

The true value of certainty

In 2022, IBIA and BIMCO published the results of a survey on bunker licensing and MFMs. In that survey nearly 95 percent of buyer respondents indicated they would prefer to buy bunkers from a supplier with MFMs installed[10].

Despite this finding, suppliers who have installed MFMs in ports where they were not mandated have consistently argued that buyers are not willing to pay a fair premium for true and accurate delivery quantities. However, the same BIMCO-IBIA survey found that almost 60 percent of respondents believed prices would go up were MFMs to be introduced. This suggests that buyers would be willing to pay extra for MFM measurement. True or false, the impact on price is open to considerable debate. This is discussed further below.

While buyers overwhelmingly confirm in surveys that they are willing to pay more for the certainty and transparency that MFMs offer, it is sometimes difficult to see real evidence of this in the marketplace. Without doubt, significant educational work still needs to be done to demonstrate the real value of the certainty MFM-based delivery can offer. While the evidence of consistent shortages is often obvious there is a collective denial by many on the buy-side of the extent of the problem.

Having said that, some buyers are clearly willing to put their money where their mouth is. In 2021, after agreeing to pay a premium for a bunker contract in Rotterdam using MFMs, Peter Grünwaldt, Vice-President and Head of Bunkering at leading publicly listed tanker owner and operator, Hafnia, pointed out that, "…the argument from suppliers for not adopting this has always been that nobody is prepared to pay for it. Now that excuse is gone…"[11].

10. BIMCO-IBIA BL & MFM Survey Analysis, May 2022 (https://www.bimco.org/news/priority-news/20220706-ibia-bimco-bunker-survey)
11. https://shippingwatch.com/carriers/Tanker/article12786032.ece

Short deliveries continue to be tolerated because much of the industry remains fixated on the compromise of cheapest face-value pricing and shows insufficient concern for the potential quality issues and almost inevitable quantity issues this business model implies. Buyers are commonly benchmarked by management to obtain the lowest price against a price index. This distorts the market in favour of those that cheat at the expense of those who are honest. In unregulated ports, which make up the majority of locations, suppliers that take gains by distorting transactions are incentivised to continue this behaviour, while those that don't go unrewarded and risk going out of business.

Change is long overdue. Bunkering suffers reputationally from its lack of transparency. Opaque dealings create space for corruption to flourish and magnify market distortions that make it difficult for the price mechanism to operate effectively.

And this is no sideshow business. Bunker fuel powers global maritime trade. It is at the heart of the global economy.

Decarbonisation and digitalisation

The climate crisis demands urgent action by all parties to reduce emissions and accelerate the energy transition. This is a live issue for the maritime industry. Recent estimates suggest that maritime trade is responsible for 2.89 percent[12] of global emissions. If it were a country, it would be the world's sixth biggest CO_2 emitter[13]. What is more, the continued growth in the demand for shipping worldwide is accelerating maritime emissions. Without action, shipping could be responsible for over 10 percent of global emissions within a few decades.

The shipping industry understands the needs for urgent action. The International Maritime Organization (IMO), the United Nations body regulating shipping, announced an accelerated strategy in 2023 which aims to reach net zero by close to 2050. Achieving this will require the industry to set a course towards cleaner fuels.

An opaque, distortive bunker market acts as an obstacle to that. If shipowners cannot accurately identify how much fuel they are using, it is far harder to identify which vessels and fuels perform more efficiently. With carbon taxes and other regulatory incentives likely in the near future, it is more important than ever that shipowners have accurate inventories of their actual fuel consumption and related emissions. This adds urgency to the case for implementing mass flow metering.

Rune Kongstein of Glander International emphasised this point in a recent article discussing the soon-to-be introduced European Union Emissions Trading System[14]. "Malpractice that emerged while bunker fuels were cheap will no longer be tolerated when fuel costs more than USD1,000/MT with emissions allowances included… That will mean much more robust systems to reduce quality and quantity disputes and demonstrate regulation compliance…".

Widespread use of MFMs would be transformative for the industry, providing a major step forward in transparency. With MFMs all parties get simultaneous, real-time access to the same fuel delivery data. This is a key building block for the industry's digitalisation and opens the way to blockchain-based shipping. When every supplier and every buyer has real-time access to their fuel mass data, overall shipping costs will fall, ullage-based disputes will disappear, supply chains will accelerate, energy transition efforts will gain focus and intensity, and the most efficient operators will be rewarded according to the added value they bring to the market.

Regulation is limited and uneven

The prize is huge, but, unfortunately, with entrenched interests benefiting from the status quo, it seems there is little appetite for change.

Ultimately, the only surefire way to create a level and transparent global playing field is for the designated regulatory authorities to introduce mandatory licensing. Regulators need to introduce calibrated MFMs across the board. Without that, nothing will change, and the 'games' will continue.

The question is how this can be achieved. The current environment is clearly sub-optimal. It persists at least partly because regulatory authorities in many ports and countries have been reluctant to get involved in the bunker industry.

Implementing effective local regulation is never easy. Ports, customs, and local weights and measures authorities know they must proceed carefully and orchestrate their actions if they want to get to grips with an industry that doesn't want to be regulated.

Added to that, these regulatory measures may need to be multi-jurisdictional, as there is a perception that, without that, those implementing higher standards will be at a competitive disadvantage internationally.

12. 2018 data, Fourth IMO GHG Study 2020, International Maritime Organization (IMO)
13. Based on 2020 data, https://worldpopulationreview.com/country-rankings/co2-emissions-by-country
14. Glander International: 'EU ETS will revolutionise the bunker industry" – May 3, 2023 https://www.bunkerspot.com/global/58922-glander-international-eu-ets-will-revolutionise-the-bunker-industry?utm_medium=email&utm_campaign=Bunkerspot&utm_content=Bunkerspot+CID_18461c19289371aed89c7f5c4be83361&utm_source=Bunkerspot percent 20Noon percent 20Report&utm_term

Lessons from Singapore

Singapore's experience suggests that this concern may not be well grounded. Singapore's Maritime Port Authority (MPA), in conjunction with other regulatory bodies, has developed a comprehensive regulatory framework for bunkering by requiring all local bunker suppliers to meet SS 524:2021, the Singapore specification for quality management in the bunker supply chain, which incorporates both SS 648 and SS 600. This has been highly beneficial for the port.

Over the last six years, Singapore has shown that implementing a certified, calibrated MFM system works. It has been a key factor in transforming one of the world's most challenging bunker markets (in terms of quantity measurement) into one where quantity measurement concerns (at least from barge to ship) have totally disappeared. All this has been achieved with Singapore maintaining its prowess as the world's largest bunkering location and the cheapest in Asia.

Singapore continues to build on industry feedback to improve on its existing standards. It has extended standards upstream in the supply chain to include terminals with SS 660:2020, its code of practice for bunker cargo delivery from oil terminal to bunker tanker using mass flow meters. A new standard for electronic documents and processes for bunker transactions (E-BDN) is another work in progress.

The MPA's success provides a model for the rest of the industry. Having said that, it must also be recognised that what Singapore has achieved may be harder to implement in other jurisdictions. Laxer regulatory regimes have, up to now, shown little if any willingness to tackle the fundamental problems of the industry.

Regulating the bunker industry in Singapore

SS 648:2019, Singapore's bunker MFM code of practice, enhances fair trade along the bunker supply chain by specifying rigorous requirements for calibrated MFM delivery. It aims to enhance the efficiency of bunkering operations and promote best practice in the measurement of bunker fuel delivered. Its measurement methodologies and custody transfer requirements are mirrored in the ISO 22192 international standard.

Key sections include:

Bunker fuel quality. This covers bunker fuel specifications, sampling requirements and related documentation.

Metrological control. This specifies the metrological traceability, calibration and re-calibration requirements for certified MFM systems. It also specifies the required maintenance and control of an in-service MFM system.

System integrity. The requirements and procedures that ensure the system integrity of an MFM system at each stage (i.e. pre-installation, installation, commissioning and operation). This includes documentation, equipment checks for mechanical, software, electrical and operational security.

Meter selection and installation. The selection and installation requirements for a qualifying MFM system, including pre-selection screening, site survey and the responsibilities of the bunker fuel suppliers and meter vendors in this process.

MFM system verification. This describes the verification process that ensures that eligible MFM systems satisfy the standard's metrological and system integrity parameters.

Metering procedures. The pre-delivery, delivery and post-delivery documentation and procedures required when transacting bunker fuel via an MFM system.

Dispute management. This describes the process for managing quality or quantity disputes should these arise.

How MFMs promote transparency

There is a clear need for accurate quantity measurement during bunkering. Calibrated MFMs provide the best mechanism for that.

Mass flow metering and transaction transparency

Bunker fuel is sold to ships by mass, typically in metric tonnes, but transaction sizes have traditionally been arrived at indirectly, by estimating volume. The standard way to do this has been by manually dipping and gauging the tanks. In real-world conditions, this low-tech approach can only ever provide an approximation of the volumes transacted – some level of inaccuracy is inevitable. It has been estimated for instance that a 10°C temperature change will vary the cost of a 1,000MT delivery at USD300 per metric tonne by up to USD2,100 and a 3kg/m^3 difference in density can affect costs by USD1,000. This excludes the effect of dip tank measurement errors. Buyers typically employ independent quantity surveyors to minimise this risk, incurring an additional cost of up to USD2,000 per transaction[15]. Most market participants have accepted this as an unavoidable cost of doing business, while others, especially on the supply side, have taken advantage to game the system.

To combat this, some industry voices have advocated the use of volumetric flow meters. While these can deliver more precise measurement, they are measuring volume not mass. Since accurate volume-to-mass conversion is practically impossible this is not a realistic long-term solution for accurate fuel quantity measurement.

Volume-to-mass conversion challenges are at the root of many transaction disputes. The bunker fuel conversion calculation relies on the density, temperature and pressure characteristics of the fuel being delivered. All of these are subject to variation during the delivery process. As single-phase instruments, volumetric flow meters are unable to quantify aeration effects on the measurements. This can result in significant inaccuracies in highly aerated conditions.

Coriolis MFMs on the other hand are two-phased measurement instruments. They can therefore detect the presence of aeration. Its precise impact can be quantified using relevant algorithms. Operators are also able to use this data to reduce air introduction along the process system.

A correctly calibrated MFM measures mass accurately and directly. Direct mass flow measurement delivers accurate transaction data by eliminating the variability caused by the physical properties of fluids. Whereas volumes are affected by changes in temperature and pressure, mass remains constant. This gives the buyer and seller certainty about the size of their transaction. What is more, MFM-based fuel delivery makes transactional disputes far less likely, reducing the risk of time loss (demurrage costs) for both buyer and seller, not to mention the management time lost solving a commercial dispute. Another advantage is that it allows suppliers and buyers to track trade details that are both accurate and indisputable in real time. This increased clarity and control results in lower costs and reduced delays for all parties.

How do MFMs work?

Although MFMs have only gained traction in the bunker industry relatively recently, the technology has been with us for some time. The first patents for MFMs were issued back in the 1950s. The American Petroleum Institute approved their use for custody transfer measurement in 2002.

As the name suggests, a mass flow meter measures the rate of flow of mass through a pipe. It does that by mapping the inertia of fluid in motion, using the Coriolis effect.

Within each MFM is an exciter that generates an oscillating frequency in the fluid flow stream. Fore and aft sensors detect the phase shift in oscillation that occurs as fluid flows through its inner tubes. This phase shift is dictated by fluid flow inertia, which is a direct function of the rate and quantity of fluid flowing through the pipe. Simultaneously, separate metrics track oscillating frequency in the inner tubes to calculate fluid density.

As well as measuring mass flow and density, MFM systems use other sensors and algorithms to acquire holistic datasets, including pressure, temperature, aeration, vibrations (damping) etc., at two-second intervals. These provide raw data profiles that can be used for detailed operational analysis.

15. https://www.exxonmobil.com/en/marine/technicalresource/marine-resources/marine-fuels-mass-flow-metering-system

The need for standardised MFM calibration

Suppliers and ports around the world may claim to have MFMs installed, but unless there is an agreed and rigorously enforced regulatory process that includes calibration and certification there is no guarantee that their MFMs are generating accurate results. To ensure high accuracy and repeatability each installed mass flow meter needs to be individually calibrated by an ISO/IEC 17025 accredited flow laboratory before installation, as well as in-situ and during operations. Calibration needs to be repeated on a regular basis.

Standards such as SS 648/ISO 22192 provide good guidance on the calibration requirements. These require each MFM to be first calibrated in an accredited laboratory using water at various flow points and conditions. Since the pipeline design and operating condition of every bunker tanker is different, the flow meter as part of the bunker tanker's process system needs to undergo a series of 'meter-in, meter-out' tests to confirm its accuracy/repeatability upon installation and commissioning on site. The SS 648/ISO 22192 standards also include metrological controls to ensure system integrity and frequent verification checks to detect any zero-point drifts during the MFM's life cycle.

The Coriolis effect – a primer

The Coriolis effect describes an inertial or fictitious force that appears to act on objects in motion within a rotating frame of reference. To illustrate, consider what happens when a ball is thrown from one side of a clockwise-rotating carousel at a target directly opposite. The ball travels forward, as predicted by Newtonian laws of motion. However, while the ball is in the air, the rotation of the carousel moves the target to the right. As a result, the ball lands to the left of the target. This is readily apparent to any observer stationed outside the carousel. However, from the point of view of the thrower standing inside the carousel, the ball's arc of motion appears to have been deflected to the left.

This is because within the carousel, the relative positions of the thrower and their target remain unchanged and the thrower therefore does not perceive any clockwise rotation or recognise that their own position has changed. They can, however, identify its effect on objects in motion. This is perceived experientially as a change in the ball's trajectory rather than in their own position.

This Coriolis effect is most widely understood through its impact on weather systems, but applies within any rotating body. Since the Earth is spherical, its rotational speed varies by latitude. A fixed location on the equator travels eastwards at around 1,600 kilometres per hour, whereas points at the north and south poles remain stationery. The differing Coriolis effects at different latitudes explain, for instance, why air currents rotate clockwise north of the equator and anti-clockwise in the south.

MFMs take advantage of the Coriolis principle to measure the mass flow rate of fluids. They rely on the fact that when fluid flows through a rotating pipe, the deflecting inertial force the Coriolis effect exerts on that fluid is determined by its mass flow rate. Accurate measurement of the Coriolis effect derives mass flow, which determines the mass delivered across a specific time period.

Building a pathway to digital bunkering

A properly calibrated MFM produces a flow of digital information in real time. Data readings taken at two-second intervals can be used to create accurate delivery information. The digital data generated by MFMs is a key foundation for a fully digital bunker marketplace. These ideas are currently being developed by the MPA in Singapore with its call for joint industry projects to digitalise the bunker sector[16]. Their declared aim is "…to enhance bunker operations with the objectives of building up confidence in electronic documentations/processes within the sector and demonstrating value in terms of improving efficiency/productivity and transparency."

Their ambition is to move bunkering data beyond accurate quantity measurement to build a secure digital system for transactions that is both transparent and trusted, allowing for the ultimate development of blockchain financial transactions. The MPA is well on its way to achieving these aspirational goals. TFG Marine has been actively involved, launching the first electronic bunker financial transaction in June 2022. Minerva Bunkering has been pursuing similar goals through ADP, its proprietary digital bunkering platform. ADP enables data collected by the mass flow meter to populate digital bunkering documentation and reporting.

Adopting a mandatory global standard

The benefits of mass flow metering are clear. Being able to measure mass flow directly and share transaction data in real time provides transactional transparency to all parties. However, implementing such a system successfully in an industry with a long history of opaque pricing and inconsistent standards will take determination, persistence and flexibility.

To build trust and transparency all parties need to be confident that all supply chain participants are playing by the same rules. That depends on establishing a consistent global framework for MFM delivery. Ultimately, a single mandatory licensing regime is the only realistic way to establish a level playing field for all buyers and sellers. This is unlikely to be achieved by setting up a global regulatory body. A more practical approach would be for each major port to conform to global standards founded on a consistent, broadly-based licensing structure.

With just such a structure now tried and tested there it makes sense for other maritime authorities and ports to follow Singapore's lead. They can do this most easily by adopting the ISO 22192 international standard (which closely mirrors Singapore's SS 648). The signatories to this document, key stakeholders in the bunker industry, are collectively advocating that ISO 22192 be adopted in all jurisdictions.

The IBIA's recently published position on the advantages of MFMs in the bunker industry reflects similar priorities[17]. It notes that SS 648 provides a more holistic and harmonised approach to ensuring the MFM system installed on a specific bunker tanker conforms to the requirements of a bunker operation than the diverse national and regional legislative frameworks currently in force at many bunker ports around the world. The IBIA is also calling for ISO 22192 to be adopted globally.

A joined-up approach to implementation

Major gains are achievable through the introduction of calibrated MFM, but getting to that point will take a collaborative effort across the marine fuels supply chain. Suppliers, vessel owners, customers, port authorities and regulators will need to work together.

The history and market conditions of marine fuel supply have helped to bring about the bunker delivery measurement problem. While not defending the practices adopted by many suppliers (and some shipowners) it is important to understand the cause-and-effect relationships that exist when deciding on the right course of action to rectify this problem. There are entrenched attitudes that continue to be damaging to the shipping and bunkering industry, providing a real barrier to credibility, trust, modernisation and digitalisation.

Adopting certified and calibrated MFMs is a self-evidently sensible solution for addressing quantity measurement concerns. It can also act as a springboard to transform bunkering into a modernised, transparent and digitally enabled industry.

Given that, there should be a rush from suppliers, port authorities and governments to adopt these practices, but progress has been slow. The issues have been well publicised and widely discussed and one can only conclude that the existing, unsatisfactory status quo in many ports around the world has tacit support from some key market players, including oil companies, shipowners, governments and port authorities.

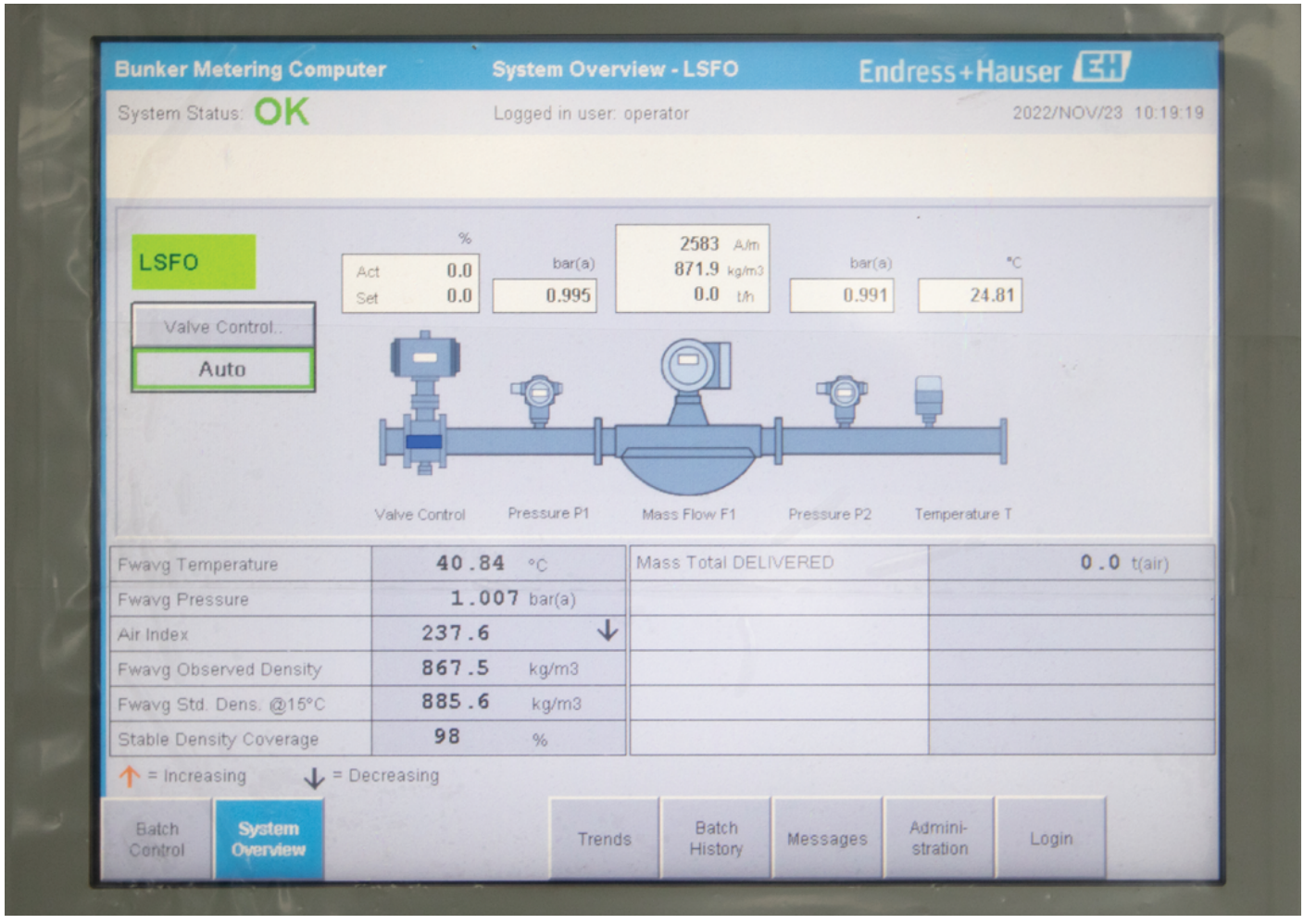
In some jurisdictions, the scale of the task may be a constraint. Some countries have existing regulatory regimes that create significant barriers to action. Their regulators may not see shipping, oil or bunkering as vitally important to their national interest. But this is not the case everywhere. There are many maritime nations that face few regulatory restrictions and have a strong incentive to act.

16. https://www.mpa.gov.sg/maritime-singapore/innovation-and-r-d/mint-fund-call-for-proposals/digital-bunkering

17. https://ibia.net/ibias-position-on-coriolis-mass-flow-meter-mfm-adoption-in-the-bunker-industry/

A broad-based licensing structure within each major port can eliminate quantity issues and can also help to impact quality problems. However this may not be immediately achievable in every jurisdiction. Progress can still be made in non-compliant locations by encouraging individual suppliers to create their own MFM systems which, when properly installed and regularly calibrated, could provide quantity measurement security.

But if this is to happen, the main bunker buyers must be willing to buy from MFM-adopting suppliers. In the past, individual efforts to introduce MFM have failed either due to poor calibration/ maintenance or, more often, because suppliers have branded their output as MFM supply without including proper checks and balances. This might be addressed by suppliers implementing MFMs in conjunction with an accredited conformity assessment body. More generally, for supplier-based MFM to work, the bunker buyers need to recognise that traditional delivery techniques often result in shortfalls and it makes economic sense to reward MFM-adopting suppliers financially by paying a realistic price in return for the value they gain from the receipt of accurate delivery quantities.



Practical considerations

What is needed to create a unified licensing system that will be adopted by ports and what practical considerations and objections do regulators need to deal with?

Who pays for the infrastructure?

The suppliers and barging companies opposed to MFMs frequently say that they cost too much to install and maintain. Neutralising this cost argument and defusing supplier/barge owner opposition is essential to moving forward.

The bunkering industry remains a tight margin business. At times, it is more challenging for the barge owner/operator than the physical supplier. In many locations, the suppliers and the barge owners/operators are distinct companies. Although any regulatory scheme will impose specific commitments on each party, the direct costs of installing, maintaining and calibrating MFMs are likely to fall on the barging company.

In Singapore, the MPA encouraged suppliers with co-funding for MFM installations[18]. In other jurisdictions, a licensing regime where all parties pay a fee to subsidise installation and fund ongoing administration/calibration might be a more practical solution.

Managing supply chain issues

Correctly installed MFM quantity measurement systems provide accurate delivery quantities from barge to receiving vessel. The challenge for the physical supplier and barge company is that when the barge receives its cargo it generally does so based on a volumetric flow meter at the loading terminal. These volume figures determine the billed volume to the receiving vessel. While protests are possible, they are not normally upheld unless an obvious shoreside error is apparent. Anyone involved in loading bunker barges will have consistently seen differences between shore loading quantities and quantities on barges.

While it is true that these often seem to benefit the party with storage at the loading terminal, there may well be specific circumstances at loading terminals creating unintended discrepancies between shore and barge. Irrespective of the cause, these shore-to-barge differences are often cited by suppliers and barging companies that oppose MFM licensing. They contend, understandably, that requiring them to install MFMs will result in lost inventories and associated financial losses unless loading terminals are made to operate on the same basis.

Installing MFM systems at loading terminals would provide a much more level playing field for all. The MPA is currently introducing guidelines[19] to encourage terminals to adopt MFM. However, it also needs to be recognised that implementing MFMs upstream in the supply chain is likely to require additional regulatory action. This will involve engaging with large multinational oil companies and their storage clients who may well resist such moves.

Getting regulators onside

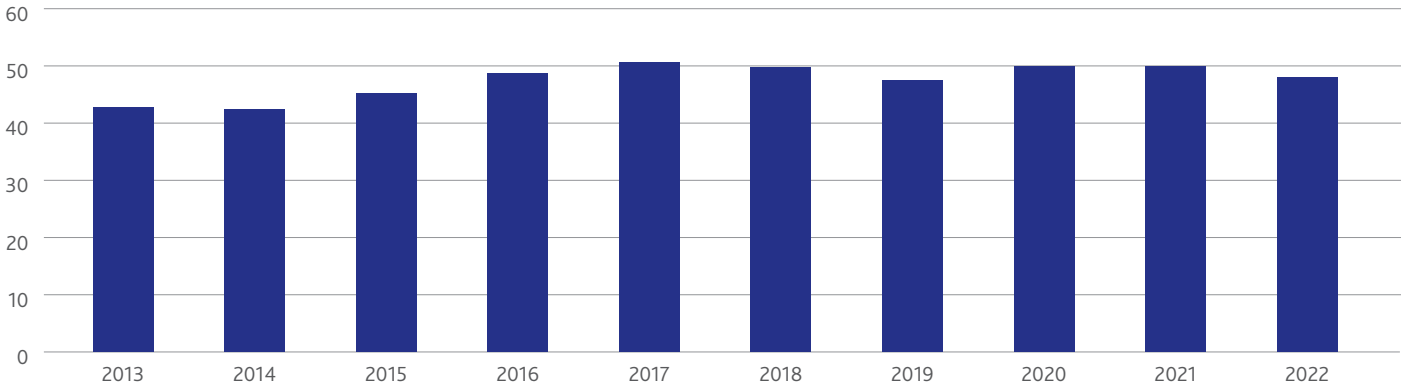
Although most regulators would prefer not to perpetuate a bunker environment that allows unethical suppliers to gain competitive advantage by misleading buyers on quantity, they also have to take account of the commercial context. Whether an MFM regime will impact market competitiveness and volumes is clearly a consideration – regulatory authorities don't want to risk killing the goose that lays the golden egg.

Suppliers that support the status quo tend to do so for commercial reasons and some port authorities take the same view, especially where bunkering is important and there is a perception that they risk losing business. CE Delft's report for the Port of Rotterdam[20] articulated this concern: "The size of the Rotterdam bunker market could shrink in the short term due to increased bunker prices, as shipping companies decide to bunker at other, cheaper ports." Oft-repeated rationalisations raised by regulators for retaining the status quo – that this is not a big problem, that there are few complaints, that implementing MFM licensing with all its logistical challenges is disproportionate – are perhaps convenient. The truth is that much of the regulatory inertia that currently exists is founded on commercial concerns.

However, publicly available information suggests these fears are misplaced. Prior to the 2017 introduction of MFMs in Singapore it was widely argued that Singapore would lose volume to competitive ports because prices would have to go up and buyers would disappear[21]. As the bar chart opposite shows, bunker demand has actually grown since 2016. In 2017, the year MFM was introduced, demand reached record levels. Singapore remains the world's largest bunkering port and continues to be competitive with other global supply ports.

18. https://www.nas.gov.sg/archivesonline/data/pdfdoc/20140415004.htm
19. https://www.manifoldtimes.com/news/sibcon-2020-singapore-introduces-new-mfm-bunkering-standards-ss-660-and-tr-80/
20. Summary of CE Delft Study for Port of Rotterdam – CE Delft 2022
21. https://shipandbunker.com/news/apac/888433-despite-worries-over-singapore-mfms-bunker-surveyor-sees-increased-demand-for-its-services

Singapore bunker demand 2013-2022



Fuel price differentials with Singapore at key bunkering ports pre- and post-MFM installation (USD/mt)[22]

IF0 380CST

	Rotterdam	Hong Kong	Fujairah	Busan
2016 (pre-MFM)	-18.47	+9.83	+2.24	+23.82
2017 (post-MFM)	-20.88	+7.53	-2.13	+23.83
Implied MFM price effect	**+2.41**	**+2.30**	**+4.37**	**-0.01**

MGO

	Rotterdam	Hong Kong	Fujairah	Busan
2017 (pre-MFM)	-20.61	+12.20	+72.71	+35.64
2018 (post-MFM)	-29.84	+27.48	+70.71	+36.67
Implied MFM price effect	**+9.23**	**-15.28**	**+2.00**	**-1.03**

22. Compiled by 2050 Marine Energy using data from Ship & Bunker

Managing price sensitivity

There is a stubborn perception in certain parts of the market that moving to MFM-based delivery will raise prices. This is highly unlikely over the long term. On the contrary, the widespread use of MFMs will create a more efficient market that lowers costs for all participants.

However, participants' concerns about the effects on their supply chains as the market transitions to MFM are hampering global efforts to move away from the status quo. It is therefore important to address the commercial sensitivities of regulators, suppliers and buyers directly.

The actual evidence for higher prices at MFM-licensed locations is weak. 2050 Marine Energy has plotted the price differentials between 380 CST fuel oil and marine gas oil at four non-MFM locations against Singapore both before and after MFM was introduced. The impact on headline prices was minimal, which likely contributed to the lack of impact on demand.

The tables on page 18 compare bunker fuel prices at key ports against Singapore prices before and after MFM was introduced. There was no real change in the relative costs of Singapore- and Busan-sourced 380CST and only a small increase in Singapore's differential with Fujairah (USD 4.37/mt) post-MFM. MFM delivery for MGO came a year later, but here too there was little discernible impact on price competitiveness. The price differential with Rotterdam worsened slightly, by USD9.23/mt, but Singapore's price competitiveness with Hong Kong actually improved across this period, by USD15.28/mt.

In some ways, this is a surprising finding. As discussed previously, headline prices take no account of the effects of short loading. Since MFM-based delivery provides high levels of assurance to all parties, it removes that possibility. One would anticipate that in a low-margin market this would result in an adjustment in the headline price that retained cost neutrality between suppliers and buyers. This did not materialise in Singapore.

It is estimated that on average over 3 percent[23] in energy value is lost to bunker buyers using traditional delivery methods. Using MFM-based delivery shipowners receive 100 percent of what they pay for. Given this, a headline price premium of 3.1 percent (i.e. 1/0.97) for MFM-delivered bunker fuel would be cost neutral for buyers. The Singapore data challenges this theory. After MFM was introduced, the headline price differentials between Singapore and non-MFM locations remained broadly unchanged.

There was, in effect, a transfer of value to buyers. And this is before factoring in additional cost savings from transaction transparency and increased efficiency. A recent Singapore Maritime Port Authority study[24] found that shipowners on average saved around three hours per transaction using MFM delivery versus manual sounding. The same study also identified a 25 percent reduction in disputes for MFM transactions.

However, Singapore's experience may be atypical. As a high-volume port and an important outlet for refiners and commodity traders, the need to maintain their volumes to remain internationally competitive may constrain their ability to increase prices. Demand too is relatively price inelastic as the supply chain is more likely to accept price increases in such locations.

In smaller ports and more remote locations, supply and demand are likely to be more price-elastic. In such places, especially where measurement inaccuracies have previously helped to stimulate demand, there may be more resistance to change.

The hope is that buyers would recognise the value of tightening the regulatory regime and continue to support those smaller locations that introduce licensing, but this cannot be relied upon. If this support is not initially forthcoming, the best outcome for these smaller ports may be rapid and widespread MFM licensing in the larger ports, which encourages buyers to recognise the advantages of transparency and digitalisation and adapt their operations accordingly.

23. https://shipandbunker.com/news/world/869260-interview-blues-adrian-tolson-calls-for-major-rethink-after-large-bunker-quantity-shortfalls-revealed

24. https://scic.sg/sdoscic/images/Public_TR_48_Case_Study_Presentation.pdf

Industry collaboration

A recurring theme underpinning the desire to introduce MFMs is the necessity for broad industry collaboration in this process. Those that prefer things to stay as they are may still be in a majority, but that is diminishing rapidly. An increasing number want to see change.

For many market participants, accuracy and transparency are fundamental business tenets. Some are ready to act now. Those port authorities looking to introduce MFMs have won significant backing from suppliers, buyers and others in the bunkering industry. Others support change in principle but would prefer to see a coordinated global shift so that early movers don't lose out.

To be effective, change requires regulatory authorities to engage with all parts of the supply chain. There needs to be a wide-ranging and honest debate that lays bare the shortcomings of the current system and makes the case for transparency and digitalisation. Once everything is out in the open, change becomes much easier, because when the facts are known 'no need for change' becomes indefensible.

So what is the next step, and how should regulation be implemented?

Introducing MFM regulation

The case for regulation is founded on the need to rebuild trust and transparency in the industry. MFMs provide suppliers and buyers with the technical mechanism for monitoring transactions accurately. But this is not enough on its own. Suppliers may continue to short-change their customers with poorly calibrated and uncertified MFMs.

Without consistent and rigorous procedures, there is the risk that sub-optimal practices will persist. Introducing MFMs without an agreed set of standards simply shifts the problem elsewhere. Worse, it undermines the argument for MFMs as a tool for modernising the industry.

Singapore has demonstrated how this can be achieved. Its all-encompassing approach to regulation has raised industry standards by transforming business practice across its supply chain.

Singapore's regulatory regime provides a solid foundation for the industry that should be emulated globally. The question for the industry is how best to put this into practice.

A single global regulatory system will be hard to achieve and difficult to manage. A more immediate and effective approach is for individual port authorities and national governments to regulate locally and coordinate their efforts within a common international framework. That way, regulatory systems can be introduced that are internationally aligned but responsive to local conditions.

Singapore's bunker fuel supply licensing programme is robust, comprehensive and enforceable. The MPA has licensing requirements for all four different levels of service providers: bunker surveyors, bunker tankers, bunker tanker operators and physical suppliers. These requirements can and do change frequently. In addition, all members of the bunker supply chain, as well as others (including vessels taking bunkers), must abide by a common set of standards governing bunkering activity in the port. These include SS 600, Singapore Standard Code of Practice for Bunkering; SS 648, Singapore Standard Code of Practice for Bunker Mass Flow Metering; SS 524, Singapore Standard Specification for Quality Management for Bunker Supply Chain; and the Singapore MPA's Standards for Port Limit Bunker Tankers.

These extensive requirements might prove daunting for port authorities in less regimented and regulated regions. In other supply locations, there may be existing regulations that can be adapted for bunkering needs.

Singapore's all-encompassing approach to regulation was a rational response to extreme circumstances. Prior to licensing, its bunker supply community's reputation had been badly tarnished by repeated scandals. Introducing a rigorous regulatory regime has brought much-needed order and clarity. Singapore is now widely regarded as one of the best places in the world to conduct bunkering business. All this has been achieved without damaging the port's competitiveness.

Singapore's full-fledged approach to regulation provides a route map that is adaptable to even the most unregulated supply environment. A fully comprehensive licensing system is the ideal endpoint, denying the opportunity for any entity to work outside the licensing system, but it is important to remain practical and accept that different areas or ports will have different approaches.

As discussed above, individual suppliers or groups of suppliers in poorly regulated bunker supply ports can install their own certified and accurate MFM systems without local regulation. The success of such systems obviously depends on the support of the buying community.

At the core of this licensing framework, at least from the supply side, is the Singapore Standard (SS 648: Code of Practice for Bunker Mass Flow Metering). This document is mirrored in ISO 22192 – Bunkering of Marine Fuel Using the Coriolis Mass Flowmeter (MFM) System.

The practices followed in these documents can either be used in their entirety or adapted to local usage providing for the mandatory usage of MFMs in a supply location. The comprehensive nature of the Singapore MPA's work provides a useful roadmap for other regulators.

Roadmap for regulators introducing MFM licensing

1 **Does your supply port have specific reputational or logistical issues that need to be addressed through regulation? Are these Issues experienced by other supply ports in your immediate geographical vicinity?** It may be that regional collaboration between ports will be required to prevent unfair competition and to ensure the regulation that is introduced is sufficiently robust.

2 **Does the port or region have the regulatory authority to mandate MFMs? If not, who does?** If there are multiple regulators, consider how their efforts can be coordinated.

3 **Consider how MFM licensing can form an integral part of broader licensing for all bunkering stakeholders.** Embedding MFM licensing within a coherent regulatory framework that applies across the bunkering supply chain can help to ensure a level playing field for all market participants. This may take time to implement in full. Introducing a specific code of practice for MFM bunkering should be an early priority.

4 **Engage with various stakeholders (suppliers, buyers and others) to persuade them to adopt externally calibrated and certified MFMs.** It will be useful to canvass stakeholders at an early stage and incorporate their priorities and sensitivities into implementation. Financial support for smaller bunkering operators may accelerate adoption. Introducing a schedule for mandatory compliance will help to focus minds and catalyse action.

5 **Confirm that standards are in place that ensure any implementation is 'cheat proof'.** In most cases, adopting ISO 22192 will be the most efficient way to ensure this. Regulators will need to introduce an end-to-end bunker licensing scheme that mandates the use of MFMs that are checked and recalibrated independently to maintain accuracy and transparency. The overall system should include mandatory procedures for maintenance and checks, dispute and litigation control, licensing requirements, with policing (audit) that is independently verified.

Conclusion and recommendations

Standards-based MFM delivery can help eliminate the quantity delivery issues that continue to hold back bunkering. A secure ecosystem with MFM at its core will limit disputes, build trust, enhance industry efficiency and cut bunkering time. Its transparency and digitalisation benefits equip the shipping industry with tools it needs to meet the IMO's carbon reduction ambition of net zero by near-2050.

Alongside the broad consensus that standards-compliant MFM delivery will have a positive long-term impact, there is continuing concern that early adopters will place themselves at a competitive disadvantage. This is hindering progress.

But this only strengthens the case for swift transition. Navigating that journey successfully calls for a multi-pronged approach, with the active engagement of many different stakeholders.

Port authorities should be looking to adopt ISO 22192, the international standard recommended by the International Bunker Industry Association (IBIA), as soon as possible. Currently, this may seem challenging at some smaller ports. Decisive action at key maritime hubs can shift the dial.

Marine fuel suppliers must progressively introduce ISO 22192-compliant MFM systems, not just where it is mandatory, but at other international locations. In their non-MFM jurisdictions, they can still offer calibrated MFM delivery by teaming up with accredited conformity assessment bodies.

Shipowners and fuel buyers should aim to continue to buy from these suppliers even if headline prices move higher. Educational initiatives setting out the real costs and risks of non-MFM delivery can provide commercial rationale.

Above all, industry stakeholders need to join forces across the bunker supply chain to promote standards-compliant mass flow metering internationally. By endorsing this paper, the signatories below have shown they are ready to act together to make change happen.

There is a powerful case for implementing standards-compliant mass flow metering across the bunker industry. Adopted worldwide, it will be transformational. What is needed now is for the industry to work together to make it happen.

About Adrian Tolson

Adrian Tolson, of 2050 Marine Energy, is an internationally recognised expert and consultant on the marine fuel market. He is also a Board Member of the International Bunker Industry Association. Adrian's career includes 30 years in the physical bunker supply industry working in diverse roles with increasing management responsibility. For much of the last decade Adrian has acted as an industry supply chain consultant engaging with refiners, traders, suppliers, buyers, and regulators. In recent years his work has increasingly focused on adapting the marine fuel industry to shipping decarbonisation.

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