Sulphur Emissions Offsetting Pilot

S-Offset

Final Report

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For

SEAaT

V2: October 2006

1 Executive Summary

In 2005 the cross-industry grouping of shipowners and oil companies SEAaT (Shipping Emissions Abatement and Trading) instigated a pilot exercise to investigate the potential for the controlled offsetting of sulphur emissions from ships in the North Sea SOx Emission Control Area. The pilot involved the collection of real data from 58 ships operating in the North Sea between April 2005 and March 2006. BMT Ltd. acted in the capacity of an independent observer and manager of the data collection and assessment. This is the final summary report.

Shipping is under growing pressure to reduce its emissions to air. Pressures exist at both a local (e.g. port environment) and global (transboundary pollution transport and greenhouse gas issues) level. Regulation is gradually coming into effect internationally and through regional actions in Europe and in North America. Simultaneously emission trading schemes are developing and the relevance of such schemes for mobile sources, such as ships and aircraft, is receiving close attention. The experience on land is that successful schemes lower costs of compliance for industry and the cost of reducing emissions is not the same for all operators. For shipping, technology may prove to be able to significantly reduce emissions below legislative requirements. Trading could provide an economic incentive to reduce emissions, which will improve compliance and benefit the environment. Trading can be a mechanism for creating options, attracting capital into abatement technology and for ensuring sustainability of environmental improvements. As a mobile source of emissions, with changing trading patterns, ship emissions trading could offer a way of complying at short notice and it is also contemplated that it could be used as a transition mechanism in the face of increasingly stringent regulations on a range of emissions from ships.

Shipping is international in nature and most regulation is governed by international treaty created through the processes of the International Maritime Organization (IMO). The marine pollution treaty (MARPOL 73/78) now has added Annex VI which, in particular, deals with SO2 and NOx. Annex VI (Prevention of Air Pollution from Ships) was adopted in 1997, but only came into force in May 2005. The global requirements of Annex VI are now regarded as relatively modest standards, so already they are under review in a process initiated at the 53rd session of IMO Marine Environment Protection Committee. Under MARPOL Annex VI the general global limit on sulphur content in fuels is 4.5%. This is very little challenge as the present average sulphur content in heavy fuel oil (HFO) bunkers is around 2.7%. Cognizant of this Annex VI also provides for a process to define more local SOx emission control areas (SECA) and two have been agreed so far, in the Baltic (came into force 19 May 2006) and in the North Sea (to come into force 21 November 2007). Within the SECA the limit on fuel sulphur content will be 1.5%. As an alternative to burning low sulphur fuel an exhaust gas cleaning system of equivalent effect is also permitted.

Regulations that are expressed in terms of a relative limit, such as is the case for ship emissions of SOx, do not lend themselves to the most common trading principle of cap and trade, as each operational event is required to meet a standard without expressing a total ceiling. A method that can deal with relative limits is offsetting. Offsetting is a simple form of balancing that allows some ships to exceed a prescribed relative limit while others perform better than the limit, allowing a consortium of ships to on average at least achieve the regulatory limit designed for a single ship. The environmental outcome for a "relative limit" scheme is not controlled in total, but depends on improved performance from the constituent parts. The SEAaT pilot study has been based on offsetting sulphur emissions.

Seven companies participated in the pilot project, each providing operational data from a number of ships, on a continuous basis from April 1st 2005 to 31st March 2006. All ships reported on fuel consumption and position data when inside the North Sea SECA, and submitted daily information on a weekly or monthly basis. Not all vessels were present in the North SEA SECA at all times and indeed some made only occasional visits. Of the 58 vessels, 10 ships operated exclusively within the SECA. At the outset of the pilot each operator made a choice on how their ship should operate for the purpose of the pilot. The choices were: to assume the use of abatement equipment (sea-water scrubbers); to assume the use of gasoil ; or to use regular HFO with same sulphur content as in present operations. (mostly ships visiting the SECA for relatively short periods).

The result was a balance between credits generated and the demand for credits from visiting ships. This varied from month to month. The credit generating intra-SECA vessels (ferries, shuttle tankers and short sea cargo vessels) had regular operations and produced a steady level of credits, averaging around 180 tonnes of sulphur per month, whereas the more transient "purchasing" vessels produced a demand that varied between 60 and 180, averaging around 100 tonnes per month over the year of the pilot. An excess of credits was generated which was held in a credit bank. As a result the pilot fleet had a better environmental performance, by 25%, than required under the SECA regulations, delivering an average equivalent fuel sulphur content of 1.2%.

An important dimension of offsetting, even within a relatively small sea area as the North Sea, is the geographical distribution of credit generators and purchasers. Information in the pilot was obtained on SECA entry and departure points and intended destinations. No effort was made in the pilot to design the fleet for a geographical balance of generators and purchasers for the avoidance of "hot spots", but for a fully operational scheme such considerations would be made and one of the obligations of the scheme managers would be to demonstrate a suitable balance.

On the basis of realistic sea water scrubbing efficiency and operating costs, the cost of the total pilot operation has been compared with the reference SECA operation (i.e. all HFO vessels converted to 1.5% S fuel and all gasoil vessels continuing to burn gasoil). The offsetting pilot delivers a total cost benefit over the reference SECA operation (based on 1.5% low sulphur fuel), for a LSFO premium over HSFO greater than approximately $30-$35. Further, if it is assumed that the excess credits could be sold at a price proportional to the LSFO premium then a further significant cost improvement can be realised. In the best case, if all credits were sold to land sources the fleet performance would remain at 1.2% and the cost saving would approach 10% for a LSFO of $50 per tonne of fuel and for a premium of $100 the saving could exceed 20%.

Additionally, if the major gasoil burning element in the pilot fleet were replaced with a vessel fitted with a scrubber and burning heavy fuel oil, then the total cost of operating the pilot fleet would reduce by 14% ($14m) and still produce <u>the same environmental performance</u>.

For an individual vessel the report concludes that sea water scrubbing should be a candidate for consideration if the "effective cost per tonne" is less than twice that of the 1.5% LSFO premium to HFO. It is observed that the "effective cost per tonne" of abatement depends on a number of factors associated with intensity of operation within the SECA, age and ownership considerations.

Overall the pilot exercise has been deemed to be successful and informative. It has been demonstrated that compliance through offsetting can be significantly cheaper than if all vessels were to individually meet the 1.5% fuel sulphur content standard. In the context of a group of seven international shipping companies and 58 participating vessels it has been practically demonstrated how a data gathering scheme could operate in order to manage an offsetting consortium. This has led to the definition of a set of conditions for a sulphur offsetting trading scheme. Subject to the existence of suitable regulatory permissions, the envisaged system could have the key features of:

- Improved visibility of the environmental performance of ships in the SECA and a reduced risk of non-compliance with SECA regulations.
- Accountability of the scheme to ensure environmental compliance and the avoidance of geographical "hotspots".
- A strong potential for cost savings at an individual vessel and overall fleet level.
- Compatibility of a ship-ship trading scheme with other proposed ship-land credit sales proposals.
- Individual operator flexibility to offset within its own fleet and if desired to individually "go beyond compliance".
- Scheme flexibility to adjust to gradually changing regulatory standards.

Significantly an offsetting trading arrangement would provide options for the shipping community at no detriment to the environment and provide higher standards of monitoring and enforcement. It should promote investment in abatement technology and in all means to reduce the cost of creating environmental benefit. With appropriate accountability requirements, as described in this report, the use of offsetting schemes offers society a low risk instrument to encourage the transition of shipping toward a greener, more sustainable future.

2 Introduction

Shipping is under growing pressure to reduce its emissions to air. Pressures exist at both a local (e.g. port environment) and global (transboundary pollution transport and greenhouse gas issues) level. Regulation is gradually coming into effect internationally (IMO) and through regional actions in Europe. North America may be next. Simultaneously emission trading schemes are rapidly developing and the relevance of such schemes for mobile sources, such as ships and aircraft, is receiving close attention.

Until the 1990s very little consideration was given to the emissions to the atmosphere from ships. Although increasing control was being applied to large combustion plants and road vehicles on land, ships were generally regarded as being too mobile, too far offshore and too unimportant to warrant significant attention.

A number of factors changed this perception – a growing understanding of the long range transboundary transport of pollutants; a growing percentage contribution of shipping to total emissions, as a result of reduced land emissions and increasing shipping activity and the growing expense of making further reductions from land based sources.

The general perception of shipping is, nonetheless, that of an environmentally friendly mode of transport, so it is of surprise to many that (Robinson 2005[1]):

- In total volume, EU ship SO2 and NOx currently total about 80% of all land sources combined and that by 2020 will be higher.[2]
- Shipping produces 100 times more SO2 than aviation.
- Per t/km ships emit 50 times more SO2 and slightly more NOx than new trucks
- Impact of emissions depends on location; modelling shows shipping contributes 90% of acid excess in N Europe and 15-30% of particles in all coastal areas.

Shipping is international in nature and most regulation is governed by international treaty created through the processes of the International Maritime Organization (IMO). The marine pollution treaty (MARPOL 73/78) now has added Annex VI which, in particular, deals with SO2 and NOx. Annex VI (Prevention of Air Pollution from Ships) was adopted in 1997, but only came into force in May 2005 (IMO 2005). The global requirements of Annex VI are now regarded as relatively modest standards, so already they are under review in a process initiated at MEPC 53 (53rd session of IMO Marine Environment Protection Committee).

In the meantime the European Union has been active in promoting reductions in ship emissions to air. The marine fuel Directive 2005/33/EC tackles sulphur emissions by implementing MARPOL Annex VI, together with some additional strengthening measures that fall within its legal competence. In parallel, the European Commission has undertaken a wide range of consultancy studies[3] to quantify emissions, examine technologies and consider the alternatives of market based incentives as opposed to "command and control" regulation. Schemes to reward good environmental behaviour have existed for some years (e.g. Green Award[4]) and, specifically, Sweden has rewarded reduced air emissions at its ports with rebates on port and fairway dues[5].

Through the IMO process prescribed in MARPOL, European member states have developed SO_2 Emission Control Areas (SECAs) in European waters and the debate in the US and Canada has advanced. North American authorities are considering emissions trading schemes at ports, which could include ocean going vessels and the possibility of a

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[1] Robinson, N. "Annex VI & EU rules – regulatory perspectives" Presentation to Fairplay Awareness Briefing, London, 28 November 2005. See also http://ec.europa.eu/environment/air/transport.htm#3.

[2] This translates into 44% of the total. Similarly, in background Paper No. 6 to EUs Green Book (section 3.1.5.6) it is noted that in year 2000, SO2 and NOx emissions from shipping represented 39% and 36% respectively of total SO2 and NOx emissions in EU-15.

[3] EU policies and studies, 2005 - http://europa.eu.int/comm/environment/air/transport.htm#3

[4] Green Award, 2005 – Green Award Foundation at www.greenaward.org

[5] http://www.sjofartsverket.se/upload/2205/New%20fairway%20duesEng.pdf - INFORMATION CONCERNING NEW FAIRWAY DUES, Swedish Maritime Administration, 10 September 2004

West Coast (US, Canada and Mexico) SECA is under discussion. West Coast ports have directly experienced the congestion from increased container traffic resulting from global growth and the move of production to Asia, and China in particular. This has intensified the concern about land side pollution from port vicinity air emissions, with a special focus on particulates and their effect on human health.[6]

By comparison with SOx, NOx and particulates, ship emissions of greenhouse gases have had a lower profile. However, in Europe, total CO2 from shipping activities exceeds that of aviation and inevitably this is becoming a target of environmental legislation. At present there is no international regulation, though IMO has commenced a programme of CO2 indexing.

Because of the lifetime of most ships, fleet renewal is generally slow, so improved environmental performance needs to depend in part on retro-fit technologies, on the use of lower sulphur fuels and on fleet management strategies to reduce fuel consumption. In a number of land based situations the quest for cost efficient reductions in emitted pollution has benefited from the ability to trade emission credits within a regulated scheme. A significant number of trading / incentive schemes exist world-wide. Mainly for power plants they have been developed from the early 1990s, covering a range of pollutants, including SOx, NOx, and CO2. Of particular note are:

US Acid Rain program

- Operating for a decade
- SOx emissions have decreased by 30% more than originally required
- Pollution reduction technology costs reduced by 40%
- Abatement technology efficiencies improved to 95%

US NOx State Implementation Plan

- Four years of operation
- NOx levels in 2004 were 50% less than in 2000
- Close to 100% compliance

EU ETS – trading greenhouse gases

- Commenced 2005
- 12,000 plants across EU participating
- Markets rapidly developing

The experience on land is that successful schemes lower costs of compliance for industry and the cost of reducing emissions is not the same for all operators. For shipping, technology may prove to be able to significantly reduce emissions below legislative requirements. If so trading could provide an economic incentive to reduce emissions, which will improve compliance and benefit the environment. Trading can be a mechanism for creating options, attracting capital into abatement technology and for installations and for ensuring sustainability of environmental improvements.

As a mobile source of emissions, with changing trading patterns, ship emissions trading could offer a way of complying at short notice and it is also contemplated that it could be used as a transition mechanism in the face of increasingly stringent regulations on a range of emissions from ships.

Given this background SEAaT (Ship Emissions Abatement and Trading)[7] launched a pilot study based on real shipping movements to investigate some of the characteristics of the production of emissions and to evaluate the potential of a particular type of trading scheme, offsetting, to deal with sulphur emissions. BMT Ltd was contracted to oversee the data collection, to perform analysis of the data and provide independent external reporting.

3 Emission regulations and North Sea SECA

Under MARPOL Annex VI the general global limit on sulphur content in fuels is 4.5%. This is very little challenge as the present average sulphur content in heavy fuel oil (HFO) bunkers is around 2.7%. Cognizant of this Annex VI also provides for a process to define more local SOx emission control areas (SECA) and two have been agreed so far, in the Baltic (came into force 19 May 2006) and in the North Sea (to come into force 21 November 2007). Within the SECA the limit on fuel sulphur content will be 1.5%. As an alternative to burning low sulphur fuel an exhaust gas cleaning system of equivalent effect (defined as 6gSOx/kWh) is

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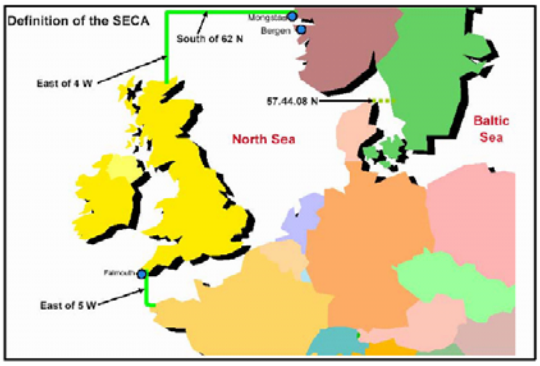
[6] See www.seaat.org/media/USA%20legislation.doc and for example the San Pedro Bay Ports Clean Air Action Plan at http://www.portoflosangeles.org/DOC/REPORT_Clean_Air_Overview_English.pdf#search=%22San%20Pedro%20Bay%20Clean%20Air%20Action%20Plan%22

[7] http://www.seaat.org/

also permitted. The geographical boundaries of the North Sea SECA are depicted in the diagram below.

European law (marine fuel Directive 2005/33/EC) extends MARPOL Annex VI somewhat in that additionally all passenger ferries will be restricted to 1.5% in all (irrespective of MARPOL SECA boundaries) European territorial waters and from 2010 all ships at berth in EU ports will be restricted to 0.1% sulphur fuel. Meantime just as the Annex VI provisions are already under review, the European Commission has also undertaken to review air emissions regulations again in the next few years. The pressure to reduce emissions further will grow, but this may also be an incentive to develop further cost-efficient technical and trading mechanisms.



For NOx emissions, the MARPOL Annex VI limits on emissions from diesel engines are expressed in g/kWh, with limits dependent on engine rpm. IMO has developed a detailed NOx Technical Code (IMO 2005 and IMO MARPOL Amendments 2005) which regulates the enforcement of these rules. In practice there are a number of ways of improving engine NOx performance, which give varying benefits at different prices. As a result NOx has also been considered to have potential for trading or more generally to be influenced by market based instruments.

At present there are no standards for ship emission of CO2. IMO's indexing trials (IMO MEPC52/4/2) have been initiated and the European Commission is also considering this issue. CO2 is predominantly a function of fuel consumption, which in turn is highly dependent on installed power and engine rating in operation. The index (expressed as gram CO2 per tonne mile (of cargo)) is intended to be stable only as a long term average of transport efficiency for a particular ship over many voyages (including ballast). Individual voyage index calculations will be highly variable. Whether this approach can lead to a relative limit (standard as for SOx and NOx) for regulatory purposes is highly questionable at the moment. In opposition to the idea of a relative standard is the desire by some regulators to press for a ceiling on total emissions. The European Commission has expressed a desire for shipping to join the EU Emissions Trading Scheme (see text box). Such a move would directly impact upon other pollutants through the effective capping of fuel consumption or the requirement to buy additional CO2 (effectively "fuel") credits.

For all ship emissions there is a growing need to consider how best to monitor and verify what they are on a case by case basis. Direct (stack emission) monitoring and more indirect methods may all play a part and some are already sanctioned in present legislation, especially under MARPOL for NOx. In principle, however, it has been demonstrated (e.g. PWC 2005[8], Brown 2005[9]) that emissions from ships can be monitored and verified and this provides a necessary element in a framework for potential emissions trading.

[8] Price Waterhouse Cooper "Demo Project final report" April 2005, available at www.demoproject.org
[9] Brown, S., "MARPOL Annex VI – Regulation 13, Compliance using MariNOx Direct Measurement and Monitoring Method" *Presentation to Fairplay Awareness Briefing* London, 28 November 2005 and http://www.martek-marine.com/product_details.php?edit=40

Brussels targets CO2 emissions in maritime sector
By Fiona Harvey in London,
Published: November 21 2005

The maritime industry is likely to follow the aviation industry in being brought within the remit of the European Union's emissions trading scheme, the European Commission signalled on Monday.

Stavros Dimas, the European commissioner for the environment, singled out maritime transport as one of the next large sectors to be targeted by the scheme, along with aviation, which he said would be covered by the scheme as early as 2009 or 2010.

The chemicals sector and aluminium smelting are the other likely candidates for inclusion within the emissions trading scheme, which began in January and already covers several of the most energy-intensive industries, including power generation, steel and cement making. Companies covered by the scheme are issued with tradable permits to emit a certain amount of carbon dioxide, and are fined if they exceed those limits.

Mr Dimas resisted suggestions by representatives of industries such as aluminium smelting that the cost of emitting carbon dioxide under the scheme was encouraging companies to look elsewhere to site their facilities. He said: "The cost [of carbon dioxide] is marginal. Emissions trading is not a reason for any company to move out of Europe."

Permits to emit carbon dioxide under the scheme were selling on Monday for €21.65 ($25.40) per tonne, according to Point Carbon, an analyst company, down from a high of €29 in July.

The European Commission will initiate a consultation on the scheme next year, designed to help member states meet their targets for reducing greenhouse gas emissions under the United Nations-brokered Kyoto protocol on climate change.

Other measures to be considered include extending the scheme to include gases other than carbon dioxide, such as methane.

Mr Dimas said the EU as a whole was on track to meet its obligations under the Kyoto protocol by the 2012 deadline stipulated in the treaty.

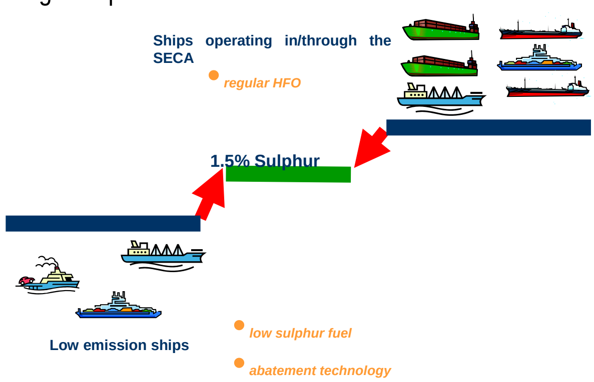
http://news.ft.com/cms/s/33f7f2a8-5abc-11da-8628-0000779e2340.html

4 Emissions Trading Principles

Perhaps the most commonly envisaged form of trading is Cap and Trade – a system in which total allowances are determined, allowing participants to emit and trade according to their resulting permits, which are either initially allocated and/or auctioned (e.g. EU ETS). For shipping to join the EU ETS for CO2 a system of capped allowances would have to be created. Because of the mobility of ships (by comparison with, say, land-based power stations) the method of doing so still requires further study. The European Commission has been considering, for example, whether shipping emissions in European waters may be allocated to countries (Member States) as part of their national emissions ceiling.

However, whatever the means of allocating tradable permits, the simple principle is one of using them to cover one's own emissions or selling those not required to another emitter. The environmental result is associated with the level of the cap if all permits are used.

Regulations that are expressed in terms of a relative limit, such as is the case for ship emissions of SOx and NOx, do not lend themselves to the cap principle in an obvious way, as each operational event is required to meet a standard (based on per kWh) without expressing a total ceiling (i.e. no constraint on number of kWh or miles sailed within a control area). A method that can deal with relative limits is offsetting. Offsetting is a simple form of balancing that allows some ships to exceed a prescribed relative limit (i.e. 1.5% sulphur fuel content equivalent in a SECA) while others perform better than the limit, allowing a consortium of ships to on average at least achieve the regulatory limit designed for a single ship.



To some extent offsetting also offers the opportunity to manage the geographical distribution of emissions and to protect sensitive areas.

No such scheme would be allowed to exceed the limit, but it could, of course, do better. The environmental result for a relative limit scheme is not controlled in total, but depends on improved performance from the constituent parts. The SEAaT pilot study is based on offsetting sulphur emissions and is described the sections below.

5 Pilot Project

Seven companies participated in the pilot project, each providing operational data from a number of ships, on a continuous basis from April 1st 2005 to 31st March 2006. The make-up of ships in the project consortium is given in Table 1.

Operator	Number of vessels in pilot	Vessel type
Teekay Shipping	4	Oil shuttle tankers
Stena Line	3	Car / PAX ferries
BP Shipping	23	Oil tankers
P&O Ferries	5	Car / PAX ferries
NOL (APL)	8	Container
OOCL	6	Container
E R Schiffahrt	9	General cargo
Total	58	

Table 1

All ships reported on fuel consumption and position data when inside the North Sea SECA, and submitted daily information on a weekly or monthly basis. The reporting form was a simple spreadsheet (Table 2).

Not all vessels were present in the North SEA SECA at all times and indeed some made only occasional visits.

Of the 58 vessels, 10 ships operated exclusively within the SECA. In total the remaining 48 ships made 504 separate entries into the SECA. Individually crossings were as infrequent as 1 and a maximum of more than 100 in the year. The entry pattern is shown in Figure 1.

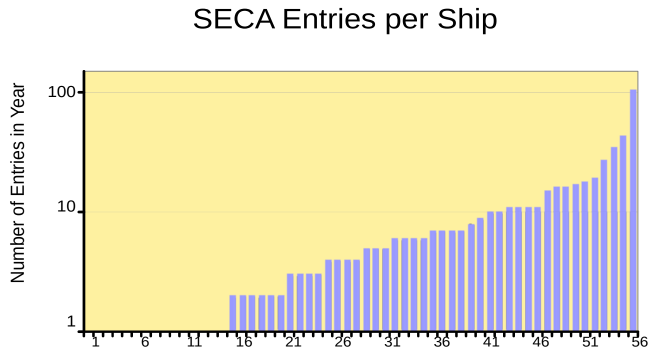


Figure 1

At the outset of the pilot each operator made a choice on how their ship should operate for the purpose of the pilot. The choices were:

1. to assume the use of abatement equipment (sea-water scrubbers) – 7 ships
2. to assume the use of gasoil – 15 ships (mostly ships already using gasoil)
3. use normal HFO with same sulphur content as present operations, ranging from 1.1% sulphur content to 3.3% – 36 ships (mostly ships visiting the SECA for relatively short periods)

Data collection - North Sea SECA - Vessel name:
Month:

Reminders: Use any clear designation for noting ship's position - latitude and longitude or GPS notation
Enter fuel consumption each day in metric tonnes only
Enter distances travelled in nautical miles

Wk	Date	Time entered North Sea SECA	Position on entering North Sea SECA	CONSUMPTION AT SEA				CONSUMPTION AT BERTH				Route	Port of Consumption	Time left North Sea SECA	Position on leaving North Sea SECA	Distance travelled inside North Sea SECA (nautical miles)
				Fuel consumption (HFO) at sea (mt/day)	Fuel consumption (MGO/MDO) at sea (mt/day)	Sulphur content bunkers (HFO) used at sea (%)	Sulphur content bunkers (MGO/MDO) used at sea (%)	Fuel consumption (HFO) at berth (mt/day)	Fuel consumption (MGO/MDO) at berth (mt/day)	Sulphur content bunkers (HFO) used at berth (%)	Sulphur content bunkers (MGO/MDO) used at berth (%)					
1																
2																

Table 2

Ships in the "pilot fleet" consumed 270,000 tonnes of fuel, perhaps around 0.1% to 0.2% of the consumption of world shipping and between 1% and 2% of that in the North Sea. These figures are based on the reported consumption from each ship using the returns illustrated in Table 2.

For the purposes of the pilot both gasoil and abatement of high sulphur fuel oil was assumed to lead to a sulphur content of 0.2%. For ships with sea water scrubbers burning average HFO with 2.7% sulphur content, this equates to an efficiency of the abatement of 93%, which is well within the specification of ship sea water scrubbers and is being borne out by present practical tests. On the basis of the reported data and the operating choices the sulphur emission for each vessel was calculated (both for the actual 2005-06 performance and for the pilot simulation).

In the course of the pilot data was received on a weekly or monthly basis, using the simple standardised forms for daily data collection on-board (Table 2). The data was electronically transmitted to the project office for quality assurance and then a process of automated data analysis per ship per day, creating a data base of each emission event. Aggregate analysis was performed on a monthly basis providing information on:

- Sulphur (or SO_2) credits generated and required (purchased).
- Fuel consumption in SECA and at berth
- Environmental performance
- Notional financial transactions

The process was relatively straightforward and was capable of further automation were such a system to be utilised on a permanent basis. The most obvious difference from a "real life system" was the absence of verification of actual emissions. This will be discussed in section 8.

6 Results of Pilot Project

Fifty eight ships in total participated in the pilot. This was a fixed fleet, whereas in a working live system the composition would be actively managed to achieve optimum performance. The ten "intra SECA" ships were ever present, but as a result of their movements the forty eight other vessels contributed to the pilot only in certain months.

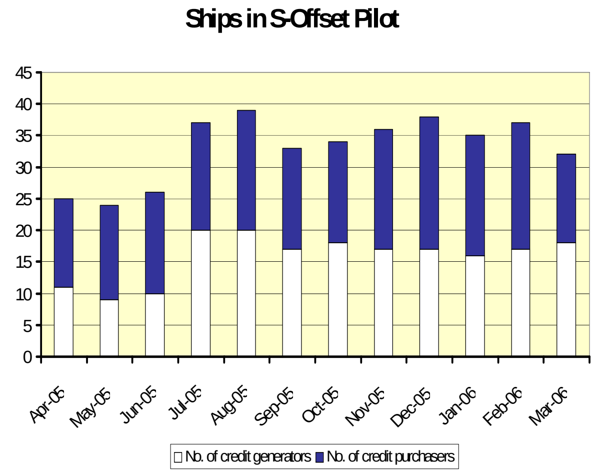


Figure 2

The monthly pattern of participating ships is shown in Figure 2. Numbers ranged from a minimum of 24 to a maximum of 39.

Accordingly the fuel consumed by the pilot vessels within the SECA varied on a month by month basis, as can be seen in Figure 3. This pattern illustrates the levelling effect that the permanent intra SECA vessels have on fuel consumption. Indeed the lowest figures in January and February are due to reduced winter schedules of certain ferries.

The offsetting trading arrangements have been described in section 4. Vessels operating at the equivalent of a fuel sulphur level below 1.5% were calculated to be generating *credits* and those operating at above 1.5% were calculated to be generating a ***credit purchase*** requirement. The calculation is simply the difference between the tonnes of sulphur[10] allowed (based on 1.5% S content) and the tonnes of sulphur simulated in the pilot, based on the choices described in section 5.

[10] Tonnes of sulphur dioxide emitted are 2 x that of sulphur.

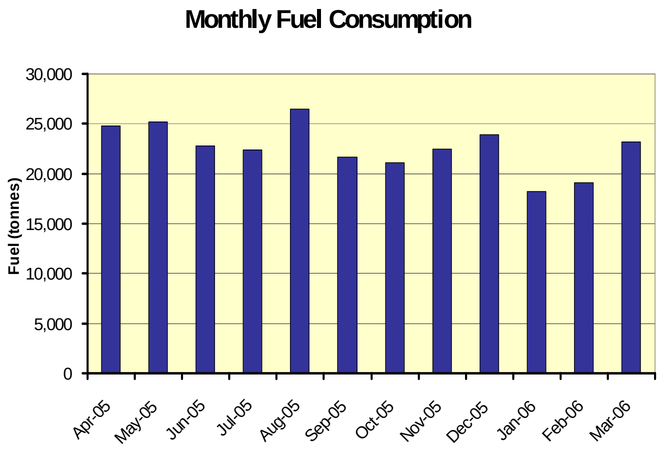


Figure 3

For the pilot the resulting balance between credits (tonnes of S) generated and the demand for purchases is displayed in Figure 4. The regular operations of the credit generating intra-SECA vessels are seen to produce a steady level of credits, averaging around 180 tonnes per month, whereas the more transient "purchasing" vessels produced a demand that varied between 60 and 180, averaging around 100 tonnes per month over the year of the pilot.

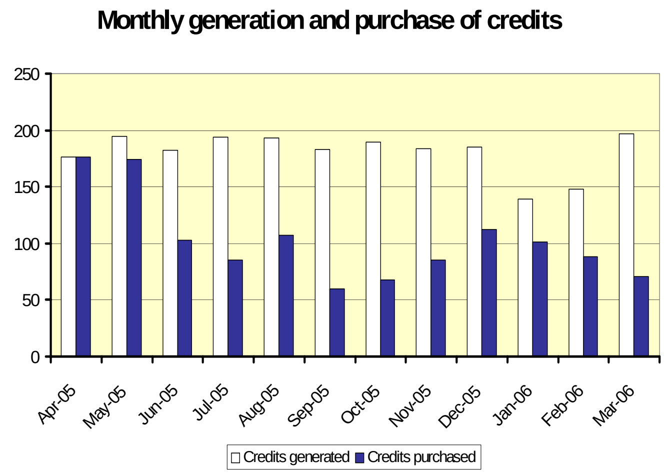


Figure 4

The overall results are summarised in Table 3. The excess of credits generated over the purchasing requirement is evident in the build up of the credit bank. As a result the pilot fleet had a better environmental performance, by 25%, than required under the SECA regulations, showing an average equivalent fuel sulphur content of 1.2%.

The table shows that on average the purchasers in the pilot were burning HFO with a sulphur content averaging 2.7% and the credit generators achieved 0.2% as this was the assumption for both gas oil and the effective efficiency of the sea water scrubbers.

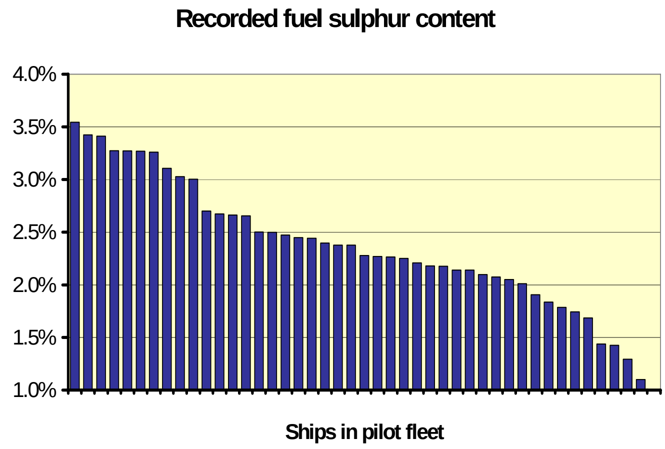


Figure 5

Although the average HFO S content was 2.7%, it was, nonetheless, noted that a number of HFO vessels were burning relatively low sulphur fuel oil, presumably purchased at modest premiums over a high sulphur option. A chart of the distribution of content actually recorded per ship is given in Figure 5

S-Offset Pilot - Apr 05 to Mar 06	
Active participating ships	58
Net emission credit generators	24
Net emission credit purchasers	34
Credits generated (tonnes S)	2,158
Credits purchased (tonnes S)	1,223
Credit bank (tonnes S)	935
SECA reference (1.5%) emission of sulphur (tonnes S)	4,082
Simulated emission of sulphur (tonnes S)	3,147
Actual emission of sulphur (tonnes S)	4,848
Fuel consumption (tonnes)	271,317
Reduction in emitted sulphur re SECA rules	23%
Reduction in emitted sulphur re 2005	35%
Average effective S content	1.2%
Average Purchaser S content	2.7%
Average Generator S content	0.2%

Table 3

Effectively the pilot project constituted a snapshot of the operation of the participating ships over a one year period. The particular behaviour of this fleet of vessels can be put into context by considering the following scenarios.

"HFO" - all ships consuming fuel in the North Sea SECA geographical area. This is today's "worst case" scenario in terms of emissions.

"2005/6" - this represents the actual performance of the ships in the pilot.

"Pilot" – this is the scenario simulated in the pilot

"Scenario A" – this scenario assumes that additional credit purchasing ships were available, at a level equivalent to month 1 (see Figure 4).

"Scenario B" – this scenario assumes a lower level of scrubber efficiency (70%, reduced from 93%).

The effect of the above scenarios in terms of overall equivalent fuel sulphur content is shown in Figure 6. Whereas the pilot was restricted to the defined fleet it is reasonable to assume that excess credits which were generated would have been sold, in a future operating system, to other SECA visiting ships. Selling at the level of month 1 throughout the year is described as scenario A and the arrow in the figure simply illustrates that if all excess credits were sold that the average S content by definition reaches 1.5%.

Scenario B is a circumstance in which fewer credits are generated, say because of dramatically reduced scrubber efficiency. This would raise the effective S content, but, in the example shown, the fleet would still perform better than the regulatory requirement. The combined scenario A+B just adds the two effects (more purchasers and less efficient scrubbing) bringing the overall performance close to the regulatory requirement.

These scenarios provide an insight into some of the factors that would exist in reality and how a trading system could be actively managed to achieve the credit balance and meet SECA regulations.

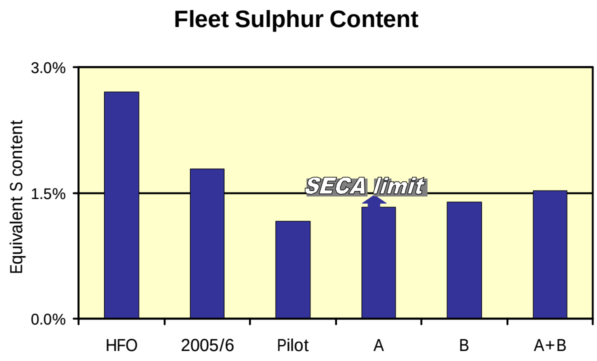
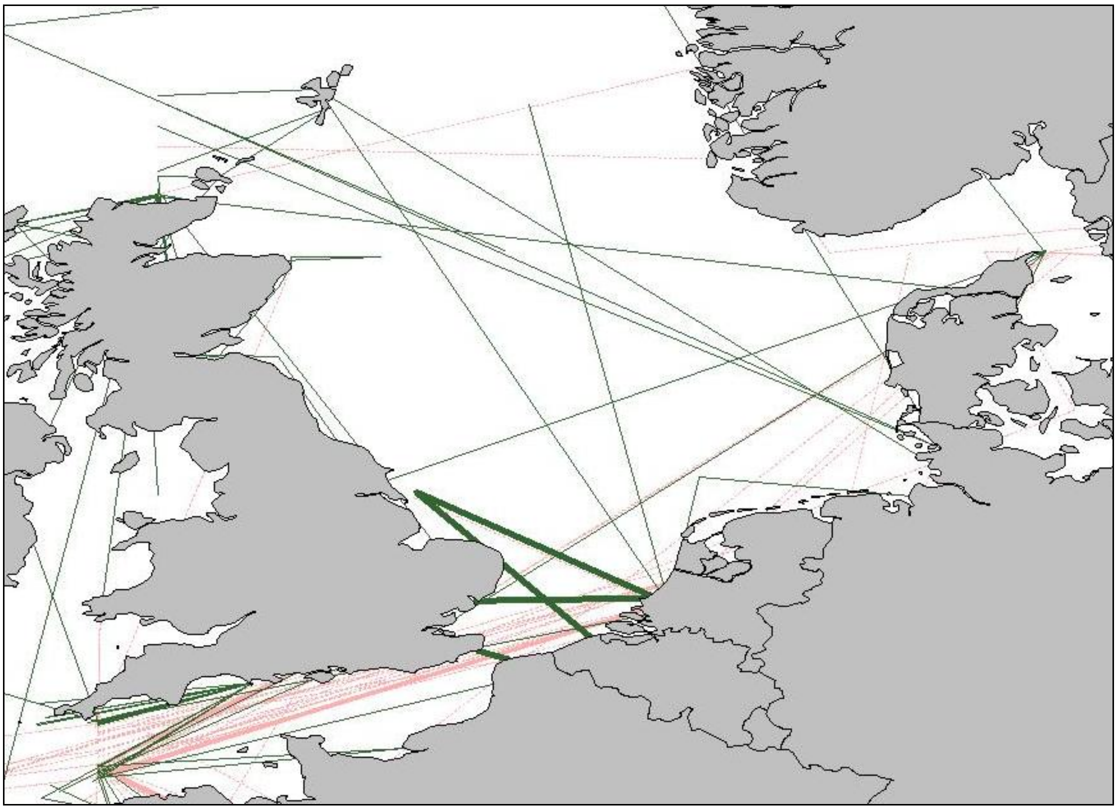


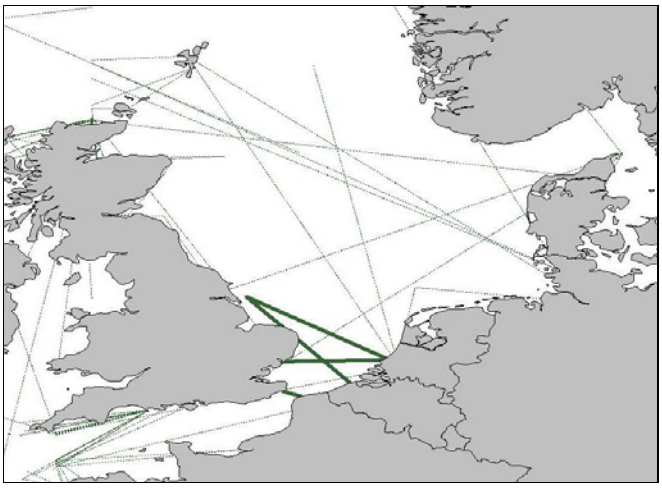
Figure 6

An essential ingredient of such a trading system is the mechanism for trading the credits that are generated and the cost implications to both credit generators and credit purchasers. In the pilot exercise credits were automatically allocated to those that required them from the pool of credits generated by the abatement and low sulphur fuel ships. As a complement a number of simulated trading exercises were undertaken. These and a discussion of cost parameters are discussed in section 7.

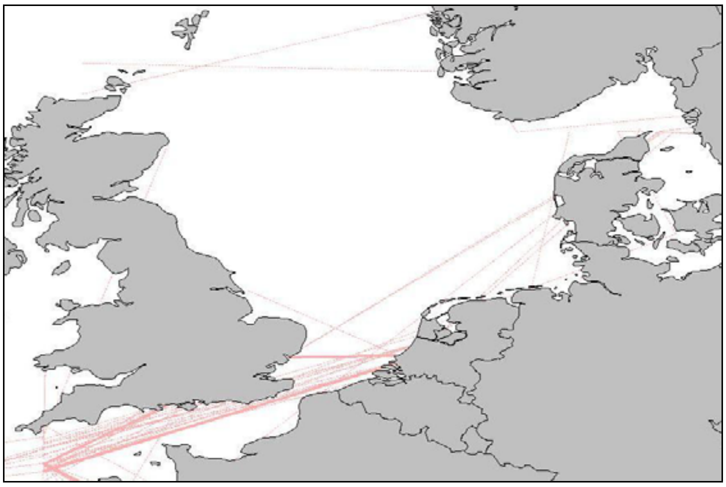
An important dimension of offsetting, even within a relatively small sea area as the North Sea, is the geographical distribution of credit generators and purchasers. Information in the pilot was obtained on SECA entry and departure points and intended destinations. This information has been plotted in Figure 7. The lines are point to point rather than actual routings, but the figures convey an impression of where the pilot fleet operated. The heaviest lines represent the greatest activity.

No effort was made in the pilot to design the fleet for a geographical balance of generators and purchasers or for the avoidance of "hot spots". It must be stressed that no conclusion on "hot spots" should be drawn from these figures. For a fully operational scheme, on the other hand, such considerations would be made and one of the obligations of the scheme managers would be to demonstrate a suitable balance. The scheme managers would ensure that a base load of credit generators covering sensitive coastal and port areas would exist as a pre-requisite for the release of credits for sale.





Green – vessels operating below 1.5% S



Red – vessels operating above 1.5% S

Figure 7

7 Trading and Economics

The pilot information on possible credit generation and demand describes the potential for a sulphur / SO2 offsetting scheme within the North Sea SECA. The attraction of such a scheme is, of course, strongly driven by its economics and practicalities. First we consider some of the cost elements.

7.1 Scrubber Costs

Information was gathered for a previous European Commission study[11] and this has been generally verified by further enquiries. Capital cost estimates for scrubber installations are expressed in Figure 8. The range in the figure approximately relates to retrofit or new build.

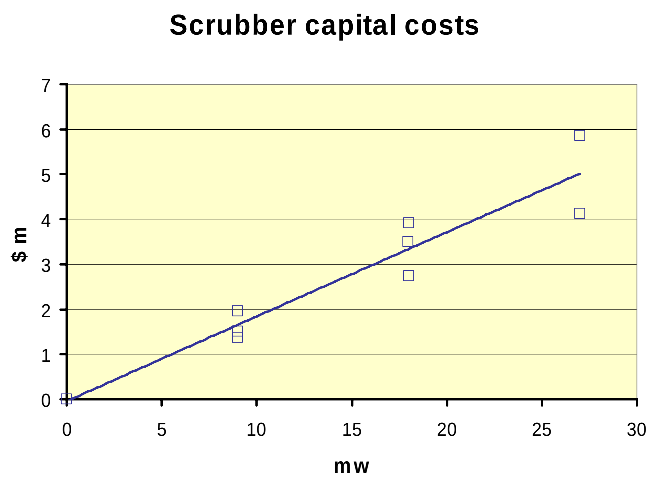


Figure 8

It is convenient to convert the capital and operating costs into cost per tonne of fuel consumed and cost per tonne of SO2 abated. However very different numbers can be arrived at depending on the assumptions made for:

- Amortisation period (depending on expected life of the equipment, remaining life of vessel, acceptable pay back period, predicted time of use in a SECA and forecast of changing regulation).
- Fuel to be consumed in a SECA.
- Efficiency of abatement by scrubber.

[11] Entec 2005: European Commission, Directorate General Environment. Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments, Task 2c – SO2 Abatement, Final Report, August 2005, Entec UK Limited http://ec.europa.eu/environment/air/pdf/task2_so2.pdf

Entec (2005) assumed that the capital cost could be written off over 15 years. In the numbers that follow in this report a more conservative 5 years has been chosen.

Costs for the seven "scrubber" ships in the pilot have been estimated from Figure 8. The costs have been spread over 5 years of fuel consumption to get a $/tonne figure ($3/t has been added representing a 1 to 2% parasitic extra fuel consumption). The resulting range of costs for the ships in the pilot is $35/t to $72/t; see Table 4.

Ship id.	Power mw	Fuel p.a. in SECA	Total cost per t $
S1	20	11,736	66
S2	11	5,817	72
S3	17	9,355	70
S4	23	16,577	55
S5	18	20,732	35
S6	38	23,154	63
S7	19	15,236	53

Table 4: Cost per tonne of fuel based on 5 year amortisation

On this basis the cost of the **total** pilot operation has been compared with the reference SECA operation (i.e. all HFO vessels converted to 1.5% S fuel and all gasoil vessels continuing to burn gasoil).

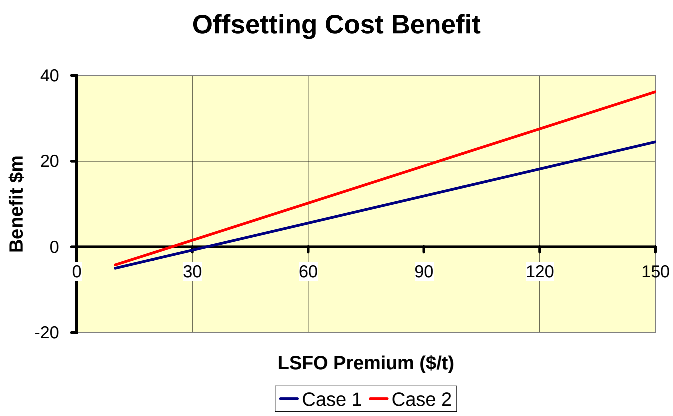


Figure 9

Generally (Figure 9) the offsetting pilot delivers a total cost benefit over the reference SECA operation based on 1.5% low sulphur fuel, for a LSFO premium over HSFO greater than approximately $30-$35. Two cases are shown in the figure:

- Case 1: this is the offsetting pilot as reported in Table 3, which delivered an average equivalent S content of 1.2%.
- Case 2: the offsetting pilot has been modified with the excess credits sold at a price proportional to the LSFO premium. In this case the average equivalent S content would be 1.5% if all credits were sold to other ships, or the fleet performance would remain at 1.2% if all credits were sold to land sources. Case 2 gives an overall improvement in cost benefit relative to case 1. These circumstances depict a situation in which the regulatory overall standard is achieved (S=1.5%) at a considerably cheaper cost than by straight compliance by each ship. If the LSFO premium were $50/tonne the cost saving would approach $10million across the fleet of 58 ships and for a premium of $100, the saving could exceed $20 million.

The cost benefit in Figure 9 does not reveal the total cost of operation. This is shown in Figure 10 on the basis of a baseline heavy fuel oil price of around $300 per tonne.

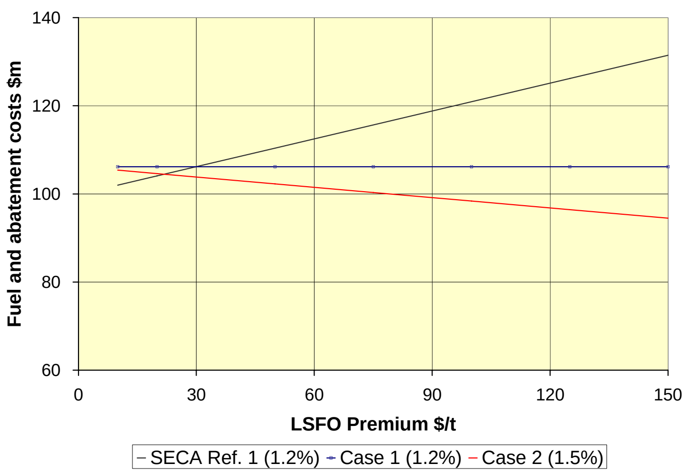


Figure 10

Case 1 has an operating cost of $106m. The SECA reference cost line starts a little lower but climbs through $106m at an LSFO premium of $33/t and rises to greater than $130m at a premium of $150/t. It should also be observed that Case 1 delivers the same environmental benefit as the SECA reference (average S of 1.2%). The SECA reference average S content is less than 1.5% owing to the inclusion of gasoil burning ships in the fleet.

Case 2 has a reducing cost with increasing LSFO premium because the excess credits are sold at an increasing price, to the net benefit of the “pilot” fleet.

It is appropriate to note that if the major gasoil burning element in the pilot fleet (representing nearly 20% of the fuel consumed) were replaced with a vessel fitted with a scrubber and burning heavy fuel oil, then the total cost of operating the pilot fleet would reduce by 14% ($14m) and still produce the same environmental performance.

7.2 Fuel Switching Costs

In the pilot operations described above the ships were assumed to be burning HFO, gasoil or operating scrubbers: no fuel switching is involved. However, in the “SECA reference” case all, except the gasoil burning vessels, are assumed to switch to low sulphur fuel oil with a content of 1.5%. The costs involved depend upon the pattern of operation. For those vessels operating exclusively within the SECA the cost is that of the premium for LSFO. For those vessels switching on entry additional costs are associated with a dual fuel approach – fuel storage tanks and additional LSFO fuel consumption on the approach to and departure from the SECA.

No detailed calculations have been made for dual fuel usage for the specific ships in the pilot, therefore it is appropriate to consider the LSFO premium in Figure 9 and Figure 10 to be a composite of the actual LSFO premium and an additional cost for average dual fuel use costs.

The cost balance between abatement using scrubbers and the use of LSFO can be simply illustrated as follows through the diagram shown in Figure 11.

Conveniently for this illustration the effective sulphur content of a scrubber abated vessel (say 0.2%) is as much below the SECA limit (1.5%) as typical HFO is above (say 2.8%). Therefore two ships burning the same quantity of fuel create the same net emissions if both burn 1.5% LSFO or if both burn HFO, one with abatement and one without. This is a straight comparison between compliance per individual ship and the concept of offsetting.

The green line in the figure, labelled "abatement cost boundary", is the neutral line: when scrubbing costs fall on the line then the two strategies - (a) LSFO; (b) offsetting - cost the same. If scrubbing costs less i.e. below the green line, then offsetting is the cheaper of the two options.

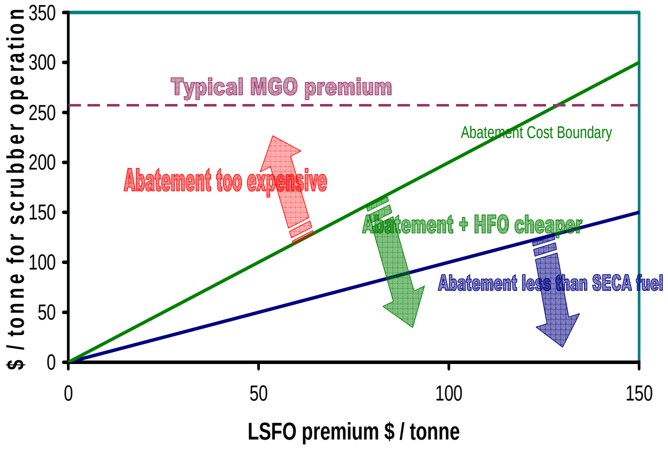


Figure 11

The lower blue line is simply the line where abatement and LSFO cost the same: if scrubbing costs fall below the line then irrespective of an offsetting trading scheme, an operator might wish to choose this option.

When scrubbing costs fall above the green boundary, then abatement will be too expensive. A line for the gasoil premium has been added to show that gasoil as a form of sulphur abatement (all other factors being equal) is a very expensive way of creating credits relative to a 1.5% SECA limit.

Of course for a particular vessel, as discussed above in section 7.1, the effective cost per tonne of fuel depends on a number of factors, but especially, how many tonnes of fuel the vessel will consume in SECA waters over a given number of years. The circumstances of each ship are different, which is why the creation of options is valuable. The "abatement cost per tonne" for each vessel not only depends on physical characteristics, but also on the business strategy an owner has for the vessel; its projected life in the SECA; its probable operating schedule and the required return on investment criteria.

Broadly this illustration says that sea water scrubbing should be a candidate for consideration for a particular ship if the effective cost per tonne is less than twice that of the 1.5% LSFO premium to HFO. Without offsetting, scrubbing is only attractive if the effective cost per tonne is simply less than the 1.5% LSFO premium.

7.3 Simulated trading

During the course of the pilot exercise three separate trading simulation events were run – between the participants; as part of a training exercise for one of the partner shipping companies and at an international conference.

Inevitably each session was too short to allow the participants to research their business strategy in a way that reflected the real world, but generally the participants quickly realised which vessels were suitable for abatement investment and which would be appropriate to operate as purchasers.

The trading exercises demonstrated that overall cost savings could be achieved by employing offsetting and also indicated the nature of the controls and responsibilities that should exist. These lessons have been absorbed into the conclusions in sections 8 and 9.

8 Implications for a sulphur trading scheme for ships

As a result of the pilot exercise – its results, simulations and shipping company interactions – this author concludes that a number of key elements should be contained in an offsetting trading scheme:

- SO_2 credits should be generated before use.
- Purchasers should possess credits before entry to the SECA.
- Purchasers should be able to buy forward subject to subsequent availability.
- Credit generators using scrubbing for abatement should be required to provide auditable emission monitoring

records. For day to day operation of the scheme the total daily emission of S (or SO_2) would be utilised alongside recorded fuel consumption and voyage details.

- Credits generated by very low sulphur fuels should be able to be substantiated by bunker receipts, recorded fuel consumption and voyage details. The pilot has demonstrated that collection of such data is not difficult. Also simple algorithms would be used to automatically check for consistency of information.
- Purchasers should be able to substantiate their purchase requirements by bunker receipts, recorded fuel consumption and voyage details. Automated checking would apply as for credit generators.
- Credit generation and use should be recorded according to a small number of sub-zones of the North Sea SECA to allow management for the avoidance of hotspots.
- Credits should have a life time of order of a year.
- Credits should be able to be retired at any time by a credit generator or purchaser.
- Offsetting within a company fleet should be permitted, but the same standards of monitoring and proof should be required as for all other participants in the scheme. This is independent of the fact that in such circumstances the credits transferred between company vessels would be exchanged rather than sold and purchased.
- A managing agent, responsible to statutory authorities, should be accountable for the performance of the scheme, its record keeping, reporting and integrity. Although for very small offsetting arrangements it may be possible for shipping companies to report directly to regulatory authorities, for a scheme of any size and complexity a central clearing house will be necessary.
- Non-performance penalties for the scheme as a whole should be levied in environmental terms (subsequent generation of an excess of credits greater than the non-performance shortfall).
- Contracts between the managing agent and the participants may need to include financial guarantees or withholdings to manage any non-performance.
- The scheme should ensure a market is made in SO_2 shipping credits. This could include sales to non-shipping purchasers and markets, under general rules developed in detail for the scheme and agreed by a participants' board. This recommendation recognises the initiative being promoted by the Swedish Shipowners Association for SO_2 and NO_x[12].

The points above are indicative of the features required of an offsetting scheme and whereas the detail should be subject to refinement, amplification and to some extent alignment with other initiatives, the experience of this pilot and the monitoring and verification project DEMO[13] suggest that such schemes could be viable, attractive to users, environmentally sound and an aid to enforcement.

9 Conclusions

SEAaT's pilot exercise to explore the principles of offsetting of sulphur emissions within a SOx Emission Control Area has proved to be successful and informative. In the environment of a group of seven international shipping companies and 58 participating vessels it has been practically demonstrated how a data gathering scheme could operate in order to manage an offsetting consortium.

Within the pilot fleet the group has generated and exchanged emissions credits, met the environmental requirement and established a safety margin of excess credits. Without the sale of the excess credits outside the pilot fleet an average fuel sulphur content of 1.2% was achieved; an environmental benefit relative to the regulatory standard.

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[12] Emissions Trading Schemes in Europe for SO2 & NOX including shipping, Swedish Shipowners' Association, Version 1.1, Gothenburg 12 May 2006

[13] http://www.pwc.com/Extweb/challenges.nsf/docid/012D6594EA49D8D780257188002C1B85

Fundamentally it has been demonstrated that compliance (i.e. achieving the prescribed environmental standard) through offsetting can be significantly cheaper[14] than if all vessels individually meet the 1.5% fuel sulphur content standard.

The experience of the pilot project has led to the definition of a set of conditions appropriate to the running of a feasible sulphur offsetting trading scheme, subject, of course, to the development of regulatory permissions to operate such a system. The envisaged system could have the key features of:

- Improved visibility of the environmental performance of ships in the SECA and a reduced risk of non-compliance with SECA regulations.
- Accountability of the scheme to ensure environmental compliance and the avoidance of geographical "hotspots".
- A strong potential for cost savings at an individual vessel and overall fleet level.
- Compatibility of a ship-ship trading scheme with other proposed ship-land credit sales proposals.
- Individual operator flexibility to offset within its own fleet and if desired to individually "go beyond compliance".
- Scheme flexibility to adjust gradually to changing regulatory standards.

Significantly an offsetting trading arrangement would provide options for the shipping community at no detriment to the environment and with higher standards of monitoring and enforcement. It should promote investment in abatement technology and in all means to reduce the cost of creating environmental benefit. With appropriate accountability requirements, as described in this report, the use of offsetting schemes offers society a low risk instrument to encourage the transition of shipping toward a greener, more sustainable future.

[14] Cheaper by almost 10% for a low sulphur premium of $50 per tonne