IMO 0.5% S GLOBAL: SCRUBBERS YES OR SCRUBBERS NO?

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1. Introduction and Summary

The new IMO 2020 Sulfur (0.5 wt%) regulation [1] is creating fear and despair worldwide. Everybody is afraid of the impossibility of making new bunker blend recipes that satisfy the regulation, and "are sleepwalking into Gasoil". Of course, it is not true, as RAI showed in our internal research on making IMO 2020 compliant fuels in the US Gulf Coast. [2][6]

What about alternatives such as using scrubbers? Is it really cheaper than buying ULSFO or MGO? In theory, it allows you to keep buying cheap IFO 3.5w%S. Maybe you are thinking that it is an infeasible solution because the cost will be enormous. But we can show you that is not as bad as you thought. IT IS NOT CHEAP, but it is significantly cheaper than switching completely to 2020 compliant MGO.

This paper describes two Return On Investment (ROI) calculations to determine if a scrubber is is justified. The ROI and payback vary with ship size (different fuel consumption rates), and vary from a couple of months for Container PostPanamax-es to more than one year for smaller ferry's and small Panamax Bulkers. You can use the calculators yourself with your own parameters for your specific case situation [3],[4]. The difference between the two calculators is that the first one is a quick ball-park estimator, while the second one calculates the internal rate of return, and net present value, using CAPEX, OPEX, life of equipment, interest rates, and depreciation.

2. What is a Scrubber?

A scrubber is a pretty large electro-mechanical-chemical device that you attach to the vessel exhaust chimney to clean the bunker-burning engine exhaust gas Sulfur to an acceptable level, below 0.5 m/m% S globally, and below 0.1 m/m%S in ECA's.

It does that by simply chemically converting the SO2 and SO3 in the exhaust gas to rather benign Calcium Sulfate.

The most frequently used scrubbers, are either open-loop or closed loop type (Fig. 1).

- In the open-loop scrubber, the water with CaSo4 is simply thrown into the ocean; obviously, this is pretty cheap. It also affects the alkalinity of the seawater which affects the marine environment.

- In the closed-loop scrubber, we filter the CaSo4 out as “sludge” and dispose of it properly in a port equipped for sludge disposal. Doing so is more expensive.

Fig. 1 SOx Scrubber

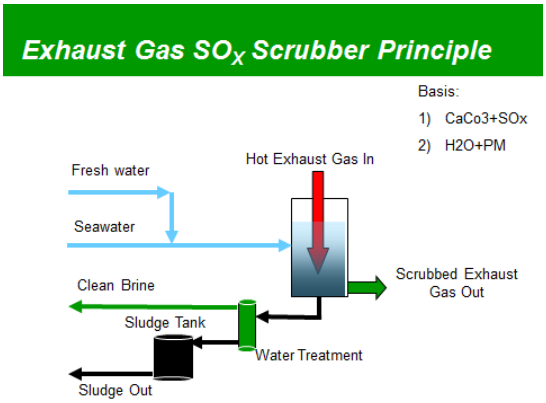


Fig. 2 Wartsilla SOx Scrubber

Credit: Wartsilla

There are other considerations impacting costs:

1. They are big space consumers, and weigh many tons, so you must have the space to install them and support their weight (Fig. 2)
2. The must be equipped with performance monitoring electronics (sensors and computers) to prove that the cleaned exhaust meets the IMO 2020 specs
3. They create “back-pressure” on the engine, which affects energy efficiency
4. The engine exhaust and sludge are highly corrosive, which limit the life of the scrubber, even with the use of corrosion-resistant materials
5. The cost of sludge disposal is non-trivial, as is the scrubber periodic maintenance cost

BUT…SCRUBBERS WORK!

3. Payback and Return On Investment (ROI) Scenarios

The money-saving capability of a scrubber relies on the price differential between today’s IFO380 3.5%S and LS MGO, which is of the order of $150 to $200/MT. The price differential was relatively constant for the last decade, and even if oil prices drop to $40/bbl as forecast, will still hold approximately true.

The price differential is due to two factors:

- Inherently, the “bottom of the barrel” residue is much cheaper than any other distillation fraction cut from a barrel of crude oil, such as Gasoils (kerosene, jet, diesel, light and heavy atmospheric gasoil)
- Secondly, the high cost of desulfurization, which traditionally uses Hydrogen, catalyst, and energy to “bind” Sulfur species to Hydrogen in the form of H2S, which can be readily isolated and converted to elemental Sulfur. All this costs enormous amounts of money.

3.1 Assumptions for Calculating ROI

To estimate payback time, we analyzed two cases spanning min/max vessel fuel consumption ranges, from 40 t/day to 300 t/day.

The main assumptions used are:

- Life of scrubber: 10 years
- Price of scrubber, installed: 5 million USD
- Annual maintenance cost: 1 million USD/year in sludge disposal, scrubber inspections and minor repairs, and performance monitoring instrumentation and software
- Prices of fuels and maintenance costs are in 2017 USD using Singapore prices, and assumed constant during the course of the next 10 years

We created a simple spreadsheet [3] that uses your daily fuel consumption, and fuel prices (IFO 380 3.5 Wt%S and 0.1%S ECA Marine Gasoil), to estimate the payback. We simulated two cases spanning a wide range of fuel consumption: case one is a Post Panamax Container ship with a daily fuel consumption of 300 t/d; case number two is Panamax Bulk Carrier with a daily fuel consumption of 40 t/d.

3.2 Variability of Payback Time vs. Daily Fuel Consumption

Ships come in various sizes and engine fuel consumption, so one of the obvious questions is the variability of payback with ship size/fuel consumption. Is there a “sweet” spot break-even point?

The literature search revealed:

- Relative insensitivity of scrubber price (capital expenditure, CAPEX) vs. scrubbing capacity, around +/- 20%. So we are speaking about investments of roughly 4 to 6 M$ installed cost.
- Higher sensitivity of scrubber operating expenditure (OPEX) vs. scrubbing capacity, particularly in the cost of chemicals supplies, sludge disposition in a port with adequate disposal capacity, periodic inspections and minor repairs due to the highly corrosive environment, and minor tests and adjustments to performance monitoring instrumentation and software. We used an upper OPEX estimate of US$ 1 million/year.

A sensitivity analysis shows that the break-even point is less than one year in all cases of daily fuel consumption level above 40t/d. A partial view of the scrubber ROI calculator is shown in Fig. 3 for a post-Panamax case.

The scrubber ROI spreadsheet is designed for an end user to plug-in their own numbers:

- daily fuel consumption,
- current fuel prices in the user geographic location, including IFO 380 3.5% S, IFO380 0.5% S, 0.5%S MGO, and 0.1%S ECA MGO,
- scrubber CAPEX cost
- scrubber OPEX cost

The user can change the assumptions, vary the prices, type of fuel used for comparison, and see the resulting ROI payback time.

Fig. 3 Comparing Annual Fuel Cost for Ships and Scrubber - Post PANAMAX Case

* Basis: Singapore, May 16, 2017

		Costs/Yr	
		2017	2020
Ship Type	Daily Fuel Consumption, t/d	100% non-ECA 3.5%S IFO380 Operation	100% ECA 0.1%S MGO Operation
Post Panamax Container Ship	**300**	$34,875,750	$49,713,000
VLCC	**100**	$11,625,250	$16,571,000
Panamax Bulk Carrier	**40**	$4,650,100	$6,628,400
Passenger Ferry	**35**	$4,068,838	$5,799,850
Sample Prices: Singapore, May 16, 2017	USD/MT		
IFO 380 3.5%S	**318.5**		
IFO 380 0.5%S RAI Recipe	**365**		
MGO 0.5%S	**430**		
MGO 0.1%S	**454**		
Scrubber Economics Assumptions			
Scrubber Cost	5,000,000	USD (one time)	
Scrubber annual maintenance	1,000,000	USD (per year)	
Assuming 10 years life of scrubbers, the maintenance cost is	10,000,000	USD (per 10 years)	
Scrubber Cost (Capex+Opex) for 10 years	15,000,000	USD (per 10 years)	
Annual Scrubber Cost (Capex+Opex) for 10 yr lifecycle	1,500,000	USD (per year)	
Post Panamax Container Ship Case			
Case 1 - 100% of time Use MGO			
Price differential for Post-PANAMX/yr, switching from IFO380 3.5%S to MGO 0.1%S	**$14,837,250**	**USD**	It is the increment a
Buying the MGO 0.1%S for 10 Years (assuming invariance of price)	**$497,130,000**	**USD per 10 years**	
Buying the IFO 3.5%S for 10 years (assuming invariance of price)	**$348,757,500**	**USD per 10 years**	cost of buying IFO38
Scrubber payback switching from IFO 3.5% S to MGO 0.1% S			
Buying the MGO 0.1%S for 10 Years (assuming invariance of price)	**$497,130,000**	**USD per 10 years**	
Buying the IFO 3.5%S for 10 years (assuming invariance of price)	**$348,757,500**	**USD per 10 years**	
Delta (MGO 0.1% S - IFO 3.5% S) for 10 years	**$148,372,500**	**USD per 10 years**	
Scrubber Payback	**0.10**	**Years**	

3.2 Exceptions on Using Scrubbers

For smaller vessels using less than 40t/d, like those in a fishing fleet, the payback is still favorable BUT there is ONE BIG PROBLEM: space, and additionally the ability to carry the extra weigh on a smaller vessel, and the impact of back pressure on engine efficiency and fuel consumption.

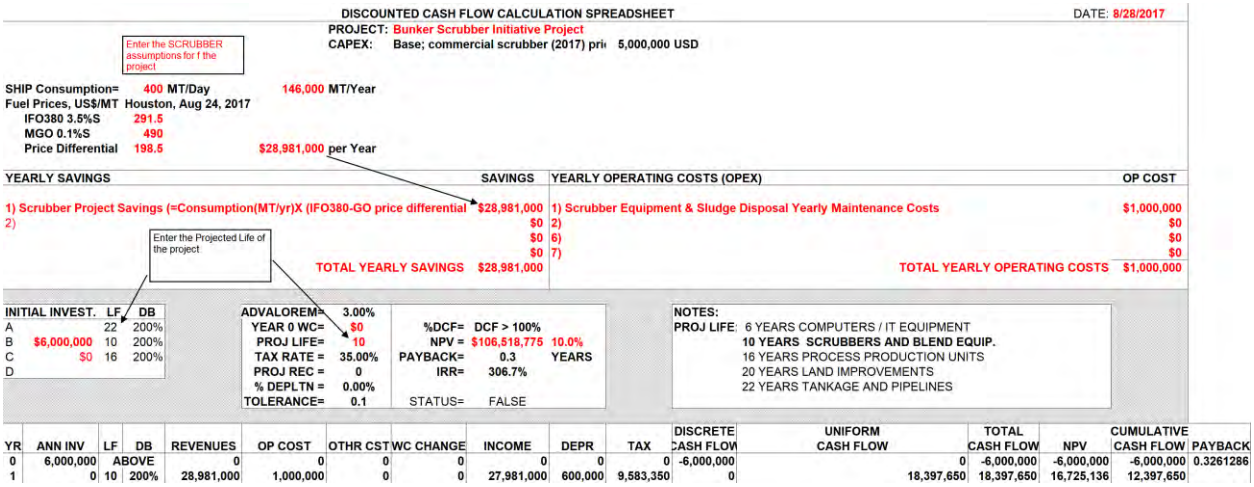
For these smaller vessels, the alternative to scrubbing is using 0.1%-0.5%S MGO's, using ECA fuels costing about US$100 less than 0.1%S MGO, or using 0.5%S ULSFO produced with "clever" recipes using low Sulfur crudes [2] [6] costing just about the same as the common IFO380 3.5%S, maybe US$10 to 20 more per ton.

4. Scrubber Discounted Cash Flow (DCF) Analysis Spreadsheet

For those you interested in a more precise simulation to calculate the Discounted Cash Flow (DCF or IRR) return and suitable for parametric sensitivity analysis, we have a more detailed Scrubber DCF spreadsheet available as licensed commercial software [4], (Fig. 4). It takes into

account more than fuel consumption and CAPEX/OPEX prices: life of the project, interest rates, depreciation, etc.

Fig. 4 SOx Scrubber DCF Calculator



DISCOUNTED CASH FLOW CALCULATION SPREADSHEET — DATE: 8/28/2017

PROJECT: Bunker Scrubber Initiative Project

CAPEX: Base; commercial scrubber (2017) pri 5,000,000 USD

Enter the SCRUBBER assumptions for the project

SHIP Consumption= 400 MT/Day 146,000 MT/Year

Fuel Prices, US$/MT Houston, Aug 24, 2017

IFO380 3.5%S 291.5

MGO 0.1%S 490

Price Differential 198.5 $28,981,000 per Year

YEARLY SAVINGS	SAVINGS
1) Scrubber Project Savings (=Consumption(MT/yr)X (IFO380-GO price differential	$28,981,000
2)	$0
	$0
	$0
TOTAL YEARLY SAVINGS	$28,981,000

YEARLY OPERATING COSTS (OPEX)	OP COST
1) Scrubber Equipment & Sludge Disposal Yearly Maintenance Costs	$1,000,000
2)	$0
6)	$0
7)	$0
TOTAL YEARLY OPERATING COSTS	$1,000,000

Enter the Projected Life of the project

INITIAL INVEST.	LF	DB
A	22	200%
B $6,000,000	10	200%
C $0	16	200%
D		

ADVALOREM=	3.00%		
YEAR 0 WC=	$0	%DCF=	DCF > 100%
PROJ LIFE=	10	NPV =	$106,518,775 10.0%
TAX RATE =	35.00%	PAYBACK=	0.3 YEARS
PROJ REC =	0	IRR=	306.7%
% DEPLTN =	0.00%		
TOLERANCE=	0.1	STATUS=	FALSE

NOTES:

PROJ LIFE: 6 YEARS COMPUTERS / IT EQUIPMENT
10 YEARS SCRUBBERS AND BLEND EQUIP.
16 YEARS PROCESS PRODUCTION UNITS
20 YEARS LAND IMPROVEMENTS
22 YEARS TANKAGE AND PIPELINES

YR	ANN INV	LF	DB	REVENUES	OP COST	OTHR CST	WC CHANGE	INCOME	DEPR	TAX	DISCRETE CASH FLOW	UNIFORM CASH FLOW	TOTAL CASH FLOW	NPV	CUMULATIVE CASH FLOW	PAYBACK
0	6,000,000	ABOVE		0	0	0	0	0	0	0	-6,000,000	0	-6,000,000	-6,000,000	-6,000,000	0.3261286
1	0	10	200%	28,981,000	1,000,000	0	0	27,981,000	600,000	9,583,350	0	18,397,650	18,397,650	16,725,136	12,397,650	

5. Conclusions

For all cases where daily fuel consumptions is greater than 40 t/d, scrubbers will pay for themselves in significantly less than one year, compared with “sleepwalking into gasoil” [5].

For smaller vessels, using economically produced ULSFO (not ECA MGO or hybrids) makes a lot of economic sense [2], although availability outside USA might be a problem due to good availability of cutter stocks (mostly FCC LCO and slurry).

As you can see from the table above, the utilization of scrubbers depends on three factors: price of fuel oil and differential to marine gasoil, daily fuel consumption, and price of scrubbers and cost of annual maintenance.

If the daily fuel consumption is close to 300 t/d, burning IFO with 3.5%S and using scrubbers is much more economical than switching to a new fuel with lower sulfur content, i.e. 0.1%S or 0.5%S MGO.

If the daily fuel consumption is an order of magnitude lower than 300 t/d, i.e. less than about 40 t/d, switching from IFO380 3.5%S to IFO380 0.5%S is more economical than to keep burning an IFO380 with 3.5%S and using scrubbers.

All depends of what is your daily fuel consumption.

The other alternative is ignoring IMO 2020, forgetting scrubbers and low sulfur fuel and keep burning IFO380 3.5%S.

Of course, this alternative will be illegal after 2020., but enforcing compliance is another story.

Except for EU and US ECA areas, unless IMO provides a “James Bond” type security system to enforce compliance for all the ships in the middle of the ocean, there is a great chance that many ships will be burning IFO 3.5%S and in proximity of a port switching on the scrubbers!

References

[1] IMO Marine Environment Protection Committee Regulation14.1.3 and 14.8 of MARPOL Annex VI (November 2016)

[2] Barsamian, A., Curcio, L.E,.”Study of Practical IFO380 recipes in US GC for 2020 Compliance”, August 2017, submitted to O&GJ for publication

[3] Barsamian, A., Curcio, L., “ Scrubber Return On Investment MS Excel Calculator”, August 2017, spreadsheet available on request (info@refautom.com)

[4] Barsamian, A., Curcio, L., “ Scrubber Discounted Cash Flow Calculator Spreadsheet”, August 2017, info available on request (info@refautom.com)

[5] Sharma, A., “The Industry is Woefully Unprepared for 2020 and Just Sleepwalking into Gasoil”, Ship & BunkerJuly 19, 2017

[6] Barsamian, A., Curcio, L.E,.” Use of SmartBlend Bunker Blend Optimizer to obtain IMO 2020-compliant IFO380 Recipes”, August 2017