

# Impacts from clean shipping for Port Cities

*– Report from four EnviSuM workshops*



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## Introduction

This report presents the results from the cross-border discussions that have been taken during four workshops which have been hosted by the EnviSuM project. The overall aim of the workshops was to explore the approaches taken by ports and port cities in the Baltic Sea Region to support clean shipping and comply with the SECA legislation. The focus was also to learn about the long-term visions on clean shipping towards 2020 and even 2030 among maritime stakeholders.

The background for the work is the SECA legislation, which demands that ships sailing in the Baltic and North Seas cannot use fuels with more than 0.1 % of sulphur content from the 1<sup>st</sup> of January 2015. The shipowners sailing in this area have several options to comply with the regulation, including using low sulphur Marine Gas Oil (MGO), Ultra-Low Sulphur Heavy Oil (ULSFO), switch to Liquefied Natural Gas (LNG), methanol, or use an exhaust gas cleaning device (often referred to as a scrubber). The central question for this report is which solutions that shipowners have chosen to comply with SECA as well as how ports and port cities have supported the industry to adopt specific clean shipping measures.

The workshops were part of the EnviSuM project - Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies. The EnviSuM project was funded by the European Regional Development Fund and focused on studying technical efficiency and socio-economic impacts of clean shipping solutions. The project among other provided the shipping sector with guidance on how to support future investment decisions and furthermore investigated the performance of different available measures such as fuels and abatement techniques to meet the emission reduction targets. The EnviSuM project provided tested and analysed results on the efficiency of the different clean shipping solutions allowing the project consortium to make recommendations benefiting the environment and the health of the people of the Baltic Sea Region while supporting the maritime businesses and promoting economic growth.

For more information on the project visit the website: <https://blogit.utu.fi/envisum/>

## The four workshops

The following four workshops have been held in order to explore the approaches taken by ports and port cities to support clean shipping and reduce negative impacts from air emissions.

1. *SECA: Strategies to help the maritime industry developing*, May 10<sup>th</sup> 2017 at Miljöförvaltningen in Gothenburg, Sweden
2. *Impacts from ship emissions and possibilities collaboration in BSR*, March 23<sup>rd</sup> of 2018 at the EXPORTFORUM in St. Petersburg, Russia as part of the Baltic Sea Day
3. *Are Retrofitted Scrubbers the right solution to meet the Global Sulphur Cap?* September 11<sup>th</sup>, 2018 at Bureau Veritas in Copenhagen, Denmark
4. *Impacts from SECA in Baltic Sea ports – The effects of present and future air emissions from ships*, Port of Gdynia Authority, Gdynia, Poland on September 19<sup>th</sup>, 2018



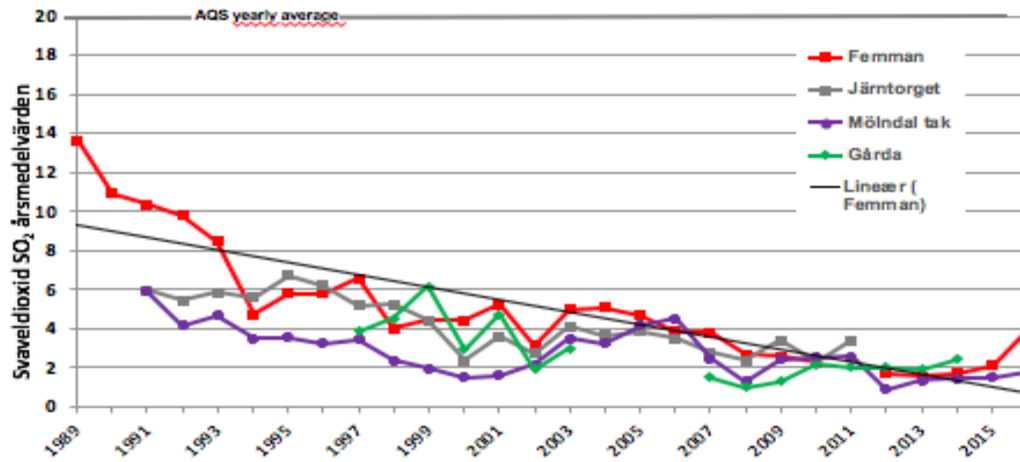
The participants at the workshops were key stakeholders such as policy makers, port authorities, environmental agencies, shipowners, producers of maritime equipment and services as well as researchers and experts from the EnviSuM project. The aim of the workshops was to examine both the initial expectations, possibilities, business potential and expected impacts of SECA. The workshops were arranged as moderated sessions in order to ensure inputs from participants.

### Workshop 1: SECA: Strategies to help the maritime industry developing

The first workshop was held the 10<sup>th</sup> of May 2017 at Miljöförvaltningen in Gothenburg. The workshop had the title “Port performance – challenges turned into business opportunities - *Splinter session 1, Workshop: SECA: Strategies to help the maritime industry developing*” and was part of a two day event arranged by the GoLNG and EnviSuM projects. The focus of the workshop was to describe the impacts from SECA on the City of Gothenburg, as well as the challenges and opportunities that relate to this new regulation. First there were several presentations. Hereafter there was a panel debate workshop discussion with, Patrick Gerber, CTO at TS Energia OÜ, Erik Bäck, Business Developer at the Environmental Department of the City of Gothenburg, Marcin Włodarski, Project Manager at Baltic Ports Organization and Professor Gunnar Prause from the Technical university of Tallin.

During his presentation on the Impacts of SECA, Erik Bäck from the City of Gothenburg talked about how the Gothenburg has been working on air measurements and quality modelling for decades. The city has several measurement stations and as it is shown below, the SO<sub>2</sub> levels in the city of Gothenburg have been falling steady over the years due to a focussed effort.

## Sulphur dioxide – 1989-2016



SUSTAINABLE CITY - OPEN TO THE WORLD

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*Slide from the presentation from Erik Bäck, Business Developer, the Environmental Department, City of Gothenburg*

Patrick Gerber, CTO at TS Energia OÜ hereafter presented the New challenges and opportunities for maritime stakeholders resulting from SECA. First Patrik presented some of the challenges at the port. These include that the bunkering companies are experiencing a diversification of fuels, as MGO is being substituted with several other fuels. Tallink has invested in an LNG driven vessel and changing the business model, which creates a new fuel supply chain. The traditional business models are under pressure due to SECA, as new infrastructure and services for bunkering LNG, delivering scrubber wastewater etc. are emerging. The Port of Tallinn has established scrubber waste water system. The regulation has created big changes for maritime stakeholders and will continue to do so in the future. Ports have to make investments in additional infrastructure which is a cost, but on the other hand also creates new opportunities.

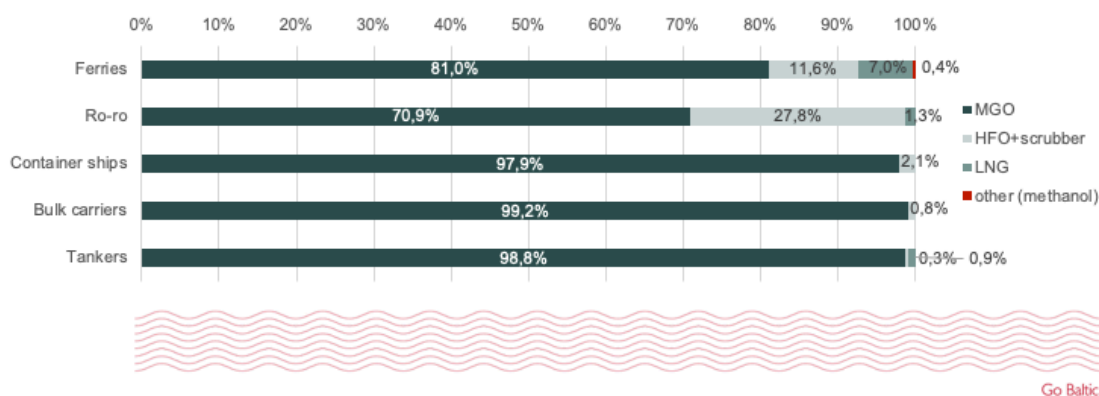
Helen Jansson from the ZVT platform continued with a presentation on Private Public Partnerships - Economic incentives for Greentech and alternative fuels. ZVT - Zero Vision Tool is a collaboration method and project platform where maritime related issues are discussed and solved. Within the platform, representatives of industry, academy, agencies and administrations meet to share experiences and find common, workable and effective solutions.

The effect of SECA on Baltic Sea Ports was presented by Marcin Włodarski, Project Manager at Baltic Ports Organization. Out of the 1.524 shipping which mainly operate in the Baltic sea the vast majority use MGO. Marcin started by presenting the compliance levels with SECA. Hereafter, he showed examples of LNG powered ships operating in the Baltic Sea and the different LNG bunkering solutions available in the Baltic Sea ports. He also showed the network existing LNG bunkering infrastructure available in the Baltic Sea.



## Compliance with SECA

Technology applied in order to meet sulphur regulations by ships operators in short sea shipping in European SECA.



Slide from Marcin Włodarskis presentation.

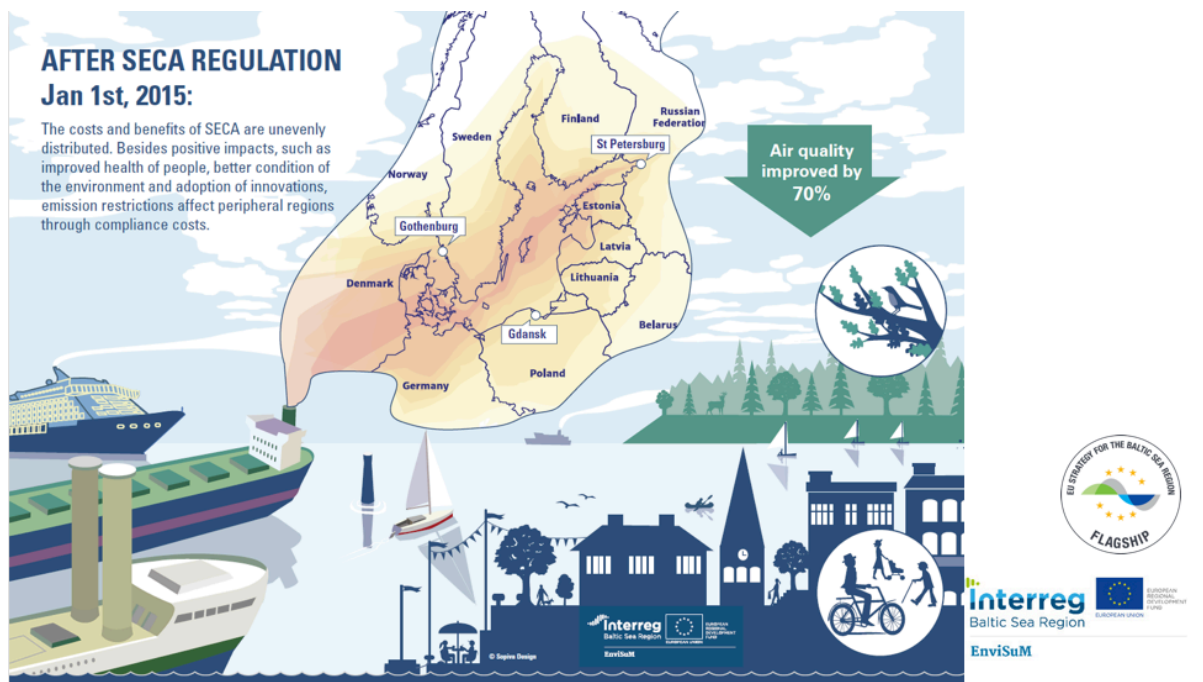
### Workshop 2: Impacts from ship emissions and possibilities collaboration in BSR

The second workshop was held on March 23<sup>rd</sup>, 2018 at the EXPOFORUM in St. Petersburg as part of the Baltic Sea Day. The goal of the workshop was to present the positive effects of environmental regulations on air quality and human health with special focus on urban areas, and to discuss the possibilities for increasing collaboration within clean shipping around the Baltic Sea.

The first session had title Ship emissions and air quality modelling with emphasis on cities. The first presentation was on Ship emissions at Urban and Regional Scale, by Jukka-Pekka Jalkanen, Senior researcher, Ph.D. at the Finnish Meteorological Institute. Hereafter followed a presentation on Regional Air Quality modelling, by Jan Eiof Jonson, Scientist, Norwegian Meteorological Institute. Jan was followed by Professor Tadeusz Borkowski from the Maritime University of Szczecin talked about Changes in air quality in the Tri-City (Gdynia, Sopot and Gdansk) related to the operation of seaports and changes in SECA requirements.

The second session was on Benefits from compliance with SECA. The first presentation was on Compliance measurements of ship emissions of Sulphur and NOx from airborne and fixed remote measurements, by Prof. Johan Mellqvist, Chalmers University. Hereafter followed a presentation on the Benefits of SECA compliance by Sari Repka, Environmental Specialist at University of Turku and Manager of the EnviSuM project.





*Slide from the presentation of Sari Repka on the Effect of the SECA regulation.*

The third session was on Collaboration within Clean Shipping. Firstly, Alexey Bakhtov, Project Researcher at HELCOM's Green Team gave a presentation on the Green technology and alternative fuels in shipping. Hereafter followed a workshop discussion with the presenters and the audience.

The conclusion of the discussion was as follows:

An important aim of the EnviSuM project was to support politicians in order to make decisions based on facts, such for example that modal shift did not happen though it was expected to happen due to the SECA regulation. Involvement of Russian side was declared and confirmed what was admitted as important issue, because there is a common goal to be targeted. Furthermore, Environment and Economic analysis should be in good balance.

During the round table there were two rounds of discussion. During the first round of discussion the effect of the SECA regulation on air emissions, modelling and human health was discussed. The conclusion was that the SECA regulation has led to great improvements on human health in the BSR. In the future: there will be use of alternative fuels, and more will be developed, in some cases the technology already exist, but the problem is more likely in the energy production side and a cost issue; regulation is affecting, but it will be adapted; to some opinion regulation affect economic issues which reduces competitiveness of shipping.

In terms of compliance of SECA and NECA it was noted that SECA was considered to be costlier than it finally was. NECA could be even less costly, but costs are unevenly distributed. Some will benefit (for example those who have technologies), while others will lose. NECA is quite easily taken care of, if there are devices installed on board ships. Equipment, maintenance and other (urea) will cause costs. Profit that can be obtained is less related to NECA. Options for compliance: switch to another fuel, or completely different type of fuel, for example LNG, (realistic option only for new buildings). LNG is compliant fuel, but there exist problems when thinking the climate, for example methane slip. LNG is called bridge fuel in the way towards biofuels, namely biomethane. The situation with new fuels is not always only positive/problem-free; there can arise new kind of emission or side effects which can be

harder to handle than the original problem. Economic factors related to greenhouse gases, LNG etc.; not clear picture of the effects of the compliance. For ex. cargo shipping companies' business is not profitable due to compliance. In addition to regulation, operating in ice conditions where more engine power is needed, the competition situation is not fair compared to warm water situation. However, there is a general agreement that the safety comes first.

### **Workshop 3: Are Retrofitted Scrubbers the right solution to meet the Global Sulphur Cap?**

The third workshop was held in Copenhagen on September 11<sup>th</sup>, 2018 at Bureau Veritas. Since the most common solution to meet the SECA requirements, apart from using MGO, has been to install a scrubber, it was decided to focus on the financial, technical and environmental aspects of using scrubbers. Scrubbers is a relatively new technology in the maritime industry and the costs as well as the technical and environmental performance can be unpredictable. There is no standard price for a scrubber as everything depends on size, age and other conditions. The capital investment may vary from 3 million USD to even 12 million USD per vessel. Altogether, the investment might turn out to be quite costly at the beginning. But how about the payback time and ROI? When does it pay off to invest in scrubbers? What is the business case and what are the possible methods of financing the equipment? And how do scrubbers perform technically and environmentally compared to MGO and LNG?

The workshop touched upon the topic from the economic angle, where the speakers presented business cases of different ways of investing in scrubbers as well as share experiences on their performance. It addressed the socio-economic, financial and environmental effects of SECA and 2020 Global Sulphur Limit regulation and explored the needs of the maritime industry when making clean shipping investments.

Poul Woodall, Director of Environment & Sustainability at DFDS A/S presented their status with scrubbers. DFDS has 18 scrubber vessels in operation, as well as 9 new buildings and conversions of 12 existing vessels in pipeline. DFDS has had good experiences with scrubbers but underlines that many parameters need to be taken into consideration, such as technical performance, future oil prices, fuel availability, deployment and sustainability. The feasibility of scrubbers is dependent on the individual case.

Rune Jørgensen Daae, Sales Manager at MAN Energy Solutions presented the challenges in retrofitting and upgrading to scrubbers. Some of the challenges are extra power requirements, a potential ban of open loop scrubbers in the future, as well as dock and installation time for vessels. Furthermore, increased operational costs for maintenance, chemicals and discharge fees need to be taken into account. The conclusion was that it is necessary to make a wholistic evaluation of the vessel and take technical and operational aspects into consideration.

Anders Amstrup Fournais, Attorney at Hafnia Law Firm gave some legal perspectives on the possibilities for taking mortgage in a scrubber installed on board a ship based on a similar case from the aviation industry. The overall message was that it is not possible to take a mortgage on the scrubber separately as the scrubber is considered a part of the ship. The solution could therefore be to take a mortgage in the whole ship if the loan-to-value ratio of the ship makes this possible.

Henriette Brent-Petersen from Danish Ship Finance gave a presentation on the business case of scrubbers and the economic impacts where both costs and economic advantages were presented on the different ship segments. According to Henriette it is not only the potential cost saving of installing a scrubber which should be considered, but to a higher degree the potential for gaining a competitive cost advantage compared to other ship owners in the same segment, which can be used to attract more chartering and thereby increase revenues. However, on the long run, the competitiveness of a scrubbers could be reversed. Whether a scrubber overall is a good investment or not is therefore difficult to determine.



Jesper Jensen from TORM presented their work with scrubbers. TORM will install scrubbers on all their 13 new buildings, while the remaining ships will be a combination of retrofitting scrubbers and running on compliant 0,5% sulphur fuel. The decision on whether to install a scrubber depends on parameters such as the remaining lifetime of the vessel, the fuel consumption, sailing pattern and fuel availability, investment costs as well as the price differential between MGO/ULSHFO and HFO.

#### Workshop 4: Impacts from SECA in Baltic Sea ports – The effects of present and future air emissions from ships

The fourth and final workshop was held at the Port of Gdynia Authority on September 19<sup>th</sup>, 2018.

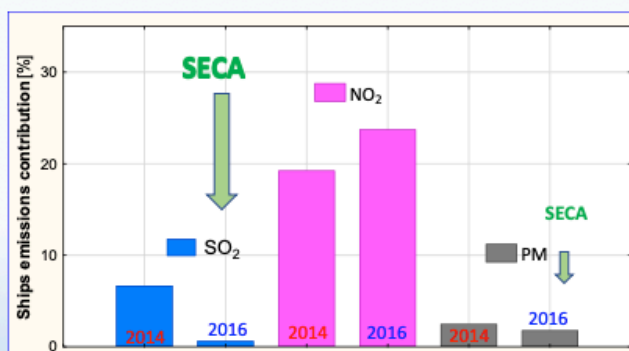
The focus was on presenting and answering the following questions:

- What are the air emissions from ships calling Baltic Sea ports?
- How are ship-emissions measured, modelled and calculated?
- What are the present and future effects of air emissions in the Baltic Sea?
- How has SECA affected the Tri-City?

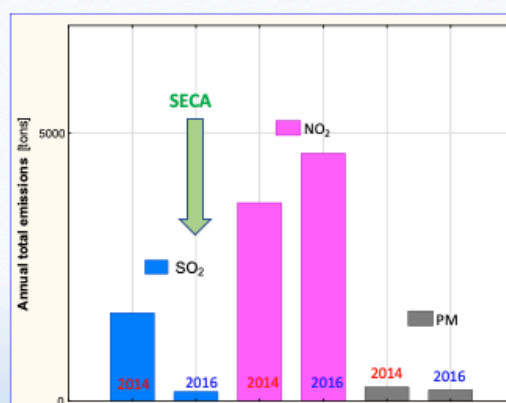
There were 14 presentations during the workshop, mainly from EnviSuM partners. Overall the results showed, that emissions have decreased and that the air quality has improved. One of the presentations given, was by Professor Tadeusz Borkowski from the Maritime University of Szczecin, on the topic of Emission of ship's calling to Gdynia and Gdansk Ports. His work shows that the SECA limit introduced in 2015 caused a very significant decrease in SO<sub>2</sub> emissions, from 6.7% in 2014 to 0.65% in 2016, and to a lesser extent a reduction in PM emissions from 2.5% in 2014 to 1.8% in 2016. There is also an unwanted effect of the port activity, which is the increase in NO<sub>2</sub> total urban emissions from 19.3% in 2014 to 23.8% in 2016.

#### Tri-city - ships emission inventory results

Contribution of ports and ships in urban total emission



Ships annual emission comparison 2014 and 2016



Slide from Tadeusz Borkowski's presentation on the impacts from SECA

The presentations mainly focused on disseminating the results from the EnviSuM project. The final report with results from the project can be downloaded here:

[https://static1.squarespace.com/static/56a0c84dfb36b1be19213613/t/5cc987b35c89530001bc86a6/1556711353646/FinalReport\\_EnviSuM2019.pdf](https://static1.squarespace.com/static/56a0c84dfb36b1be19213613/t/5cc987b35c89530001bc86a6/1556711353646/FinalReport_EnviSuM2019.pdf)

Hereafter followed a discussion. The key points were:

Leading shipowners should work together with other stakeholders such as researchers and authorities in order to develop and set the air emission limit values, as companies otherwise can come around the emissions measurements, in the same way which has happened in the car industry. Industry will always be ahead, and it is therefore important to collaborate with companies. However, industry will probably not “walk in the same direction” in this regard and it is therefore important to start collaborating with some few leading companies that can show the way for the rest of the industry.

Organic substances are still causing a lot of problems in the areas near to the emissions. Those could be regulated in the future. These emissions could be dealt with through filters, but there needs to be an agreement on which particles to filter e.g. PM2.5 or PM10, and how to measure them. It is e.g. difficult to measure mass of particles coming out of a scrubber and it is therefore important to standardise the measurement of particles as the first step.

Regulation of SO<sub>2</sub> and NO<sub>x</sub> is in place and black carbon is probably coming. Looking into the future neither scrubbers nor SCR<sub>s</sub> will solve the challenges with global warming. CO<sub>2</sub> regulations are coming in 2050, but it can be expected that this might be tightened even further. LNG solves problems on air emissions on the short run, but on the long run new solutions have to be found in order to deal with climate change.

## **Discussion:**

The following discussion presents a combination of the results from the four EnviSuM workshops.

### **Before SECA**

In the period prior to the January 1<sup>st</sup>, 2015, when SECA entered into force, there was great fear among many industry representatives and analysts regarding the potential negative economic impacts from the new sulphur regulation in the Baltic Sea. Fuel costs are often the main cost component for many shipowners, and since the compliant fuels (mainly MGO) are substantially more expensive than heavy fuel oil, there was fear that the increased costs would affect the shipowners very negatively. In 2014 many shipowners were already struggling with low profitability as a result of the financial crisis and the resulting low freight rates due to overcapacity on most ship segments. One of the main concerns was that it would become very expensive for shippers to send goods with short sea shipping and that they instead would transport goods by truck. It was feared that this would lead to more congestion on roads, increase CO<sub>2</sub> emissions, as well as further deteriorate the market situation of shipping in the BSR. Furthermore, many feared that many ship owners would deliberately not comply with SECA in order to reduce costs, and that this would create market distortion. However, the oil prices fell dramatically during 2015 and the switch to MGO did not lead to high expenditure increases for the shipowners. The effects of SECA were therefore far less dramatic than anticipated before the regulation entered into force.

### **MGO**

The cities and ports have chosen to support the solutions that the market has adopted, especially the ship owners. After the first four years with SECA it is evident, that most shipowners have opted for switch from HFO to MGO in order to comply with the sulphur requirements. The reason for this is, that it is easy to implement as only minor adjustments have to be made on board the ships. This has resulted in dramatic

reductions in the SO<sub>2</sub> emissions from ships and thereby reduced the exposure to the citizens living in cities around the Baltic Sea. It has furthermore demanded little changes in the supply chain, as it only requires supplying a fuel with a lower sulphur content.

#### Scrubbers:

Several shipowners have opted to install a scrubber, which makes it possible to keep using HFO. This has also resulted in reductions of air emissions but has demanded more actions from ports, and companies in ports. One of the changes is that ports in some countries have to be able to receive the scrubber water, if the ship owner is operating a closed loop scrubber. However, this is only the case in some countries and most scrubber wastewater is discharged into the sea. During the time SECA has been into effect, scrubbers have seen an increasing popularity among ship owners. The reason for this is the short return on investment (ROI) period which in some cases is even less than two years. ROI is expected to become even shorter as the Global Sulphur Cap 2020 enters into force and the price differential between 0,5 sulphur compliant fuel and HFO increases. The demand for scrubbers has increased dramatically as the global restriction come closer and in 2019 it is very difficult to get a scrubber installation before the new rules enter into force. Some of the main challenges for scrubbers are that they do not meet the future NO<sub>x</sub> requirements, for which additional end of pipe solutions have to be installed. Furthermore, most scrubbers run as open loop scrubbers, where the exhaust gas is washed but the substances are discharged into the sea with the wastewater. This has raised a lot of controversy among ports, authorities, NGOs as well as the general public since pollution shifts from air to water. Furthermore, the use of scrubbers increases energy consumption adding costs but also adding CO<sub>2</sub> emissions. The range of the increased fuel consumption is not clear, but some estimations are that up to 10% of additional fuel consumption is needed when using scrubbers. This furthermore gives the shipowners an incentive for cheating and not using the scrubber, as large amounts can be saved by turning them off.

#### LNG

It was expected that a huge price differential between MGO and LNG would make it very attractive for shipowners to invest in either retrofitting ships for LNG or make new builds than run on either dual fuel with LNG as one of the fuels, or fully LNG propulsion. However, in practice very few LNG ships have been seen in the SECA area, and those who have been built, have mainly been related to trade in Norway due to the NO<sub>x</sub> tax and support from the NO<sub>x</sub> fund. The global uptake of LNG as a fuel has been slow and has mainly been seen on cruise ships and ferries as well as in tankers that use some of the gas they transport, and which boils off for propulsion.

LNG is seen as a transition fuel by many, as it is still a fossil fuel that contributes to global warming. Furthermore, it is difficult to retrofit LNG on existing vessels as it is difficult to find the space for the tanks on board. On new buildings it is easier to make room for LNG tanks, but they still take up more space as the volume to energy ratio is higher compared to MGO and HFO. Furthermore, a new LNG building is rather expensive. At the same time, very few bunker facilities have been created, making it difficult for shipowners to bunker their LNG vessels. This might change in the future as LNG becomes wider used in society. In general, the political support for LNG has been declining as global warming is becoming increasingly important on the political agenda. Even though LNG engines are efficient, LNG still contributes to global warming, both as it is a fossil fuel that increases CO<sub>2</sub> levels in the atmosphere but also due to the methane slip of non-combusted gas that is emitted to the atmosphere is higher than many engine manufacturers have specified. NO<sub>x</sub> regulation might improve the overall competitiveness of LNG along with the fact that the known gas reserves are very large. On the other hand, the high investment costs in the whole value chain of LNG infrastructure from carriers, bunkering facilities and vessels along with the increasing focus on global warming might be a major barrier in the future. One enabler of LNG as a fuel might be the possibility to easily switch to other sources of gas which are sustainable, such as Liquid Bio Methane (LBM) or even synthetic gases. However, these types of gases are not available at the amounts needed to power the global merchant fleet in a foreseeable future.

#### Future legislation:

SECA has substantially reduced SO<sub>2</sub> emissions from shipping in the Baltic Sea. The implementation of the Global Sulphur Cap 2020 will furthermore reduce SO<sub>2</sub> emission in the SECA area from the January 1<sup>st</sup>, 2020 as emissions outside of SECA also affect air quality inside the SECA area. However, SECA has only led to limited overall reductions in SO<sub>2</sub> emissions in the Baltic Sea, as there are many other sources of SO<sub>2</sub> emissions.

Emissions of NO<sub>x</sub> from shipping in the BSR is still a concern but are expected to fall substantially as the effects of the NECA regulation (NO<sub>x</sub> Emission Control Area) starts to impact from the 2021, where new buildings have to comply with stricter emission requirements. Furthermore, emission of black carbon and particulate matter are a health concern and it is possible that these emissions also will be regulated in the future.

However, especially the emission of Green House Gases is of great concern due to the global warming potential. Ships are the most energy and carbon efficient mode of transport, and as ships gradually have become more energy efficient over the past decades in order to save fuel, the CO<sub>2</sub> emissions per transport work has decreased drastically. On the other hand, shipping is almost 100% dependent on fossil fuels. It is therefore likely that there will be stricter CO<sub>2</sub> regulation in the maritime industry in the future than those already approved by 2050. However, a transition towards renewable energy carriers in the maritime industry will take a lot of time, since the lifetime of a ship often is 20-30 years, and the ships that are entering the market today will last for decades.

Another potential for future legislation is regulating the emission of un-combusted methane gas from LNG engines. Measurements from the EnviSuM project show, that the actual "methane slip" (the amount of un burned gas that is emitted to the atmosphere) is higher than expected. This is of great concern since Methane is a potent Green House Gas that is estimated to have a 25 times higher Global Warming Potential than CO<sub>2</sub> per weight unit.

## Conclusion

The background for this work is the SECA legislation, which demands that ships sailing in the Baltic and North Seas cannot use fuels with more than 0.1 % of sulphur content from the 1<sup>st</sup> of January 2015. Four workshops have been arranged to explore the approaches taken by ports and port cities in the Baltic Sea Region to support clean shipping and comply with the SECA legislation.

After the first four years with SECA it is evident, that most shipowners have opted to switch from HFO to MGO in order to comply with the requirements. The reason for this is, that it is easy to implement as only minor adjustments have to be made on board the ships. SECA has substantially reduced SO<sub>2</sub> emissions from shipping in the Baltic Sea. And contrary to what many feared, most ships are in compliance with SECA and the modal shift from sea to land transport did not happen.

The uptake of LNG as a fuel is going slower than anticipated. However, there are examples of LNG powered vessels in operation and different LNG bunkering solutions available. There is a network of existing LNG bunkering infrastructure available in the Baltic Sea, which is slowly growing. LNG is seen by many as a bridge fuel towards biofuels, namely biomethane, as LNG is fossil and contributes to global warming. Furthermore, LNG is expensive and difficult to retrofit on existing vessels.

Several shipowners have opted to install scrubbers, which makes it possible to keep using HFO. Scrubbers have a short return on investment period which in some cases is less than two years. However, many parameters need to be taken into consideration, such as technical performance, future oil prices, fuel availability, deployment and sustainability. The feasibility of scrubbers is dependent on the individual case. The business case not only depends on the potential cost saving, but to a higher degree on the potential for gaining a competitive cost advantage compared to other ships in the same segment. Whether a scrubber overall is a good investment or not on the long run is questionable.

Scrubbers reduce SO<sub>2</sub> emissions but also require actions from ports, and port companies. One change is that ports in some counties have to be able to receive the scrubber wastewater, if the ship owner is operating a closed loop scrubber. However, this is only the case in some counties and most scrubber wastewater is discharged into the sea. The scrubber “washes” the exhaust gas but the substances are discharged into the sea with the wastewater. This has raised a lot of controversy among ports, authorities, NGOs as well as the general public since pollution shifts from air to water. Furthermore, the use of scrubbers increases energy consumption adding costs but also CO<sub>2</sub> emissions. At the same time current scrubbers do not meet the future NO<sub>x</sub> requirements and additional end-of-pipe solutions have to be installed.

Leading shipowners should work together with other stakeholders such as researchers and authorities in order develop and set the air emission limit values, as companies otherwise can come around the emissions measurements, in the same way which has happened in the car industry. However, industry will probably not “walk in the same direction” in this regard and it is therefore important to start collaborating with some few leading companies that can show the way for the rest of the industry.

Emissions of NO<sub>x</sub> from shipping in the BSR is still a concern but are expected to fall substantially as the effects of the NECA regulation (NO<sub>x</sub> Emission Control Area) starts to impact from the 2021, where new buildings have to comply with stricter emission requirements. Furthermore, emission of black carbon and particulate matter are a health concern and it is possible that these emissions also will be regulated in the future. At the same time, emission of Green House Gases is of great concern due to the global warming potential. Even though ships are the most energy and carbon efficient mode of transport, shipping is almost 100% dependent on fossil fuels. Another potential for future legislation is regulating the emission of un-combusted methane gas from LNG engines.