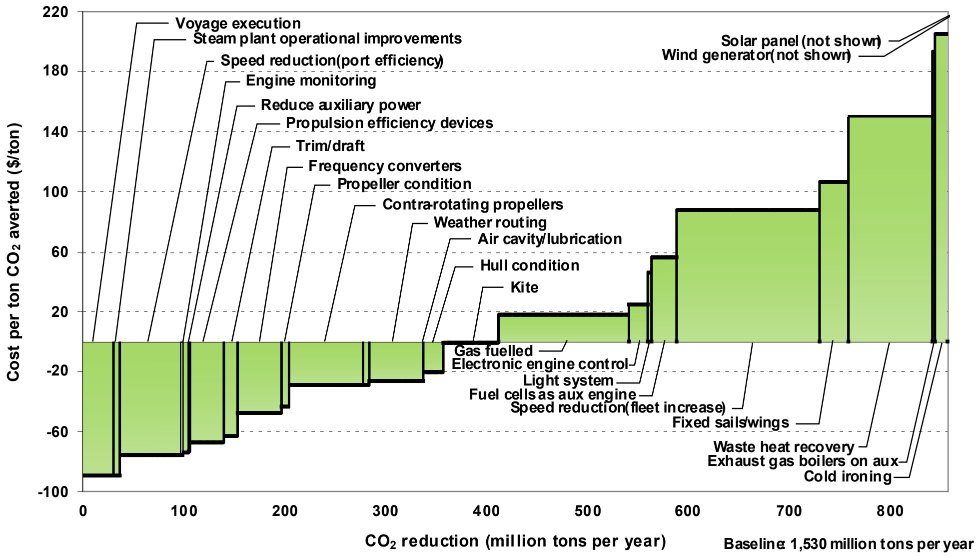
Pathways to low carbon shipping

Abatement potential towards 2030

Average abatement curves for world shipping fleet 2030



Executive summary

In June 2009 DNV issued the first *Pathway to Low Carbon Shipping* which demonstrated the potential to reduce the CO_2 emission of the existing fleet by 15% in a cost efficient manner. In this second *Pathway to Low Carbon Shipping* DNV has analysed the projected fleet in 2030. The study demonstrates that CO_2 emissions by 2030 can be reduced by 30% below baseline in a cost-effective way, and by almost 60% if all the identified measures are included. While there is no single measure which could make it all happen, the aggregated effect of all the measures is significant. This will ensure an industry that operates in a more energy efficient manner and also accepts its share of the common responsibility to reduce CO_2 emissions.

Det Norske Veritas
15 December 2009

MANAGING RISK

Pathways to low carbon shipping

Abatement potential towards 2030

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In June 2009 DNV published the first version of *Pathways to Low Carbon Shipping*[1], looking at what could be done to reduce CO_2 emissions from shipping in 2009. The main finding was that, on the existing fleet, shipping can potentially cut CO_2 emissions by 15% in a cost effective way.

Following up on the first version of *Pathways to Low Carbon Shipping*, this study demonstrates the potential for cutting emissions in the year 2030 by introducing CO_2 emission reductions measures for both the existing fleet and newbuildings in the years to come.

The abatement curves for shipping have been developed based on actual experience gained from energy efficiency studies DNV has undertaken with individual shipowners, as well as literature and industry sources. The work is also based on DNV's own research and technology outlook. [2, 3]

Figure 1 – Average abatement curves for world shipping fleet 2030

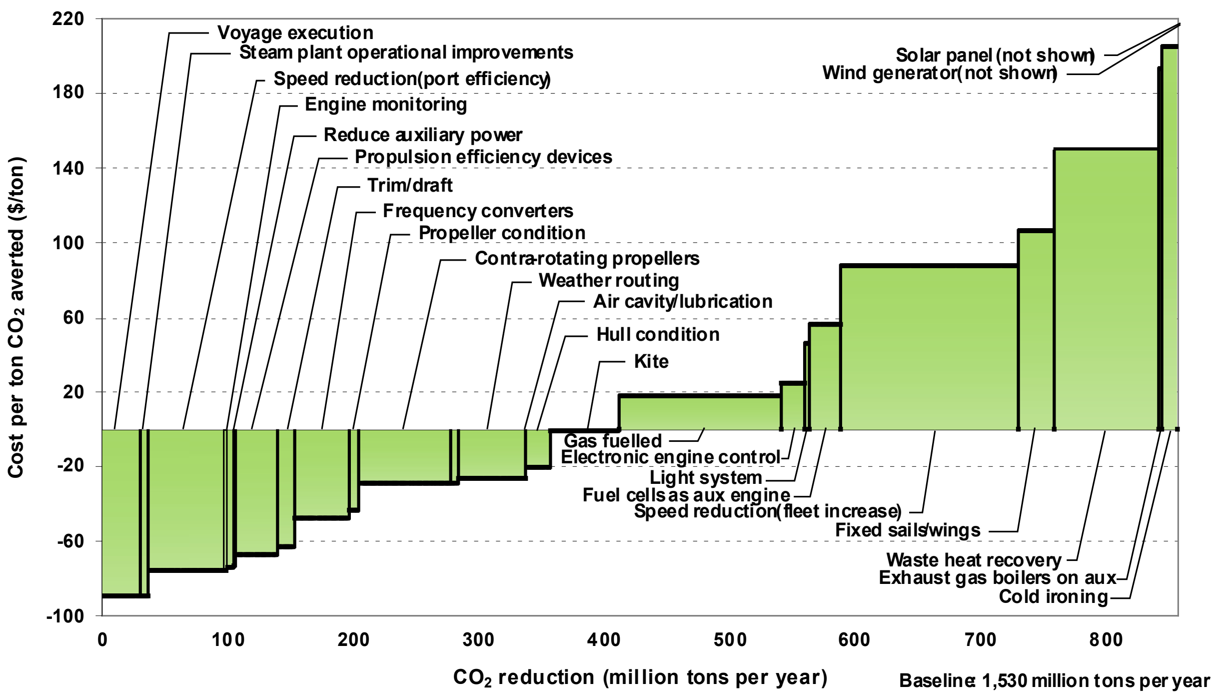


Figure 1 illustrates the reductions achievable by selected emission reducing measures plotted against their estimated cost-effectiveness[4] for the world fleet (see Box on next page for how to read the curves). In total, 25 different measures have been included in the analysis, of which 17 are considered technical measures and 8 operational measures.

The fleet model from the IMO GHG[5] study has been used as a baseline for 2009, and the total CO_2 emissions from the analysed fleet[4] in 2009 are estimated to be 925 MT. The baseline emissions for 2030 are calculated by DNV's scenario model to 1,530 MT, taking into account a significant world fleet growth over the period. DNV's scenario model[3] is built up by every year introducing a set of new vessels and scrapping a number of older vessels. The average modelled fleet growth is 2.3%, which is significantly lower than what has been experienced recently, but in line with long term historical growth. The baseline is a scenario where the measures described in this study are not implemented, and it depends heavily on fleet growth estimates. It is recognised that both lower and higher future scenarios have been reported[2, 5].

How to read the abatement curves?

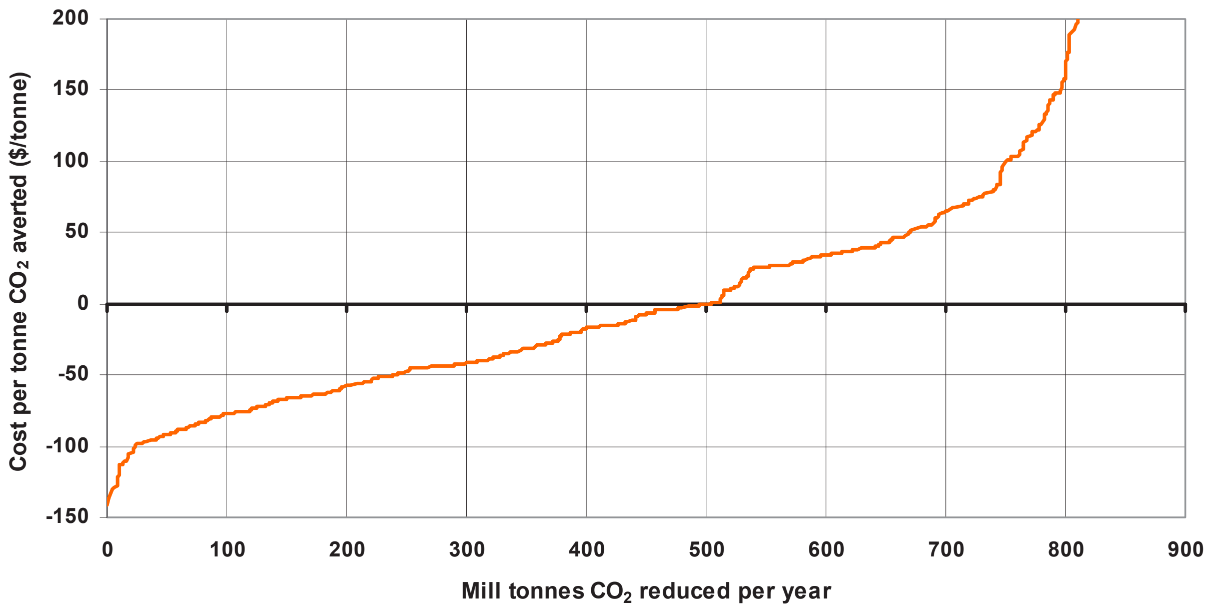
The abatement curves illustrated in Figure 1 summarise the technical and operational opportunities to reduce emissions from the shipping fleet sailing in 2030. The width of each bar represents the potential of that measure to reduce CO_2 emissions from the world feet compared to a baseline scenario. The height of each bar represents the average marginal cost of avoiding 1 ton of CO_2 emissions through that measure assuming that all measures to the left are already applied. In Figure 1 the marginal cost shown is the average cost for all ship segments. The graph is arranged from left to right with increasing cost per tonne CO_2 averted. The effect of the remaining measures decrease as one measure is implemented, and the most cost-effective measures are implemented first.

Where the bars cross the x-axis, the measures start to give a net cost instead of a net cost reduction. Any future carbon cost is not included in the illustration, but will in principle improve the cost-effectiveness of the measures.

Many of the operational and technical measures that have been assessed are available for implementation on existing vessels today and were included in the study of the present abatement potential[2]. Other measures are available for newbuildings that are ordered today. Some of the measures are not yet commercially available on a larger scale, and the model assumes they will be implemented at a later stage, e.g. in 2015 or 2020. The assumptions per measures, regarding reduction, costs, phasing in etc, is based on DNV research and foresight work.

The abatement potential of the individual measures is illustrated in Figure 1. The total results are illustrated in Figure 2, not showing the individual measures.

Figure 2 – Detailed Abatement curves for world shipping fleet 2030



In the DNV analysis, the world fleet has been divided into 59 segments to obtain the total world fleet result in 2030. These 59 segments represent the major shiptypes that constitute the world fleet[6], examples are post-Panamax container vessels, Suezmax tankers and platform supply vessels. Each of these segments has been modelled separately with regard to:

- operational assumptions
- the reduction potential of each measure,
- the cost of each measure
- the year when available measures are phased in

As our research covers 59 different segments, the cost and reduction effects of the different measures vary significantly from one segment to another. The measures modelled are only included for the shiptypes to which they are applicable. As an example container ships normally operate at speeds which mean that kites are not effective.

In Figure 2 the marginal cost and effect of each of the 25 measures are plotted for each of the 59 individual ship segments. The figure therefore consists of the 25*59 datapoints, sorted by increasing marginal cost. Figure 2 thus present the accurate results from the modelling, while Figure 1 focuses on visualising the measures and the methodology.

Table 1 presents some of the main results from Figure 2, focusing on different reduction pathways for the world fleet, highlighting the economic aspect.

Table 1 – Emission reduction and emission level in 2030 for specific abatement cost levels (based on Figure 2)

Abatement cost level [$]	Emission reduction [%]	Emission level [MT]
Baseline	0	1,530
0	33	1,030
35	40	925[a]
70	45	820[b]
100	50	790
All options	56	670

a) equals 2009 emission level
b) equals 2005 emission level

Table 1 shows the abatement cost levels necessary for ensuring a given emission reduction, and the remaining emission level. In order to compensate for the modeled growth of 65% in CO_2 emissions over the 2009-2030 period, all measures that cost below approximately 35 $/ton need to be implemented.

Shipping will depend on carbon-based fuel in the decades to come, and non-conventional fuels, like nuclear, 2nd generation biofuel and hydrogen have not been included in this study as they are not believed to be commercially available on a larger scale until after 2030. Less carbon-intensive fuels are, however, effective to reduce CO_2 emissions from shipping, and most promising one is natural gas.

The relevance to a ship owner

This analysis is primarily designed to support decisions regarding *policy and regulations.* The model used includes the entire world fleet[7] divided into a manageable set of ship segments.

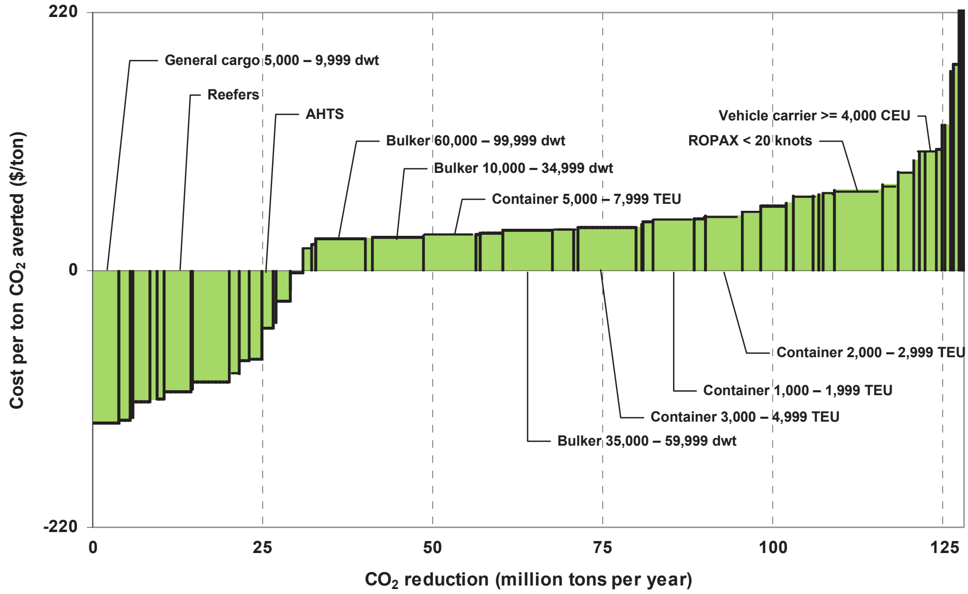
The results presented here represent the average emission reductions for ships within the different segments, modelled for a characteristic (average) ship within each segment. Detailed analysis of individual ships within the same segment might give different emission and cost curves depending on technical and operational aspects, and take into account measures that may a\already have been implemented onboard.

Hence, a ship owner should read the results with care and not expect the results to be directly transferable to own ships or fleet. In the DNV models, individual CO_2 reducing measures can be analysed and the effects and costs may be accurately assessed taking into account specific details of each vessel and the operational patterns.

Along the coast and on the continental shelf of Norway gas-fuelled ferries and supply vessels have been in operation for many years, and gas powered vessels and extension of the gas infrastructure have a significant potential to reduce shipping emissions. Figure 3 illustrates the abatement curves for the various gas powered vessels in the world fleet that are used in the study. No retrofit installation has been included. Similar curves can be developed for the other 24 measures as well.

Figure 3 illustrates that Gas Fuelled Engines are most cost-effective for smaller ships such as reefers and general cargo vessels. The total marginal abatement potential for gas fuelled engines is 125 MT, or 8% of the total emissions in 2030 taking into account all other more cost-effective measures first before switching to gas. For 17 out of the 59 vessel types it is cost-effective to install gas-fuelled engines.

Figure 3 – Abatement curves for Gas Fuelled vessels – all ship segments modelled



What is a *realistic* reduction potential?

This study has estimated the potential reduction in the world fleet's CO_2 emissions, if a set of available measures is implemented. The aim has been to identify the maximum obtainable emission reduction in 2030.

Where emission reduction and sound economic rationale pull in the same direction, widespread implementation of cost-effective measures will occur over time. The rate of uptake of new technology is important; one crucial factor for achieving large reductions fast is the widespread use of technology as soon as it becomes available. Technical and operational measures are considered to be the most effective means of achieving significant reductions in emissions.

Different fiscal measures (e.g. a global fuel levy or emission trading scheme via the IMO) are incentives to enforce faster implementation. Enforcement through regulatory means is necessary to ensure full implementation where one cannot wait for the economic pull to work.

DNV believes carbon neutral growth is a realistic target for what can be achieved through technical and operational measures

In this study DNV has pointed out the costs of meeting specific emission reduction targets. This may serve as an important decision parameter when choosing a pathway for future emissions from shipping.

Conclusions

Predicting future emissions involves significant uncertainty. Important elements include uncertainty in the price and effect of measures, the rate of uptake of new technologies and the fleet growth estimates. However, DNV believe that the single most important uncertainty factor is the fuel price. The fuel price in the years leading up to 2030 will vary significantly. In this study a fuel price of 350 $/t[7] for a standard bunker oil and 500 $/t for a high quality bunker oil has been used. A sensitivity analysis shows that increasing the fuel price to 500 $/t (standard) and 700 $/t (high quality) would increase the cost-effective emission reduction from 500 to 625 MT.

The results in this memo illustrate what can be done with 25 different measures applied to the existing fleet and the newbuildings built in the period 2010 to 2030. The conclusion is that the world fleet has the potential to reduce emissions by 500 MT or 30% below baseline in a cost-efficient way, and by close to 60% if all measures are included. With the expected moderate growth in the shipping fleet, the implementation of most of the measures presented in this study will be necessary to ensure carbon neutral growth from shipping.

DNV believes that the most important technical and operational measures we know today have been included, but other measures can be added to the study to further extend the results. Further, we foresee that many new measures will emerge in the next two decades, and some of them may have a significant effect also before 2030.

The measures included in this study only to a small extent include structural measures, where all counterparts in shipping work together to reduce emissions. Examples of such measures are improved contracts between charterers and shippers and fewer ballast journeys. Structural measures have a significant potential to reduce emissions beyond that described in this study.

If shipping follows the anticipated growth in CO_2 emissions over next twenty years, additional effort beyond the measures included in this study must be implemented to cut the emissions significantly below today's level. While there is no single measure which could make it all happen, the aggregated effect of all the measures is significant. This will ensure an industry that operates in a more energy efficient manner and also accepts its share of the common responsibility to reduce CO_2 emissions. Revolutionary non-carbon based solutions could well be found in the period from 2030 to 2050 continuing the absolute reduction in CO_2 emissions relative to 2009.

References/Footnotes:

1. Pathways to Low Carbon Shipping, DNV Memo to the IMO Secretary General, 9th June 2009
2. The environmental impacts of increased international maritime shipping, past trends and future perspectives. OECD/ITF Global Forum on Transport and Environment in a Globalising World 10-12 November 2008, Guadalajara, Mexico, Endresen, Dalsøren, Eide, Isaksen, Sørgård
3. CO2 emissions form shipping – technical and operational options for emission reduction, DNV and LR, Submission from Norway, MEPC 58/INF.14, October 2008
4. Cost-effeiveness assessment of CO_2 redusing measures in shipping, Maritime Policy & Managmement Journal, August 2009, Eide, Endresen, Skjong, Longva, Alvik
5. Second IMO GHG Study 2009, Update of the 2000 IMO GHG Study, Final report covering Phase 1 and Phase 2, MEPC 59/INF.10.
6. This study considers both the international and domestic fleet, but service vessels (tugs, work boats etc) and fishing vessels are excluded.
7. All costs included in this study refer to 2009 prices

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