Institut für
Seeverkehrswirtschaft
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Climate targets for maritime shipping are hardly achievable

- Ambitious goals, challenges and solutions -

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Content

I List of abbreviations

ABI	Amtsblatt der Europäischen Union (Official Journal of the European Union)
ABS	American Bureau of Shipping (Classification Society)
a.m.	Ante meridiem (Lat.)
Bj.	Build year
BMJ	Bundesministerium der Justiz (Federal Ministry of Justice)
bpb	Bundeszentrale für politische Bildung
BRT/BRZ	Bruttoregistertonne
BV	Bureau Veritas (Classification Society)
CATF	Clean Air Task Force
Cf.	Confer (Lat.)
CH4	Methan
Circ.	Circular
ClassNK	Nippon Kaiji Kyokai (ClassNK) (Classification Society)
CO2	Carbon dioxide
CO2(eq)	Carbon dioxide Equivalent
CCS	Carbon Capture and Storage
dhm	Deutsches Historisches Museum
Mediterranean Shipping Company	
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik
DNV	Det Norske Veritas (Classification Society)
DSC	Data collection system for fuel oil consumption of ships
DVZ	Deutsche Verkehrs-Zeitung
dwt	Deadweight Tonnage
ECA	European Court of Auditors
ed./eds.	Editor / editors
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
e.g.	exempli gratia (Lat.) (for example)
EHRL	Emissionshandelsrichtline (Emissions Trading Directive)
et al.	Et alli (Lat.) (and others)
etc.	Et cetera (Lat.)
EU	European Union
EU-ETS	EU Emissions Trading System
EWR	Europäische Wirtschaftsraum (European Economic Area)
f. /ff.	Following
FiS	Forschungs-Informations-System
FSRU	Floating Storage and Regasification Unit
GCU	Gas Combustion Unit
GHG	Greenhouse Gas
gt	Gross tonnage
HAPAG	Hamburg-Amerikanische Packetfahrt-Actien-Gesellschaf
HFO	Heavy fuel oil
ibid	Ibidem (Lat.) (in the same place)
inwl	Institut für nachhaltige Wirtschaft und Logistik
IMCO	Inter-Governmental Maritime Consultative Organization (Predecessor of the IMO)
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
km	Kilometer
kW	Kilowatt
Lat.	Latin
LFL	Low Flashpoint Liquid
LGIM	Liquid Gas Injection Methanol
LH2	Hydrogen
LNG	Liquified Natural Gas
LOHC	liquid-organic hydrogen carrier
LR	Lloyd's Register (Classification Society)
m	Meter
MAN ES	MAN Energy Solutions
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MEPC	Marine Environment Protection Committee
Mio.	Million/Millionen
MGO	Marine gasoil
MRV	Monitoring, Reporting, and Verification
MSC	Maritime Safety Committee
MW	Megawatt
n.a.	(Author) not available
n.d.	No date
NOx	Nitrogen oxides
Nr	Number
N2O	Nitrous oxide
p.	Page
p.a.	per annum (Lat.) (per year)
para.	Paragraph
PIK	Potsdam-Institut für Klimafolgenforschung
Pkt.	Punkt
p.m.	post meridiem (Lat.)
PwC	Pricewaterhouse Coopers GmbH
Reg. Nr.	Register Nummer
prm	revolutions per minute
SEEMP	Ship Energy Efficiency Management Plan
t	tons
Tab.	Table
TEU	Twenty-foot Equivalent Unit
THB	Täglicher Hafenbericht
tpa	Tonnes per Annum (Tonnen pro Jahr)
t/m	Tons per Mile
TTW	Tank-to-wheels
UBA	Umweltbundesamt (Federal Environment Agency)
UN	United Nations
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
VDR	Verband Deutscher Reeder (German Shipowners' Association)
VLAC	Very Large Ammonia Carrier
WEF	World Economic Forum
WMO	World Meteorological Organization

0 Introduction

The world's oceans have always been an important transportation route for mankind. With the advent of propulsion technologies in maritime transport based on the combustion of fossil fuels, an enormous increase in transport performance began, which enabled continuity in the operation of routes due to reduced dependence on wind and weather.

Compared to the steam-powered ships that still predominated at first (which required huge coal bunkers, engine rooms and armies of stokers), ships powered by liquid bunker fuels required little fuel in terms of volume and hardly any space for the engines, which created more room for payload. Due to the high labour intensity, but above all due to the significantly lower efficiency of steam propulsion with fossil coal[1] the maritime transport sector finally switched to diesel engines using heavy fuel oil or distillates. The triumphant advance of the marine diesel engine had begun.

1 Focus on climate emissions from maritime shipping

The diesel engine has revolutionized international shipping and led to an enormous increase in performance. Worldwide maritime traffic has risen continuously (with the exception of a few years). In 1999, around 5.91 billion tons were transported by sea with a transport capacity of 28.99 trillion tons.[2] 25 years later, Clarkson estimates (in 2023) that a good 12.37 billion tons were transported, which corresponds to a transport capacity of 62.31 trillion tm.[3] This means an increase of 114.9% in transport volume and 109.2% in transport performance from 1999 to 2023 (average annual growth of 3.2% and 3.1% respectively). In the same period, the world population rose from 6.09 billion people[4] in 1999 to 8.06 billion people in 2024 [5]. This corresponds to an average annual increase of just under 1.2%. This means that both transport volumes and transport performance have risen much faster than population growth. Around 80% of global trade is currently transported by sea[6] and of around one third of global shipping movements, the port of destination or departure is in the EU. Shipping therefore has a considerable impact on the environment, the climate and ultimately on flora, fauna and people through the pollutants it emits. The emission of air pollutants is one of the many environmental impacts. The reduction of these environmental impacts and the improvement of environmental protection in shipping is widely referred to as “green shipping” and has become increasingly important in recent decades. In this context, there have been and continue to be numerous activities at international, European and national level to counteract these effects on the environment.

As the size and speed of ships has increased, so has concern about the environmental damage they cause, particularly their negative contribution to climate change. In the last 50 years, maritime transport alone has consumed just under 8 billion tons[7] of bunker oil for ship propulsion worldwide, resulting in emissions of around 25 billion tons of CO_2. According to Statista, the annual CO_2 emissions caused by international shipping have doubled since 1970 compared to 2022 (1970: 353.8 million tonnes; to 2022: 709.7 million tonnes of CO_2).[8] However, the above-mentioned emission volumes only

1) Cf. Berg, F.; et al.; Schiffmaschinen, with further references, For example, the thermal efficiency of piston steam engines at their peak was 13%, and the efficiency of high-pressure boilers with 70 atü and 460°C was 17% higher
2) Cf. n.a.; Clarkson (ed.); Seaborne Trade Monitor - World Seaborne Trade Summary (Tab. 1: million tonnes; Tab. 2: trillion tonne miles)
3) Cf. n.a.; 2023 Shipping Market Review - Shipping Intelligence Weekly, 05 January 2024, https://cyprusshippingnews.com/wp-content/uploads/2024/01/Annual-Review-2023-Analysis.pdf, accessed on 23.08.2024 11:57
4) Cf. n.a.; UN (ed.); World Population Prospects 2024, United Nations DESA / Population Division, File GEN/01/REV1: Demographic indicators by region, subregion and country, annually for 1950-2100
5) n.d.; UN (ed.); World Population Prospects 2024 (file GEN/01/REV1: Demographic indicators by region, subregion and country, annual for 1950-2100
6) n.a.; bpb (ed.); Globalisierung - Seefracht; Reported on: 24.09.2024; according to other figures, 90% and more of the weight of goods in cross-border trade in goods is transported by sea. Cf. n.d.; FiS (ed.); Efficient maritime transport as a driving force of globalization; as at: 12.06.2024
7) Own calculations, based on data from IEA (ed.); World deliveries of oil products to international marine bunkers for selected regions, 1972-2019; update of 30 July 2021 and data from Statistica.com for the years 2020-2021 and shipandbunker.com for the years 2022-2023 (in total 7.921 billion tonnes)
8) Cf. n.a.; Statista.com (ed.); Development of CO_2 emissions from global shipping in the years 1970 to 2022; Reported on: 17.07.2024; It should be noted that for a balanced assessment, however, the emission quantities must be related to the transport performance provided (for example in the unit tonne-kilometre).

represent the direct CO_2 emissions from shipping from the tank to the 'propeller' (based on a TTW analysis) and do not yet take into account the associated emissions from the production of the consumed propulsion fuels (based on a WTW analysis). In addition, other greenhouse gas emissions (besides CO_2) such as methane (CH_4), nitrous oxide (N_2O), etc. (which are categorised as greenhouse gases under the Kyoto Protocol) have not yet been taken into account.[9] Despite low emission volumes, these contribute significantly (by a factor of 28 for methane and 265 for nitrous oxide as CO_2 equivalent)[10] to the group of greenhouse gases emitted by shipping. A consideration of greenhouse gas emissions based on lifecycle emissions[11] leads to a further increase in the annual greenhouse gas emissions actually caused by this transport sector for shipping, as an estimate by the Japanese classification society ClassNK from 2023 for the years 2018 and 2021 shows. According to this, the life cycle emissions from shipping (based on WTW including CO_2 equivalents) are estimated at approx. 731 million tonnes of $CO_{2(eq)}$ for 2008 and 798 million tonnes $CO_{2(eq)}$ in 2021.[12]

The climate gases produced by shipping are increasingly in the public eye. By 2023, for example, almost 8 billion tonnes of bunker oils (such as HFO, MDO, MGO including LPG and LNG) will have been burned for ship propulsion in the last 50 years, resulting in emissions of around 25 billion tonnes of CO_2 alone.

2 IMO already committed to reducing greenhouse gases under the Kyoto Protocol

Due to increasing warnings from scientists worldwide about the associated risks[13], the topic of 'climate change' was institutionalised through the creation of a World Climate Conference (WCC), which made its debut in Geneva in 1979[14]. Climate change was officially 'recognised' at the second World Climate Conference in Toronto in 1988.[15] The final communiqué of the climate conference emphasised that the dangers to the Earth's atmosphere were already so serious that immediate action was essential.[16] Four years later, at the 1992 World Summit on Environment and Development in Rio de Janeiro, 154 countries signed the United Nations Framework Convention on Climate Change (UNFCCC)[17], which came into force as a multilateral agreement in 1994. With the Framework Convention on Climate Change, the international community recognises global climate change as a serious problem and commits itself to action. Three years later, in December 1997, the Kyoto Protocol agreement directly addressed the IMO to continue limiting greenhouse gases in accordance with Article 2 (2).[18]

In the same year as the establishment of the Marine Environment Protection Committee (MEPC),[19] the IMO adopted the International Convention for the Prevention of Pollution from Ships (MARPOL)[20] in 1973, which sets standards for minimising pollution from both operational activities and accidents, including oil pollution, sewage and air emissions. The MARPOL Convention has been updated over the years with amendments to take account of various environmental concerns relating to shipping. In the year the Kyoto Protocol was adopted (1997), Annex VI (on air pollution) was added (but did not enter

9) Cf. n.a.; UNFCC (ed.); The Kyoto Protocol to the United Nations Framework Convention on Climate Change; n.d.; there Annex A; p. 28;
10) Cf. Myhre, G. (et al.); IPCC (ed.); Climate Change 2013 – The Physical Science Basis; Chapter 8 - Anthropogenic and Natural Radiative Forcing; Tab. 8.7, p. 714
11) Cf. n.a.; IMO (ed.); Resolution MEPC 376(80); Guideline on Life Cycle GHG Intensety of Marine Fuels (LCA Guidelines); MEPC 80/17/Add. 1; Annex 14
12) Cf. n.a.; Pathway to Zero-Emission in International Shippin – Understanding the 2023 IMO GHG Strategy, P. 3; 2023; https://www.classnk.or.jp/hp/pdf/info_service/ghg/PathwaytoZero-EmissioninInternationalShipping_ClassNK_EN.pdf; accessed on 30.08.2024; 17:15
13) See, among others, J. Hansen et. Al (1981) Climate Impact of Increasing Atmospheric Carbon Dioxide and: Broecker, W. S.; Climatic Change: Are We on the Verge of Pronounced Global Warming?; 1975
14) Cf. n.a.; WMO (ed.); Declaration of the World Climate Conference, Geneva, 1979; https://dgvn.de/fileadmin/user_upload/DOKUMENTE/WCC-3/Declaration_WCC1.pdf; accessed on 26.08.2024; 16:10
15) Cf. n.a.; WMO (ed.); Proceedings, World conference, Toronto, Canada; https://digitallibrary.un.org/record/106359?ln=en&v=pdf; accessed on 26.08.2024; 16:15
16) See n.a.; WMO (ed.); Proceeding Acts - The Changing Atmosphere, 1988, Toronto (Canada); p. 296
17) Cf. n.a.; UN (ed.); United Nations Framework Convention on Climate Change (UNFCC), 1992
18) Cf. n.a.; UNFCC (ed.); The Kyoto Protocol to the United Nations Framework..., ibid., p. 4
19) Cf. n.a.; IMCO (ed.); IMCO Resolution A.297(VIII); Establishment of a Marine Environment Protection Committee; https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.297(8).pdf; accessed on 03.09.2024; 14:20
20) Cf. n.a.; IMO (ed.); International Convention for the Prevention of Pollution from Ships (MARPOL)); https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx; accessed on 29.08.2024; 16:00

into force until 2005),[21] which has continued to be amended to the present day.[22] The Marine Environment Protection Committee (MEPC), founded in 1973 as a subsidiary body of the General Assembly, was granted constitutional status in 1985 and has since functioned as a Conference of the Parties,[23] which can decide on modifications and additions to MARPOL.[24] Initially, however, the IMO focussed strongly on reducing or limiting air pollutants such as sulphur dioxide, nitrogen oxides and particulate matter[25], and on preparing studies.

Following the establishment of the Marine Environment Protection Committee (MEPC), the IMO adopted the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1973. However, it took almost another quarter of a century before the Kyoto Climate Change Conference in 1997 for the IMO to address the issue of limiting greenhouse gases produced by shipping.

3 The IMO's long road to a climate strategy

In 2000, the IMO published its first study on greenhouse gas emissions from shipping, which estimated that international shipping contributes 1.8% of man-made CO_2 emissions.[26] By 2020, three further studies on the same topic, each updated by the IMO, followed in 2009, 2014 and 2020[27] with increasing shares to ultimately 2.89% of CO_2 emissions (for 2018) attributed to shipping[28]. The most recently outlined possible future scenarios assume a further increase in the coming decades.

As early as 2003, the IMO General Assembly mandated the Marine Environment Protection Committee (MEPC) with Resolution A.963(23) to develop mechanisms to reduce greenhouse gas emissions from ships. However, it was not until 2011 that the IMO adopted the first internationally binding measures to improve the energy efficiency of ships with MEPC Resolution 203(62)[29] by means of a regulation on the Energy Efficiency Design Index (EEDI), which was, however, only addressed to new ships. Regulations on the SEMP and EEOI followed.[30] However, all of these measures were only classified by the IMO as technical and operational reduction measures[31] and did not yet represent a strategy for reducing greenhouse gases in the maritime sector. In April 2013, the European Commission presented the EU strategy for adapting to climate change as part of a strategy package[32] and proposed in early 2014 to set a reduction target of 40% by 2030 compared to 1990 levels for the EU's internal greenhouse gas emissions.[33] Back in December 2015, the international community adopted the Paris Agreement (at the UN Climate Change Conference (COP 21) with 195 countries and the European

21) Cf. IMO (ed.); International Convention for the Prevention of Pollution ..., ibid.
22) See with further references above; IMO (ed.); Index of MEPC Resolutions and Guidelines related to MARPOL Annex VI; n.d..; https://www.imo.org/en/OurWork/Environment/Pages/Index-of-MEPC-Resolutions-and-Guidelines-related-to-MARPOL-Annex-VI.aspx; accessed on 29.08.2024; 16:35
23) Cf. n.a.; IMO (ed.); Convention on the International Maritime Organization; https://www.imo.org/en/About/Conventions/Pages/Convention-on-the-International-Maritime-Organization.aspx; accessed on 29.08.2024; 17:00
24) Cf. n.a.; UBA (ed.); Further relevant international agreements and arrangements; Report Number 3553 of 22.12.2014; https://www.umweltbundesamt.de/themen/nachhaltigkeit-strategien-internationales/arktis/rechtlicher-institutioneller-rahmen-der-arktis/weitere-relevante-internationale-abkommen; accessed on 29.08.2024; 16:30
25) The regulations for nitrogen oxides were included in Regulation 13 and those for sulphur dioxide and particulate matter in Regulation 14 of the MARPOL Annex VI regulations. The regulations have been continuously updated over the decades.
26) Cf. IMO (ed.); Study of Greenhouse Gas Emissions from Ships; 2000; https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/First%20IMO%20GHG%20study.pdf; accessed on 25.08.2024; 22:30
27) Cf. IMO (Ed.); Second IMO GHG Study 2009; and: n.a., IMO (Ed.); Third IMO GHG Study 2014; and Faber, J., (et al.); Fourth IMO GHG Study; 2020.
28) Cf. n.a.; IMO (ed.); Reduction of GHG Emissions from Ships; Fourth IMO GHG Study 2020 – Final Report; Summary; Annex 1, P. 1; Publ. MEPC 75/7/15
29) Cf. n.a.; IMO (ed.); Resolution MEPC 203(62) – MEPC 62/24/Add.1 – Annex 19; https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Technical%20and%20Operational%20Measures/Resolution%20MEPC.203%2862%29.pdf; accessed on 29.08.2024; 22:45
30) Cf. n.a.; IMO (ed.); Resolution MEPC 213(63) – 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP); MEPC 63/23, Annex 9; which has been expanded many times since then; and: see n.a.; MEPC (ed.); MEPC.1/Circ. 684; Guidelines for Voluntary use of the Ship Energy Efficiency Indicator (EEOI)
31) See n.a.; MEPC (ed.); Report of the Committee for the Protection of the Maritime Environment on the 59 Session; p. 33, No. 4.41; MEPC 59/24, of 27.07.2009
32) Cf. n.a.; European Commission (ed.); Communications from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions; An EU Strategy on Adaptation to Climate Change; COM(2013) 216 final; of 16.4.2014
33) Cf. n.a.; European Commission (ed.); Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A framework for climate and energy policy 2020-2030; COM(2014) 15 final of 22.01.2014; there: 2.1 Greenhouse gas emissions target, p. 6[34]) Cf. n.a.; UN (ed.); Paris Agreement; 2015; https://unfccc.int/sites/default/files/english_paris_agreement.pdf; accessed on 26.08.2024; 17:35

Union) to limit global warming to well below 2˚C compared to pre-industrial times and to make efforts to limit it to 1.5˚C.[34] In order to contribute to this ambitious goal with maritime shipping, the IMO adopted its own (provisional) strategy for reducing greenhouse gas emissions for the first time in April 2018 with MEPC Resolution 304(72), which aims to reduce greenhouse gas emissions from shipping by at least 50% by 2050 compared to 2008 levels.[35] The achievement of climate neutrality in shipping was set by the IMO for the year 2100 and confirmed by the VDR.[36]

In October of the same year, the IMO approved a follow-up program through MEPC 73, which served as a planning tool to define short-term measures (until 2023) and set a time frame for medium-term measures until the end of 2030 and long-term measures beyond 2030.[37] In July 2021, however, the EU published significantly more ambitious targets with the "Fit for 55" program, which are based on the European Climate Law (Regulation (EU) 2021/1119) adopted the previous month[38]. The "package" is intended to achieve the target set out in the European Climate Law of reducing greenhouse gas emissions in the EU by at least 55% by 2030 compared to 1990 levels and making Europe climate-neutral by 2050.[39]

The IMO had thus fallen well short of its 50% target of decarbonization by 2050. The VSM had therefore accused the IMO of "coasting" on climate protection.[40] However, in July 2023, the IMO member states finally adopted Resolution 377(80), the IMO Strategy 2023 to reduce greenhouse gas emissions from ships with significantly more stringent targets to combat harmful greenhouse gas emissions with the ambitious goal of achieving net-zero emissions by 2050[41]. This brought the IMO into line with EU requirements.

This was followed shortly afterwards in September 2023 by the adoption of EU Regulation 2023/1805 on the use of renewable and low-carbon fuels in maritime transport (also known as FuelEU Maritime), which will come into force in the EU from 2025.[42] The EU regulation stipulates that the average amount of greenhouse gases (GHG) generated by a ship's energy consumption per year must not exceed a specified limit. The limit value will be successively reduced in six stages by an initial 2% in 2025 to 80% in 2050. In addition, from 2030, ships that dock for more than two hours at a berth on the Trans-European Transport Network (TEN-T) must use shore-side electricity or emission-free technologies such as energy storage or on-board power supply from wind, solar or fuel cells. The EU has thus once again intensified its efforts to achieve climate neutrality by 2050 compared to the IMO's endeavours.

Following the adoption of the Kyoto Protocol in 1997, the IMO's focus until well into the present day was essentially solely on reducing air pollutants and conducting greenhouse gas studies. The climate neutrality of the industry was initially postponed until the end of the 21st century. Only the EU's massive efforts to achieve climate neutrality by the middle of the century led to a reorientation of the IMO's goals with the adoption of a climate strategy to achieve climate neutrality in maritime transport by 2050.

34) Cf. n.a.; UN (ed.); Paris Agreement; 2015; https://unfccc.int/sites/default/files/english_paris_agreement.pdf; accessed on 26.08.2024; 17:35

35) Cf. n.a.; IMO (ed.); Resolution MEPC 304(72); Initial IMO Strategy on Reduction of GHG Emissions from Ships; there: Level of Ambition and Guiding Principles, Point 3.1.3, p. 35

36) Cf. n.a.; VDR (ed.); IMO on course for concrete CO_2 reduction measures; Report from: 15.11.2019; https://www.reederverband.de/de/imo-auf-kurs-fuer-konkrete-co2-reduktionsmassnahmen; accessed on 30.08.2024; 14:45

37) See n.a.; IMO (ed.); Marine Environment Protection Committee (MEPC 73) approves programme to follow up on the initial IMO strategy on the reduction of greenhouse gas emissions from ships; Reported on: 22.10.2018; see also: MEPC 73/19; Report of the Marine Environment Protection Committee on its seventy-third session, 26.10.2018, Section 7, Reduction of greenhouse gas emissions from ships, p. 35 ff.

38) Cf. n.a.; EUR-lex (ed.); Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (European Climate Law)

39) Cf. n.a.; European Council (ed.); 'Fit for 55'; n.d.

40) Cf. n.a.; Tagesschau (ed.); Klimaneutral bis 2050 "oder kurz danach"; from: 07.07.2024 02:25pm; https://www.tagesschau.de/wirtschaft/weltwirtschaft/imo-schifffahrt-klima-100.html; accessed on 30.08.2024; 11:30

41) Cf. n.a.; IMO (ed.); Resolution MEPC 377(80); 2023 IMO Strategy on Reduction of GHG Emissions from Ships; there 3.3.4, p. 6; https://wwwcdn.imo.org/localresources/en/MediaCentre/PressBriefings/Documents/Resolution%20MEPC.377(80).pdf; MEPC 80/WP.12; Annex 1; abgerufen am 26.08.2024; 16:50

42) Cf. n.a.; OJ (ed.); Regulation (EU) 2023/1805 of the European Parliament and of the Council of 13 Sept. 2023 on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC; in OJ: L 234/48 of 22.09.2023

4 Fleet expansion with alternative fuels

The decision by the EU and the IMO to achieve climate neutrality for maritime transport by 2050 has also resulted in the adoption of interim targets by both organisations. In international maritime transport, the IMO aims to achieve a reduction in greenhouse gas emissions of at least 20% by 2030 (the target is 30%) compared to the emissions caused by shipping in 2008.[43] For the year 2040, the reduction level should be at least 70 % according to IMO guidelines (the target is 80 %).[44]

To achieve the interim targets, the stakeholders have taken accompanying measures to improve the empirical data situation (e.g. through EU Regulation 2015/757 on the monitoring of carbon dioxide emissions from maritime transport (MRV)[45] and MEPC Resolution 278(70) on the data collection system for fuel oil consumption of ships [DSC][46]) and to influence the quantity of greenhouse gas emissions in such a way that the reduction targets are achieved in total (e.g. through regulations on EEDI[47], EEXI[48], CII[49] etc.).

At the same time, by amending the Emissions Trading Directive (ETSD) in May 2023, the EU decided to include maritime transport in emissions trading (EU ETS 1) from 2024[50], which will lead to a gradual increase in the price per tonne of fuel used for ship operators on European destinations[51]. However, neither the EU nor the IMO have specified which individual measures the players must take to achieve the desired reduction targets. This is also reflected in the heterogeneous mix of shipowners, who on the one hand pursue fuel-reducing measures through optimisation in shipbuilding and operation, e.g. by reducing resistance, increasing efficiency and measures in operation (slow steaming or ultra-slow steaming)[52], but also rely on the use of alternative fuels, which ultimately have to be climate-neutral. When it comes to the fuel of the future, however, there is a great deal of uncertainty in the industry.[53]

LNG dual-fuel operation

An analysis of the fleet based on the ship engines used (based on data from Clarkson) shows that by mid-2024, 1,409 ships (corresponding to 116.8 million tonnes) worldwide will be able to operate with alternative fuels such as LNG, ethane, ammonia, hydrogen, methanol, biofuel and nuclear propulsion, or in combination as dual fuel. At 78.3%, ships that can be operated with LNG account for the largest share. The use of LNG fuel in ship propulsion is often viewed favourably as a bridging technology.[54] The order backlog also included 1,442 ships with alternative fuels (116.8 million tonnes), of which 942 ships are listed for the use of LNG. This still corresponds to a good 65.3% (85.7 million tonnes) of ships (including LNG) with alternative fuel propulsion. However, engine manufacturer MAN expects a

43) Cf. n.a.; IMO (ed.); Resolution MEPC 377(80); 2023 IMO Strategy, ibid.; Nr. 3.4.1, p. 6
44) Cf. ibid, Nr. 3.4.2, p. 6
45) Cf. n.a.; OJ (ed.); Regulation (EU) 2015/757 of the European Parliament and of the Council on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport and amending Directive 2009/16/EC
46) Cf. n.a.; MEPC (ed.); Resolution MEPC 278(70); Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 relating thereto – Amendments to MARPOL Annex VI (Data collection system for fuel oil consumption of Ships; MEPC 70/18/Add. 1, Annex 3
47) Cf. n.a.; MEPC (ed.); Resolution MEPC.364(79); 2022 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI for New Ships; MEPC 79/15/Add.1 Annex 9
48) Cf. n.a.; MEPC (ed.); Resolution MEPC 334(76); 2021 Guidelines on Survey and Certification on the Attained Energy Efficiency Existing Ship Index (EEXI); MEPC 76/15/Add.2; Annex 8
49) Cf. n.a.; MEPC (ed.); Resolution MEPC.339(76); 2021 Guidelines on the Operational Carbon Intensity Rating of the Ships (CII Rating Guidelines, G4); MEPC 76/15/Add.2; Annex 13
50) Cf. n.a.; ABI (ed.); Directive (EU) 2023/959 of the European Parliament and of the Council amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 establishing and operating a market stability reserve for the scheme for greenhouse gas emission allowance trading within the Union; Official Journal of the European Union; L130/134; https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32023L0959; accessed on 03.09.2024; 10:00
51) Cf. Hollmann, M.; DVZ (ed.); Warum CO_2-Emissionen in der Schifffahrt zum Kostenfaktor werden; message f.: 13.12.2022; https://www.dvz.de/unternehmen/see/detail/news/warum-co2-emissionen-in-der-schifffahrt-zum-kostenfaktor-werden.html; accessed on 08.09.2024; 22:45
52) Cf. Hübscher, A., Ansätze zur Realisierung von Green-Shipping, in Maritime Wirtschaft – Theorie, Empirie und Politik – Festschrift zum 65. Geburtstag von Manfred Zachcial, 2010, p. 177 f.
53) Cf. n.a.; VDR (ed.); Auf Kurs Klimaneutralität; in: Deutsche Seeschifffahrt; 01/23, p. 37; https://www.reederverband.de/sites/default/files/publikationen/deutsche_seeschifffahrt/deutsche_seeschifffahrt_-_ausgabe_q1-2023.pdf; accessed on 04.09.2024; 16:20
54) See, among others: n.a.; DVZ (ed.); LNG als Treibstoff: Schifffahrt braucht viel Zeit; message f.: 18.06.2019; as well as: n.a.; IHK-Nord (ed.); FuelEU Maritime - Nutzung karstoffarmer Treibstoffe in der Schifffahrt; as well as: n.a.; Wissenschaftlicher Dienst (WD 8) - Deutscher Bundestag; Maßnahmen zur Minderung von Emissionen in der Schifffahrt; Status: 04.05.2018; p. 13 with further references

significant decline in order numbers in the LNG sector, as it estimates that LNG will only account for around 23% of the power ordered for 2-stroke engines by 2030.[55]

In terms of marine fuel, LNG is still a niche market. In 2023, LNG bunker sales in the three major bunker transhipment centres (Singapore, Rotterdam and Fujeira) were still at 0.39 million tonnes and had increased to almost 0.42 million tonnes by the first half of 2024 alone.[56] This corresponds to a good doubling in 2024 compared to the previous year. The share of current LNG bunker sales at the world's three largest bunkering centres still averages 1.2% and has doubled compared to 2023. However, the sale of (climate-neutral) bio-LNG has so far only reached a marginal volume of just under 1,000 tonnes. Critics, such as the International Council on Clean Transportation, argue that the use of LNG does not contribute to the reduction of greenhouse gases overall, as methane emitted along the supply chain and during combustion has a far more damaging effect on the climate than the carbon dioxide saved.[57] However, according to a current study by the ICCT from 2024, the methane slip (caused in particular by 4-stroke engines) when using LNG is significantly greater than previously thought.[58]

In addition, the type of gas extraction in the case of fracking, as well as the energy required for cooling for compression and any boil-off during transport, are increasingly coming into focus. This makes the alternative use of LNG a climate-damaging option.[59] In the US, this led to President Biden requesting in Jan. 2024 that additional exports of LNG to countries without free trade agreements be paused so that the Department of Energy could review their energy costs, America's energy security and the impact on the environment.[60]

Methanol-Dual-Fuel

In 2015, the Stena Line ferry Germanica became the first ferry in the world to successfully operate on methanol after being converted to dual-fuel operation.[61] Since December 2020, the adoption of an IMO guideline for the use of methyl/ethyl alcohol has provided a clear set of rules for the use of methanol as a marine fuel.[62] The classification societies also have regulations on bunkering.[63] At 30 ships (1.2 million tonnes) worldwide, the current operation of ships using methanol is still more than manageable. However, the order backlog shows a rapid development with 246 ships (18.8 million tonnes). Engine manufacturers are offering 4-stroke and 2-stroke engines as dual-fuel engines that can run on methanol or have announced them for 2025 and 2026. The Danish shipping company A.P. Møller-Mærsk is using the world's largest 2-stroke dual-fuel methanol engine in ship operation with the container ship ANE MAERSK (16,592 TEU), which was completed in Jan. 2024. From the outside, the ship differs from conventional container freighters because the tanks for methanol require more space than when operating with MGO, so the bridge is located at the very front of the bow.[64] In the coming years, Maersk plans to put another 24 container ships with methanol propulsion into operation.[65] Hapag Lloyd and Seaspan convert five container ships of 10,000 TEU each to methanol propulsion.[66] Engine manufacturer MAN expects methanol to account for around 35% of the power ordered for 2-stroke engines by 2030.[67]

55) Cf. Hansel, G.; Heise.de (ed.); Klimaneutrale Schifffahrt: Im Fahrwasser von Ammoniak und Methanol; message f.: 04.04.2024; https://www.heise.de/news/Schifffahrt-Ammoniak-oder-Methanol-was-kommt-nach-dem-Schweroel-9674269.html; accessed on 05.09.2024; 14:45

56) Own calculations based on bunker sales from the ports of Singapore, Rotterdam and Fujeira

57) Cf. Pavlenko, N. (et al.); International Council on clean Transport (ed.); The climate implications of using LNG as a marine fuel; 2020

58) Cf. n.a.; Hansa (ed.); Methanschlupf bei LNG-Schiffen größer als gedacht; message f.: 26. Jan. 2024

59) Cf. Howarth, R. W.; The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States; Energy Sci. Eng. 2024;1–17

60) Cf. Gardener, T.; Reuters (ed.); Biden pauses LNG export approvals after pressure from climate activists; message from 26. Jan. 2024

61) Cf. Prospich, P.; Methanol – der unterschätzte Kraftstoff; message f.: 15.05.2021; https://veus-shipping.com/2021/05/methanol-der-unterschaetzte-kraftstoff/; accessed on 06.09.2024; 12:00

62) Cf. n.a.; MSC (ed.); Interim Guidlines fort the Safety of Ships using Methyl/Ethyl Alcohol as Fuel; 2020; MSC.1/Circ. 1621

63) Cf. n.a.; ABS (ed.); Methanol Bunkering: Technical and operational Advisory; 2024; https://ww2.eagle.org/content/dam/eagle/advisories-and-debriefs/methanol-bunkering-advisory.pdf; accessed on 05.09.2024; 14:15

64) Cf. n.a.; NDR (ed.); Methanol-betriebener Frachter "Ane Maersk" erstmals in Hamburg; From 28.03.2024

65) Cf. n.a.; Maersk (ed.); Maersk to deploy first large methanol-enabled vessel on Asia - Europe trade lane; message f.: 07.12.2023

66) Cf. n.a.; Hapag-Lloyd (ed.); Hapag-Lloyd und Seaspan rüsten fünf Schiffe auf Methanol-Antrieb um; Press release from 16.04.2024

67) Cf. Hansel, G.; Heise.de (ed.); Klimaneutrale Schifffahrt; ibid; https://www.heise.de/news/Schifffahrt-Ammoniak-oder-Methanol-was-kommt-nach-dem-Schweroel-9674269.html; accessed on 05.09.2024; 14:45

A major advantage of using methanol as a fuel is that existing tank storage concepts for HFO and/or MDO/MGO can be used in new builds and for retrofitting. However, an adapted dimensioning of the fuel tanks (with the same range by a factor of 2.4)[68] is necessary due to the comparatively lower energy content compared to conventional fuels.[69]

However, the number of users of methanol as a marine fuel will also increase due to the possibility of conversion, as MAN, for example, as the largest supplier of marine engines, will offer a methanol retrofit for four-stroke engines of the 48/60 engine series to methanol dual-fuel operation from 2025.[70] The use of methanol-based fuel cells in the maritime sector, on the other hand, is still in the development and test phase, which is why there are currently only a few projects.[71]

Ammonia dual-fuel operation

Ammonia fuel is receiving a great deal of attention worldwide in the endeavour to reduce greenhouse gases. As the world's largest marine engine manufacturer, MAN expects ammonia to account for around 40% of the power ordered for 2-stroke engines as early as 2030.[72] In the long term, MAN ES expects ammonia to make up around 35% of the fuel used in large merchant ships by 2050.[73] However, no ships with ammonia propulsion are currently registered in the merchant fleet. This is different in the current order book (beginning of Sept. 2024): 26 merchant ships and two tugs were already listed here (based on data from Clarkson Research) with primarily 25 orders for bulk carriers and the feeder container ship *Yara Eyde* (capacity 1,400 TEU).

In addition to MAN, Swiss engine manufacturer WinGD announced that it will deliver its first ammonia-powered marine engine for the propulsion of a liquefied petroleum gas and ammonia tanker (for Exmar LPG) in 2025.[74]

When using ammonia as a future marine fuel, the aim of engine manufacturers is to optimise or design the combustion process in the engines in such a way that any nitrous oxide emissions (due to their high GWP) are negligible. In addition, engine slip must be strictly limited.[75] As with methanol operation, ammonia operation will also require an adapted dimensioning of the fuel tanks (here by a factor of 2.8 to 3.4) [76] (due to the comparatively lower energy content of ammonia compared to conventional fuels).

Fuel cells

After more than ten years of development work, the IMO's Maritime Safety Committee (MSC) adopted a safety regulation for the authorisation of ships with fuel cell propulsion in mid-2022[77]. This has created the framework conditions for a broad application in commercial shipping in order to realise emission-free shipping with efficient energy converters and climate-neutral fuels and to enable a successful market ramp-up for the use of fuel cell systems in the maritime sector.[78] Fuel cells are therefore regarded as the technology of the future.[79] Conceptually, fuel cells can be divided into low-temperature fuel cells (which are usually operated with pure hydrogen) and high-temperature fuel

68) Cf. n.a.; MAN ES (ed.); MAN B&W two-stroke engine operating on ammonia; 2020; p. 7; https://www.man-es.com/docs/default-source/document-sync/man-b-w-two-stroke-engine-operating-on-ammonia-eng.pdf?sfvrsn=c4bb6fea_5; accessed on 06.09.2024; 11:35
69) Cf. n.a.; inwl (ed.); Potenzialanalyse Methanol als emissionsneutraler Energieträger für Schifffahrt und Energiewirtschaft; 2018; p. 19
70) Cf. n.a.; MAN ES (ed.); MAN PrimeServ bietet ab 2025 Methanol-Retrofit für MAN Viertaktmotoren an; message f.: 26.07.2024; https://www.man-es.com/de/unternehmen/pressemitteilungen/press-details/2024/07/26/man-primeserv-bietet-ab-2025-methanol-retrofit-f%C3%BCr-man-viertaktmotoren-an; accessed on 05.09.2024; 14:30
71) Cf. Wissner, N, (et al.); Öko-Institut (ed.); Methanol as a marine fuel; 2023; p. 17; https://www.oeko.de/fileadmin/oekodoc/Methanol-as-a-marine-fuel.pdf; accessed on 17.09.2024; 11:55
72) Cf. Hansel, G.; Heise.de (ed.); Klimaneutrale Schifffahrt: ..., ibid.
73) Cf. n.a.; MAN ES (ed.); Immer mehr Schiffbauprojekte mit Ammoniakmotoren; message f.: 11.04.2024; https://www.man-es.com/de/unternehmen/pressemitteilungen/press-details/2024/04/11/immer-mehr-schiffbauprojekte-mit-ammoniakmotoren; accessed on 08.09.2024; 23:00
74) Cf. n.a.; WinGD (ed.); WinGD expands X-DF-A segment reach with AET's first ammonia aframax order; message from: 07.05.2024
75) Cf. n.a.; UBA (ed.); Kurzeinschätzung von Ammoniak als Energieträger und Transportmedium für Wasserstoff; message from.: 28.02.2022; p. 3 f.
76) Cf. n.a.; MAN ES (ed.); MAN B&W two-stroke engine operating on ammonia; ibid., p. 7
77) Cf. n.a.; MSC (ed.); Interim Guidelines for the Safety of Ship using Fuel Cell Power Installations; MSC. 1/Circ. 1647 from 15.06.2022
78) Cf. n.a.; Now-GmbH.de (ed.); e4ships – Brennstoffzellen im Einsatz; n.d.; https://www.now-gmbh.de/aktuelles/pressemitteilungen/brennstoffzellen-duerfen-endlich-an-bord/; accessed on 19.09.2024; 16:10
79) Cf. n.a.; Fraunhofer (ed.); Weltweit erste Hochtemperatur-Brennstoffzelle mit Ammoniak für Schiffe; Reported on: 01.03.2022; https://www.fraunhofer.de/de/presse/presseinformationen/2021/maerz-2021/weltweit-erste-hochtemperatur-brennstoffzelle-mit-ammoniak-fuer-schiffe.html; accessed on 20.09.2024; 11:30

cells (which can also be operated with other fuels in addition to hydrogen, such as methanol, ammonia, natural gas or low-sulphur diesel fuel).[80] The advantage of using fuel cells lies in their high efficiency, significantly lower emissions of air pollutants and lower noise emissions.[81] The associated high costs are still seen as a disadvantage.[82] In the majority of cases, ship propulsion based on hydrogen involves an electric motor in the drive train[83], with fuel cells being used in many cases. However, carbon-free ammonia and methanol (which can be produced as green methanol from renewable energy sources in the near future) can also be used in fuel cells. Generating electricity with ammonia works in a similar way to hydrogen-based systems.

There are currently fewer than 30 ships in the active fleet (as of 2022) that are (partially) powered by fuel cells.[84] However, according to Clarkson Research, there are currently 33 other ships (including options; with just under 774,200 gt) in the order book that want to use hydrogen as an alternative fuel for propulsion with fuel cells, of which the cruise shipping industry with 13 ships (590,000 gt) and the group of non-merchant vessels (with 43,000 gt) account for the largest shares.

In the area of alternative fuels, hydrogen, biofuel and nuclear propulsion (of which 13 Russian icebreakers with a good 330,000 gt are currently in operational use with nuclear propulsion and seven other Russian icebreakers with the same technology with another 330,000 gt are listed in the order book) represent the smallest group, which is probably due to the low availability of the 'fuel' to date, the high costs and the high risks (especially for insurers for ships with nuclear propulsion).

The clear majority of ships in maritime transport still operate with conventional fuels. These fuels also dominate in newbuilds, especially when propulsion systems that are not yet operated with climate-neutral LNG are taken into account. However, a small proportion of newbuilds are designed for operation with alternative fuels such as ammonia and methanol in dual-fuel engines, which can also continue to use conventional fuels. However, the majority of fuels available for these ships are not yet climate-neutral, meaning that overall, there is currently no visible reduction in greenhouse gas emissions from the maritime shipping sector. Achieving the now ambitious goals of the IMO and the EU to be climate-neutral by 2050 stands and falls with the (early) availability of climate-neutral fuels. Production capacities for green hydrogen as the basis for the production of alternative fuels such as methanol and ammonia must therefore be expanded quickly in order to meet demand in a timely manner. One ray of hope, however, is the emerging trend towards retrofitting the engines of the existing fleet with alternative fuels such as methanol and ammonia.

5 Availability of alternative fuels

Germany[85], the EU[86] and many countries around the world[87] are increasingly focussing on hydrogen as the energy carrier of the future. The future energy carrier hydrogen is to be utilised in direct form or as electricity-based synthetic fuels in the form of e-fuels (chemically composed fuels). The synthetically generated fuels (ammonia, methanol, e-diesel, e-kerosene, etc.) all contain hydrogen. In the production of carbon-based future fuels, the carbon atom must be taken directly from the air[88] or

80) Cf. n.a.; DKE (ed.); Fuel cells in shipping; Message from: 27.06.2022.; https://www.dke.de/de/arbeitsfelder/energy/news/brennstoffzellen-in-der-schifffahrt; accessed on 19.09.2024; 16:20 ;
81) Cf. n.a.; TWI Ltd. (ed.); Was sind die Vor- und Nachteile von Wasserstoff-Brennstoffzellen;https://www.twi-global.com/locations/deutschland/was-wir-tun/haeufig-gestellte-fragen/was-sind-die-vor-und-nachteile-von-wasserstoff-brennstoffzellen; aberufen am 19.09.2024; 16:30
82) Cf. n.a.; DLR (ed.); DLR belegt Marktpotenzial und Nachhaltigkeit von Fähren mit Brennstoffzellen-Antrieb; Report dated: 9.09.2022
83) Cf. n.a.; Baumüller (ed.); Wasserstoff Schiffsantrieb – emissionsfreie Zukunft mariner Mobilität; n.d.; https://www.baumueller.com/de/branchen/schiffbau/wasserstoff-schiffsantrieb; accessed on 19.09.2024; 15:30
84) Cf. Elkafas, A. G. (et al.); Fuel Cell Systems for Maritime: A Review of Research Development, Commercial Products, Applications, and Perspectives; 2023; with further explanations.
85) Cf. n.a.; Bundesregierung (ed.); Nationale Wasserstoffstrategie - Energie aus klimafreundlichem Gas; Report dated: 26.07.2023; with further references.
86) Cf. n.a.; European Commission (ed.); Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – A Hydrogen Strategy for a Climate-Neutral Europe; Report dated: 08.07.2020.
87) Cf. n.a.; WEF (ed.); Green Hydrogen in China: A Roadmap for Progress – White Paper; June 2023; 2.2, p. 21. Cf. n.a.; India.gov.in (Ed.); National Green Hydrogen Mission; n.d. Cf. Thielges, S.; bpb (Ed.); Die energiepolitische Agenda der Biden-Administration; Report dated: 05.07.2024; with further references.
88) Cf. n.a.; Bundesregierung (ed.); Klimaneutrale Kraftstoffe Sprit aus Luft und Ökostrom; Report dated: 4.12.2019.

from stored CO_2 from CCS capture. The use of e-fuels therefore represents a form of indirect electrification of the energy system. A fundamental problem in the production of e-fuels is the loss-intensive conversion stages. Depending on the specific application, only around 16% to 48% of the electrical energy used is converted into useful energy[89], which means that, depending on the quantities of e-fuels to be used, disproportionately large quantities of sustainably generated electrical energy must be provided. E-fuels, insofar as they are currently produced in Germany, still have a clearly negative climate footprint compared to the fossil reference.[90] According to DNV, 44 to 63 million tonnes (oil equivalents) of carbon-neutral fuels will be available worldwide in 2030, of which shipping alone (depending on the reductions in fuel consumption achieved by then) will require 10% to 100%[91] in order to achieve the IMO target of reducing total CO_2 emissions from shipping by 20% by 2030 compared to 2008 levels[92]

According to an updated target from the EU Commission's REPowerEU plan, around 20 million tonnes of green hydrogen (10 million tonnes of own production and 10 million tonnes of imports) are expected in the EU by 2030.[93] However, a separate model calculation by the Commission from 2023 concludes that hydrogen imports will be relatively modest by 2040 and will be less than 10 million tonnes.[94] A report by the European Court of Auditors from mid-2024 therefore concludes that the results targeted for 2030 for the import and production of sustainably produced hydrogen are too ambitious and that the targets are not based on a solid analysis, but are driven by political will. In its own analysis, the Court of Auditors assumes that the production target of 10 million tonnes, which could require up to 140 GW of electrolyser capacity (input), will probably not be achieved by 2030.[95]

A study by the Fraunhofer Institute for Systems and Innovation Research (ISI) from Feb. 2024 sees little hope for the German government's expansion plans. So far, the capacity of all electrolysers amounts to just over 0.1 GW. Germany must expect the highest prices worldwide - demand is high, but the potential capacity in Germany is low.[96]

To make matters worse, the Norwegian energy company Equinor recently cancelled a hydrogen project worth billions for export from Norway to Germany because the costs were too high. Blue hydrogen (produced from natural gas by capturing and storing the resulting CO_2 using a CCS process) was to be delivered from Norway to Germany via an offshore pipeline.[97] Shell's Norwegian subsidiary is also pausing its plans to produce 450,000 tonnes of blue hydrogen annually for Germany due to a lack of cost efficiency and the lack of market maturity for blue hydrogen.[98] As a result, all of this news fits in with the latest analysis by McKinsey from autumn 2024, according to which just 12-18 million tonnes p.a. (based on the completion rate of renewable energy projects) of the announced demand of 48 million tonnes p.a. by 2030 can be provided for the supply of 'clean' hydrogen worldwide.[99] Two thirds of this will come from renewable energies and the remaining third from low-carbon hydrogen production.[100] Under these 'shortage scenarios', however, it is questionable whether the globally envisaged projects for alternative fuels will be available to the required extent. At the very least, achieving the desired targets for the production of sustainable hydrogen, the production of (synthetic)

89) Cf. Ueckerdt, F. (et al.) (PIK); Potential and risks of hydrogen-based e-fuels in climate change mitigation; 2021; p. 4; according to DNV, the share is about 22.4% in maritime transport; Cf. n.a.; DNV (ed.); Energy Transition Outlook 2024 – Maritime Forecast to 2050, 2024; Fig. 1-5, p. 8; and 27% according to Meyer-Larsen, N. (et al.); DMZ (Ed.); Die Rolle der maritimen Wirtschaft bei der Etablierung einer deutschen Wasserstoffwirtschaft; 4.4.2, p. 92.

90) Cf. Witschel, M. (et al.); Fraunhofer (ed.); Diskussionsbeitrag - Eine kritische Diskussion der beschlossenen Maßnahmen zur E-Fuel-Förderung im Modernisierungspaket für Klimaschutz und Planungsbeschleunigung der Bundesregierung vom 28.03.2023; p. 4, with further references.

91) The range of 10% to 100% projected by DNV is based on the degree of implementation of fuel-reducing measures in maritime transport.

92) Cf. n.a.; DNV (ed.); Energy Transition Outlook 2024 ...; ibid.; p. 37

93) Cf. n.a.; European Commission (ed.); Hydrogen; n.d.; https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en; accessed on 02.10.2024; 14:00

94) Cf. n.a.; ECA (ed.); Sonderbericht 11 – 2024; Die Industriepolitik der EU im Bereich erneuerbarer Wasserstoff: Rechtsrahmen weitgehend angenommen – Zeit für einen Realitätscheck; 2024; para. 28, p. 27; with reference to n.a.; EU Commission (ed.); SWD(2024) 63; Commission Staff Working Document – Impact Assessment Report – Part 3; dated: 6.02.2024; p. 28.

95) Cf. n.a.; ECA (ed.); Sonderbericht 11 – 2024 ..., ibid.; para. 39, p. 32.

96) Cf. n.a.; Fraunhofer.de (ed.); Globaler H2-Potenzialatlas: Wie entwickelt sich die internationale Wasserstoffwirtschaft in Zukunft?: Press release dated 6 Dec. 2024.

97) Cf. n.a.; Energynews (ed.); Equinor to stop supplying blue hydrogen to Germany; Report dated: 23.09.2024.; https://energynews.pro/en/equinor-to-stop-supplying-blue-hydrogen-to-germany/; accessed on 02.10.2024; 14:20

98) Cf. n.a.; Blackout-news.de (ed.); Shell stoppt Pläne für Wasserstoff in Norwegen; Report dated: 01.10.2024.

99) Cf. n.a.; McKinsey (ed.); Hydrogen Insides 2024; as of Sept. 2024; p. 4.; https://hydrogencouncil.com/wp-content/uploads/2024/09/Hydrogen-Insights-2024.pdf; accessed on 02.10.2024; 13:40

100) Cf. ibid, p. 12

alternative fuels and the achievement of decarbonisation targets in the most diverse sectors of the economy and thus also in maritime shipping remains more than ambitious at present.

The higher costs of alternative fuels will not lead to supply bottlenecks in maritime transport, as recent developments have shown, for example, in the price trends for charter rates in container transport as a result of rerouting in the face of massive attacks on seagoing vessels in the Horn of Africa by rebels from trades to Europe away from the Suez Canal passage through the Mediterranean around South Africa.[101] In addition, shipowners have so far passed on increases in fuel costs to their customers through their regulations (Bunker Adjustment Charge[102], Bunker Adjustment Factor[103], Bunker Recovery Charge[104], Fuel Recovery Surcharge[105], etc.).

A PwC shipping company study published at the end of 2023 shows that nine out of ten German shipping companies continue to rely on the use of low-sulphur marine diesel such as MGO (Marine Gasoil) and VLSFO (Very Low Sulphur Fuel Oil). The message between the lines shows that the acceptance of alternative fuels has declined. However, a more differentiated picture emerges for new builds.

A policy focussing on sustainable alternative fuels requires significant efforts to provide the necessary fuels in order to achieve the set climate targets on time.

6 Conclusion

After the fundamental realisation of a man-made climate crisis and the importance of greenhouse gas emissions in this context, it took a long time for the first political measures to be taken, and it took even longer for the IMO to be assigned a decisive role in the area of CO_2 reduction in maritime shipping. Only in recent years has the IMO set itself and its member states targets for reducing CO_2 emissions and formulated guidelines and instruments to support the achievement of these targets. Driven in part by the EU's stricter targets and requirements, the IMO has committed itself to achieving climate neutrality in shipping by 2050 and has also formulated interim targets along the way. However, the ISL's analysis of the fleet and order book, for example, shows that despite all the positive efforts, achieving the target is still a long way off. Added to this is the fact that there is a very high probability that there will be sufficient quantities of none of the alternative fuels to meet demand from shipping, let alone from all competing sectors. It cannot be assumed that shipping will commit to just one or two alternative fuels. Rather, there will be a mix of the various options described above. What most of these alternatives have in common is that they can only be truly "green" if they are produced using green electricity and avoiding fossil fuels (e.g. natural gas), and that the efficiency of the transformation from green electricity to PtX (e-fuels, e-LNG, etc.) is low. A multiple of the electrical energy from renewable sources is therefore required to meet the expected demand for sustainable electricity (consumed directly, e.g. through electric heating, e-mobility, energy transition in production, etc.) and hydrogen and its derivatives. This electricity can only be produced in part in Germany, but even for this there is a lack of capacity or the necessary framework conditions and permits.

101) Cf. Jann, T.; THB (ed.); Huthi-Attacken verändern den Welthandel; Report dated: 18 Dec. 2023.
102) Cf. n.a.; Evergreen-Shipping (ed.); Bunker Adjustment Charge (B.A.C); n.d.
103) Cf. n.a.; Maersk (ed.); Bunker Adjustment Factor (BAF); Report dated: 2 Sept. 2024; Cf. n.a.; CNC (ed.); Intra-Asia Market: Bunker Adjustment Factor (BAF) Update Effective 1 January 2025; Cf. n.a.; CMA-CGM (ed.); Australia, New Zealand and Sofrana ANL: Bunker Adjustment Factor (BAF) Effective 1 January 2025.
104) Cf. n.a.; MSC (ed.); EU Price Announcement – Trade From India & Pakistan To Europe; Report dated: 18 Jan. 2024.; https://www.msc.com/en/newsroom/customer-advisories/2024/january/price-announcement-india-pakistan-to-europe; https://www.cma-cgm.com/assets/public/documents/Q1%202025%20BAF%20with%20CMA%20trades%20031224.pdf; https://www.cnc-line.com/news/285/intra-asia-market-bunker-adjustment-factor-baf-update-effective-1-january-2025
105) Cf. n.a.; Hapag-Lloyd (ed.); Globale Preis-Ankündigung – Marine Fuel Recovery Surcharge (MFR) (Q1 2025).

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