OXFORD ECONOMICS

ENVIRONMENTAL COMMITMENT, INNOVATION, AND RESULTS OF THE CRUISE INDUSTRY

REPORT PRODUCED FOR: CRUISE LINES INTERNATIONAL ASSOCIATION

SEPTEMBER 2020

EXECUTIVE SUMMARY

Cruise Lines International Association (CLIA) member cruise lines and shipping industry partners have demonstrated a commitment to the development and implementation of environmentally responsible technologies, policies, and practices. Readers should note that statistics related to new ships on order and those to be removed from the fleet are subject to fluctuation due to the dynamic situation presented by the COVID-19 pandemic. While cruise ships comprise less than 1% of the global maritime community, cruise lines are at the forefront in developing responsible environmental practices and innovative technologies, which benefit the entire shipping industry. The cruise industry has invested over $23.5 billion into a variety of onboard and portside technologies as well as cleaner fuel sources to reduce its environmental impact while providing a unique tourism experience to a growing cohort of travellers. The International Maritime Organization (IMO) drives global compliance with its emissions and waste management standards through the International Convention for the Prevention of Pollution from Ships (MARPOL) and partners with governmental bodies to apply more stringent regional standards. CLIA members satisfy these regulatory structures in accordance with CLIA's Environmental Policy and have commenced unified efforts to achieve ambitious goals and meet rising expectations.

The 2020 Environmental Technologies and Practices (ETP) inventory conducted by CLIA covered 258 oceangoing ships representing 98.5% of existing global passenger capacity as well as build specifications for 76 ships currently on order. The primary areas covered by the survey are Advanced Wastewater Treatment Systems (AWTS), Liquified Natural Gas (LNG) and other alternative fuels, Exhaust Gas Cleaning Systems (EGCS), and shore-side power capability. The variety of initiatives reflects two key approaches to improving fleetwide environmental performance – new ships built to more sustainable specifications and retrofitting ships in operation to replace and improve existing technologies. Progress across multiple strategies demonstrates CLIA's view that it is integral, urgent, and feasible to balance fostering growth with policy and technology changes that help preserve the air and oceans in which the industry operates.

1. AIR EMISSIONS

Regulatory Environment

The International Maritime Organization (IMO) administers global and regional regulatory guidelines through the International Convention for the Prevention of Pollution from Ships (MARPOL). MARPOL drives global compliance for prevention of pollution of oil, sewage and garbage (including plastic) from ships, among others. In total, there are six technical annexes to MARPOL.

Annex VI addresses regulations for the prevention of air pollution from ships. A key feature of MARPOL Annex VI is its designation of Emission Control Areas (ECAs) for certain air emissions which are subject to more stringent regulations and provide a model for ocean management policy in other high-traffic regions. There are currently four ECAs: the Baltic Sea ECA, the North Sea ECA, the North American ECA, and the US Caribbean ECA. Regulations 13 and 14 which concern nitrogen oxides (NOx) and sulfur oxides (SOx), respectively, therefore provide different guidance for global and ECA compliance.

MARPOL Annex VI Regulation 13 – Nitrogen Oxides (NOx)

Regulation 13 of MARPOL defines limits on diesel engine NOx emissions in terms of three tiers which correspond to the date when the ship in question was built. For marine diesel engines with over 130kW output power, the tiers apply as follows:

3 Tiers

For NOx regulation based on ship build date & engine rpm

All ships operating within ECAs held to Tier III (highest) standard

IMO MARPOL Annex VI Regulation 13 NOx Caps by Tier

Nitrogen Oxide Emissions Caps - Global

		Total weighted cycle emission limit (g/kWh)		
Tier	Ship built on/after:	rpm < 130	130 ≤ rpm ≤ 1999	rpm ≥ 2000
I	January 2000	17	45·rpm(-0.2)	9.8
II	January 2011	14.4	44·rpm(-0.23)	7.7
III	January 2016	3.4	9·rpm(-0.2)	2

Source: IMO

Since 1 January 2016, compliance with the tier III standard was mandatory in the North American ECA and the United States Caribbean ECA, irrespective of the above finer ship characteristics. Tier III compliance will expand to include the Baltic Sea ECA and North Sea ECA beginning on 1 January 2021.

MARPOL Annex VI Regulation 14 – Sulfur Oxides (SOx) and Particulate Matter (PM)

0.5%

Maximum global fuel oil sulfur content (by mass) beginning 1 January 2020

Existing 0.1% cap within all ECAs

Regulation 14 of MARPOL dictates limits on sulfur content in fuel oil with the objective of limiting SOx and PM emissions. Regulation 14 also allows alternative means of compliance with low sulphur fuel requirements such as exhaust gas cleaning systems. Similar to NOx caps, required levels differ between oceangoing vessels operating globally and those that operate within ECAs and both have tightened over time. However, unlike NOx regulation, these limits apply to all fuel oil, combustion equipment, and devices on board and are measured by mass in fuel oil. The recent history of regulatory advancement is as follows:

IMO MARPOL Annex VI Regulation 14 Sulfur Content in Fuel Oil Caps

Sulfur Content in Fuel Oil Caps

Global		ECA	
Effective Date	Sulfur Cap (mass share in fuel oil)	Effective Date	Sulfur Cap (mass share in fuel oil)
prior to January 2012	4.50%	prior to January 2010	1.50%
January 2012	3.50%	January 2010	1.00%
January 2020	0.50%	January 2015	0.10%

Source: IMO

CLIA Initiatives and Performance

Liquified Natural Gas (LNG) and Other Alternative Fuel Sources

CLIA constituents are addressing air emissions by transitioning to cleaner-burning fuels such as Liquified Natural Gas (LNG), biofuels, and synthetic fuels while installing Exhaust Gas Cleaning Systems (EGCS) on ships that rely on legacy fuel sources. Presently, LNG is the primary alternative fuel source being implemented due to its strong environmental performance, growing land-based infrastructure, and established technological viability. Burning LNG produces virtually zero sulfur emissions, 85% fewer nitrogen oxide emissions, 95-100% fewer particulate emissions, and the industry estimates up to 20% fewer greenhouse gas emissions. The industry is working closely with partners to mitigate the potential risk associated with burning LNG and methane slip. Natural gas extraction, refinement, and distribution operations have grown, aided by both environmental and economic efficiency, enabling cruise ships to refuel at ports worldwide.

25 Ships

On order or under construction committed to rely on LNG for primary propulsion

49% of new global passenger capacity

With the introduction of a fourth LNG-operated ship to the global cruise fleet, there are currently 25 ships on order or under construction committed to relying on LNG for primary propulsion, representing 49% of new passenger capacity. Investment, development, and adoption of still cleaner-burning biofuels and synthetic fuels face key hurdles such as fuel density, safe storage, and global availability. However, the contemporary engine technology enables LNG-reliant ships to transition to future fuel sources with minimal structural intervention required.

LNG Case Study:

CLIA Executive Partner – Nauticor

Nauticor, a subsidiary of Gasum, is a Hamburg, Germany-based provider of LNG as bunker fuel to the shipping industry. They enable operators of cruise liners, tankers, ferries, container liners, and more to improve their environmental performance by moving away from conventional fuels. LNG outperforms key legacy fuel sources such as Heavy Fuel Oil (HFO), which composes around 84% of marine bunker fuel utilization, and Marine Gas Oil

(MGO)[1]. The latter can be utilized in its Low Sulfur (LS-MGO) form to meet ECA standards for sulfur content below 0.1%; however, its performance still falls short of LNG's complete elimination of SOx emissions[2].

Outside of the cruise industry, LNG has faced longer-than-expected adoption times primarily due to falling overall oil prices and a decades-long shipping crisis. The shipping crisis revolves around widespread over-capacity amid moderating shipping demand. Concurrently, recent demand growth has aided shipyards to continue building LNG-enabled vessels. Presently, French shipping company CMA CGM S.A. and German shipping company Hapag-Lloyd AG, among others, have announced adoption of LNG in their container shipping businesses and have brought renewed positive signals to the broader market[3][4].

DNV GL, a global vessel classification society, expressed the benefits of LNG fuel:

> "LNG fuel as a solution to curb harmful emissions is indisputable. It emits zero sulphur oxides (SOx) and virtually zero particulate matter (PM). Compared to HFO, it emits up to 90% less nitrogen oxides (NOx) The environmental agenda is today shifting to focus more on greenhouse gases. Employing current best practices and appropriate technologies to minimize methane leakage, gas offers the potential for up to a 25% reduction."

Exhaust Gas Cleaning Systems (EGCS), Water Fuel Emulsion (WFE), and Data Solutions

69%

Portion of global passenger capacity utilizing EGCS to meet or exceed air emissions requirements

25% increase over 2018

The longevity of cruise ships and their engines tempers the pace of transition to alternative fuel sources but does not impede the goal of fleetwide emissions reduction. EGCS are currently installed on ships that comprise 69% of global passenger capacity, reflecting a 25% increase over 2018 ETP inventory levels, and 95% of new ships not relying on LNG as their primary fuel source will have EGCS installed. These systems reduce exhaust sulfur oxide levels by as much as 98%, typical total particulate matter levels by 50% or more, and nitrogen oxide levels by up to 12%. The future cruise fleet will leverage EGCS technology and LNG fuel to lessen air emissions.

Alongside EGCS, WFE treatments further limit the air emissions of heavy fuels and diesel oil. By mixing water with the fuel using various methods, emulsified fuels are able to simultaneously reduce nitrogen oxide emissions by as much as 50% and particulate matter emissions by up to 90%[5]. In addition to fewer emissions, WFE technology grants a 5% savings on fuel consumption[6].

[1] (International Energy Agency 2017)
[2] (Marquard & Bahls 2015)
[3] (CMA CGM S.A. 2019)
[4] (Hapag-Lloyd AG 2019)
[5] (Holtbecker & Geist 1998)
[6] (Hielscher Ultrasound Technology 2020)

Currently, over one-quarter of global passenger capacity is equipped with WFE technology.

EGCS and WFE empowers cruise ships to meet or exceed MARPOL requirements using existing engine technology and demonstrates the value of implementing auxiliary technologies that produce desired environmental outcomes in retrofitting initiatives.

Data analysis, optimization, and automation have long played key roles in the broader shipping industry, and the cruise industry has been among the leaders. Multiple shipbuilders have entered this market, offering digital solutions that operate alongside upgraded or improved ship components. These digital solutions broadly operate on two levels: optimizing internal functions such as engine and fuel type utilization and optimizing vessel-level decisions such as route and trim. Digital solutions are available both for new builds and for retrofitting jobs and are flexible to account for the pace of adoption of newer physical components.

EGCS and Data Solutions Case Study:

CLIA Executive Partner – MAN Energy Solutions

MAN Energy Solutions is an Augsburg, Germany-based engine and auxiliary system produce that develops and installs solutions for addressing emissions and efficiency goals. MAN offers DeNOx and DeSOx EGCS for ships operating diesel fuel engines which are implemented alongside scrubbers and additional catalytic converters, when necessary, to bring ships within the most stringent IMO ECA standards.

MAN's ECOMAP digital solution produces efficiency gains that can reduce overall annual fuel consumption by 1-2%. The ECOMAP system operates MAN's diesel engines' entirely electronic fuel injection systems, applying calculated electronic parameters to maximize emissions compliance and power utilization. The ECOMAP system is capable of managing multiple engines in conjunction with a vessel's power management system as well.

Multi-dimensional digital systems now require further digitization for decision-making. These systems rely on Artificial Intelligence (AI) and Machine Learning (ML) for map selection and application, driving development into an entirely new space. Further, ECOMAP enables ship operators to directly manage their ships remotely from control centers. Specialists which may otherwise have been allocated across the fleet can now focus on fleetwide refinements for safety, cost, and performance. The spill-over of investment in digital solutions by larger segments of the international shipping community will benefit cruise lines as digital solutions are naturally lest costly to implement fleetwide compared to upgrades to physical infrastructure.

2. WASTEWATER

Regulatory Environment

Wastewater treatment falls under IMO MARPOL Annex I and IV as well as various, more stringent regional and national regulations.

Wastewater is categorized as either graywater, blackwater, or bilge water.

- Graywater – water that is incidental to the operation of the ship and results from activities such as food preparation, laundry, and showers.
- Blackwater – water flushed down a toilet
- Bilge water – water that collects on the lowest part of a ship's hull and can contain oil, grease, or other contaminants that have dripped from various sources such as shaft seals, evaporators, or other machinery

MARPOL Annex IV provides a framework to ensure environmentally friendly wastewater practices regarding the discharge of sewage are implemented, while Annex I Regulation 15 focuses on the discharge of oil or oily mixtures such as bilge water.

MARPOL Annex IV Regulation 11 – Discharge of Sewage

The MARPOL Annex IV discharge standards prohibit discharging untreated sewage within specific distances from shore and require sewage treatment plants on vessels over 400 gross tonnage or which may carry more than 15 persons. Additionally, Annex IV requires ships to be equipped with an approved sewage treatment plant, an approved sewage comminuting and disinfecting system, or a sewage holding tank of approved capacity in order to discharge sewage into the sea.

Further restrictions are that no treated sewage can be released within three nautical miles of land, and that sewage that is either treated or untreated can be released more than 12 nautical miles from land. In any case, the sewage must be stored in holding tanks and must be discharged at a rate no greater than the moderate rates defined by the IMO while traveling at a minimum speed of 4 knots.

Additionally, the sewage treatment plant must adhere to the ship's International Sewage Pollution Prevention Certificate, and the effluent must not produce visible floating solids nor cause discoloration of the surrounding water.

MARPOL Annex IV Regulation 11.3 - Special Areas

As of January 2013, new regulations entered force requiring a sewage treatment plant that meets stringent nitrogen and phosphorous standards for all passenger ships or a holding tank for wastewater to be discharged at a port facility. The only current Special Area this applies to is the Baltic Sea area.

Member states in Special Areas must ensure that reception facilities for sewage are provided in ports and terminals in the special area and which are used by passenger ships. These facilities must be adequate to meet the needs of those passenger ships and operated so as not to cause undue delay to them.

MARPOL Annex I Regulation 15 – Discharge of Oil

Under Annex I Regulation 15, ships of more than 400 gross tonnage seeking to discharge oil or oily mixtures into the sea must observe certain standards and procedures. The ship must be proceeding en route, and the oily liquid must be processed through approved oil filtering equipment such that the oil content of the discharge without dilution does not exceed 15 parts per million. Discharge in one of the 10 special areas designated in the Annex follows the same guidelines as outside of special areas but with different requirements for the oil filtering equipment.

The discharge shall also not contain chemicals or other substances in quantities that are hazardous for the marine environment or are used for the dilution of the discharge to meet regulations. When traces of oil from the discharge are visible following expulsion from the ship, then a prompt investigation must be conducted to determine whether there has been a violation of this regulation. Lastly, the residual oil that is removed from the bilge water must be held for either reuse or disposal in reception facilities ashore.

There are additional restrictions in the Annex relevant to oil tankers but are not applicable for other ships.

CLIA Initiatives and Performance

CLIA Policies

Wastewater	MARPOL Annex IV	CLIA Policy
Untreated Sewage	Distance >12 nm	Strictly prohibited
Treated Sewage	Distance >3 nm Speed >4 knots	Distance > 4 nm Speed >6 knots
Baltic Sea Special Area	In effect for all ships June 1, 2021	Adopted for all ships where adequate port facilities are available in 2016

Under MARPOL Annex IV, the discharge of untreated sewage is permitted at a defined rate at an approved distance from shore. However, CLIA's more stringent policy further provides that during normal operations all sewage be treated prior to discharge, regardless of location.

The IMO's standards allow for the discharge of treated sewage under the conditions that the ship is greater than three nautical miles to shore and traveling at a minimum speed of four knots. Again, CLIA enforces more restrictive and environmentally friendly standards, as the Compendium of Member Policies lays out that member lines must be at least four nautical miles to shore and traveling at a minimum speed of six knots to discharge treated sewage.

With regards to oily liquids such as bilge water or other oil-based wastewater, all of CLIA's members have agreed to meet or exceed the international standards for oil removal prior to discharge.

Advanced Water Treatment Systems (AWTS)

70%

Portion of global passenger capacity utilizing AWTS to generate effluent discharge equivalent to best shoreside treatment plants

9% increase over 2019

CLIA's member ships have broadly adopted Advanced Wastewater Treatment Systems (AWTS). AWTS rely on tertiary-level treatment, which refers to bacteriological methods of breaking down contaminants in gray and black water. The treated effluent, which may then be discharged at sea, is often equivalent to effluent produced by the best shoreside treatment plants, and consistent with CLIA policy, far exceeds international requirements. CLIA stipulates that any bio-residual from AWTS may be landed ashore, incinerated, or discharged at sea in accordance with MARPOL Annex IV.

99%

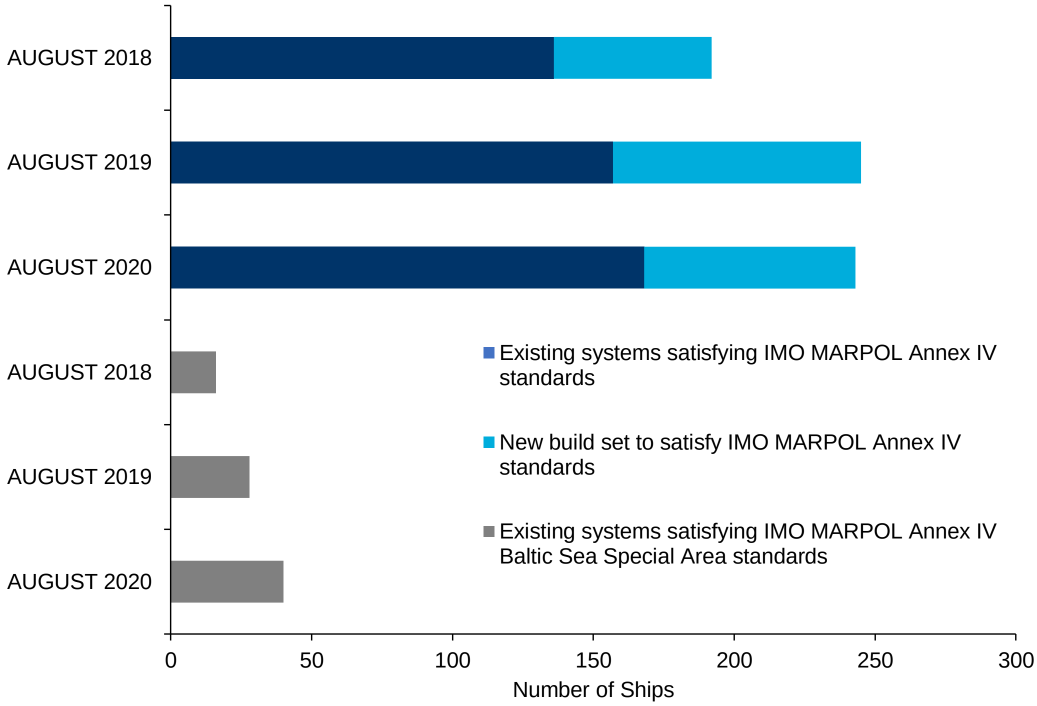
New capacity on order specified to have AWTS

Will bring total global passenger capacity utilizing AWTS to 78.5%

Notably, 99% of new capacity on order are specified to have AWTS installed. This will increase global capacity coverage from 70% of current global capacity to approximately 78.5% of expected future capacity if projected installations are completed without change. Furthermore, there has been a nearly 43% increase in the current number of ships with AWTS capable of meeting the rigorous Baltic Sea Special Area standards from last year, representing a nearly 90% increase in current global capacity coverage.

The Baltic Sea Special Area restrictions took effect for new passenger ships on June 1, 2019 and will not take effect for existing passenger ships until June 1, 2021. Despite the delay between passage and implementation of the Special Area, CLIA member lines, recognizing the extraordinary eutrophication situation in the Baltic Sea, had voluntarily begun following this new regulation ahead of schedule. By 2016, five years before required, all CLIA Member lines had adopted a policy of following the Special Area restriction where adequate port reception facilities are available under a 'no special fee' arrangement.

Current and Committed Implementation of AWTS



AWTS Case Study:

CLIA Executive Partner – Wärtsilä

Located in Helsinki, Finland, Wärtsilä emphasizes technological innovation and total efficiency to maximize the environmental and economic performance of vessels and power plants. They provide a number of technologies for the cruise industry to improve environmental performance including Advanced Wastewater Treatment Systems (AWTS). They supply complete waste treatment systems for cruise vessels that are able to handle all the waste streams and comply with the strictest regulatory requirements found in maritime. These solutions are able to clean the waste streams of liquid (food, graywater, blackwater) so that the effluent is removed of all substances that are harmful for the environment and it is safe to discharge back to sea again.

AWTS use processes to reduce the level of contaminants in wastewater to a level unattainable through conventional secondary or biological treatments. Membrane bioreactors, which use the combination of a membrane process along with a biological wastewater treatment process, are now a widely used AWTS in land-based wastewater treatment.

In the initial step, the wastewater is screened to separate solids. The liquid is then sent into the bioreactor and membrane filtration system to remove the impurities, followed by ultraviolet light or chemical treatment to destroy any remaining germs. The treated liquid is then either discharged or kept in the ballast tank. These water treatment systems are tested regularly to ensure they are meeting international standards.

The innovative Wärtsilä Membrane BioReactor (MBR) system allows for the high purity treatment of wastewater, exceeding effluent discharge standards worldwide. This system uses biological degradation and external membrane separation to treat gray and black water without the need for additional chemicals hazardous to the maritime or shipboard environments. This system is compliant to the Baltic Sea Special Area regulation and can achieve such performance with lower energy and chemical consumption than other alternatives. The latest Wärtsilä AWTS optimization results in more than a 25% savings in energy consumption plus consumables.

3. RECYCLING

Regulatory Environment

Annex V of MARPOL contains regulations for the prevention of pollution by garbage from ships. One of the leading concerns is plastics, which can remain floating in the ocean for years. Other rubbish can be degraded while in the ocean, but this process can be slow.

MARPOL Annex V – Prevention of Pollution by Garbage from Ships

MARPOL Annex V applies to all ships operating in the marine environment. This Annex prohibits the discharge of all garbage into the sea, with the exceptions of food waste, cargo residues, cleaning agents and additives, and animal carcasses when following guidelines set forth by in regulations 4-6 of the Annex.

Annex V obliges governments to provide adequate port reception facilities for the reception of garbage without causing undue delay to ships in order to facilitate compliance with these discharge requirements. The Annex also recognizes a number of special areas, which due to their oceanographic and ecological conditions require special mandatory methods for the prevention of marine pollution by garbage.

Additionally, Annex V requires all ships over 100 gross tonnage or which may carry more than 15 persons to carry a garbage management plan on board and a garbage record book, which include written procedures for minimizing, collecting, storing, processing and disposing of garbage and recording all disposal and incineration operations.

MARPOL Annex V Regulation 4 – Outside special areas and Arctic waters

Regulation 4 sets the garbage discharging standards while ships are outside of special areas and Arctic waters.

Food waste that is comminuted or ground so that it passes through mesh screens with smaller than 25 millimeter openings may be discharged when greater than three nautical miles from nearest land. Food waste that is not comminuted or ground may still be discharged, but the ship must be greater than 12 nautical miles from nearest land. Additionally, all cargo residues that are not harmful to the marine environment may be discharged at a distance greater than 12 nautical miles from nearest land.

All cleaning agents and additives that are not harmful to the marine environment may be discharged.

Animal carcasses should be split to ensure it sinks and should be discarded as far from the nearest land as possible, preferably greater than 100 nautical miles.

MARPOL Annex V Regulation 5 – Alongside or near offshore platforms

This regulation is relevant for ships located within 500 meters of offshore platforms that are more than 12 nautical miles from nearest land. In such a circumstance, the only garbage discharge permitted is comminuted or ground food wastes that can pass through a screen with mesh no larger than 25 millimeters.

MARPOL Annex V Regulation 6 – Within special areas and Arctic waters

Annex V specifies eight special areas, which along with Arctic waters, require stricter regulations than what is prescribed out in Regulation 4.

Comminuted or ground food wastes are only permitted when the nearest distance to land, ice-shelf, or fast ice is greater than 12 nautical miles away. In the Antarctic area, the discharge of avian products is not permitted unless incinerated, autoclaved, or treated to be made sterile.

The discharge of cleaning agents and additives deck and external surfaces washwater that are not harmful to marine environments may be discharged. Cleaning agents and additives in cargo hold washwater are permitted to be discharged when the ship is greater than 12 nautical miles from the nearest land, ice-shelf, or fast ice and en route.

Cargo residues contained in washwater that cannot be recovered and are not harmful to the marine environment may be discharged when the ship is greater than 12 nautical miles from the nearest land, ice-shelf, or fast ice and en route.

The discharge of all other garbage is prohibited under Regulation 6.

CLIA Initiatives and Performance

CLIA Procedures

Specified garbage management practices may fall outside of regulatory frameworks, as a result CLIA member policy provides a framework both for the reduction of single-use materials onboard and for the care and transfer to land of waste that is produced. These policies are synthesized in the CLIA Compendium of Member Policies which outlines, among other categories, how best to address domestic waste. Domestic waste refers to waste generated in the accommodation spaces on board, aside from waste water which is processed separately.

CLIA policy provides a variety of accepted waste management techniques such as compactors and shredders to pre-treat waste for transaction to land-based recycling and disposal programs. Aligning techniques with municipal and private land-based treatment sites presents another venue for collaboration and stewardship from the cruise industry with the goal of keeping waste out of the ocean.

Plastic goods are an aspect of domestic waste that CLIA has placed emphasis on as the impact of macro and microplastic pollution has risen in priority. CLIA member lines have successfully implemented initiatives to reduce the use of plastic with reusable or biodegradable alternatives where possible, such as reusable bottles and totes instead of plastic bottles and bags. In order to make sure that what little plastic is still in use gets properly recycled, member cruise lines have begun hand-sorting trash, carefully separating plastics and other recyclable materials from what can be incinerated or sent to a shoreside landfill.

CLIA members have adopted best industry practices for the handling and management of hazardous waste. These practices include identifying and segregating hazardous waste aboard cruise vessels for individual handling and to not comingle or mix materials identified as hazardous waste with other waste streams. This practice helps in preventing harmful discharges such as silver from photo processing and arsenic from electronic waste from entering marine ecosystems.

Shipboard dry-cleaning facilities typically use a chlorinated solvent that produces a small amount of hazardous waste. CLIA members have been implementing methods that do not produce hazardous waste, such as using non-toxic solvents or using wet cleaning processes that do not use any solvents.

CLIA members have agreed upon the preferred handling method by various authorities for the recycling of fluorescent lamps and high intensity discharge lamps. These lamps contain small amounts of mercury that can be harmful to human health and the environment.

CLIA Member Line's Performance

Many of CLIA member lines demonstrate their commitment to the environment by taking the initiative to exceed CLIA policy on recycling and environmental protection practices, which already surpass international regulations. Highly trained environmental officers aboard cruise ships have helped some cruise ships to repurpose 100% of all waste generated onboard. This has been achieved through five key methodologies:

1. Working with suppliers to **reduce** materials and use more sustainable materials.
2. Improving the **reusability** of materials, such as opting for paper straws and aluminium or reusable glass bottles over single-use plastics alternatives.
3. **Donating** discarded materials to vulnerable communities throughout the world.
4. Maximizing **recycling** onboard by hand-sorting trash and storing the recyclable waste onboard in appropriate facilities until a recycling hub is reached. To this end, crew members - regardless of their position - are trained to reduce waste and identify and sort recyclables.
5. **Converting** waste into energy through a plethora of potential avenues, such as repurposing food waste into energy for onboard use and recycling hot water to heat passenger cabins.

In addition to the implementation of these practices, CLIA member lines actively encourage passengers to participate in the effort to reduce the environmental impact through providing receptacles for recycling drink containers and offering environmental education classes.

In addition to protecting the environment through reducing waste, CLIA member lines acknowledge the importance of a robust biosecurity system to prevent the introduction of invasive species to alien environments. Members are strongly committed to the prevention of transferring aquatic species through hull fouling. To aid in this effort, over 90% of CLIA member ships follow strict biofouling management plans, which include strict maintenance requirements and the use of anti-fouling paint. The measures to prevent fouling on ship hulls significantly reduce the risk of invasive species and even provide supplementary benefits in the form of reduced fuel use and air emissions.

4. CARBON REDUCTION

Regulatory Environment

In 2011, the IMO adopted a new chapter for MARPOL Annex VI to enact ship energy efficiency regulations for ships of 400 gross tonnage and above. Improved energy efficiency for ships would reduce carbon emissions as well as other greenhouse gases.

The regulations Annex VI mandates are the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships.

MARPOL Annex VI – Energy Efficiency Design Index (EEDI)

The EEDI is a performance-based regulation. There are no specified requirements as long as ships meet the minimum mandatory energy-efficiency performance level. This gives ship designer and builders autonomy in what cost-efficient technologies and ship designs they prefer to use to comply with the regulation.

This regulation addresses technical- and design-based improvements for reducing carbon emissions by stimulating continued development in technologies that influence the fuel efficiency of a ship.

MARPOL Annex VI – Ship Energy Efficiency Management Plan (SEEMP)

Regulation 22 requires ships to keep a SEEMP on board. The SEEMP provides a management framework designed to improve the operational energy efficiency of a ship while at sea and in port. Examples of operational measures that could improve energy efficiency would be weather routing, trim and draught optimization, and just-in-time arrivals in ports.

Additional proposals for strengthening operational efficiency include mandatory carbon intensity reduction targets, speed optimization for the voyage, and ship speed limits. However, these measures have not yet been adopted.

CLIA Initiatives and Performance

40% Target

For reduction in rate of carbon emissions by 2030

Compared to 2008 level

CLIA Initiative

In 2018, CLIA committed to a 40% reduction in the rate of carbon emissions across the cruise industry's global fleet by 2030 as an initial step towards their goal of being carbon-free by the end of the century. CLIA members have demonstrated their commitment to carbon reduction through optimizing energy efficiency through conservation and energy management.

This reduction will be fuelled by innovative technologies and optimized procedural practices. Some such technological improvements on this front that are being implemented include:

- The advent and widespread use of ecological, non-toxic, slick hull paint coatings, which have been estimated to improve fuel efficiency by five percent and has been adopted by about 77 percent of CLIA member ships.

- More bulbous bow designs that reduce fuel usage for propulsion upwards of 15 percent when compared to the traditional V-shape.
- The use of advanced materials in ship applications, such as advanced strength-enhanced steel, that provide energy savings through reducing ship weight and providing a more hydrodynamic surface.
- The installation of tinted windows, high efficiency appliances and HVAC systems, and windows that capture and recycle heat reduce energy use from heating and air conditioning.
- Switching to LED lights which use 80 percent less energy and last 25 times longer than previous lighting systems.
- Installation of solar panels for emissions-free energy.

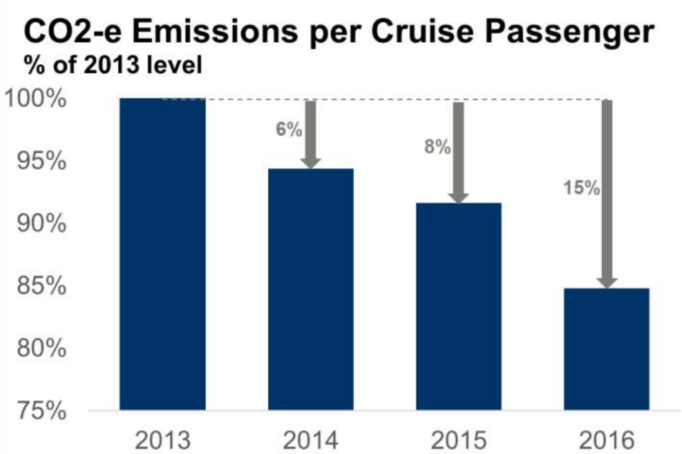
$23.5 Billion

Invested in new energy efficiency technologies and cleaner fuels

CLIA member cruise lines are investing heavily in implementing these carbon reduction technologies along with continual funding for research and development of further carbon reducing technologies, such as zero-carbon fuels. There are a number of zero-carbon fuels being researched and developed, such as ammonia used in internal combustion engines, fuel cells, and electric motors combined with batteries.

Procedurally, the cruise industry has been performing data analytics for itineraries to maximize fuel efficiency. Findings in this field have led to reductions in fuel consumption through optimized speed, routs, and distances travelled.

Individual CLIA member lines have set and achieved ambitious company carbon reduction goals. Some of these goals include designing energy efficient hulls to help reduce CO2 emissions of new ships by 20 percent when compared to ships built just a few years ago to refitting older ships with improved propulsion technology that is 10% more energy efficient. One member cruise line starting on January 1, 2020 became carbon-neutral. This has been accomplished through the implementation of carbon reducing technologies that have helped reduce their carbon emission rate 29%, well on their way to meeting the 40% reduction goal by 2030, along with blue carbon credits for the conservation and restoration of coastal and marine ecosystems.



Source: CLIA, Griffith University

50%

New ships on order specified to fitted with SSE systems

27% increase over 2019

Shore-Side Electricity (SSE)

Alongside these new technologies to meet CLIA's carbon reduction goal, cruise lines continue to implement shore-side electricity (SSE), also known as cold-ironing, which allows cruise ship operators to turn off the ship engines while in port and rely on more efficient municipal power systems when available, to reduce overall emissions. When measured in the Port of Charleston, CO2 emissions are reduced by an estimated 36% (Corbett and Comer, 2013) and another study found that SSE offers the potential to reduce CO2 emissions by over 800,000 tons in Europe alone (Winkel et al., 2016).

The objective of expanding SSE availability at ports presents a valuable opportunity for advocacy and cooperation with port operators that could have influence on the broader adoption of SSE capabilities by other shipping industry participants. Today, 68 CLIA member ships are outfitted with SSE capacity and 102 ships are set to be built new or retrofitted with the technology in the coming years. As a result, 32% of current global passenger capacity is covered by ships fitted with SSE capacity and, if the current order book was to remain the same, that would rise to 57% of expected future capacity.

The primary bottleneck for SSE utilization remains the availability of high-wattage power sources and interfaces at port. To date, 14 ports, of more than 800 ports visited by CLIA member ships each year, provide SSE capacity; however, not all berths at each port have the technology, and coordination with respect to using the proper berths is underdeveloped. SSE availability is also limited geographically, appearing at a variety of ports on the east and west coasts of North America, Hamburg, Germany, Kristiansand, Norway, and Shanghai, China. CLIA's global reach and proximity to industry partners will privilege it to share best practices from these leading ports with others as additional ports begin to implement SSE technology, underlining CLIA's role in representing industry leadership in matters of shared infrastructure.

SSE Case Study:

CLIA Executive Partner – Cruise Gate Hamburg

While ships SSE capabilities have been increasing rapidly, a secondary requirement for the use of SSE is port compatibility. Cruise Gate Hamburg, the terminal operator of the Port of Hamburg, has been at the forefront of the proliferation of SSE use in Europe. Hamburg has enjoyed extraordinarily high growth in the cruise sector over the past few years with number of passengers increasing approximately 75 percent between 2015 and 2018.

650 ton

Reduction in carbon emissions in the Port of Hamburg thanks to SSE technology

To become 100% of current emissions upon completion of shore-side power expansion project

Hamburg first launched its onshore power station pilot project in 2016. Since then, Hamburg's Altona cruise terminal has begun regular operations of the onshore power station, supplying cruise ships with eco-friendly power from ashore. With ship's own generators shut down completely, and instead being powered by emissions-free energy from its berth, SSE technology has significantly contributed to emissions reduction in the Port of Hamburg. Despite only one of its three terminals having an operational shore power station, in 2018 this was estimated to have reduced CO2 emissions by over 650 tons.

While Hamburg's Altona terminal is already equipped with SSE capability, a new project expanding shore power supply to all terminals with an alternative marine power station is underway and is expected to be completed in 2022. Switching the energy source from the ship's main and auxiliary engines to a municipal power system reduces emissions but having the shore-side power grid be reliant on renewable power will eliminate all existing CO2 and pollutant emissions at berth.

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The modelling and results presented here are based on information provided by third parties, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

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