ALL ABOARD:

How the Biden-Harris Administration Can Help Ships Kick Fossil Fuels

Navigating Our Way to a Zero-Emission Shipping Industry

PUBLISHED 2021

Ocean Conservancy®

PACIFIC ENVIRONMENT

All Aboard: How the Biden-Harris Administration Can Help Ships Kick Fossil Fuels

NAVIGATING OUR WAY TO A ZERO-EMISSION SHIPPING INDUSTRY

WRITTEN BY

PACIFIC ENVIRONMENT

Ocean Conservancy

ABOUT PACIFIC ENVIRONMENT

Pacific Environment is a global environmental organization that protects communities and wildlife of the Pacific Rim. We support community leaders to fight climate change, protect the oceans, build just societies, and move away from fossil fuels toward a green economy.

ABOUT OCEAN CONSERVANCY

Ocean Conservancy is working to protect the ocean from today's greatest global challenges. Together with our partners, we create science-based solutions for a healthy ocean and the wildlife and communities that depend on it.

ACKNOWLEDGMENTS

The authors thank Amanda Ullman, PhD candidate at the University of North Carolina, for producing an extensive policy literature review and independent research that served as the foundation for this report. We are grateful to the more than dozen port authority representatives and shipping and maritime experts interviewed and consulted throughout its development. Finally, we are grateful for lead writing by John Byrne Barry and design by Patricia Chambers.

CONTENTS

ALL ABOARD:

How the Biden-Harris Administration Can Help Ships Kick Fossil Fuels

Navigating Our Way to a Zero-Emission Shipping Industry

Dedicated to the sailors, seafarers, port operators, and coastal, port and freight corridor communities that have moved the world and suffered disproportionately from fossil fuel pollution. We seek to support their fights for environmental justice in this report.

Suggested Citation:
Barry, J., Rose, M., and Hubbell, D. *'All Aboard,'*
Pacific Environment and Ocean Conservancy, Washington D.C., 2021

Cover photo: Alamy Stock Photo | All photos Alamy.com unless otherwise noted.

Executive Summary: Imagine Zero-Emission Shipping by 2035

It's 2035, and the San Pedro Bay Port Complex (Los Angeles and Long Beach), the busiest in the United States and once notoriously called a "diesel death zone," is now a zero-emissions port.

All the ships that dock there, no matter the flags they fly, are powered by clean, renewable sources, as are the trucks, trains, and heavy equipment that make the harbor hum. All the other commercial shipping ports in the United States have kicked fossil fuels, and their emissions are zero. The ships that call on these ports are zero-emission, well to wake, and are powered by batteries, green hydrogen, green ammonia, fuel cells, and wind.

Port equipment is connected to a grid powered by renewables like wind and solar, and communities in and around the ports, which have suffered disproportionately for decades from excessive exposure to toxic pollutants, now breathe clean and healthy air.

Developing these zero-emission ships and accelerating the zero-emission transition at ports has spurred infrastructure projects from coast to coast, not the least of which is a sweeping transformation of the nation's electrical grid, which now generates the majority of its power from renewable sources. The ports have been built and are operated by thousands of well-paid union workers.

EXECUTIVE SUMMARY

The United States and China have established a "zero-emission shipping corridor" between the busiest port clusters in each country — from ChIna's Pearl River Delta to the United States' San Pedro Bay Port Complex.

The U.S. policy to decarbonize shipping, launched during the first year of the Biden-Harris administration, has, combined with similar advances in Europe and Asia, helped galvanize a clean ship movement worldwide.

While more action is required to wean the world economy from fossil fuels, the rate of global warming has slowed, and the planet is on course to limit the increase to 1.5˚C, thereby preventing the worst consequences of global warming.

How does this bright and promising future, just fourteen years from now, come to be?

Today, in 2021, the global shipping industry is a massive global warming polluter, emitting an estimated 1 billion metric tons of carbon dioxide each year.[1] If shipping were a country, it would be the sixth-largest emitter in the world, larger than Germany.[2]

Greenhouse gases that contribute to global warming are not the only problem caused by the industry's emissions — communities that live in and around ports, which are most often working-class communities of color, experience deadly pollution, which causes an estimated 250,000 premature deaths and 6 million childhood asthma cases globally each year.[3]

Ships play a larger role in society today than ever before. Around eighty percent of all international trade, from clothes to cars to couches, is carried by ships.[4]

Shipping is so "efficient" now that when Scottish fishers catch cod in the North Atlantic, they ship those fish to China for filleting and ship the fish back to Scotland to be sold in local markets because shipping costs less than filleting the fish in Scotland.[5]

Of course, this "efficiency" does not account for the environmental costs. Not the least of which is runaway climate change.

EXECUTIVE SUMMARY

And yet ocean-going trade volumes are projected to grow by as much as 130 percent by 2050, which will lead to dangerous increases in greenhouse gases and air pollution — unless we commit to a crash program of decarbonizing shipping.[6]

However, we know that the shipping industry can change, and change quickly. In the early 1900s, it switched from coal to diesel in ten to twenty years.[7]

To prevent the worst-case scenarios of climate disruption, we urgently need a similarly rapid transformation.

Pacific Environment and Ocean Conservancy call on the United States to commit to helping achieve a zero-emission shipping industry by 2035. We urge the Biden-Harris administration to exercise its "port state control" authority under international law to set a progressive "clean ship standard" for all ships calling U.S. ports.

The policy should require progressive cuts in carbon dioxide equivalents (CO_2e) — 50 percent by 2025, 80 percent by 2030, and 100 percent by 2035. That would prevent 213 million metric tons of CO_2e from entering the atmosphere by 2035 and every year thereafter.[8]

In addition to achieving lifesaving emissions reductions, this U.S. policy will create positive ripple effects globally, helping force the development of a zero-emission vessel market and accelerate zero-emission research, development, and demonstration across the maritime supply chain.

This report details 20 policy actions the U.S. government can take to achieve a national zero-emission ship standard and help achieve zero-emission shipping by 2035.

It's an ambitious agenda that will require leaps in technology, massive investments, global cooperation, and, perhaps most of all, resolute political will and courage.

But it is possible. And urgently necessary.

"At any given moment, more than fifty thousand ships are crossing oceans or loading or unloading at ports, from Shanghai and Los Angeles to Antwerp and Singapore."

1. The Wind in Their Sails
The state of the shipping industry

For centuries, all the ships that crossed the oceans were zero-emission vessels. They were powered by renewable energy — the wind in their sails. In the 1800s, piston-engine steamships took over, fueled by wood, then later coal. In the early 1900s, the industry switched to cheaper diesel fuels, but as the demand for gasoline and other products refined from crude oil heated up, it turned to cheaper "residual fuels" left over from the refinery process.

Nearly 80 percent of today's merchant ships run on pitch-black heavy oils thick as molasses and high in carbon. The other 20 percent are powered by marine gas oil, or, increasingly, liquified natural gas (LNG), another potent global-warming fuel.

At any given moment, more than fifty thousand ships are crossing oceans or loading or unloading at ports, from Shanghai and Los Angeles to Antwerp and Singapore.

These ships include oil tankers, general cargo ships, cruise ships, and container ships, which revolutionized the flow of goods around the globe just fifty years ago. Container ships, which carry lockable, stackable metal boxes that are hoisted from trucks onto ships by dockside cranes, and vice versa, have cut shipping costs sharply and become one of the mainstays of global trade. The global shipping fleet has quadrupled in size since the 1980s.

Until containers came on the scene, it cost too much to transport products to a port. Now, the cost of shipping a can of beer from Europe to Asia is a penny.[9]

Zero-emission shipping ***will*** cost more, ***at first***, but not so much that it will undermine the efficiency of shipping. The volume of shipping will almost certainly continue to grow, even as shippers are required to cut emissions.

Denmark-based Maersk, the world's largest shipping company, has committed to net-zero emissions from its ocean shipping by 2050 and estimates that decarbonizing shipping would add only 6 cents to a pair of $100 running shoes.[10]

According to the International Maritime Organization (IMO), a specialized agency of the United Nations charged with regulating shipping, ocean-going CO2 emissions are projected to grow by as much as 130 percent by 2050 from 2018 levels.[11] This growth will lead to dangerous increases in greenhouse gases and air pollution — unless we commit to a crash program of decarbonizing shipping.

Another critical factor that underpins the global shipping industry is the "flag of convenience" practice, which allows ship owners to register their ship in another country's registry — usually to avoid regulations, taxes, and labor rules in their own country.

This practice began during the Prohibition Era when owners of U.S. passenger ships registered their vessels in Panama so they could serve alcohol. Today, more ships fly the Panamanian flag than any other country's flag, followed by Liberia, Marshall Islands, Hong Kong, and Singapore.[12]

The high (and largely uncounted) emissions from shipping

While we know the global shipping industry is a massive global warming polluter, for the last several decades, the world has had limited access to accurate ship emissions data, relying largely on shipping companies' voluntary reporting to the United Nations and analyses by third-party academics and non-governmental groups (NGOs).

While the drafters of the Kyoto Protocol debated an approach to accounting for shipping's emissions by country, no firm method was agreed on — they delegated that challenge to the IMO. The bulk of the emissions are generated outside of national borders, and most ships fly flags of convenience, which muddies the waters even more.

To this day, shippers are not held accountable for their emissions. Like aviation, the global shipping industry was included in drafts of the Paris Climate Agreement, but not explicitly addressed in the final document.

Historically, no nation has stepped up and counted shipping industry emissions as theirs or regulated them accordingly. But we cannot hope to meet the 1.5˚C scenario unless nations account for shipping emissions.

Now there is an opportunity to bring the accounting home.

In a March 2021 letter to U.S. President Joe Biden, European Commission President Ursula von der Leyen, and U.K. Prime Minister Boris Johnson, a transatlantic coalition of 12 NGOs urged that shipping emissions be accounted for in the nationally determined contributions (NDCs) to the Paris Agreement, that all ship emissions be split on a 50:50 basis between the country of origin and country of destination.[13] Incorporating ship emissions into NDCs could add a much-needed level of accountability.

Ships' greenhouse gases don't just impact the air and the atmosphere. They have a direct effect on the oceans the ships cross, contributing to ocean warming, deoxygenation, and acidification. This impacts marine ecosystems and the communities that depend on them. Even under a 1.5˚C warming scenario, the best-case scenario, an estimated 70 to 90 percent of coral reefs will die out. Under a 2˚C or higher scenario, virtually all coral reefs — including the Great Florida Reef, the largest coral reef ecosystem in the continental United States and the third-largest in the world, would be gone.

The responsibility of the United States as the planet's largest consumer

While the United States is not the world's largest shipbuilder, it is the largest per capita consumer and largest per capita emitter of greenhouse gases, and thus bears an outsized responsibility to tackle fossil-fuel pollution from ships and prevent the worst-case scenarios of climate disruption.

It also has the opportunity to play a global leadership role in the move to zero-emission shipping.

The United States can, and must, leverage its "port state control" and consumer muscle to set a "clean ship standard" requiring ships calling at our ports to make steady reductions in carbon intensity year-over-year until they become zero-emission.

"Even under a 1.5°C warming scenario, the best-case scenario, an estimated 70 to 90 percent of coral reefs will die out."

"According to the IMO, ocean-going CO2 emissions are projected to grow by as much as 130 percent by 2050 from 2018 levels."

PORT STATE CONTROL

Port state control means that the home country — where the ships are loading or unloading cargo — has the right to inspect foreign ships to verify that they are complying with international rules and require them to abide by their domestic laws.

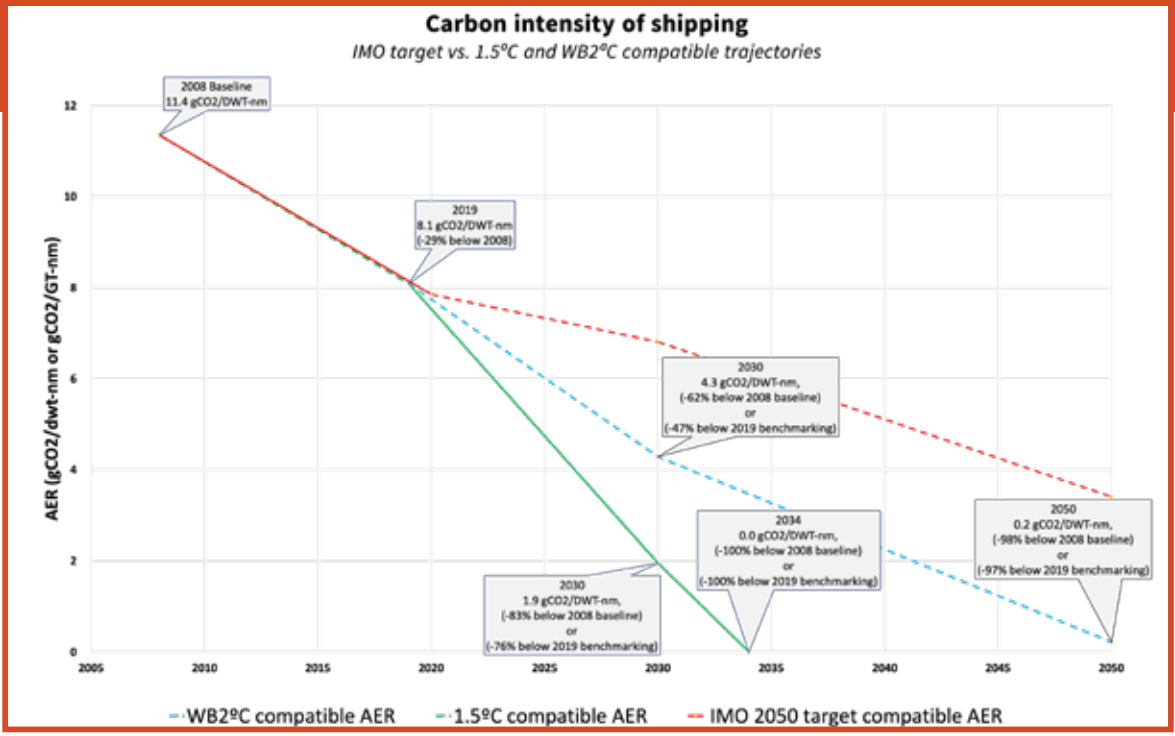
There are multiple examples where one nation has successfully set a standard. After the *Exxon Valdez* oil spill in 1989, the U.S. Congress passed a law that mandated that oil tankers in U.S. water be double-hulled. Today, all of the more than 12,000 tankers in the world have double hulls.[14]

In 2018, to protect its fjords, Norway passed a law requiring zero-emission cruise ships and ferries by 2026.[15]

Requiring that all vessels calling at U.S. ports adopt zero-emissions technology would reduce shipping emissions by 213 million metric tons of CO2e annually.[16]

"The U.S. should exercise its port state control authority under international law and set a progressive clean ship standard consistent with a 1.5°C decarbonization pathway for all ships calling U.S. Ports. "

"The policy should require progressive CO2e intensity improvements."



Source: Transport & Environment

The good news is that we have learned from history that the industry *can* change, *and* change quickly. In the early 1900s, it switched from coal to diesel in ten to twenty years.

Especially important will be governments pushing the market for new technologies like battery power and green hydrogen power, so that they're one day cheaper and cleaner than the dirty fuels being used now.

In the United States, one key initiative would be to fund the expansion of the National Renewable Energy Laboratory's (NREL) H2 grid project to advance affordable hydrogen production. The lab needs $4 billion to achieve full realization of the H2Grid scenario.[17]

Pacific Environment and Ocean Conservancy urge the United States to commit to helping achieve a zero-emission shipping industry by 2035. At the center of this policy, the United States should exercise its port state control authority under international law and set a progressive clean ship standard consistent with a 1.5°C decarbonization pathway for all ships calling U.S. ports.

The policy should require progressive CO2e intensity improvements — 50 percent by 2025, 80 percent by 2030, and 100 percent by 2035. Zero-emission shipping won't solve the climate crisis by itself. But without it, we'll be in a world of trouble.

U.S. ports are pollution hot-spots. Frontline communities next door to ports, refineries, and other major polluters are often called "sacrifice zones."

2. Environmental Justice: Eliminating Emissions in U.S. Ports

U.S. ports are pollution hotspots. Frontline communities next door to ports, refineries, and other major polluters are often called "sacrifice zones."[18]

The majority of the shipping industry's annual 1 billion tons of emissions come from burning carbon-heavy fuels to power the ships at sea, but a significant fraction comes while vessels idle "at-berth," as cargo and/or passengers are loaded and unloaded.

Ships release two types of pollutants: climate-warming greenhouse gases, like CO2 and methane (CH4); and what the EPA calls "criteria pollutants," specifically sulfur oxides (SOx), nitrogen oxides (NOx), and particulates (PM2.5), all of which cause grave health consequences.

Communities near the ports in Los Angeles and Long Beach are largely working-class communities of color whose health and wellbeing have been compromised for decades. After years of suffering severe respiratory distress or cardiac arrest related to air pollution, frontline communities and public health authorities coined the term "diesel death zone" to describe the freight corridors in and around the port complex. Communities living near the San Pedro Port Complex Corridor and along transit highways continue to suffer from high rates of asthma, cancer, and early onset illnesses. They are demanding a just transition to zero emission future.

But even if all the ships were zero-emission vessels, other port infrastructure challenges public health. The massive cranes, trucks, trains, and other cargo handling equipment cause significant pollution.

While this report expressly focuses on the ship-side transition, Pacific Environment and Ocean Conservancy fully support a policy approach to achieve zero-emission ports comprehensively.

Emissions Standards to Advance Environmental Justice

Ultimately, the best way to end fossil fuel pollution and existential climate risk in port communities is to transition ships off fossil fuels entirely.

An "operational standard," that is, a goal-based policy mechanism, which requires progressive improvements in ships' operational carbon intensity, is therefore an essential environmental justice policy. Operational standards that require progressive, year-over-year improvements in absolute carbon equivalent emissions or carbon equivalent intensity emissions can generate both immediate reductions and provide market certainty to accelerate ships' ultimate transition away from fossil fuels.

Because we face a climate emergency, policymakers must ratchet up carbon emissions reduction. The United States should put in place an operational carbon equivalent standard aligned with a 1.5˚C decarbonization pathway.

Operational standards *do not* constrain market innovation. To meet year-over-year targets, companies retain the flexibility to improve their energy efficiency through wind-assisted propulsion or choose the most appropriate technology — batteries for ferries, compressed hydrogen for small/mid-size vessels, and liquid hydrogen or ammonia for the largest — to fit their operational profile, but all must be certified as having zero well-to-wake carbon dioxide equivalent emissions.

Indeed, a 1.5˚C-aligned clean-ship standard can advance environmental justice, rapidly achieve climate mitigation gains, *and* encourage market-led innovation.

Clean shore power is an interim step

One reason ports are so polluted is that most ships continue to burn their dirty fuels while they are "at-berth," that is, docking at the port. The most popular strategy to reduce air pollution from ships' auxiliary engines while at-berth is for the ships to plug into shore power, what the industry calls "cold ironing."

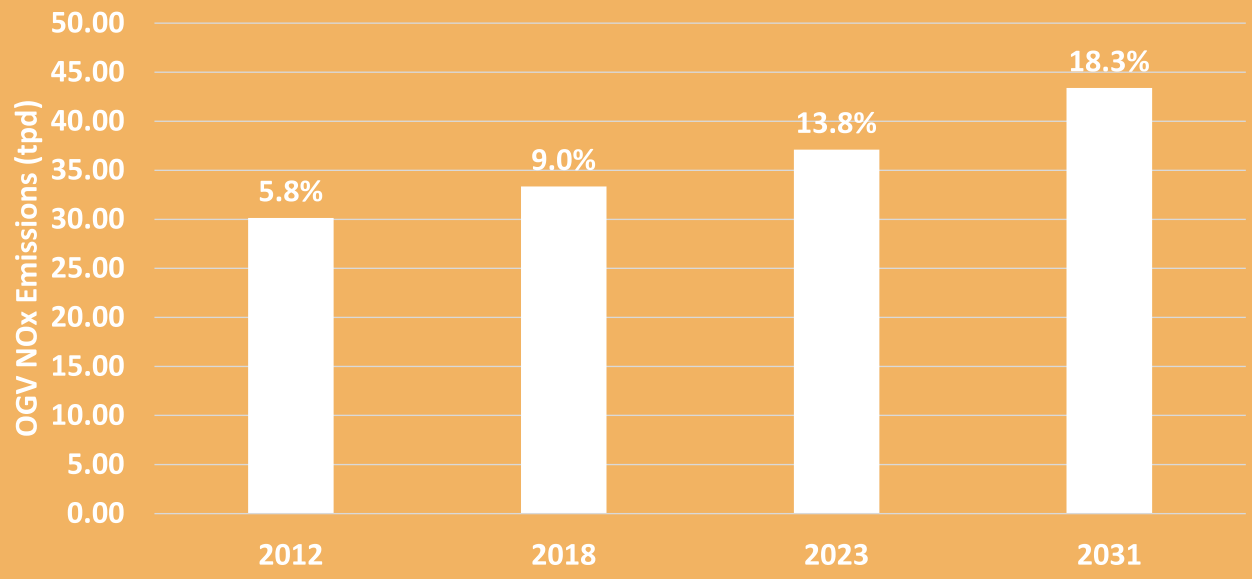
Shore power allows ships to keep their lights, heat, and electricity going without running their engines. In 2008, the Port of Seattle became the first port in the world to provide shore power to cruise ships, and participating ships have reduced their CO2 emissions by 29 percent while in port.[19, 20] (The ships plug into Seattle's utility grid, which is 90 percent powered by hydroelectricity and other renewables.)[21]

Though shore power has a positive impact on reducing carbon emissions that contribute to climate disruption, it is first and foremost a public health measure. Reducing ship emissions reduces premature deaths, asthma, lung disease, and a myriad of other pollution-related health problems.

Shore power, known in the shipping industry as “cold ironing,” allows ships to turn off their auxiliary engines while at-berth and to plug into the port’s electricity grid.

By 2023, oceangoing ships will surpass heavy-duty diesel trucks to become Southern California’s largest source of smog-forming nitrogen oxide pollution, a dangerous air pollutant that contributes to asthma, cancer, and premature death.

OGV NOx Emissions Contribution



Significant OGV NOx emission reductions are needed for attainment of ozone standards.

Source: Soutch Coast AQMD

Promising examples of shore power

California put in place at-berth emissions standards in 2010 and has seen a corresponding cut in NOx emissions in 2020 by 80 percent compared to when the law went into effect a decade earlier.

But the rules only apply to the largest shipping fleets, only to the ports of San Diego, Long Beach, Los Angeles, Hueneme (Ventura County), Oakland, and San Francisco, and only to fleets that load and unload at these ports more than 25 times per year.[22] So about half of the 8,000 vessels that visit California ports are not required to meet these standards.[23] Once fully implemented to cover more ships, the shore power benchmarks are expected to reduce potential cancer risk in the portside communities of Los Angeles and Long Beach by 55 percent.[24]

The California rules state that shore-power-equipped ships *must* use shore power if the ship is equipped to do so, *and* shore power is available at berth. Otherwise, shipping fleets must reduce emissions through other shipside or shoreside control technologies.

Unfortunately, shore power is currently available at only 11 ports in North America (Juneau, Vancouver, Seattle, Tacoma, San Francisco, Oakland, Hueneme, Los Angeles, Long Beach, San Diego, and Brooklyn)[25] and 21 worldwide,[26] one reason being that shore power is generally more expensive than marine fuel, and most ships are not equipped to take advantage of it.

California is the only U.S. jurisdiction that requires shore power, and there are only a few outside the United States, such as the UK's Clean Maritime Plan and the Shenzhen Air Quality Enhancement Plan in China. The European Union requires ports to have shore power by 2025.[27]

Expanding shore power infrastructure across U.S. ports has not only cleaned up pollution and improved public health; it has also contributed to economic development, including well-paying jobs in construction and operation. Establishing shore power in just one Long Beach terminal — Pier C — created 60 union jobs. Using this as a baseline, we could estimate that installing shore power in all 350-plus port terminals in the United States could create more than 200,000 new well-paying union jobs.[28]

POLICY RECOMMENDATIONS

1. **Set U.S. policy to decarbonize shipping by 2035.** To maintain global temperature goals below 1.5°C and avoid the worst impact of a warming planet, the U.S. must align all relevant policies — domestic and international — with this timeline.

2. **Set a federal zero emission ship standard.** The Biden-Harris administration should exercise its port-state-control authority under international law and set a progressive standard consistent with a 1.5°C decarbonization pathway for all ships loading and unloading at U.S. ports. These standards should require carbon reductions of 50 percent by 2025, 80 percent by 2030, and 100 percent by 2035.

3. **Eliminate in-port ship emissions by 2030.** By 2030, all ships at-berth or at-anchor in U.S. ports should emit zero greenhouse gases and zero criteria pollutants. We recommend focusing on the zero-emission outcomes, which gives shipping companies flexibility in how to meet these mandates.

A container ship and tugboat arrive in the port of Long Beach. Together, the Ports of Long Beach and Los Angeles make the San Pedro Bay Port Complex, managing over 30% of all national maritime trade or 4% of global maritime trade.

The California rules required progressively higher reductions in emissions — from 50 percent in 2014 to 70 percent in 2017 to 80 percent in 2020. Ships can now plug into shore power at nine terminals at the Port of Los Angeles — seven container and two cruiser.

East and Gulf coasts offer fewer opportunities for ocean-going vessels to access shore power — the Port of New York's cruise terminal in Brooklyn offers shore power, but only a third of the ships use it.[29]

In the absence of federal mandates and investment and/or increasing requests from vessel operators, these ports are unlikely to independently install it.

Shore power infrastructure costs vary by port, but the California Air Resources Board reports it to be about $5 million per berth.[30]

Of course, shore power only works if ships can plug in. Retrofitting ocean vessels to take advantage of shore power can cost between $500,000 and $2 million per ship, depending on vessel size and whether an on-board transformer is needed.[31] Since it costs half as much to include that technology in the initial build, we recommended that new vessels include shore power in their original design.

4. **Require biannual port emissions inventories to ensure compliance.** U.S. ports are not currently required to conduct an annual inventory of air pollutants or greenhouse gases. Uniform reporting of emissions is needed to ensure compliance with a zero-emission target by 2030.

5. **Establish an Environmental Justice Ports Advisory Commission.** For decades the perspectives and interests of communities living in major American port cities have been sidelined to accommodate rapid growth of the shipping industry. An Environmental Justice American Ports Advisory Commission, or a ports and shipping working group within the White House Environmental Justice Council, should be established to prioritize frontline community perspectives in port and shipping policy decisions.

"In 2018, commercial ships calling on U.S. ports burned 3,474 million gallons of fuel, mostly high-carbon heavy fuel oil. We must replace these climate-endangering fuels with alternatives."

3. The Rise of Zero-Emissions Propulsion

How batteries, green hydrogen, and green ammonia can make shipping clean

We can only reach our goal of zero-emission shipping with zero-emission fuels — fuels that are not just zero-emission when the ships are sailing, but from well to wake.

Fossil fuels do not qualify.

In 2018, commercial ships calling on U.S. ports burned 3,474 million gallons of fuel, mostly high-carbon heavy fuel oil.[32]
We must replace these climate-endangering fuels with alternatives that produce no emissions over their lifecycle and can be used by ocean vessels carrying heavy loads over long distances.

The best options are green hydrogen, green ammonia, fuel cells, batteries, and wind. Let's look at them one at a time.

GREEN AMMONIA

"In 2020, the International Energy Association (IEA) named ammonia to be the most promising fuel for the maritime industry."

GREEN HYDROGEN

"Green hydrogen is suddenly gaining ground. Linde announced a new 24-megawatt electrolyzer to produce green hydrogen"

Fuels we recommend

Green hydrogen fuel, that is, hydrogen manufactured by electrolyzing water using renewable energy, is emerging as one of the best ways to power a cargo ship across the ocean with zero emissions.

Electrolyzers, which can be as small as a refrigerator or large as a power plant, split water molecules (H_2O) into hydrogen and oxygen. When hydrogen is used to power a ship, it turns back into water.

Green hydrogen is suddenly gaining ground. In January 2021, Linde, a German company founded to refrigerate beer, announced a new 24-megawatt electrolyzer to produce green hydrogen at its Leunawerke chemical complex in Saxony-Anhalt.

It will become the world's largest electrolyzer, but in the same month, a consortium of six European Union countries, including Germany, sought EU Green Deal funding for one four times as large — a 100-MW alkaline electrolyzer plant in Spain.[33]

In 2017, the *Energy Observer*, a small demonstration boat covered with solar panels, began a six-year journey around the world exploring a variety of zero-emission ways to power ships, including making its own hydrogen fuel from seawater — while in transit.

The Toyota "Range Extender H2" fuel cells pump in seawater, remove salt, then separate the hydrogen from the water with electricity from the solar panels. The hydrogen is then stored in tanks until needed.[34]

Green ammonia (NH3), with three hydrogen atoms bonded to one nitrogen atom, is created by combining green hydrogen with nitrogen at high temperatures and pressures. Most ammonia today is made for fertilizers and chemicals from a carbon-intensive process.

That's not the only way. Ammonia can be created with sun, air, and water — solar energy (or other renewable sources) electrolyzes water, yielding hydrogen, which is then combined with nitrogen extracted from the air.[35] Ammonia created this way is, almost literally, "bottled sunshine."

Ammonia's advantage over hydrogen is that it's easier and less expensive to store and transport. It can be turned into a liquid at modest pressures and doesn't require *extremely* low temperatures, like hydrogen. Ammonia's boiling point is -33˚C, hydrogen's is -253˚C.[36]

Since it is a hydrogen carrier, it can be burned as fuel in internal combustion engines (although this creates NOx and nitrous oxide - a powerful GHG), turned into a fuel cell, or transformed into hydrogen fuel. It can also take advantage of existing distribution networks, like refrigerated tanks and pipelines.

In 2020, the International Energy Association (IEA) named ammonia to be the most promising fuel for the maritime industry.

But presently, there are no big ships equipped to run on ammonia and the supply of green ammonia is limited. Other sectors, such as agriculture, may be first in line to use up green ammonia before ships.

Green ammonia (NH_3) cont'd.

There are promising pilot projects in the works.

Color Fantasy, a Norwegian cruise ferry that runs between Oslo and the German port of Kiel, is testing ammonia fuel. The Nordic Green Ammonia Powered Ships (NoGAPS) is building a green-ammonia-powered ship to be in operation by 2025.

Two other Norwegian companies, Wärtsilä and Grieg Edge, plan to launch an ammonia-fueled tanker producing no greenhouse gas emissions by 2024. What makes this venture especially promising is that its potential customers are ships currently fueled by LNG. The ammonia could be mixed with the LNG or the engines can be retrofitted to run entirely on ammonia.[37]

Above: A 100kW marine fuel cell. Looks a little like a Coleman camping stove, doesn't it? *https://blog.ballard.com/fuel-cells-marine-vessels*

Fuel cells, which can be powered by hydrogen, ammonia, or other fuels, work like batteries that never need charging. As long as there's a fuel supply, they keep generating electricity. They are especially practical because they are modular and can be scaled to a wide range of power loads, from commuter ferries to huge tankers. For vessels like tugboats that work long hours and can't take time off to charge their batteries, fuel cells are an ideal fit.

Green hydrogen fuel cells can be refueled as quickly as a fossil-fuel-powered vessel. The only by-products are water and heat.

Hydrogen fuel cells are still an immature technology, they take up more space in a ship than fossil fuels do, and they are comparatively expensive. They have a low energy density compared to fossil fuels, so they require larger fuel tanks, which means less cargo space, more frequent refueling, or ship redesign.

Two years ago, the European consortium Project FLAGSHIPS began work on two demonstration zero-emission hydrogen fuel cell ships — one in Lyon, France, will be a utility vessel on the Rhône; the other, in Stavanger, Norway, a high-speed passenger ferry. They are expected to begin commercial operation later this year.[38]

Batteries are perhaps the simplest zero-emission energy source to understand because we see electric cars on the road now. There are already battery-powered tugboats and ferries and more in the works, but batteries aren't powerful enough to move large ships across oceans. Yet.

We'll need better batteries before we can do that, but batteries can be used for auxiliary power or hybrid propulsion for ocean-going vessels.

Next year, Tokyo-based Asahi Tanker plans to launch a 60-meter-long tanker powered only by lithium-ion batteries, with an energy storage system the size of 40 Tesla Model S battery packs, enough for "many hours" of work before having to recharge.[39]

China and Norway have also launched large electric vessels that run on batteries. Norway began commercial operations of electric ferries, like the Ampere, in 2015.[40] In 2017, China launched the world's first all-electric cargo ship, using a lithium battery to power the 2,000-metric-ton vessel,

While electric motors can be cheaper than internal combustion engines, the current cost of batteries per unit of energy makes it expensive, but those costs will go down.

Batteries are not zero-emission well-to-wake, of course, unless they are charged by renewable power.

Wind is making a comeback, though we're not turning back the clock to the three-masted schooners of the 19th Century. What's coming are wind propulsion technologies that generate some of the ship's power, not all of it. The ships are *wind-assisted,* not *wind-powered.*

Most wind-assisted ships don't look at all like the old-school ships that plied the oceans for centuries. There are a variety of designs for harnessing wind on ships — from soft sails, rigid sails, wing sails, and hull sails to kites, rotor sails, and wind turbines.

Kites can take advantage of high altitude winds. Wind turbines can generate electricity for onboard needs or directly propel the ship.

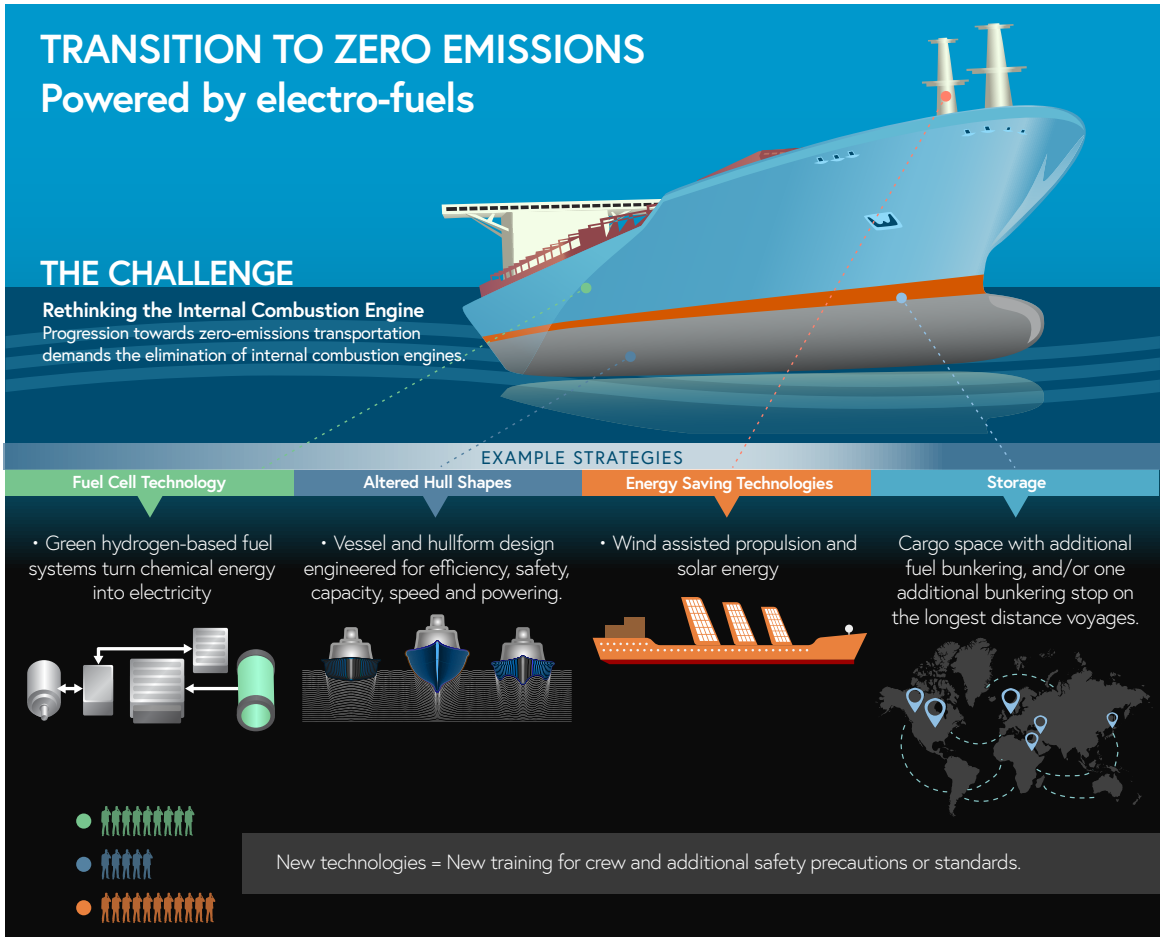
Some technologies are better suited for particular kinds of ships. Rotor sails — vertical rotating cylinders — are considered more effective than kites but are not appropriate for container ships because they lack the deck space needed. Instead, rotor sails are best suited for bulk carriers and tankers. Rotor sails are being designed today to be installed on tracks or to be tiltable to make sure they stay out of the way of loading and unloading operations and so that ships can fit under bridges on their way into port.

In 2018, the *Maersk Pelican*, a crude oil tanker, installed two 30-meter-tall white towers that look like smokestacks, but are in fact, rotor sails. In a year-long trial that took it halfway around the world, the rotors cut fuel consumption by 8 percent.[41]

The sails on the *Energy Observer*, referenced above in the green hydrogen section, reduced energy use by 18 to 42 percent,[42] which is higher than most wind-assisted ships.

The 200-meter long *Orcelle Wind*, powered by wind energy, built by Wallenius Marine AB from Sweden, will be able to carry 7,000 cars. It's designed to run entirely on wind, though it has a backup engine. Wind-assisted ships, which generate some of the ship's power, not all of it, are more likely on the horizon than wind-powered ships.

Photo: Wallenius Marine



The *E-Ship 1*, a German cargo vessel with four rotor sails, achieved between 15 and 25 percent fuel savings on two voyages, Portugal to Uruguay and Netherlands to Portugal. On the second voyage, 1,400 nautical miles, it saved 47 percent of its fuel![43]

The fuel savings, while important, are not as important as the reduction in greenhouse gases. A U.K. industry group, the International Windship Association, projects that wind propulsion ships can cut carbon emissions between 20 and 30 percent.[44]

There are already 11 ocean-going ships that have installed wind-assist systems, and dozens more in the pipeline.[45]

In February 2021, Michelin committed to send tires from Canada to France on NEOLINE sailing cargo ships that can potentially cut carbon emissions by 90 percent. Other ports they will serve include Saint Pierre, Miquelon, and Baltimore.[46]

All of the Above: For some ship owners, it may make sense to settle on one zero-emission fuel option, but that's not necessary. Combining a mix of technologies — batteries plus hydrogen plus ammonia — might well become the best path to zero emissions.

Those decisions are based on balancing a variety of factors — shipping distances, the weight of cargo, shipping design, availability of renewable energy, cost, safety, and more.

We will need additional investment in renewables power, electric grids, shore-side charging stations, hydrogen and ammonia manufacturing plants, new ship propulsion and energy storage designs, and a new infrastructure for storing and transporting these new fuels.

Fuels We Recommend

FUEL	PROS	CONS
Battery	Ideal for short-range ships like ferries, tugboats. Could be used for auxiliary power and hybrid propulsion for ocean-going vessels.	Not yet powerful enough to totally power large ships that cross oceans. Lithium-ion batteries pose safety risks.
Green Hydrogen	Zero emissions when produced with renewable sources. Can be produced by electrolyzing water. When hydrogen is used, the by-product is water.	Lower energy density than fuel oil. Storage challenges. Liquefies at extremely low temperatures. Flammable.
Green Ammonia	A "carrier" for hydrogen. Can power internal combustion engine or fuel cell or be transformed into hydrogen.	Toxic, will require additional safety and spill avoidance protocols.
Hydrogen or ammonia fuel cells	Like a battery, but never needs to be charged as long as there's a fuel source. Highly scalable. Can run on hydrogen or ammonia.	Low-density, compared to fossil fuels. Still more expensive than fossil fuels.
Wind	Unlimited, free, and renewable. Many wind-propulsion options available to fit ship owner needs.	Most likely will need to be combined with other fuel sources.

Fuels Not Recommended for Shipping

FUEL	CONS
LNG	Not zero-emission and often worse on a well-to-wake basis than conventional fuels. Methane, its main ingredient, is 87 times more potent a greenhouse gas than CO_2, and marine engines leak large amounts of unburned methane.
Biofuels	Not zero-emission and often worse on a well-to-wake basis than conventional fuels unless made from waste or non-food crops. Could result in deforestation and other environmental damage to grow feedstock.
Methanol	Not zero-emission. Made from fossil fuels, though could be made from renewable sources. Nevertheless, will emit CO2 that will contribute to climate change unless the CO2 is sourced from direct air capture.
Nuclear	Significant environmental, health and security risks.
Solar	Suitable as a source for on-board electricity, but would take up too much space on ships.

DEAD END FUELS

There are five fuels we *don't* recommend because they will not help us get to zero-emission ships soon enough — liquefied natural gas (LNG), biofuels, methanol, nuclear, and solar.

X Liquefied natural gas (LNG) is touted by its proponents as cleaner than the residual fuel ships currently burn.

France's CMA CGM SA, the world's fourth-largest container ship operator, recently ordered 22 ships to run on LNG. Other big carriers are following suit. Best-case estimate, however, according to DNV, an international ship registrar based in Norway, is that LNG will cut carbon emissions by 20 percent. That's not enough. Worse, the International Council on Clean Transportation (ICCT), an international non-profit research organization headquartered in Washington, DC, found that the most popular marine engines emit up to 82% more carbon dioxide equivalent emissions than marine gas oil.[47]

The concern with LNG is not just the carbon emissions, but that methane, the main ingredient in natural gas, and more than 80 times more potent a greenhouse gas than CO_2, is released into the atmosphere when the gas doesn't burn completely or when it leaks from well-heads, pipelines, and other sources along its production pathway. Methane emissions from shipping leapt by 150 percent from 2012 to 2018, according to the Fourth IMO GHG Study.[48]

Another concern is that companies that invest in LNG infrastructure will want to keep using it to pay back their startup costs, even as much cleaner options become available at more competitive prices. By one estimate, building and operating the necessary infrastructure for LNG at just the port of Busan would cost between $12 and 14 billion.[49]

The overarching reason for not pursuing LNG, biofuels, or methanol is that these so-called "bridge fuels" are more accurately "bridges to nowhere." They will take us on a detour in our path to zero-emission fuels, and the climate situation is too urgent not to go as directly and rapidly toward green hydrogen, green ammonia, and batteries as possible.

- Biofuels, made from wood, crops, or organic waste, promise lower carbon emissions, but not necessarily. If we look at the life cycle of palm-oil biofuels and its carbon-intensive cultivation, it produces just as much carbon emissions as fossil fuels. Plus, it leads to deforestation and other environmental damages because of the need to clear land to grow the fuel feedstock. Biofuels must be made from wastes or non-food crops to have any chance at having low or zero well-to-wake emissions. The supply of these kinds of biofuels is extremely limited, and other sectors have a higher willingness to pay for these more expensive forms of biofuels. Shipping risks being inundated with cheap, food-based biofuels that offer no climate benefits. Biofuels must be evaluated on their full well-to-wake emissions.

- Methanol is also touted as a future marine fuel, but it's made from natural gas and its potential to reduce CO2 emissions is only slightly more than for LNG. Though it is far better in terms of SOx, NOx, and particulates than conventional marine fuels. It *can* be produced from renewable sources, which would reduce its carbon footprint somewhat, and it's similar enough to existing shipping fuels that it would not require a new infrastructure.[50] Burning methanol still emits CO2, and methanol's climate credentials must be evaluated on its full well-to-wake emissions.

At a 2021 presentation to investors, Søren Skou, CEO of Danish shipping giant Maersk, said, "We will end up with ammonia or methanol as a future fuel."[51]

But the only place methanol has been used on a large scale is for cars in China, where it is created from coal and generates substantial greenhouse gases.[52]

- Nuclear energy has been used to propel ships since the 1950s, but primarily for militaries. While these ships don't emit greenhouse gases or criteria pollutants, and they allow for long times at sea without refueling, they pose significant environmental, health and security risks.

- Solar energy is well-suited to delivering electricity for on-board power demand, and of course, it can provide power to grids that recharge batteries, but the available area for energy capture on a large ship is not enough to fuel a trip across the ocean unless someone develops a technology that can turn the sun's energy into a liquid fuel source.[53]

POLICY RECOMMENDATIONS

1. **Require ships report their fuel consumption and emissions.** The United States does not have an accurate accounting system to count emissions from ships calling on our ports. We need an improved, transparent reporting system that requires ships to report these emissions to U.S. authorities to serve as a basis for accurate emissions reductions. The U.S. system should be modeled off of the European Union's Monitoring, Reporting, and Verification for ships (MRV).

   (In 2020, Congressman Raul Grijalva introduced the Ocean Based Climate Solutions Act, H.R.8632, including a provision to establish an MRV for ship emissions to accurately account for and oversee ships' emissions. The bill has yet to be introduced in the current U.S. Congress.)

2. **Bring down costs of electric and zero-emission fuel solutions relative to fossil fuel.** Producing zero-emission fuels for shipping requires substantial investment — to accelerate renewable energy infrastructure and bring down the costs, to grow electrolysis capacity, to convert energy into fuels, and more.

   The Biden-Harris administration and the U.S. Congress should explore incentives, rebates, taxes, and/or other financing mechanisms to support battery and fuel production. All efforts should also address frontline communities' concerns.

3. **Increase federal funding for zero-emission vessel innovation.** While absolute spending levels are difficult to determine, the United States spends in the low million levels each year on dedicated clean maritime technology. Federal funding for zero-emission pilot projects, demonstration projects, and research, design, development, and deployment should increase to at least $500 million per year. Among many other departments to support, we recommend the following investment increases:

   Department of Energy: Advanced Research Projects Agency–Energy (ARPA-E). ARPA-E is presently requesting $425 million annually from Congress. We recommend raising its authorization to $515 million with a directive to focus on zero-emission shipping.

   Department of Transportation: Maritime Environmental Technical Assistance Program (META). By raising the funding for this program from its current $3 million annually to $25 million will allow the program to support additional research into zero-emission vessels, fuel cell applications for ships and ports, port electrification, and energy efficiency.

Create an Advanced Technologies Loan Program for Zero-Emission Shipping. We need more companies to work on all aspects of zero-emission vessel development and fuels across the maritime supply chain. A Department of Energy Advanced Technologies Zero-Emission Shipping Program should support manufacturers of zero-emissions vessels, as well as manufacturers of components or materials that support them. The department's Loan Program Office is experienced in providing loans and loan guarantees for large-scale energy infrastructure projects, like the incubation and development of America's most successful electric-vehicle company, Tesla.

4. **Ban scrubber systems in U.S. ports and waters.** One way shipping companies maintain their reliance on dirty fossil fuels in the face of increasing air quality regulations is by installing "scrubber discharge technologies" that dump oily-filled waste water into the ocean before docking at ports. Scrubber systems should be banned as a means of compliance with clean fuel standards in U.S. waters or at U.S. ports. Thirty nations already ban scrubber systems in national waters — including major shipping nations China, Singapore, Norway, and the United Arab Emirates.

5. **Develop green marine highways for domestic ports.** One long-standing priority of the Department of Transportation has been to increase the use of U.S. waterways and support the development of "marine highways" that parallel congested interstate highways, like M-90 through the Great Lakes (which parallels I-90) and M-5 along the West Coast (which parallels I-5).

This program could, for example, support a zero-emission route for bulk carriers following M-90 bringing iron ore from Duluth to Gary.

Establishing zero-emission vessel marine highways would allow for smaller, more trial based ships to have access to a dependable alternative fuel on either end of their route, and lead to accommodation of larger and ultimately ocean-going vessels as well.

"The United States can and should lead the way to a zero-emission shipping future."

4. How We Get From Here to There
Infrastructure, investment, and market development

When a market is new and important, like the market for green hydrogen fuels, like the market for zero-emission ships, it is incumbent on governments to put into place policies, incentives, standards, infrastructures, and investments to help that market grow faster than it might on its own.

Eventually, ships will become zero-emission. So will ports and utility grids. Renewable energy will continue to expand and prices will continue to drop.

But we face a climate crisis, and "eventually" is not soon enough.

We have to get to zero-emission ships and ports and grids faster — with all deliberate speed — in order to prevent the worst consequences of global warming from happening.

How can the United States, only one country of many on the planet, boost these new fuels and technologies and the infrastructures that support them enough to meet the climate challenges we face?

The United States can and should lead the way to a zero-emission shipping future. It can build a vibrant clean ship industry domestically ***and*** use its port state control to set a "clean ship standard" that requires ships calling at our ports make steady reductions in carbon intensity.

That in turn will promote the international market for zero-emission fuels and zero-emission ships.

But even if we could snap our fingers and a genie were to grant us all the green-hydrogen fuels and batteries we needed to power ships across the ocean, we wouldn't be able to get far without being granted a second wish — for a robust infrastructure to support these zero-emission fuels. Not just here in the United States, but around the world.

We can't depend on wishes. We need infrastructure, investment, market development, and more.

The coming demand for renewable electricity

Nothing is more critical to zero-emission shipping than an ample supply of renewable energy — to charge batteries and manufacture green hydrogen and green ammonia.

Zero-emission fuels cost considerably more than the dirty fuel oil most ships burn today. Green hydrogen costs two to three times to produce compared to blue hydrogen.[54] Neither is cost-competitive with natural gas at present.

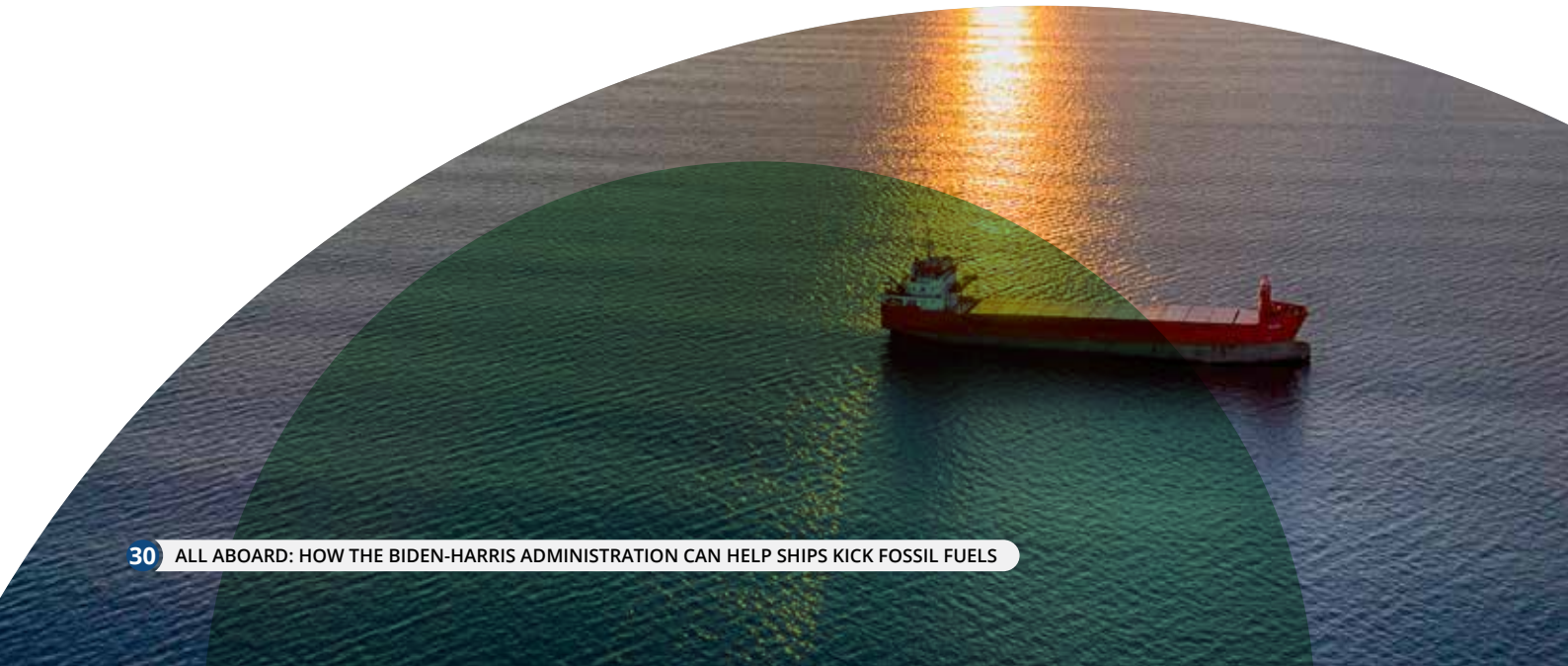
Batteries are not big enough or cost-competitive enough to power a big ship across the ocean.

The shipping industry is not the only industry seeking zero-emission sources of power. While we are promoting zero-emission shipping, other groups are fighting for zero-emission airplanes. The auto industry is moving quickly toward electric fleets.

Jakob Askou Bøss and Jennifer Layke from the World Resources Institute say that meeting the Paris agreement will require a *nine-fold global increase in renewable energy.*[55]

We are going to need more solar and wind power not only to keep global temperatures from soaring, but to meet the growing demand.

Bøss and Layke assert that one important role governments can play is to bring stakeholders together to manage land-use decisions for utility-scale wind and solar



projects, as well as develop policies so fossil-fuel workers and communities are not left behind as we transition to clean energy.

The costs of electricity from wind and solar have plummeted over the past decade. In the past ten years, solar electricity prices in the United States have dropped 89 percent — imagine your monthly rent dropping from $3,000 a decade ago to $330 today. Onshore wind prices dropped 70 percent during that same time period.

Renewable energy is unlike fossil fuel. Power plants that burn fossil fuels pay for the fuel. Renewable power plants don't — sunlight and wind are free, so the major costs come at the beginning the technology and the construction.

Not having to pay for the fuel, combined with the increasing demand, will continue to grow the industry and drive prices down, which will make green hydrogen and green ammonia less expensive as well.

The International Renewable Energy Agency (IRENA) estimates that the cost of green hydrogen could fall as steeply as wind and solar, by 40 to 80 percent in the next ten years.

But we still need policies and investment to speed up that process.[56]

The Biden-Harris administration has already launched significant policies to do so, promising to produce green hydrogen using renewable energy that costs less than natural gas, and charging the Department of Energy to spend $100 million on research and development.[57]

And within a week of being sworn in, Jennifer Granholm, the new Secretary of Energy, announced the revival of the Loan Programs Office, which was dormant during the last administration, but in 2010, loaned $465 million to Tesla, which repaid it within three years.[58] She also called for the installation of "hundreds of gigawatts" of carbon-free energy over the next four years in order to meet President Biden's target of 100 percent carbon-free electricity generation in the United States by 2035, and net-zero greenhouse gas emissions by 2050.[59]

"The World Resources Institute say that meeting the Paris agreement will require a nine-fold global increase in renewable energy."

"(IRENA) estimates that the cost of green hydrogen could fall as steeply as wind and solar, by 40 to 80 percent in the next ten years."

And last year, in the middle of the pandemic, the European Union committed €26 billion for new offshore wind farms, which will generate 7.1 gigawatts of carbon-free electricity. The EU's goal for 2050 is 300 gigawatts.[60]

Building new infrastructures for battery power and green hydrogen-based fuels

New technologies are sometimes slow to get started because of the lack of infrastructure. Would you buy an electric car if there was nowhere to charge it?

If a zero-emission ship were to dock at any U.S. port today, there would be no way to refuel for the next leg of the journey.

To transition to ocean-going vessels running on green hydrogen, we're going to have to supply our ports with the needed fuels.

Today, almost all the green hydrogen produced in the United States, and the world, is made by burning fossil fuels, and the hydrogen is used for oil refining and agricultural fertilizer. The U.S. makes ten million metric tons of green hydrogen a year, barely enough to fuel the 1,700 tugboats and 671 ferries operating in U.S. waters.[61]

For green hydrogen to become cost-competitive with gray hydrogen would require 70 GW of electrolyzer capacity, according to the Hydrogen Council, a global initiative promoting a hydrogen economy.[62]

That's about ten times more capacity than exists today.

Though green hydrogen can be stored as a gas in high-pressure tanks, turning it into a liquid is more economical for large volumes.

To do so requires high pressure and extremely low temperatures, which can be expensive. There are eight existing liquefaction plants in North America.[63]

With more research and development to make storage more efficient and with increased demand, the costs should go down.[64]

Because of the high up-front capital costs, dedicated green hydrogen pipelines only make economic sense when the fuel is being transported in high volumes.

Green hydrogen fuel can also be carried on ships, ideally by ships running on the same fuel. Four Norwegian companies — Moss Maritime, Equinor, Wilhelmsen, and DNV — are developing a 9,000-cubic-meter Liquefied Hydrogen (LH2) Bunker Vessel. Its preliminary markets are ferries and cruise ships visiting the Norwegian fjords.[65]

Because ammonia can be liquified easily, there are more options for storing and transporting compared to hydrogen. Like green hydrogen, green ammonia can be compressed in a high-pressure storage tank, but it turns into a liquid at a much more reasonable temperature compared to hydrogen. Ammonia storage tanks can be as large as 50,000 metric tons.

There are already 3,000 miles of ammonia pipelines in the United States, which transport about 2 million tons of ammonia per year.[66] It can be moved by truck or rail or sea, in "ammonia nurse tanks," pressurized steel tanks shaped like large hot dogs. Ammonia storage tanks can be as large as 50,000 metric tons, and they are compatible with current port infrastructure.[67] Also, because ammonia has been transported for decades, there are established safety protocols already in place.[68]

But even though ammonia requires less new infrastructure, producing it is still pricey. Building one green ammonia plant that could produce 700 tons per day is estimated to be $620 to 791 million.[69]

Moss Maritime's rendering of liquefied hydrogen bunker vessel developed by Moss Maritime, Wilhelmsen Ship Management, Equinor, and DNV-GL.
Photo: Moss Maritime

There are many other ways that governments can push the market — by promoting and funding research, training crews, developing new storage or transport options, overseeing safety protocols, and more.

One well-known way that federal and state governments have nurtured a nascent zero-emission technology has been tax credits for battery-electric and plug-in electric cars. Credits range from $2,500 to $7,500 from the feds. More than a dozen states offer subsidies in one way or another, from tax credits to rebates for home charging stations.[70]

POLICY RECOMMENDATIONS

1. **End public financing of fossil-fuel maritime projects, including LNG development, storage, or export/import infrastructure at any U.S ports.** In November 2019, the European Investment Bank announced that it will stop financing fossil-fuel projects, including for Europe's maritime industry, effective 2021. The ban will be complemented by a €1 trillion investment to combat climate disruption.[71] The United States should follow suit and boost support for renewable energy and other strategies to prod the shipping industry toward zero-emission fuels.

   On January 28, 2021, U.S. Special Envoy for Climate Secretary John Kerry warned that natural gas will be a stranded asset. (A stranded asset is a resource or equipment that once generated income but no longer does because of market, technology, or political shifts.)

   Kerry is right. But U.S. ports and global shipping companies are continuing to build out LNG infrastructure with support from the federal treasury. The Biden-Harris administration should halt this practice

2. **Create a Zero-Emission Ports Infrastructure Fund. For ports to reach zero-emission targets and to prepare them for zero-emission ships will require significant investment.** The EPA, working with the Department of Transportation, should establish a new fund and grant program to jumpstart the zero-emission transition at American ports, making no less than $2 billion available each year for at least the next ten years.

   (In January 2021, California Congresswoman Nanette Diaz Barragán, whose district includes the ports of Los Angeles and Long Beach, reintroduced the Climate Smart Ports Act. This bill would create that $1 billion-a-year zero-emissions ports infrastructure program, as well as protect dockworkers, address environmental injustice, and create good-paying green jobs.)

3. **Establish a short-term Zero Port Pollution Tax.** While public dollars are necessary and appropriate for many infrastructure projects, American taxpayers alone should not bear the burden of cleaning up decades of multinational corporations' pollution.

   Modeled off of Norway's successful NOx Fund and adhering to the "polluters pay" principle, the U.S. should establish a Zero Port Pollution Fund to support zero-emission vessel development and green port infrastructure through a tax on deadly criteria pollutants (NOx, SOx, and black carbon, the most dangerous component of particulate matter), as well as greenhouse gases (notably CO2 and CH4).

4. **Focus the zero-emission transition on the U.S. fleet and workforce.** The U.S. is not the world's largest shipbuilder, but it can lead by example and leverage its ocean, coastal, and river-going vessel fleet to drive rapid innovation in zero-emission vessel development. The U.S. should issue a moratorium on new fossil-fuel ship procurements, directing that all new U.S. ships built be zero-emission beginning in 2023. In tandem, the U.S. should:

   Immediately procure low/zero-emission vessels for Maritime Training Institutes. Training and familiarity with zero-emission vessels and operations will be essential for American merchant mariners. Acquiring training vessels will give mariners time to develop the necessary skills to safely operate these ships, and to develop the standards for certifying mariner's knowledge.

   Establish a Low/Zero Emissions Training Program for U.S. Mariners. In addition to procuring training vessels, the curriculums of America's university-level merchant academies should be encouraged to develop a list of courses that teach zero-emission technologies and fuels.

5. **Establish a national Ocean Ranger-style environmental enforcement program.** In 2006, Alaskan voters organized a ballot measure to establish a "National Ocean Ranger Program" to oversee cruise ships' environmental compliance. Governor Dunleavy unilaterally revoked the program, but it remains popular.

   The Biden-Harris administration should establish a similar green government jobs program that allows the Coast Guard and Environmental Protection Agency marine engineers to board vessels and act as independent observers monitoring fuel standards, pollution standards, the scrubber ban, and other marine discharge requirements.

“Beyond reporting its own greenhouse gas emissions, the United States can engage its global maritime trade partners to take collaborative actions to transition ships off fossil fuels and transform maritime supply chains accordingly. ”

5. International Action
Global collaboration is essential to clean shipping

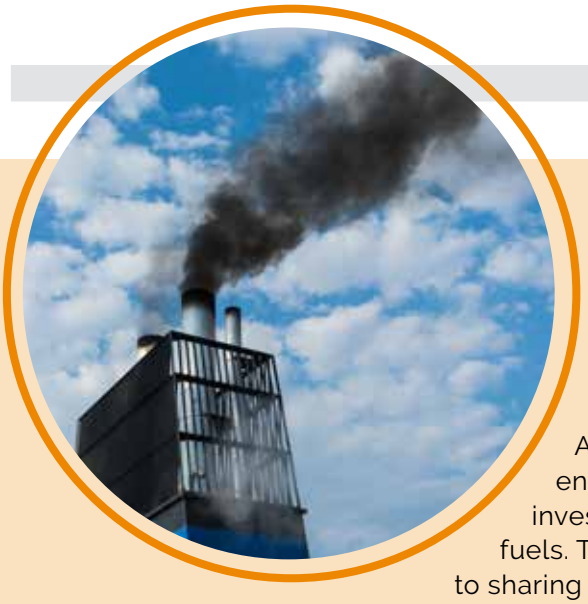
While the actions the United States takes can help lead the way to a zero-emissions shipping future, ultimately getting all ships off fossil fuels will always be a global effort. Here too, the voice of the United States could be powerful, especially if we lead by example.

Decarbonizing shipping should be a key component of United States climate diplomacy in all relevant discussions. A key first step would be including our commitments on shipping within our Nationally Determined Contributions (NDCs).

Under the Paris Agreement, an NDC is a way of reporting what mitigation measures a country takes to address their greenhouse gas emissions or adapt to climate impacts.

While shipping was not explicitly included in the Paris Agreement, nothing prevents a country from actions on shipping within their NDCs. Some countries already do so.

Using systems like the MRV recommended in section 3, the United States could better account for, and report its actions to reduce, the emissions from ships calling at United States ports.



Beyond reporting its own greenhouse gas emissions, the United States can engage its global maritime trade partners to take collaborative actions to transition ships off fossil fuels and transform maritime supply chains accordingly. This engagement can take many forms.

At the most basic level, bilateral, the U.S. can engage other nations directly and push for matching investments or shared commitments on zero-emission fuels. This kind of bilateral collaboration is a great approach to sharing the benefits and costs of innovation or tackling a topic that reaches beyond national boundaries.

For instance, to reduce air pollution from shipping, the United States and Canada previously collaborated on a North American Emissions Control Area (ECA), which required ships to switch to cleaner fuels with less sulfur, from 3.5% to 1%, and reducing nitrogen by 80% in 2010.[72] The benefits to air quality extended hundreds of miles inland.

Bilaterally and regionally, the U.S. can embark on cooperative global action to transform the world's ports and port infrastructure to support cleaner shipping. By enabling cleaner maritime "corridors," the U.S. could build the foundations for green maritime shipping lanes, incentivizing and, eventually, requiring that only zero-emission ships can travel from Rotterdam to New York. Similar lanes across North America could even help reduce road congestion.

Action at the International Maritime Organization

Finally, an ambitious voice from the United States is sorely needed at the International Maritime Organization. The International Maritime Organization (IMO), as mentioned many times throughout this report, is the primary common law regulator of the global shipping industry. Actions at the IMO are essential components and will affect the entire global shipping industry, and a rising tide of action could lift all boats.

Historically though, this action has not come quickly. The IMO has been debating action on shipping's greenhouse gas emissions for several decades, and progress has been slow. In 2011, after many debates the IMO adopted the Energy Efficiency Design Index (EEDI), a program setting mandatory efficiency goals for new ships. In 2016 it further agreed to a mandatory reporting requirement under the Data Collection System (DCS) for ships above 5,000 gross tonnes. While sector-wide, neither policy goes far enough.[73]

For instance, the EEDI has been strengthened three times, each time requiring at least an additional 10% improvement over the baseline year, but 71% of newly built containerships from 2013-2017 already exceeded the target for 2025.[74] Similarly, while DCS collects data on all ships above 5,000 GT, the information is anonymized, removing any accountability, and not publicly available.

To date, the IMO has followed this same playbook for the recent work on climate change. After a huge effort by progressive climate nations led by the Marshall Islands and other small island developing states, in 2018 the IMO adopted the Initial GHG

PARIS AGREEMENT GOALS

"Remaining aligned with warming limited to 1.5 or even 2 Celsius would require complete decarbonization by mid-century at the very latest."

Strategy on reduction of GHG emissions from ships. The plan envisions a four step set of goals, with emissions peaking, a short term action adopted by 2023, a reduction of CO2 emissions per transport work (a measure of efficiency) by 40% from 2008 levels, and an absolute reduction of "at least" 50% by 2050.[75] While this entire plan is supposed to be "consistent with the Paris Agreement temperature goals", this is far from the truth. Remaining aligned with warming limited to 1.5 or even 2 Celsius would require complete decarbonization by mid-century at the very latest.

Whether the IMO is even on track to achieve the long-term goals of its own Strategy is also in doubt. While the IMO is on track to adopt a short-term measure, the new package of options will do little to mitigate global shipping's climate impacts. The main component of the new measure is the Energy Efficiency Existing Ship Index (EEXI).

Like EEDI, EEXI would set a goal for ships to reach, with the option to limit their own engine power to save fuel. All ships now also get a letter rating, A-E, based on their energy efficiency under a Carbon Intensity Indicators. All ships would have to reach at least a passing "C" to be in good standing.

Both policies leave a lot to be desired. Assuming every ship followed EEXI, the most the measure could do is reduce GHG emissions by 0.7%-1.3% from business as usual by 2030.[76] And while ship owners could get a failing grade with the CII, it's not clear what penalties they face for doing so.

The United States has to do more, and soon, to propel the IMO to real climate action on shipping.

POLICY RECOMMENDATIONS

1. **Include emissions from international maritime transport in the U.S.' nationally determined contributions (NDCs) to the Paris Agreement.** The U.S. should take responsibility for 50 percent of all inbound/outbound emissions from ships docking its ports, split on a 50:50 basis between the country of origin and destination for all ships.

2. **Embark on 'Green Shipping Corridors' with major trade partners, looking to ports as hubs for the clean energy transition.** A corridors approach that links zero-emission fuels demand (from ships) and supply (from ports) is welcome, as it will help scale demand across multiple maritime industries and supply chains simultaneously, driving down costs and a timeline for rapid shipping decarbonization. We encourage action along three major corridors: an Americas corridor, the Transpacific corridor, and the Transatlantic corridor.

3. **Center frontline port and freight corridor communities in global shipping debates.** Global shipping debates are largely led by ship owners, ship-builders, engineers, and technicians. Frontline communities living in ports and along freight corridors are largely absent from policy debates at the global level. The Biden-Harris administration's historic commitment to advancing environmental justice should be extended to all policy fora on shipping and the high seas.

4. **Advance evidence-based principles for evaluating the climate credentials of alternative marine fuels and policies:** We urge the U.S. to advocate for the following three principles, which were developed by the International Council on Clean Transportation:

   Principle 1: CO2e not CO2: some fuels are zero-CO2 but not zero carbon dioxide equivalent.

   Principle 2: GWP20, not solely GWP100: reducing pollutants with high 20-year GWP, such as black carbon and methane, helps avoid additional near-term warming, which is important in a world that is already 1.3°C warmer than pre-industrial levels.

   Principle 3: well-to-wake, not tank-to-wake. Focusing solely on tank-to-wake emissions risks rewarding fuels with high life-cycle emissions, such as hydrogen made from fossil fuels.

5. **Increase U.S. climate ambition and environmental justice leadership at the International Maritime Organization.**

   We include IMO recommendations last deliberately in this report. For far too long, negotiations at the IMO have been treated as the primary forum for ship regulation rather than a secondary forum. This is folly. Effective global policies at the IMO will be best achieved on the back of strong national climate and shipping policies at home. That said, global agreements for shipping regulation are, of course, imperative. To align U.S. posture at the IMO with a 1.5°C decarbonization ambition, the U.S. should prioritize the following:

Reverse U.S. obstructionist positions on climate in the IMO: The United States is currently one of only two nations in the world with a formal "reservation" on the IMO's initial greenhouse gas (GHG) strategy at MEPC 76. The other is Saudi Arabia. This is an easy fix: the U.S. should promptly withdraw this reservation and announce support for ambitious short-term actions that reduce GHGs from the existing fleet before 2023; announce the intent to help create an absolute zero life-cycle GHG emission shipping sector by 2035.

Support a 1.5C-aligned short-term GHG reduction measure at the IMO, specifically a mandatory carbon dioxide equivalent standard, the Carbon Intensity Index (CII). This is a central component of a short-term climate measure moving forward to a final vote on adoption this June at IMO. This measure must be set with targets that are aligned to meet the IMO initial strategy ambitions — resulting in absolute emissions reductions by 2030 of at least 20-45 percent, which equate to carbon intensity improvements of 70 percent by 2030. To ensure these targets are delivered, it needs to include real, globally consistent, and enforceable penalties for non-compliance (e.g. the ship cannot sail).

Support Small Island States in calling for an ambitious levy to help drive mitigation and raise revenue for investment in zero emission technology and infrastructure. The Republic of Marshall Islands and the Solomon Islands have called for and submitted to the IMO a $100 per metric ton levy on carbon emissions from shipping companies as a baseline for negotiations.[77] Shipping company Trafigura has said $250-$300 is realistically the necessary carbon price for ships' fossil fuel pollution.[78] Supporting a levy any lower than these proposals would be an abdication of political commitments to environmental justice in the energy transition.

Support a 1.5C-aligned reform of the IMO's Greenhouse Gas Strategy. The IMO's Initial GHG Strategy calls for the shipping industry to halve emissions by 2050. This was an important start to catalyze shippings' clean energy transition, but is not aligned with 1.5°C. Based on the best publically available interpretations of the global carbon budget and the shipping industry's "fair share" within it, the shipping industry needs to reach absolutely zero emissions by 2036-2045.

Support a Transparent IMO Data Collection System. Currently, only aggregated shipping emissions data are publicly available, even though the IMO is collecting fuel consumption and emissions data for each ship over 5,000 gross tonnes. The United States, as a global leader and believer in the power of transparency to solve problems, should help create public, non-anonymized reporting and publishing of data collected under the IMO's Data Collection System and add "cargo carried" as a required parameter to report so we can hold ship owners accountable. The system needs to expand to cover all ships carrying more than 400 metric tons so that innovators and problem solvers around the globe can have better access to the data they need to help shippings' decarbonization.

CONCLUSION

We are already on the path to zero-emission shipping.

Just last month, a Norwegian design team unveiled the development of what they are calling the world's first zero-emission cargo ship, which will be powered by wind propulsion and green hydrogen power, and will be commercially available in 2024.[79]

New fuels, like green hydrogen and green ammonia, are gaining ground. In January 2021, Linde, a German company founded to refrigerate beer, announced a new 24-megawatt electrolyzer to produce green hydrogen at its Leunawerke chemical complex in Saxony-Anhalt.

It will become the world's largest electrolyzer, but in the same month, a consortium of six European Union countries, including Germany, sought EU Green Deal funding for one four times as powerful — a 100-MW alkaline electrolyzer plant in Spain.[80]

Two Norwegian companies, Wärtsilä and Grieg Edge, plan to launch an ammonia-fueled tanker producing no greenhouse gas emissions by 2024.

Fuel cell ships are on the horizon as well. In 2019, the European consortium Project FLAGSHIPS began work on two demonstration zero-emission hydrogen fuel cell ships — one in Lyon, France, as a utility vessel on the Rhône; the other, in Stavanger, Norway, as a high-speed passenger ferry. They are expected to begin commercial operation later this year.[81]

China and Norway have launched large electric vessels that run on batteries. Norway began commercial operations of electric ferries in 2015,[82] and China launched the world's first all-electric cargo ship in 2017.

Wind is making a comeback too. In February 2021, Michelin committed to send tires from Canada to France on NEOLINE sailing cargo ships that can potentially cut carbon emissions by 90 percent.

Eventually, whether they are fueled by green hydrogen, green ammonia, batteries, fuel cells, wind, or some combination thereof, ships will become zero-emission. So will ports and utility grids. Renewable energy will continue to expand, and prices will continue to drop.

But we face a climate crisis, and "eventually" is not soon enough. That's why it is incumbent on governments to put into place policies, incentives, standards, infrastructures, and investments to help accelerate that process.

In March 2021, at the 7th Berlin Energy Transition Dialogue, U.S. Climate Envoy John Kerry said that the science community has given us a clear picture of the chaos that awaits us if we don't act. "To keep global temperatures from rising more than 1.5˚C, we need to cut global emissions in half by 2030. I wasn't kidding when I said that this is the decisive decade."[83]

The shipping industry is only one piece of the puzzle, but as the sixth-largest emitter in the world, we can't achieve the 1.5˚C scenario unless we commit to a crash program of decarbonizing shipping.

The Biden-Harris administration has already committed to a target of 100 percent carbon-free electricity generation in the United States by 2035, and net-zero greenhouse gas emissions by 2050.[84] It charged the Department of Energy to spend $100 million on research and development on green hydrogen and other clean technologies.[85] Within a week of being sworn in, Jennifer Granholm, the new Secretary of Energy, announced the revival of the Loan Programs Office (which loaned $465 million to Tesla in 2010), and called for the installation of "hundreds of gigawatts" of carbon-free energy over the next four years.

Last year, the European Union committed €26 billion for new offshore wind farms, which will generate 7.1 gigawatts of carbon-free electricity, upping its goal for 2050 to 300 gigawatts.[86]

Historically, because most shipping emissions are generated outside of national borders and most ships fly flags of convenience, no nation has stepped up and counted shipping industry emissions as theirs or regulated them accordingly. Now there's an opportunity to bring the accounting home.

In an April 2021 letter to the U.S. President Joe Biden, European Commission President Ursula von der Leyen, and U.K. Prime Minister Boris Johnson, a transatlantic coalition of 12 NGOs urged that shipping emissions be accounted for in the nationally determined contributions (NDCs) to the Paris Agreement, that all ship emissions be split on a 50:50 basis between the country of origin and country of destination.[87]

In this report, we spell out 20 policy recommendations for the Biden-Harris to follow.

When they do, we will realize the vision of zero-emission shipping.

END NOTES

1. O'Leary, 2019.
2. World Economic Forum, 2018.
3. Sofiev, Winebrake, Johansson, et al., *Nature Communications,* 2018.
4. UNCTAD, Review of Maritime Transport, 2021.
5. George, *Ninety Percent of Everything,* 2013.
6. IMO, 2020.
7. Lombrana, *Bloomberg Green,* 2020.
8. ICCT, 2020.
9. World Shipping Council, 2021.
10. Maersk 2020 Sustainability Report.
11. IMO, 2020.
12. *Lloyd's List,* Top 10 flag states 2019.
13. Letter to President Biden, President von der Leyen, and Prime Minister Johnson from Pacific Environment, Ocean Conservancy and ten other transatlantic NGOs. March 2021.
14. Leahy, *National Geographic,* 2019.
15. Mace, *Ballard,* 2019.
16. CCT, 2020.
17. Penev & Hunter, 2018.
18. Lerner, *Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States,* 2010.
19. Ocean-Going Vessels At Berth Regulation, California Air Resources Board, n.d.
20. C40 Cities, n.d.
21. Seattle City Light. 2019 Power Mix.
22. At Berth FAQs, California Air Resources Board, n.d.
23. Barboza, *Los Angeles Times,* 2020.
24. *Seatrade Maritime News,* 2020.
25. US EPA, *Shore Power Technology Assessment at U.S. Ports,* 2017.
26. 2015 report from the International Council on Clean Transportation (ICCT) and the Wilson Center.
27. Shore Link, n.d.
28. *Long Beach Post Staff,* 2011.
29. *The Maritime Executive,* "Call for Shore Power at New York Cruise Terminals," 2020.
30. Wang, et al., 2015.
31. Ibid.
32. EPA, 2020.
33. Green Car Congress, 2020.
34. Orrall, *CNET,* 2020.
35. Gallucci, *IEEE Spectrum,* 2021.
36. Ash & Scarbrough 2019.
37. Green Car Congress, 2020.
38. *The Maritime Executive,* "Hydrogen Fuel Cell Vessels Destined for France and Norway," 2019.
39. Gallucci, *IEEE Spectrum,* 2021.
40. Ampere Electric-Powered Ferry, n.d.
41. Zeldovich, 2020.
42. Orrall, 2020.
43. Comer, Chen, Stolz, Rutherford, ICCT, 2019.
44. Degnarain, *Forbes,* 2020.
45. Safety4Sea, 2021.
46. Green Car Congress, 2021.
47. Pavlenko, et.al 2020.
48. IMO, 2020
49. Park, N., Park, S., Kook, 2019.
50. International Transport Forum, 2018.
51. Safety4Sea, 2021.
52. International Transport Forum, 2018.
53. Ibid.
54. Irena, 2020.
55. Bøss & Layke, 2020.
56. IRENA, 2020.
57. FuelCellWorks, 2021.
58. Hancock, *PVTech,* 2021.
59. Ibid.
60. WindEurope, 2021.
61. Hydrogen Council, 2020.
62. Ibid.
63. USDRIVE, 2017.
64. Ibid.
65. IMO2020: The Rise of Bulk Liquid Hydrogen in Norway, 2019.
66. Papavinasam, 2014.
67. Riviera, n.d.
68. Ash & Scarbrough 2019.
69. Kastner et al., 2020.
70. Tesla, Electric Vehicle & Solar Incentives, 2021.
71. Barbiroglio, 2019.
72. EDF. 2010. "Emission Control Areas are Critical to Protect Human Health from Shipping Pollution"
73. IMO. 2020. "Greenhouse Gas Emissions".
74. Transport & Environment. 2018. "Statistical analysis of the energy efficiency performance (EEDI) of new ships"
75. IMO. 2018. "Initial IMO Strategy on reduction of GHG emissions from ships".
76. Rutherford et al. 2020. "Potential CO2 reductions under the Energy Efficiency Existing Ship Index"
77. Adamopoulos, *Lloyd's List,* 2021.
78. Ibid.
79. *The Maritime Executive,* 2021.
80. Green Car Congress, 2020.
81. *The Maritime Executive,* 2019.
82. Ampere Electric-Powered Ferry, n.d.
83. U.S. Department of State. John Kerry, Special Presidential Envoy for Climate, 2021.
84. Ibid.
85. FuelCellWorks, 2021.
86. WindEurope, 2021.
87. Letter to President Biden, President von der Leyen, and Prime Minister Johnson from Pacific Environment, Ocean Conservancy and ten other transatlantic NGOs. April 2021.

SOURCES

Abbasov, F. (2020). *EU Shipping's Climate Record.* https://www.europarl.europa.eu/cmsdata/195333/Abbasov_MRV_Study_results_TE_EN_original.pdf

AJOT. (2017). "Port Authority of New York and New Jersey Clean Vessel Incentive Program tops enrollees for Q1 2017." https://ajot.com/news/port-authority-of-new-york-and-new-jersey-clean-vessel-incentive-program-to

American Shipper. (2007). "Study: Ship pollution causes 60,000 premature deaths." https://www.freightwaves.com/news/study-ship-pollution-causes-60000-premature-deaths

Ampere Electric-Powered Ferry. (n.d.). Ship Technology. Retrieved July 28, 2020, from https://www.ship-technology.com/projects/norled-zerocat-electric-powered-ferry/

Anenberg, S. et al. (2019). *A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015.* https://theicct.org/publications/health-impacts-transport-emissions-2010-2015

Argonne National Laboratory. (2019). *H2@Ports Workshop Summary Report.* https://publications.anl.gov/anlpubs/2020/03/158750.pdf

Ash, N. and Carpenter-Lomax, O. (2020). "'Zero-Carbon for Shipping," Ocean Conservancy, Washington, D.C.

Ash, N. and Scarbrough, T. (2019). *Sailing on solar: Could green ammonia decarbonise international shipping?* Environmental Defense Fund, London.

At Berth FAQs | California Air Resources Board. (n.d.). Retrieved July 27, 2020, from https://ww2.arb.ca.gov/resources/documents/berth-faqs

Barbiroglio, E. (2019). "European Investment Bank Will Stop Financing New Fossil Fuels Projects," Forbes. https://www.forbes.com/sites/emanuelabarbiroglio/2019/11/15/european-investment-bank-will-stop-financing-new-fossil-fuels-projects/

Barboza, T. (2020). "Port ships are becoming L.A.'s biggest polluters. Will California force a cleanup?" *Los Angeles Times.* https://www.latimes.com/california/story/2020-01-03/port-ships-are-becoming-la-worst-polluters-regulators-plug-in

Barrios, K. (2020). "Ammonia: Another Maritime Fuel of the Future?" *Xeneta.* https://www.xeneta.com/blog/ammonia-another-maritime-fuel-of-the-future

Boss, J. (2018). "Four Things Governments Can Do to Attract More Renewable Energy Investment." https://www.climateweeknyc.org/four-things-governments-can-do-attract-more-renewable-energy-investment

Brown, T. (2019). "University of Minnesota demonstrates efficient ammonia dual-fuel engine system," *Ammonia Energy Association.* https://www.ammoniaenergy.org/articles/university-of-minnesota-demonstrates-efficient-ammonia-dual-fuel-engine-system/

C40. (n.d.). "Port of Seattle Cuts Vessel Emissions by 29 percent Annually and Saves 26 percent on Energy Costs per Call." Retrieved July 27, 2020, from https://www.c40.org/case_studies/port-of-seattle-cuts-vessel-emissions-by-29-annually-and-saves-26-on-energy-costs-per-call

California Air Resources Board (CARB). (n.d.). *FARMER Program.* Retrieved August 14, 2020, from https://ww2.arb.ca.gov/our-work/programs/farmer-program/about

California Air Resources Board (CARB). (n.d.). *Ocean-Going Vessels At Berth Regulation.* Retrieved July 26, 2020, from https://ww2.arb.ca.gov/our-work/programs/ocean-going-vessels-berth-regulation

California Air Resources Board (CARB). (2020). *Control Measure for Ocean-Going Vessels At Berth (15-Day Changes).* https://ww2.arb.ca.gov/sites/default/files/classic//ports/shorepower/factsheet2020.pdf

Clean Vessel Incentive Program | Port Authority of New York and New Jersey. (n.d.). Retrieved July 27, 2020, from https://www.panynj.gov/port/en/our-port/sustainability/clean-vessel-incentive-program.html

Colman, Z. (2020). "Warren knocks SEC on climate disclosures." *Politico.* https://www.politico.com/news/2020/08/13/warren-sec-climate-394862

Comer, B. (2019). Transitioning away from heavy fuel oil in Arctic shipping.

Comer, B., Chen C., Stolz, D., Rutherford, D. International Council on Clean Transportation (ICCT). (2019). "Rotors and bubbles: Route-based assessment of innovative technologies to reduce ship fuel consumption and emissions." https://theicct.org/publications/working-paper-imo-rotorships

CSC, PE. (2020). "A proposal for an initial impact assessment of a goal-based approach to realising the substantial speed-related GHG emission reductions that are urgently needed in the short-term and to provide a framework for the full decarbonisation of shipping in the longer-term." International Maritime Organization.

"Cummins fuel cells powering North America's first commercial zero emissions ferry." (2021). https://www.cummins.com/news/2021/02/09/cummins-fuel-cells-powering-north-americas-first-commercial-zero-emissions-ferry

Deblasio, N. (2020). *Geopolitical and Market Implications of Renewable Hydrogen: New Dependencies in a Low-Carbon Energy World.* Harvard Belfer Center.

Degnarain, N. (2020) "A New Golden Age Of Sailing Is Here: Five Exciting Projects." Forbes. https://www.forbes.com/sites/nishandegnarain/2020/12/01/a-new-golden-age-of-sailing-is-here-where-is-the-leadership/?sh=12fcaf101504

Department of Energy Loan Programs Office. (n.d.). *Loan Programs Office.* Energy.Gov. Retrieved August 14, 2020, from https://www.energy.gov/lpo/loan-programs-office

DiRenzo, J. (2019). "IMO2020: The Rise of Bulk Liquid Hydrogen in Norway." *MarineLink.* https://www.marinelink.com/news/imo-rise-bulk-liquid-hydrogen-norway-468501

Dual Ports. (2019). *Feasibility of green hydrogen bunkering.* https://northsearegion.eu/media/9385/feasibility-of-green hydrogen-bunkering-final-080419.pdf

Environmental and Energy Study Institute (EESI). (2019). *Fact Sheet: Fossil Fuel Subsidies: A Closer Look at Tax Breaks and Societal Costs.* https://www.eesi.org/papers/view/fact-sheet-fossil-fuel-subsidies-a-closer-look-at-tax-breaks-and-societal-costs#1

Environmental Defense Fund. (2019). "Ninth Circuit Court of Appeals Upholds California's Low Carbon Fuel Standard." https://www.edf.org/media/ninth-circuit-court-appeals-upholds-californias-low-carbon-fuel-standard

Environmental Ship Index (ESI) – World Port Sustainability Program. (n.d.). Retrieved July 27, 2020, from https://sustainableworldports.org/environmental-ship-index-esi/

SOURCES (cont'd)

Strauss, M. (2020). "EU lawmakers agree to include shipping emissions in EU carbon market." Reuters. https://www.reuters.com/article/us-climate-change-eu-shipping-idUSKBN2481UD

EU Technical Expert Group on Sustainable Finance. (2019). *Taxonomy Technical Report.* https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-taxonomy_en.pdf

European Commission. (2016). *EU Emissions Trading System (EU ETS)*. Climate Action – European Commission. https://ec.europa.eu/clima/policies/ets_en

European Commission. (2016). *Reducing emissions from the shipping sector*: Climate Action – European Commission. https://ec.europa.eu/clima/policies/transport/shipping_en

European Commission. (2020). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Region.* https://ec.europa.eu/energy/sites/ener/files/green hydrogen_strategy.pdf

Faber, J. et al. (2016). "Estimated Index Values of Ships 2009-2015: An analysis of the design efficiency of ships that have entered the fleet since 2009." CE Delft, IMO Document MEPC 69/INF.29, 12 https://www.cleanshipping.org/download/MEPC-69-INF.29-Estimated-Index-Values-of-Ships-2009-2015-An-analysis-of-the-design-efficiency-of-ships-th...-CSC.pdf

Fernbas. (2019). *National energy and climate plans (NECPs)*. Energy – European Commission. https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en

Fu, R., Feldman, D., & Margolis, R. (2018). "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018." *Renewable Energy,* 63.

Fuel Cells. (n.d.). Energy.Gov. Retrieved July 27, 2020, from https://www.energy.gov/eere/fuelcells/fuel-cells

Fuel Cells and Hydrogen Joint Undertaking. (2019). *Hydrogen Roadmap Europe.* https://www.fch.europa.eu/sites/default/files/green hydrogen%20Roadmap%20Europe_Report.pdf

FuelCellWorks. (2021). "White House Launches American Innovation Effort to Create Jobs and Tackle Climate Change." https://fuelcellsworks.com/news/white-house-launches-american-innovation-effort-to-create-jobs-and-tackle-the-climate-crisis/

Gallucci, M. (2021). "The First Battery-Powered Tanker is Coming to Tokyo." *IEEE Spectrum.* https://spectrum.ieee.org/energywise/energy/batteries-storage/first-battery-powered-tanker-coming-to-tokyo

Gallucci, M. (2021). "Why the Shipping Industry Is Betting Big on Ammonia." *IEEE Spectrum.* https://spectrum.ieee.org/transportation/marine/why-the-shipping-industry-is-betting-big-on-ammonia

George, R. (2013). *Ninety Percent of Everything.*

Ghani, N. (2019). *Clean Maritime Plan.* United Kingdom Department for Transport.

Great Lakes Steamship Repower Incentive Program. (2012, January 18). Federal Register. https://www.federalregister.gov/documents/2012/01/18/2012-819/great-lakes-steamship-repower-incentive-program

Green Car Congress. (2020). "H24All project seeks to build Europe's first 100 MW alkaline electrolyzer plant." https://www.greencarcongress.com/2021/01/20210128-h24all.html

Green Car Congress. (2020). "Wärtsilä and Grieg to build green ammonia-fueled tanker." https://www.greencarcongress.com/2020/12/20201219-wartsila.html

Green Giraffe. (2019). "Hydrogen — A Green Future is not Blue." https://green-giraffe.eu/blog/hydrogen-green-future

Haber-Bosch process | Definition, Conditions, Importance, & Facts. (n.d.). Encyclopedia Britannica. Retrieved July 30, 2020, from https://www.britannica.com/technology/Haber-Bosch-process

Hancock, E. (2021). "New US Energy Secretary shakes up DOE, calls for 'hundreds of gigawatts' of new clean energy." *PVTech.* https://www.pv-tech.org/new-us-energy-secretary-shakes-up-doe-calls-for-hundreds-of-gigawatts-of-new-clean-energy/

Hydrogen Council. (2020). *Path to green hydrogen Competitiveness: A Cost Perspective.* https://green hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-green hydrogen-Competitiveness_Full-Study-1.pdf

Hydrogen Pipelines. (n.d.). Energy.Gov. Retrieved July 30, 2020, from https://www.energy.gov/eere/fuelcells/green hydrogen-pipelines

Hydrogen Production: Natural Gas Reforming. (n.d.). Energy.Gov. Retrieved July 30, 2020, from https://www.energy.gov/eere/fuelcells/green hydrogen-production-natural-gas-reforming

Hydrogen Storage. (n.d.). Energy.Gov. Retrieved July 30, 2020, from https://www.energy.gov/eere/fuelcells/green hydrogen-storage

IACCSEA. (n.d.). "NOx Taxes and Incentives." https://www.iaccsea.com/nox/nox-taxes-and-incentives

International Maritime Organization. (2009). *Market-Based Measures Proposals under consideration within the Expert Group on Feasibility Study and Impact Assessment of Possible Market Based Measures (MBM-EG).* http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Summary%20of%20MBM-EG%20proposals.pdf

International Maritime Organization. (2018). ADOPTION OF THE INITIAL IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS AND EXISTING IMO ACTIVITY RELATED TO REDUCING GHG EMISSIONS IN THE SHIPPING SECTOR. Note by the International Maritime Organization to the Talanoa Dialogue. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx

International Transport Forum. (2018). *Decarbonising Maritime Transport: Pathways to zero-carbon shipping by 2035.*

IRENA (2019), *Innovation landscape brief: Renewable Power-to-Hydrogen, International Renewable Energy Agency, Abu Dhabi.*

IRENA. (2020). *Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal, International Renewable Energy Agency, Abu Dhabi.*

Kastner, L., Luo, L., Maroti, S., Tsai, E., Zhang, W. (2020). "Zero-carbon fuels for marine shipping." Clean Air Task Force. Available at: https://www.catf.us/2020/07/building-a-globally-networked-supply-of-zero-carbon-shipping-fuel/

Knight, P. (2019). "The IMO 2020 Sulfur Cap in the United States: Compliance Issues." *The Maritime Executive.* https://www.maritime-executive.com/editorials/the-imo-2020-sulfur-cap-in-the-united-states-compliance-issues

Leahy, S. (2019). "Exxon Valdez changed the oil industry forever—but new threats emerge." *National Geographic.* https://www.nationalgeographic.com/environment/article/oil-spills-30-years-after-exxon-valdez

Lerner, S. (2010). *Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States.*

Liang, L. (2020). "California expands shore power requirements to more vessel types." *Seatrade Maritime News.* https://www.seatrade-maritime.com/ports-logistics/california-expands-shore-power-requirements-more-vessel-types"Liquefied green hydrogen Bunker Vessel Designed." (n.d.). The Maritime Executive. Retrieved July 31, 2020, from https://www.maritime-executive.com/article/liquefied-green hydrogen-bunker-vessel-designed"

Lloyd's List. (2019). "Top 10 flag states." https://lloydslist.maritimeintelligence.informa.com/LL1129840/Top-10-flag-states-2019

Lombrana, L. (2020). "The Shipping Industry Transformed 100 Years Ago. It Can Do it Again." Bloomberg. https://www.bloomberg.com/news/articles/2020-11-16/shipping-industry-can-cut-emissions-like-it-did-100-years-ago

Long Beach Post Staff. (2011). "With Plug-in Power for Ships Installed, Port of Long Beach Goes Greener." *Long Beach Post.* https://lbpost.com/news/with-plug-in-power-for-ships-installed-port-of-long-beach-goes-greener

Mace, A. (2019). "Here's Why Fuel Cells Will Power the World's Marine Vessels." *Ballard.* https://blog.ballard.com/fuel-cells-marine-vessels

Maersk 2020 Sustainability Report. (2020.) https://www.maersk.com/~/media_sc9/maersk/about/files/sustainability/sustainability-reports/apmm-sustainability-report-2020-a3.pdf

Mao, X., Rutherford, D., Osipova, L., & Comer, B. (2020). "Refueling assessment of a zero-emission container corridor between China and the United States: Could green hydrogen replace fossil fuels?" *The International Council on Clean Transport,* 13.

Marron, D., Toder, E., & Austin, L. (2015, June 24). Taxing Carbon: What, Why, and How. Tax Policy Center. https://www.taxpolicycenter.org/publications/taxing-carbon-what-why-and-how/full

McKinsey. (2017). The rising advantage of public-private partnerships. https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-rising-advantage-of-public-private-partnerships

Miller, D. & Porter, M. (2020). "Electric Vehicles Are the Next Dominant Class of Renewable Energy Buyers." RMI Energy Transformed. https://rmi.org/electric-vehicles-are-the-next-dominant-class-of-renewable-energy-buyers/

Nikola. (2020). *Nikola Orders Enough Electrolysis Equipment From Nel to Produce 40,000 kgs of green hydrogen Per Day.* Nikola Motor Company. https://nikolamotor.com/press_releases/nikola-orders-enough-electrolysis-equipment-from-nel-to-produce-40000-kgs-of-green hydrogen-per-day-79

O'Leary, A. (2019). *Legal Pathways to Deep Decarbonization in the United States.* Environmental Law Institute. https://www.eli.org/eli-press-books/legal-pathways-deep-decarbonization-united-states

Orrall, J. (2020). "This boat makes its own hydrogen fuel from seawater." *CNET* https://www.cnet.com/news/this-boat-makes-its-own-hydrogen-fuel-from-seawater/

Pavlenko, N., Comer, B., Zhou, Y., Clark, N., Rutherford, D. (2020). *The climate implications of using LNG as a marine fuel.* https://theicct.org/publications/climate-impacts-LNG-marine-fuel-2020

Papadias, D., Ahluwalia, R.K. (2019). Total Cost of Ownership (TCO) Analysis for Hydrogen Fuel Cells in Maritime Applications-Preliminary Results. Argonne National Laboratory. https://www.energy.gov/sites/prod/files/2019/10/f68/fcto-h2-at-ports-workshop-2019-viii5-ahluwalia.pdf

Papavinasam, S. (2014). Chapter 2—Oil and Gas Industry Network. In S. Papavinasam (Ed.), *Corrosion Control in the Oil and Gas Industry* (pp. 41–131). Gulf Professional Publishing. https://doi.org/10.1016/B978-0-12-397022-0.00002-9

Paris, C. (2020.) "Natural Gas Won't Decarbonize Shipping, But the Fuel Is Here to Stay." Wall Street Journal. https://www.wsj.com/articles/natural-gas-wont-decarbonize-shipping-but-the-fuel-is-here-to-stay-11580814000

Park, Nam Kyu & Sang Kook Park, Sang Kook. (2019). "A Study on the Estimation of Facilities in LNG Bunkering Terminal by Simulation—Busan Port Case." *Journal of Marine Science and Engineering* 7.10: 354.

Pavlenko, N., Comer, B., Zhou, Y., Clark, N, Rutherford, D. (2020). The climate implications of using LNG as a marine fuel. International Council on Clean Transporation. Available at: https://theicct.org/publications/climate-impacts-LNG-marine-fuel-2020

Penev, M., & Hunter, C. (2018, June 14). *Regional supply of green hydrogen.*

Port of Los Angeles. (2018). *Port of Los Angeles Inventory of Air Emissions—2018.* https://www.portoflosangeles.org/environment/air-quality/air-emissions-inventory

Port of Seattle. (n.d.). *Milestones in Seattle Cruise History | Port of Seattle.* Retrieved July 26, 2020, from https://www.portseattle.org/blog/milestones-seattle-cruise-history

Postrel, V. (2006). "The Container That Changed the World." *New York Times* https://www.nytimes.com/2006/03/23/business/the-container-that-changed-the-world.html

Riviera. (n.d.). *Shipping looks beyond the sulphur cap.* Riviera. Retrieved July 31, 2020, from https://www.rivieramm.com/opinion/opinion/shipping-looks-beyond-the-sulphur-cap-55383

Roser, M. (2020). "Why did renewables become so cheap so fast? And what can we do to use this global opportunity for green growth?" *Our World In Data.* https://ourworldindata.org/cheap-renewables-growth

Rutherford, D., Mao, X., Comer, B. (2020). "Potential CO2 reductions under the Energy Efficiency Existing Ship Index". International Council on Clean Transportation. https://theicct.org/publications/marine-eexi-nov2020

Safety4Sea. (2021). "New IWSA campaign to drive the decade of wind propulsion." https://safety4sea.com/new-iwsa-campaign-to-drive-the-decade-of-wind-propulsion/

Safety4Sea. (2021). "Maersk: We will end up with ammonia or methanol as a future fuel." https://safety4sea.com/maersk-we-will-end-up-with-ammonia-or-methanol-as-a-future-fuel/

SOURCES (cont'd)

Sandia National Laboratories. (2016). Feasibility of the SF-BREEZE: a Zero-Emission, green hydrogen Fuel Cell, High-Speed Passenger Ferry. *Sandia Energy.* https://energy.sandia.gov/programs/sustainable-transportation/green hydrogen/market-transformation/maritime-fuel-cells/sf-breeze/

Sandia National Laboratories: News Releases: Diesel doesn't float this boat. (n.d.). Retrieved July 31, 2020, from https://share-ng.sandia.gov/news/resources/news_releases/green hydrogen_boat/

Seattle City Light. 2019 Power Mix. https://www.seattle.gov/city-light/about-us/what-we-do

Shore Link. (n.d.). "What is shore power? | HVSC connector to ports." https://shore-link.eu/what-is-shore-power/#:~:text=The%20European%20Union%2C%20for%20example,waiting%20for%20them%20on%20arrival.

Smith, T. et al. (2016). "CO2 emissions from international shipping: Possible reduction targets and their associated pathways." Prepared by UMAS, London.https://www.u-mas.co.uk/wp-content/uploads/2020/11/Smith-et-al.-2016-Co2-emissions-in-shipping-targets-pathways.pdf

Sofiev, Winebrake, Johansson, et al. (2018). Cleaner fuels for ships provide public health benefits with climate tradeoffs. *Nature Communications 9.* https://doi.org/10.1038/s41467-017-02774-9

Søgaard. K., Bingham, C. (2020). Mapping of zero emission pilots and demonstration projects. *Global Maritime Forum.* Available at: https://www.globalmaritimeforum.org/news/mapping-of-zero-emission-pilots-and-demonstration-projects/

Tesla, Electric Vehicle & Solar Incentives, 2021 https://www.tesla.com/support/incentives

The International Council on Clean Transportation. (2017, October 10). *Vehicle NOx emissions: The basics.* https://theicct.org/cards/stack/vehicle-nox-emissions-basics#1

The Maritime Executive. (2019.) "Hydrogen Fuel Cell Vessels Destined for France and Norway." https://www.maritime-executive.com/article/hydrogen-fuel-cell-vessels-destined-for-france-and-norway

The Maritime Executive. (2021). "World's First Zero-Emission Wind and Hydrogen Power Cargo Ship." https://www.maritime-executive.com/article/world-s-first-zero-emission-wind-and-hydrogen-power-cargo-ship

Toyota. (2018, September 14). *Port of Los Angeles Preliminarily Awarded $41 Million from California Air Resources Board to Launch Zero Emissions green hydrogen-Fuel-Cell-Electric Freight Project.* Toyota USA Newsroom. https://pressroom.toyota.com/pola-preliminarily-awarded-41m-calif-air-resources-board-launch-zero-emissions-green hydrogen-fuel-project/

Transport & Environment. (2020, April). *A case for EU ship operational CO2 standards.* https://www.transportenvironment.org/sites/te/files/publications/2020_04_Briefing_Marine_fuel_blending_vs_operational_CO2_standards.pdf

U.S. Department of State. John Kerry, Special Presidential Envoy for Climate. (2021). "Remarks at the 7th Berlin Energy Transition Dialogue." https://www.state.gov/remarks-at-the-7th-berlin-energy-transition-dialogue/

U.S. Department of Transportation. (2020). *United States Flag Privately Owned Merchant Fleet Report.* https://www.maritime.dot.gov/sites/marad.dot.gov/files/docs/national-security/2846/dsusflag-fleet20200312bundle.pdf

U.S. Environmental Protection Agency (EPA). (2012). *MEMORANDUM IN RESPONSE TO PETITIONS REGARDING GREENHOUSE GAS AND OTHER EMISSIONS FROM MARINE VESSELS AND NONROAD ENGINES AND VEHICLES.* https://www.eenews.net/assets/2012/06/18/document_pm_06.pdf

US EPA, O. (2019, March 20). *Community Action Roadmap: Empowering Near-Port Communities* [Data and Tools]. US EPA. https://www.epa.gov/community-port-collaboration/community-action-roadmap-empowering-near-port-communities

USDRIVE. (2017). green hydrogen Delivery Technical Team Roadmap. https://www.energy.gov/sites/prod/files/2017/08/f36/hdtt_roadmap_July2017.pdf

Wang, H., Mao, X., & Rutherford, Dan. (2015). "Costs and benefits of shore power at the Port of Shenzhen." *The International Council on Clean Transportation,* 38.

Warren, E. (2020). *Tackling the Climate Crisis Head On* https://elizabethwarren.com/plans/climate-change#green-manufacturing.

Warren, E. (n.d.). *We Need A Blue New Deal For Our Oceans.* Retrieved July 31, 2020, from https://elizabethwarren.com/plans/blue-new-deal

Wartsila. (2020). Wärtsilä advances future fuel capabilities with first ammonia tests. https://www.wartsila.com/media/news/25-03-2020-wartsila-advances-future-fuel-capabilities-with-first-ammonia-tests-2670619

WindEurope. (2021). "Europe invests a record €26bn in offshore wind in 2020." https://windeurope.org/newsroom/press-releases/europe-invests-a-record-26-billion-euros-in-offshore-wind-in-2020/

Wingrove, M. (2016). *US operates second-largest tugboat fleet.* Riviera. https://www.rivieramm.com/news-content-hub/news-content-hub/us-operates-second-largest-tugboat-fleet-30608

World Economic Forum.(2018). "If shipping were a country, it would be the world's sixth-biggest greenhouse gas emitter." https://www.weforum.org/agenda/2018/04/if-shipping-were-a-country-it-would-be-the-world-s-sixth-biggest-greenhouse-gas-emitter

World Health Organization. (n.d.). *Ambient air pollution: Health impacts.* WHO; World Health Organization. Retrieved July 26, 2020, from http://www.who.int/airpollution/ambient/health-impacts/en/

World's First green hydrogen-Powered Cruise Ship Scheduled. (n.d.). Retrieved July 28, 2020, from https://maritime-executive.com/article/worlds-first-green hydrogen-powered-cruise-ship-scheduled

World Shipping Council. (2021). "Benefits of Liner Shipping."

Zeldovich, L. (2020). "High-Tech Sails Bring Wind Power to Big Ships." American Society of Mechanical Engineers. https://www.asme.org/topics-resources/content/high-tech-sails-bring-wind-power-to-big-ships

SUMMARY OF

Policy Recommendations

Environmental Justice RECOMMENDATIONS

1. **Set U.S. policy to decarbonize shipping by 2035.** To maintain global temperature goals below 1.5°C and avoid the worst impact of a warming planet, the U.S. must align all relevant policies — domestic and international — with this timeline.

2. **Set a federal zero emission ship standard.** The Biden-Harris administration should exercise its port-state-control authority under international law and set a progressive standard consistent with a 1.5°C decarbonization pathway for all ships loading and unloading at U.S. ports. These standards should require carbon reductions of 50 percent by 2025, 80 percent by 2030, and 100 percent by 2035.

3. **Eliminate in-port ship emissions by 2030.** By 2030, all ships at-berth or at-anchor in U.S. ports should emit zero greenhouse gases and zero criteria pollutants. We recommend focusing on the zero-emission outcomes, which gives shipping companies flexibility in how to meet these mandates.

Clean Shipping RECOMMENDATIONS

1. **Require ships report their fuel consumption and emissions.** The United States does not have an accurate accounting system to count emissions from ships calling on our ports. We need an improved, transparent reporting system that requires ships to report these emissions to U.S. authorities to serve as a basis for accurate emissions reductions. The U.S. system should be modeled off of the European Union's Monitoring, Reporting, and Verification for ships (MRV).

   (In 2020, Congressman Raul Grijalva introduced the Ocean Based Climate Solutions Act, H.R.8632, including a provision to establish an MRV for ship emissions to accurately account for and oversee ships' emissions. The bill has yet to be introduced in the current U.S. Congress.)

2. **Bring down costs of electric and zero-emission fuel solutions relative to fossil fuel.** Producing zero-emission fuels for shipping requires substantial investment — to accelerate renewable energy infrastructure and bring down the costs, to grow electrolysis capacity, to convert energy into fuels, and more.

   The Biden-Harris administration and the U.S. Congress should explore incentives, rebates, taxes, and/or other financing mechanisms to support battery and fuel production. All efforts should also address frontline communities' concerns.

3. **Increase federal funding for zero-emission vessel innovation.** While absolute spending levels are difficult to determine, the United States spends in the low million levels each year on dedicated clean maritime technology. Federal funding for zero-emission pilot projects, demonstration projects, and research, design, development, and deployment should increase to at least $500 million per year. Among many other departments to support, we recommend the following investment increases:

   Department of Energy: Advanced Research Projects Agency–Energy (ARPA-E). ARPA-E is presently requesting $425 million annually from Congress. We recommend raising its authorization to $515 million with a directive to focus on zero-emission shipping.

   Department of Transportation: Maritime Environmental Technical Assistance Program (META). By raising the funding for this program from its current $3 million annually to $25 million will allow the program to support additional research into zero-emission vessels, fuel cell applications for ships and ports, port electrification, and energy efficiency.

4. **Require biannual port emissions inventories to ensure compliance.** U.S. ports are not currently required to conduct an annual inventory of air pollutants or greenhouse gases. Uniform reporting of emissions is needed to ensure compliance with a zero-emission target by 2030.

5. **Establish an Environmental Justice Ports Advisory Commission.** For decades the perspectives and interests of communities living in major American port cities have been sidelined to accommodate rapid growth of the shipping industry. An Environmental Justice American Ports Advisory Commission, or a ports and shipping working group within the White House Environmental Justice Council, should be established to prioritize frontline community perspectives in port and shipping policy decisions.

Create an Advanced Technologies Loan Program for Zero-Emission Shipping. We need more companies to work on all aspects of zero-emission vessel development and fuels across the maritime supply chain. A Department of Energy Advanced Technologies Zero-Emission Shipping Program should support manufacturers of zero-emissions vessels, as well as manufacturers of components or materials that support them. The department's Loan Program Office is experienced in providing loans and loan guarantees for large-scale energy infrastructure projects, like the incubation and development of America's most successful electric-vehicle company, Tesla.

4. **Ban scrubber systems in U.S. ports and waters.** One way shipping companies maintain their reliance on dirty fossil fuels in the face of increasing air quality regulations is by installing "scrubber discharge technologies" that dump oily-filled waste water into the ocean before docking at ports. Scrubber systems should be banned as a means of compliance with clean fuel standards in U.S. waters or at U.S. ports. Thirty nations already ban scrubber systems in national waters — including major shipping nations China, Singapore, Norway, and the United Arab Emirates.

5. **Develop green marine highways for domestic ports.** One long-standing priority of the Department of Transportation has been to increase the use of U.S. waterways and support the development of "marine highways" that parallel congested interstate highways, like M-90 through the Great Lakes (which parallels I-90) and M-5 along the West Coast (which parallels I-5).

This program could, for example, support a zero-emission route for bulk carriers following M-90 bringing iron ore from Duluth to Gary.

Establishing zero-emission vessel marine highways would allow for smaller, more trial based ships to have access to a dependable alternative fuel on either end of their route, and lead to accommodation of larger and ultimately ocean-going vessels as well.

How We Get There RECOMMENDATIONS

1. **End public financing of fossil-fuel maritime projects, including LNG development, storage, or export/import infrastructure at any U.S ports.** In November 2019, the European Investment Bank announced that it will stop financing fossil-fuel projects, including for Europe's maritime industry, effective 2021. The ban will be complemented by a €1 trillion investment to combat climate disruption.[71] The United States should follow suit and boost support for renewable energy and other strategies to prod the shipping industry toward zero-emission fuels.

   On January 28, 2021, U.S. Special Envoy for Climate Secretary John Kerry warned that natural gas will be a stranded asset. (A stranded asset is a resource or equipment that once generated income but no longer does because of market, technology, or political shifts.)

   Kerry is right. But U.S. ports and global shipping companies are continuing to build out LNG infrastructure with support from the federal treasury. The Biden-Harris administration should halt this practice

2. **Create a Zero-Emission Ports Infrastructure Fund. For ports to reach zero-emission targets and to prepare them for zero-emission ships will require significant investment.** The EPA, working with the Department of Transportation, should establish a new fund and grant program to jumpstart the zero-emission transition at American ports, making no less than $2 billion available each year for at least the next ten years.

   (In January 2021, California Congresswoman Nanette Diaz Barragán, whose district includes the ports of Los Angeles and Long Beach, reintroduced the Climate Smart Ports Act. This bill would create that $1 billion-a-year zero-emissions ports infrastructure program, as well as protect dockworkers, address environmental injustice, and create good-paying green jobs.)

3. **Establish a short-term Zero Port Pollution Tax.** While public dollars are necessary and appropriate for many infrastructure projects, American taxpayers alone should not bear the burden of cleaning up decades of multinational corporations' pollution.

   Modeled off of Norway's successful NOx Fund and adhering to the "polluters pay" principle, the U.S. should establish a Zero Port Pollution Fund to support zero-emission vessel development and green port infrastructure through a tax on deadly criteria pollutants (NOx, SOx, and black carbon, the most dangerous component of particulate matter), as well as greenhouse gases (notably CO2 and CH4).

4. **Focus the zero-emission transition on the U.S. fleet and workforce.** The U.S. is not the world's largest shipbuilder, but it can lead by example and leverage its ocean, coastal, and river-going vessel fleet to drive rapid innovation in zero-emission vessel development. The U.S. should issue a moratorium on new fossil-fuel ship procurements, directing that all new U.S. ships built be zero-emission beginning in 2023. In tandem, the U.S. should:

   Immediately procure low/zero-emission vessels for Maritime Training Institutes. Training and familiarity with zero-emission vessels and operations will be essential for American merchant mariners. Acquiring training vessels will give mariners time to develop the necessary skills to safely operate these ships, and to develop the standards for certifying mariner's knowledge.

   Establish a Low/Zero Emissions Training Program for U.S. Mariners. In addition to procuring training vessels, the curriculums of America's university-level merchant academies should be encouraged to develop a list of courses that teach zero-emission technologies and fuels.

5. **Establish a national Ocean Ranger-style environmental enforcement program.** In 2006, Alaskan voters organized a ballot measure to establish a "National Ocean Ranger Program" to oversee cruise ships' environmental compliance. Governor Dunleavy unilaterally revoked the program, but it remains popular.

   The Biden-Harris administration should establish a similar green government jobs program that allows the Coast Guard and Environmental Protection Agency marine engineers to board vessels and act as independent observers monitoring fuel standards, pollution standards, the scrubber ban, and other marine discharge requirements.

International Action RECOMMENDATIONS

1. **Include emissions from international maritime transport in the U.S.' nationally determined contributions (NDCs) to the Paris Agreement.** The U.S. should take responsibility for 50 percent of all inbound/outbound emissions from ships docking its ports, split on a 50:50 basis between the country of origin and destination for all ships.

2. **Embark on 'Green Shipping Corridors' with major trade partners, looking to ports as hubs for the clean energy transition.** A corridors approach that links zero-emission fuels demand (from ships) and supply (from ports) is welcome, as it will help scale demand across multiple maritime industries and supply chains simultaneously, driving down costs and a timeline for rapid shipping decarbonization. We encourage action along three major corridors: an Americas corridor, the Transpacific corridor, and the Transatlantic corridor.

3. **Center frontline port and freight corridor communities in global shipping debates.** Global shipping debates are largely led by ship owners, ship-builders, engineers, and technicians. Frontline communities living in ports and along freight corridors are largely absent from policy debates at the global level. The Biden-Harris administration's historic commitment to advancing environmental justice should be extended to all policy fora on shipping and the high seas.

4. **Advance evidence-based principles for evaluating the climate credentials of alternative marine fuels and policies:** We urge the U.S. to advocate for the following three principles, which were developed by the International Council on Clean Transportation:

   Principle 1: CO2e not CO2: some fuels are zero-CO2 but not zero carbon dioxide equivalent.

   Principle 2: GWP20, not solely GWP100: reducing pollutants with high 20-year GWP, such as black carbon and methane, helps avoid additional near-term warming, which is important in a world that is already 1.3°C warmer than pre-industrial levels.

   Principle 3: well-to-wake, not tank-to-wake. Focusing solely on tank-to-wake emissions risks rewarding fuels with high life-cycle emissions, such as hydrogen made from fossil fuels.

5. **Increase U.S. climate ambition and environmental justice leadership at the International Maritime Organization.**

   We include IMO recommendations last deliberately in this report. For far too long, negotiations at the IMO have been treated as the primary forum for ship regulation rather than a secondary forum. This is folly. Effective global policies at the IMO will be best achieved on the back of strong national climate and shipping policies at home. That said, global agreements for shipping regulation are, of course, imperative. To align U.S. posture at the IMO with a 1.5°C decarbonization ambition, the U.S. should prioritize the following:

Reverse U.S. obstructionist positions on climate in the IMO: The United States is currently one of only two nations in the world with a formal "reservation" on the IMO's initial greenhouse gas (GHG) strategy at MEPC 76. The other is Saudi Arabia. This is an easy fix: the U.S. should promptly withdraw this reservation and announce support for ambitious short-term actions that reduce GHGs from the existing fleet before 2023; announce the intent to help create an absolute zero life-cycle GHG emission shipping sector by 2035.

Support a 1.5C-aligned short-term GHG reduction measure at the IMO, specifically a mandatory carbon dioxide equivalent standard, the Carbon Intensity Index (CII). This is a central component of a short-term climate measure moving forward to a final vote on adoption this June at IMO. This measure must be set with targets that are aligned to meet the IMO initial strategy ambitions — resulting in absolute emissions reductions by 2030 of at least 20-45 percent, which equate to carbon intensity improvements of 70 percent by 2030. To ensure these targets are delivered, it needs to include real, globally consistent, and enforceable penalties for non-compliance (e.g. the ship cannot sail).

Support Small Island States in calling for an ambitious levy to help drive mitigation and raise revenue for investment in zero emission technology and infrastructure. The Republic of Marshall Islands and the Solomon Islands have called for and submitted to the IMO a $100 per metric ton levy on carbon emissions from shipping companies as a baseline for negotiations.[77] Shipping company Trafigura has said $250-$300 is realistically the necessary carbon price for ships' fossil fuel pollution.[78] Supporting a levy any lower than these proposals would be an abdication of political commitments to environmental justice in the energy transition.

Support a 1.5C-aligned reform of the IMO's Greenhouse Gas Strategy. The IMO's Initial GHG Strategy calls for the shipping industry to halve emissions by 2050. This was an important start to catalyze shippings' clean energy transition, but is not aligned with 1.5°C. Based on the best publically available interpretations of the global carbon budget and the shipping industry's "fair share" within it, the shipping industry needs to reach absolutely zero emissions by 2036-2045.

Support a Transparent IMO Data Collection System. Currently, only aggregated shipping emissions data are publicly available, even though the IMO is collecting fuel consumption and emissions data for each ship over 5,000 gross tonnes. The United States, as a global leader and believer in the power of transparency to solve problems, should help create public, non-anonymized reporting and publishing of data collected under the IMO's Data Collection System and add "cargo carried" as a required parameter to report so we can hold ship owners accountable. The system needs to expand to cover all ships carrying more than 400 metric tons so that innovators and problem solvers around the globe can have better access to the data they need to help shippings' decarbonization.

Ocean Conservancy®

PACIFIC ENVIRONMENT

oceanconservancy.org

and

pacificenvironment.org