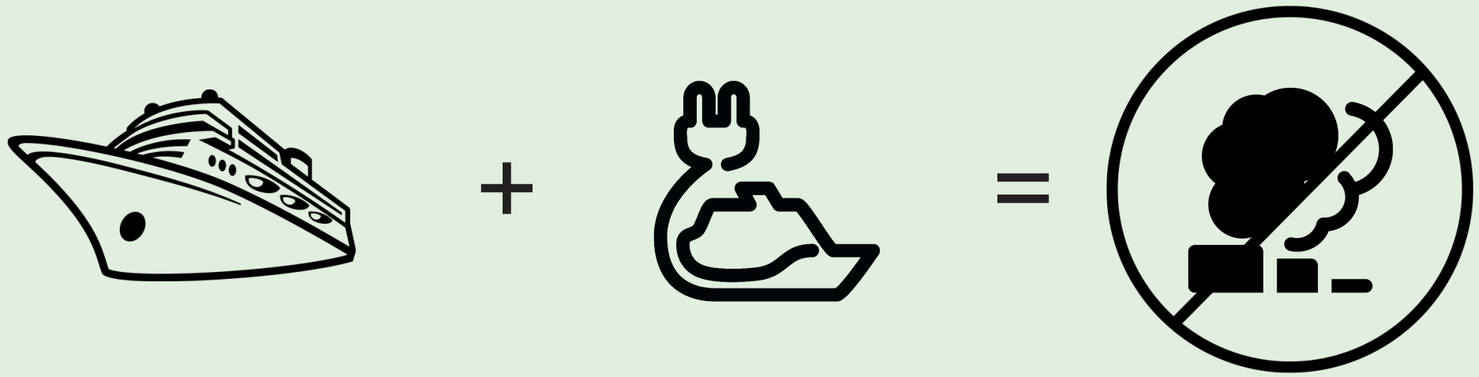
Shore Power
An Eco-Friendly Solution to Port of Miami Pollution



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Spring 2020
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Photo take with drone by Ryan Daniusis

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Introduction

1. How I got my topic

While interning at Arquitectonica during my Spring 2020 Semester, I had the opportunity to work on their MSC Cruise Terminal project (the “Port”). I noticed that a significant number of new terminals were being built nearby. Upon further research, I learned that millions of dollars were being invested over a short time period to develop these new terminals and yet the new development lacked the technical innovations being employed at other terminals around the world. Though the Port of Miami is called the “Cruise Capital of the World”, currently ALL the ships that arrive sit idle while at port. When these ships are berthed, they rely on onboard diesel auxiliary engines for the generation of electrical power to operate lighting, ventilation, pumps, cranes, and a variety of other equipment essential to the loading and unloading of cargo. These engines emit harmful pollutants directly into the adjacent residential neighborhoods and are significant contributors to air pollution. As an alternative, Shore Power can be used by marine vessels to plug into the local electricity grid and turn off auxiliary engines while at-dock. However, none of the terminals at the Miami port, old, new or proposed, appear to be performing a Shore Power Assessment to evaluate this option. This Shore Power Technology Assessment reviews the availability of shore power at ports throughout the U.S. and characterizes the technical and operational aspects of shore power systems installed.

2. Thesis Question

If a Shore Power Technology Assessment was performed, what would be the most efficient layout at the Port of Miami, based on functioning precedents? Once the assessment was completed, how would a more efficient and effective layout be financed and implemented to employ some or all the technology available?

3. My Research will Show

If other ports/states are reducing pollution by switching to shore power, why isn’t the Port of Miami? My research will show that the vessels running auxiliary engines at berth at Port of Miami are creating significant emissions that are major contributors to air pollution. More specifically, the exposure to air pollution associated with emissions from these cruise ships (including particulate matter, nitrogen oxides, ozone, and air toxics) can contribute to significant human health problems including premature mortality, increased hospital admissions for heart and lung disease, increased cancer risk, and increased respiratory symptoms. However, under the right circumstances when a vessel is connected to shore power, overall pollutant emissions can be reduced by up to 98% when utilizing power from the regional electricity grid, (depending on the mix of energy sources) and this technology should be a viable option for the Miami port.

[2]

Glossery

A - Amperes
AMEC - Advanced Maritime Emission Control
At-berth - When the vessel is stationary at the dock
Auxiliary engines - Onboard vessel engines that provide power for ancillary systems: loading/unloading, refrigeration, heating/cooling, etc.
Bunker fuel - Fuel used in marine vessels
CARB - California Air Resources Board
CO - Carbon monoxide
CO2 - Carbon dioxide
Cruise vessels - Ships that transport passengers to various ports-of-call
ECA - Emission Control Area
EIA - Energy Information Administrationl
Hotelling - Vessel operations while stationary at the dock
Hz - Hertz
HVSC - High voltage shore connection
IEC - International Electrotechnical Commission
IEEE - Institute of Electrical and Electronics Engineers
IMO - International Maritime Organization
ISO - International Organization for Standardization
kWh - Kilowatt-hours
LNG - Liquefied natural gas
LVSC - Low voltage shore connection
Main engines - The vessel's propulsion engines
MW - Megawatt
MWh - Megawatt-hours
NOx - Oxides of nitrogen
OPS - Onshore Power Supply
PM - Particulate matter
Quayside - Attached to the dock
S - Sulfur
Shore Power - Shore-side electrical power that marine vessels can plug into while at berth to power ancillary systems
SO2 - Sulfur dioxide
SOx - sulfur oxides
U.S. EPA - United States Environmental Protection Agency

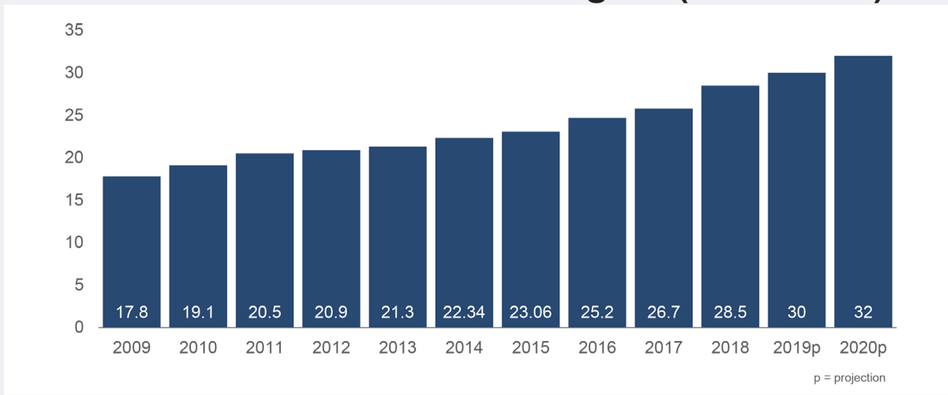
Cruise Industry History

- 1800 - The earliest ocean-going vessels were primarily concerned with cargo.
- 1818 - The Black Ball Line was a shipping company that began offering passenger service from the United States to England.
- 1830 - Steamships were introduced and dominated the transatlantic market of passenger and mail transport.
- 1850 - Ships began to cater solely to passengers and added luxuries like electric lights, more deck space, and entertainment.
- 1901 - The Prinzessin Victoria Luise, built by the American-Hamburg Company, was the first ship designed specifically with cruising in mind.
- 1912 - The sinking of the Titanic on its maiden voyage devastated the White Star Line. In 1934, Cunard bought out White Star; the resulting company name, Cunard White Star.
- 1960 - Beginning of the “modern cruise industry.” Cruise ship companies concentrated on vacation trips in the Caribbean, and created a “fun ship” image. There was a decrease in the role of ships for transporting people to a particular destination; rather, the emphasis was on the voyage itself.
- 1977 - The new cruise line image was solidified with the popularity of the TV series “The Love Boat” which ran from 1977 until 1986.
- 1988-2009 - In two short decades, the largest class cruise ships have grown a third longer (268 m to 360m), almost doubled their widths (32.2 m to 60.5 m), doubled the total passengers (2,744 to 5,400), and tripled in volume (73,000 GT to 225,000 GT).

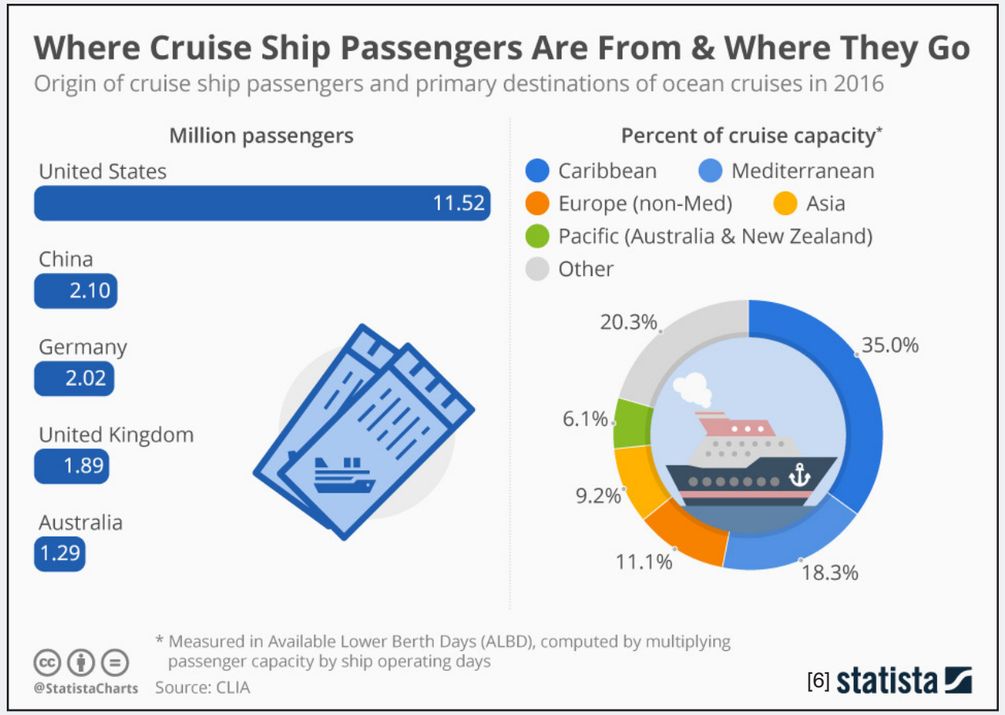
[4] Prinzessin Victoria Luise

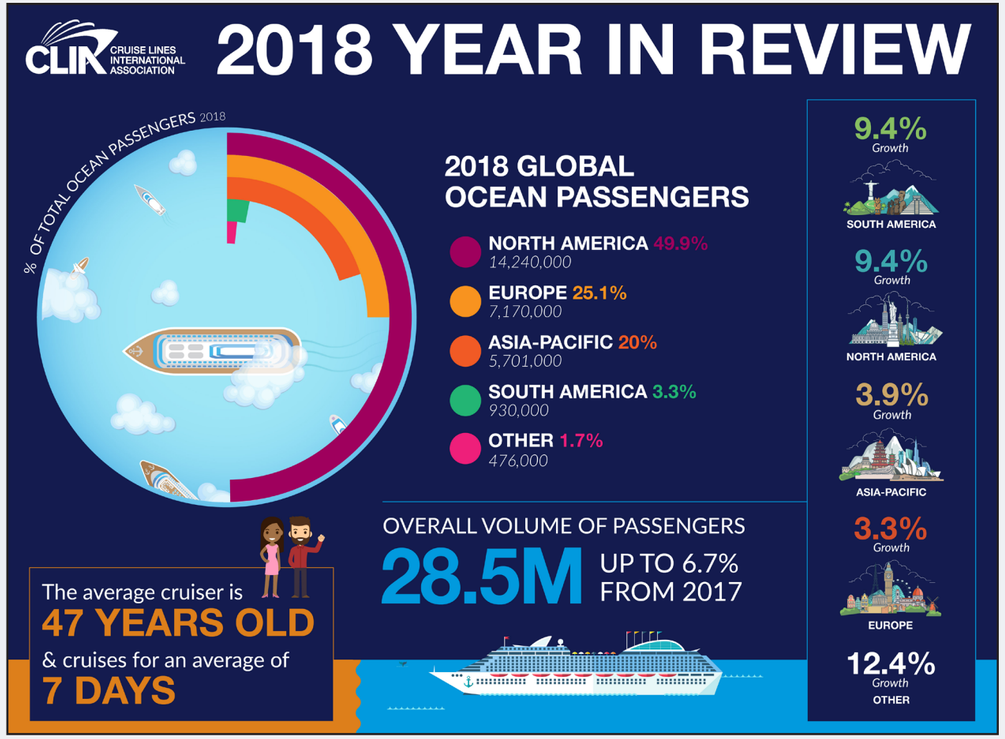
2018 Global Economic Impact

Global Ocean Cruise Passengers (In Millions)



[5] CLIA





[5] CLIA

Cruise Industry Facts

- 20.5% increase in demand for cruising between 2011 - 2016.
- 50% of cruise passengers come from the United States.
- The Caribbean is the most popular destination to travel.
- 7.2 days is the average length for a cruise holiday.
- 3,000 guests is average ship capacity.
- The average person spends $1,770 per week on a cruise.
- Symphony of the Seas and Harmony of the Seas are the world's largest cruise ships, both spanning over 1,180 ft in length. Both owned by Royal Caribbean, they are able to carry approximately 6,780 passengers each.

The largest cruise ship operators

Cruise ship companies by revenue and market share (2018)

Company	Revenue	Market share
Carnival Corporation & plc	**$18.9B**	75%
Carnival Cruise Line	*$4.3B*	
Princess Cruises	*$4.3B*	
Holland America Line	*$2.7B*	
Costa Cruises	*$2.3B*	
AIDA Cruises	*$2.2B*	
P&O Cruises	*$1.1B*	
Cunard Line	*$0.8B*	
P&O Cruises Australia	*$0.6B*	
Seabourn Cruise Line	*$0.6B*	
Royal Caribbean Cruises Ltd.	**$9.5B**	21%
Royal Caribbean Int'l	*$6.5B*	
Celebrity Cruises	*$2.5B*	
Azamara Cruises	*$0.5B*	
Norwegian Cruise Line HLD	**$5.8B**	13%
Norwegian Cruise Line	*$3.9B*	
Oceania Cruises	*$1.1B*	
Regent Seven Seas Cruises	*$0.8B*	
Other	**$11.4B**	*25%*
TOTAL	**$45.6B**	

Data: Carnival, RC, Norwegian annual reports (2018); #s rounded

[7] HUSTLE

Carnival Corporation & PLC, Royal Caribbean Cruises LTD, and Norweigan Cruise Line HLD control roughly **75% of the market**

Florida Cruise Industry

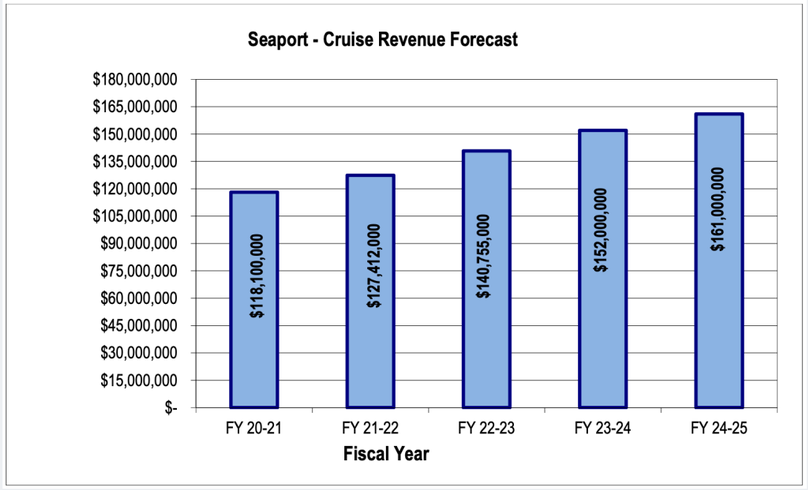
The Cruise Lines International Association (CLIA) is the world's largest cruise industry trade association, providing a unified voice and leading authority of the global cruise community.

According to CLIA's study, cruising at Florida ports generated:

11.5 million passenger and crew visits, representing nearly half (48 percent) of all passenger and crew visits in the U.S

These visits produced **$1.05 billion** in passenger and crew onshore spending.

"Florida is the first, and remains the only state, to generate more than $1 billion in annual passenger and crew expenditures,"



[9] 2019-2020 Miami Dade Budget & Multi-Year Capital Plan

Additional findings from CLIA's study:

- More than 7 million (7.08 million) cruiser passengers embarked from one of Florida's five cruise ports (Port of Miami, Port Everglades, Port Canaveral, Port of Tampa and Port of Jacksonville), accounting for 61 percent of embarkations at all U.S. ports.
- The cruise industry directly employed nearly 21,000 Floridians, representing approximately 60 percent of the total employment of all cruise lines throughout the U.S.
- Tourism-related industries received approximately $3.8 billion, or 48 percent of the cruise industry's $7.97 billion in direct spending in Florida.
- The manufacturing industry received $1.7 billion, or 21 percent of the direct spending in Florida. The three largest sectors within this industry were the food and beverage manufacturers, petroleum manufacturers and chemical manufacturers that make soap, cleaning and toiletry products.

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Port of Miami

#1 Busiest Cruise Port in the World (by number of passengers)

66% Increase in passengers from 2009 to 2019

2018-2019 Port Guide Statistics:

Total Cruise Ships Docked - 1,220

Total Cruise Passengers - 5,592,000

Total Cruise Lines (2018) - 22

Total Cruise Ships (2018) - 55

Key Advantages

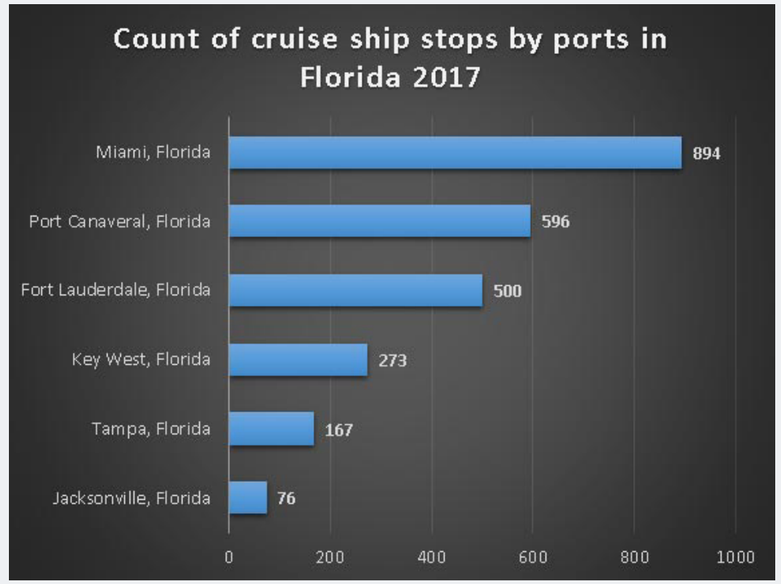
- Modern cruising at Port of Miami started over 50 years ago.
- Cruise passengers can easily discover what Miami has to offer from its prime downtown location.
- Close proximity to the Caribbean, Panama, Mexico and beyond.
- Fast access from Miami International Airport via port tunnel.
- Goods, supplies, and provisions are sourced locally
- A renowned global destination, offering cruise passengers pre-cruise and post-cruise activities that support overall travel and tourism: sport, entertainment, dining, arts, parks and beaches.

- 2018 - 2019 Port Guide - Port of Miami

The Port of Miami is governed by the Port Authority of Miami Dade County

It's #TBT... Pictured here is the old Port of Miami in the 1950's. Which is now Bayside Marketplace. The bottom of the picture shows the old Port of Miami, the small chain of islands is what is now

- @PortMiami Twitter 8/9/18



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Port of Miami History

1896

Henrey Flagler

Henry M. Flagler extended the Florida East Coast Railway to Miami the same year in which the City of Miami was incorporated. Flagler reached Biscayne Bay in 1896 and dredged the original harbor for the Port of Miami. Flagler became the chief builder and advocator in the following decades.

1903

Government Cut

U.S. Congress authorized Government Cut in 1902 and dredging began in 1903. This channel was finished in 1905, and the fill material from the dredging was used to expand Fisher Island.

1960

Resolution No. 4830 & No. 31837

On April 5, 1960 the Dade County Board of Commissioners approved Resolution No. 4830, "Joint Resolution Providing for Construction of Modern Seaport Facilities at Dodge Island Site" and on April 6, 1960 the City of Miami approved the same as City Resolution No. 31837 to construct the new Port of Miami, beginning with Dodge Island.

1979

Lummus & Sam's Island Expansion

Port of Miami was created by combining three man-made soil disposal plots, once named Dodge Island, Lummus Island, and Sam's Island. In 1979 the Port began its largest project, expanding its existing location on Dodge Island outward onto the other two.

2010

"Cruise Capital of the World"

4.1 Million Cruise Passengers and 7.3 million tons of cargo passed through the Port of Miami in 2010. It had major economic and social benefit in Miami-Dade County as well as in South Florida

2014

Deep Dredge

The "Port Miami Deep Dredge Project" deepened the channel from 42 to 50 feet. It coincided with the "New Panamax" project expanding the Panama Canal in 2016. The Deep Dredge Project allowed Post-Panamax Megaships to enter the Port of Miami.

[18]

1970 → **2017**

[12]

[12]

Port of Miami

"Up until 2017, every dollar that was invested into the port really was all port dollars, all county dollars." - Juan Kuryla, Port Director & CEO

Port of Miami contributes approximately **$43 billion dollars** and more than **22,000 jobs** to Miami-Dade County.

"About **$6 billion** of Miami-Dade's economy comes from the cruise industry" - Mayor Carlos Gimenez

"With a combination of public and private dollars, Miami-Dade County is betting on the cruise industry in a big way by devoting more than **$1.5 billion** to build five shiny new cruise terminals and two company headquarters in total" - Miami Herald

Miami-Dade County is spending more than **$700 million** on building five new cruise terminals

The County expects to get back more than **$5.8 billion** over the course of decade-long deals.

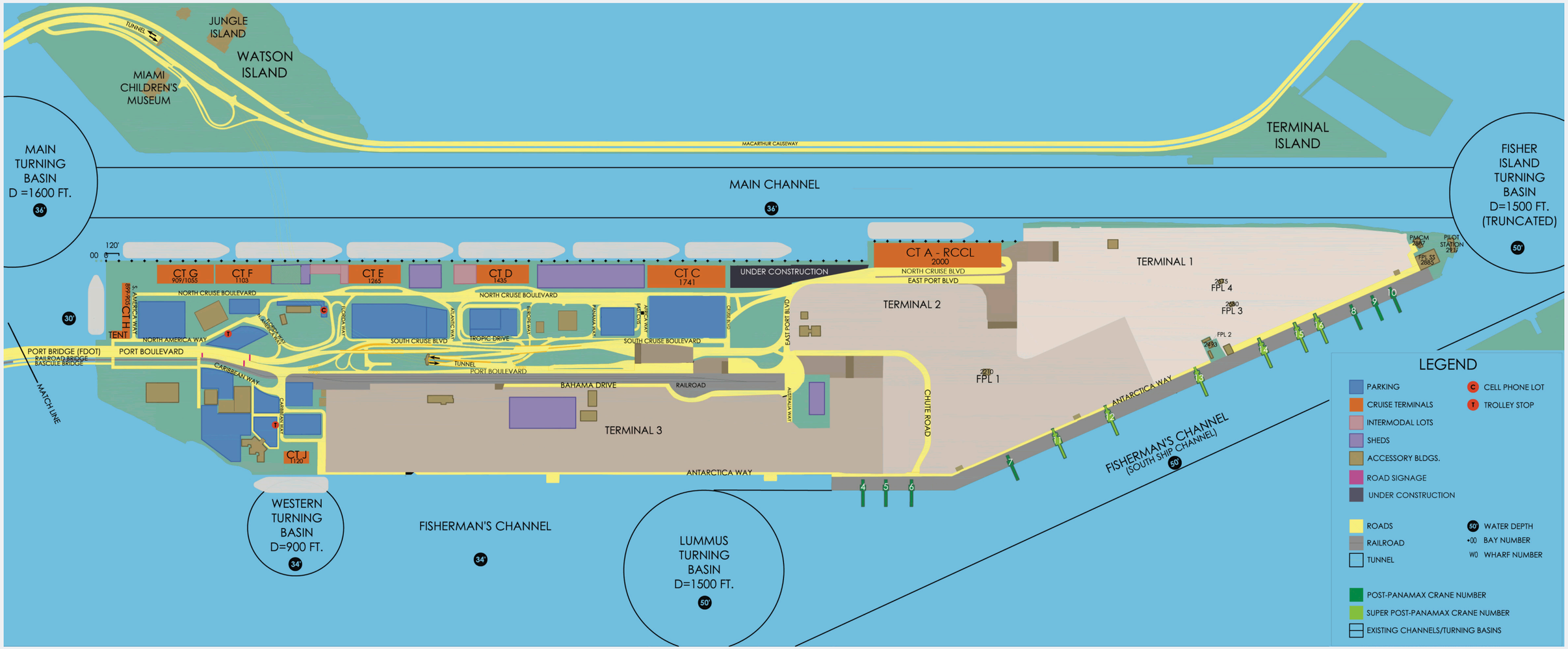
The two types of deals the county struck :

Rent Deals - The County provides a certain amount of infrastructure improvements and charges the cruise line **rent** for a set amount of years.

Surcharge Deals - The County agrees to fund the cost of the terminal with the guarantee that the companies will **pay them back using passenger fees** over three decades.

- **Miami-Dade County is spending 700 million on new terminals without shore capabilities.**
- **Will any of the $5.8 billion recouped from terminal investment be spent on shore Power?**

Port of Miami 2019 Master Plan



[14] 2019 Masterplan

The Port of Miami is accessible by bridge, by tunnel, and by train. The north half of the island is designated for cruise ships and terminals, while the south half of the island is used for Cargo ships and storage. Parking lots and garages are located in the center, dividing the two halfs.

Port of Miami

Missed Opportunity

“In 2011, The Port of Miami listed shore power in its “2035 Master Plan” as a potential sustainability project, aimed at preserving the natural and human environments surrounding the port. Even with the current unprecedented investment in cruise terminals, no progress has been made on this initiative. Kuryla said it did not come up in any of the county’s conversations with cruise companies about the terminal deals.” - Taylor Dolven, The Miami Herald

Table 8.1 in Port of Miami 2035 Master Plan (issued in 2011)

Preferred Plan Capital Costs, 2010 - 2017

2017 - $2,000,000 given to “Shore power for cruise ships”

Preferred Plan Capital Costs, 2018 - 2025

2020 - $2,000,000 given to “Shore power for cruise ships”

2023 - $2,000,000 given to “Shore power for cruise ships”

Preferred Plan Capital Costs, 2026 - 2035

2028 - $2,000,000 given to “Shore power for cruise ships”

2035 - $2,000,000 given to “Shore power for cruise ships”

2016-2019 Miami Dade Budget & Multi-Year Capital Plan

“Cruise Terminals - Concourses and Berthing Modifications”

was listed under

“Unfunded Capital Projects costing $15 Million Dollars”

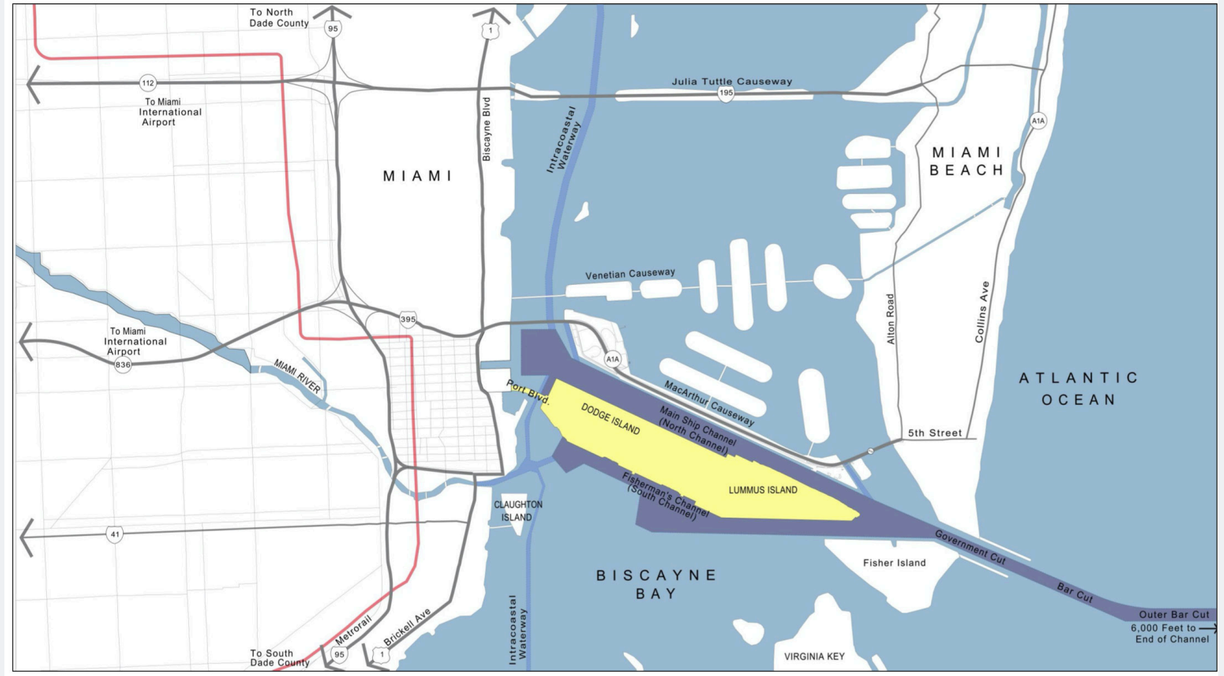
- **Was the money noted for “Shore power for cruise ships” in the 2035 Master Plan allocated accordingly?**
- **When will the City of Miami Dade start allocating funding and move “Concourses and Berthing Modifications” off the list of underfunded projects?**

Port of Miami

“This is something that I think if the client were to have expressed that need as part of any of the development project that we’re doing, we would have for sure entertained it and costed it out” - “But it just didn’t it didn’t come up.”

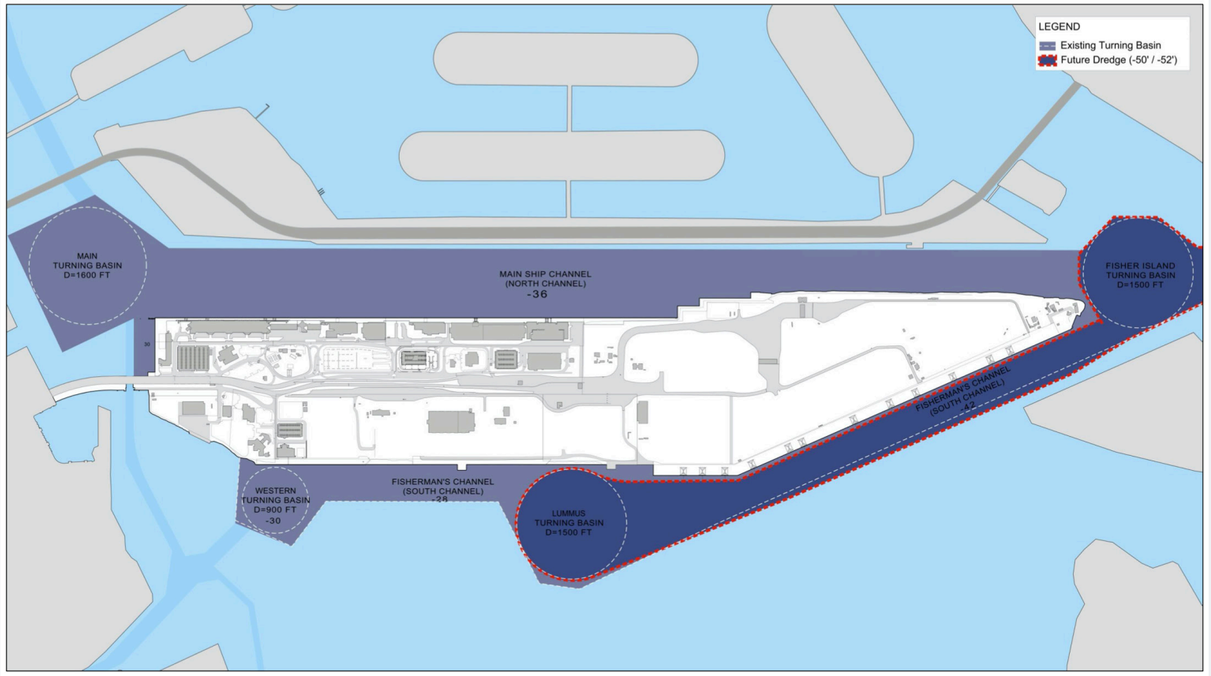
- Juan Kuryla, Port of Miami Director & CEO talking about Shore Power

Port of Miami: Location Map - 2011



Channels and Turning Basins - 2011

[11] Port of Miami 2035 Masterplan



[11] Port of Miami 2035 Masterplan

Cruise Terminals at Port of Miami

Under Construction / Design in Progress

Current Terminals

Terminals B & C:	Norwegian Cruise Line
Terminal D & E:	Carnival Cruise Line
Terminal F:	MSC Cruises & Disney Cruise Line
Terminal G:	Royal Caribbean Cruise Line & Celebrity Cruises
Terminal J:	Oceania & Regent Seven Seas

Terminal AA / AAA

MSC Cruises

MSC to design, finance, build, operate and maintain Cruise Terminals AA/AAA and its two berths
Approximate cost: $300 million
Estimated completion: 2022

Terminal A

Royal Caribbean

The Crown of Miami

2018, Royal Caribbean Cruises opened Terminal A, the largest cruise terminal in the U.S., in collaboration with Miami-Dade County. This terminal serves as homeport to some of Royal Caribbean's largest ships.

Terminal B

Norwegian Cruise Line

The Pearl of Miami

The Pearl of Miami will accommodate vessels carrying up to 5,000 cruise passengers.
Estimated cost: Approximately $239 million
Estimated completion: 2020

Terminal C

Cruise Terminal C

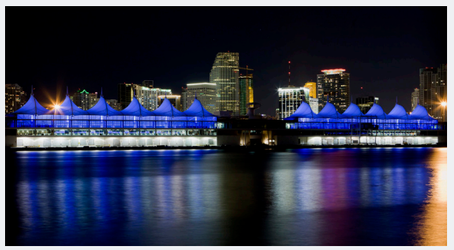
Renovations are on the way.
Estimated cost: $13 million
Estimated completion: Fall 2019

Terminal D & E

Expansion for larger class ships was completed in 2013/2018 and are LEED certified "silver". Also, made updates to the apron of the terminals for new passenger boarding bridges.
Total cost Terminal D: $7 million
Total cost Terminal E: $5-8 million

Terminal F

Carnival Corp and the County have entered into an agreement to renovate Cruise Terminal F to accommodate CCL's XL 7,000 passenger vessel
Estimated cost: $170 million
Estimated completion: 2022



Terminal G

Improvements to the terminal include enhancing the interior and waterproofing the iconic "sails," which makes the terminal one of Miami landmarks.
Completed: 2013
Total cost: $2 million

Terminal J

PortMiami's boutique cruise terminal designed to cater to small vessels and luxury cruises, Terminal J is undergoing a $3 million facelift. Upgrades include the incorporation of a fully automated "One-Stop Shop" for Customs & Border Protection (CBP); remodeling of ground floor restroom facilities, and the addition of a new exterior escalator.

Terminal V

Virgin Voyges - Palm Grove

The Virgin Voyages Terminal will be located on the northwest side of the port. The vessel will house the line's first ship Scarlet Lady.
Estimated cost: $180 million
Completion: 2021

[15] Miami Herald

Cruise Lines at Port of Miami

Home Port

Most boats at Port of Miami

Carnival

Celebrity Cruises

Regent Seven Seas Cruises

RoyalCaribbean International

Crystal Cruises

Disney Cruise Line

NCL Norwegian Cruise Line

Azamara Club Cruises

First Cruise in 2021

MSC Cruises

Oceania Cruises

Virgin Voyages

Princess Cruises

Viking Cruises — Exploring the World in Comfort

Port of Call

AIDA

Seabourn

Windstar Cruises

P&O Cruises

Hapag-Lloyd

Phoenix

Scenic — Luxury Cruises & Tours

TUI Cruises

Saga

Hurtigruten

Air Pollution & Green House Gases

[20]

While “global warming” and “climate change” are broad terms used to describe the ongoing rise of average temperature on earth, there is a scientific consensus that the use of fossil fuels are the primary cause of pollution. Cruise ships are a massive contributor to air pollution, emitting five of the six critical pollutants.

The U.S. National Ambient Air Quality Standards (NAAQS) are limits on atmospheric concentration of six pollutants that cause smog, acid rain, and other health hazards. Established by the EPA under authority of the Clean Air Act.

The six criteria air pollutants are:

Criteria Pollutants	Description	Sources	Environmental Effects	Health Effects
Ozone (O3)	Colorless gas with sweet odor	-Chemical reaction of NOx and VOCs under sunlight -Industrial emission -Motor vehicle emissions	-Spotting and stippling of plant tissue -Crop damage and decreased crop yields -Cracking of rubber -Fainting of fabric dyes and paint	-Respiratory system damage -Eye and throat irritation -Coughing -Chest pains
Sulfur dioxide (SO2)	Colorless and odorless gas	-Burning of fossil fuels (coal) -Industrial processes -Petroleum refining and production of paper and cement	-Injury or death of animals and plants -Corrosion of paint and metals -Fading of dyes and paint -Acid rain	-Damage to lungs -Respiratory disease -Narrowing of airways
Nitrogen oxides (NOx)	Colorless and odorless gas NO2: red-brown	-Automobile -Burning of fossil fuels by power plants	-Slows plant development -Fading of dyes -Can be good in low concentrations	-Irritation of eyes, lungs, nose, and throat -Increased disease vulnerability
Carbon monoxide (CO)	Colorless, odorless gas	-90% natural -10%: -Combustion of fuel -Fires	None	-Extremely toxic at low concentrations -Birth defects -Nausea and dizziness -Shortness of breath
Particulate matter (PM)	Small particles Smoke, soot, dust	-Agriculture -Windstorms -Burning of fossil fuels -Industrial processes	-Corrosion of metal -Tree and crop damage -Acid rain	-Respiratory disease -Throat, lungs, and eye irritation
Lead (Pb)	Heavy metal	-Gasoline -Paint -Smelting of metals	-Toxic in soil -Alters plant metabolism	-Affects children: brain damage -Behavior problems -Nerve disorders -Anemia and kidney damage

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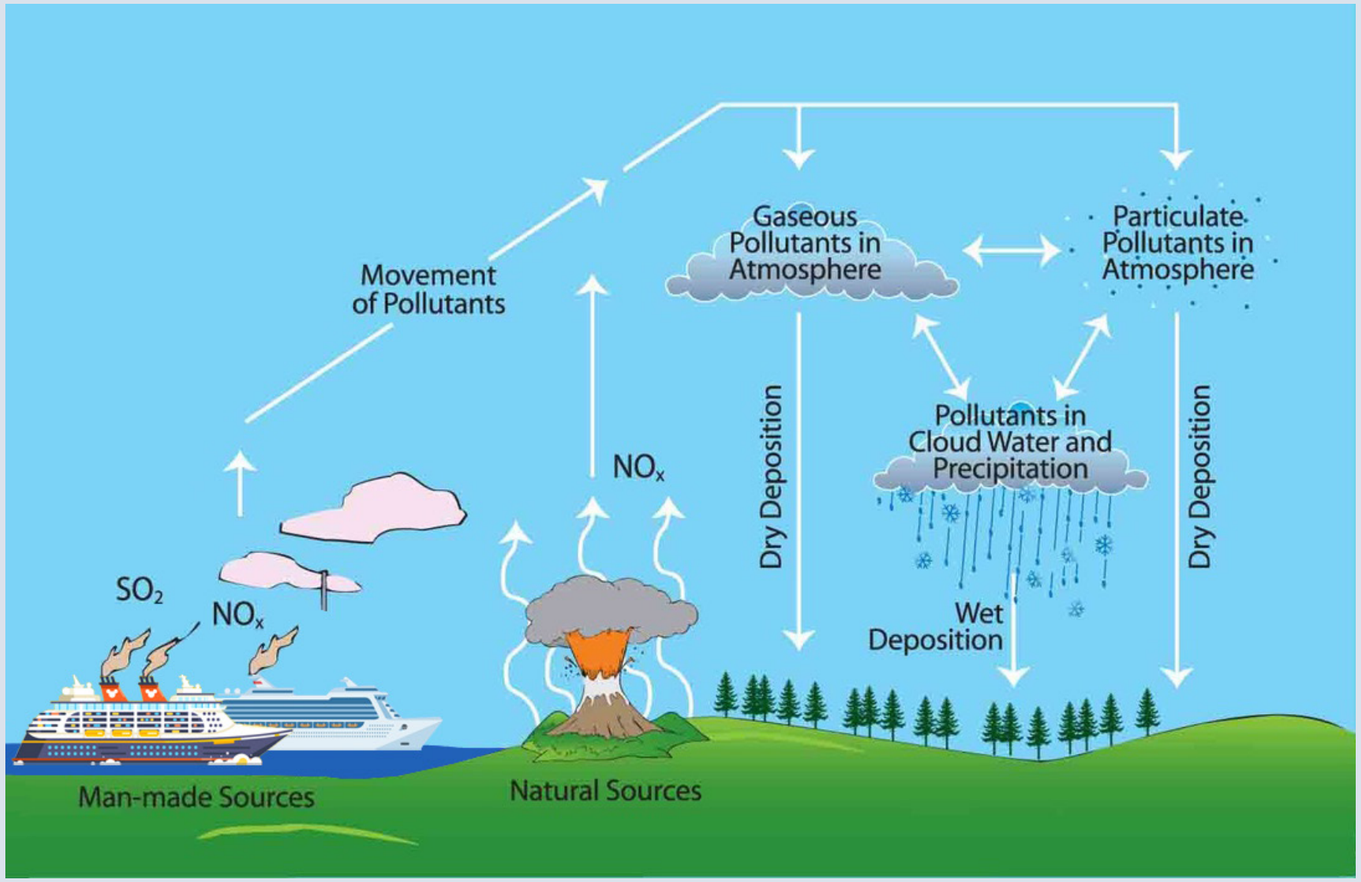


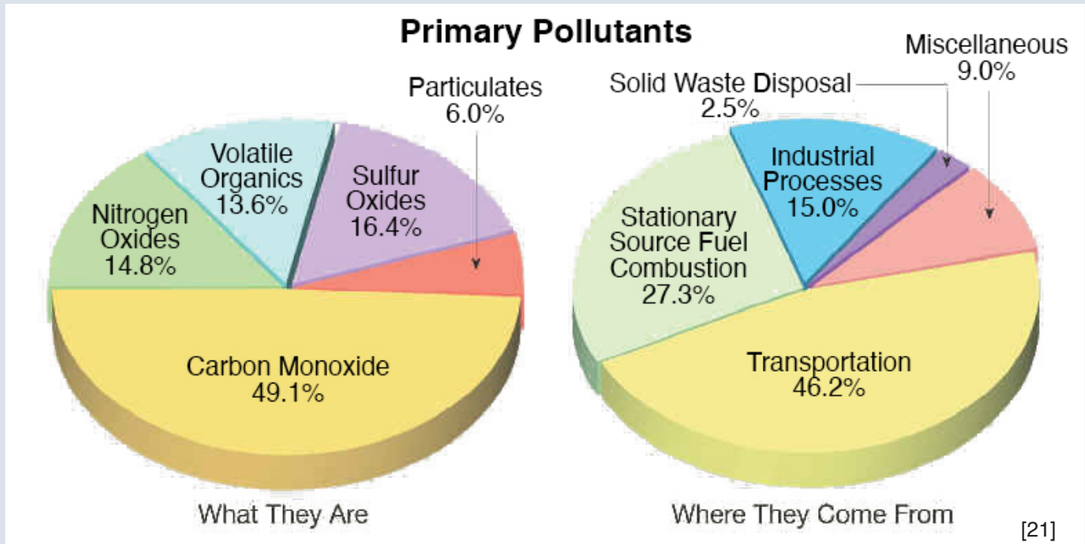
[21]

The U.S. Clean Air Act requires the EPA “to list widespread air pollutants that reasonably may be expected to endanger public health or welfare; to set primary NAAQS to protect human health with adequate margin of safety and to set secondary NAAQS to protect against welfare effects (e.g., effects on vegetation, ecosystems, visibility, climate, manmade materials, etc); and to periodically review and revise, as appropriate, the criteria and NAAQS for a given listed pollutant or class of pollutants.”

Pollution & Impact

Cruise ships are a significant source of priority pollutants such as NOx, SO2, CO, and particulate matter (PM) and the main greenhouse gas, CO2. The atmospheric emissions from ships are of particular concern when vessels are at berth, because they consume significant quantities of electrical power which is generated by inefficient onboard diesel engines leading to unnecessary emissions of priority pollutants and greenhouse gasses. One alternative to using onboard power generation is to connect ships to an onshore electrical supply; this is referred to as shoreside power or cold-ironing.

The U.S. EPA describes ship pollution as a "likely carcinogen" that is "harmful to the public generally, and especially to our children, the elderly, people with lung disease, those who exercise outside, and communities located near ports."

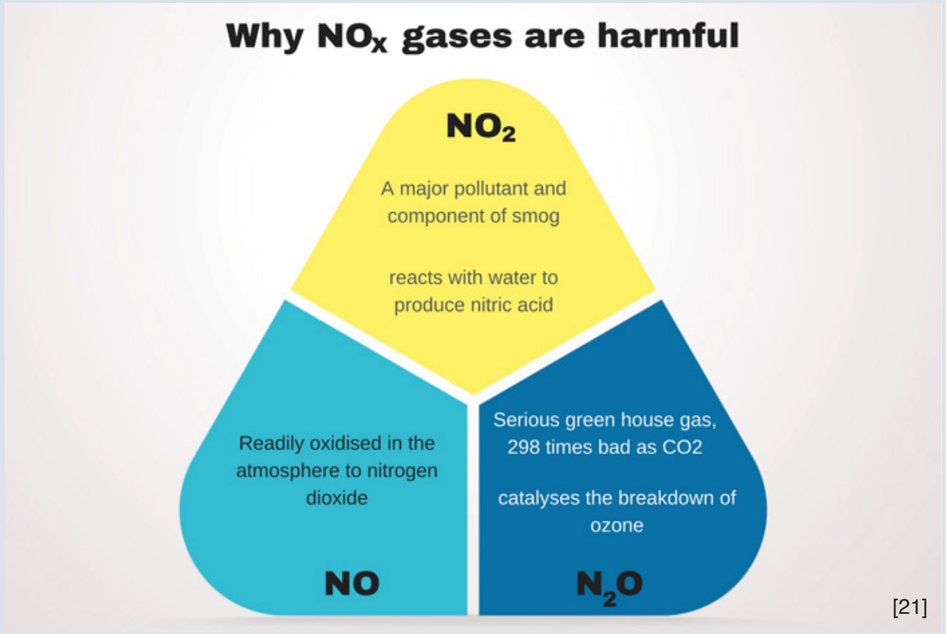


[21]

Ships produce all of the Primary Pollutants besides Lead (Volatile Organics)

Ships contribute to both Transportation and Stationary Source Fuel Combustion

Pollution & Impact



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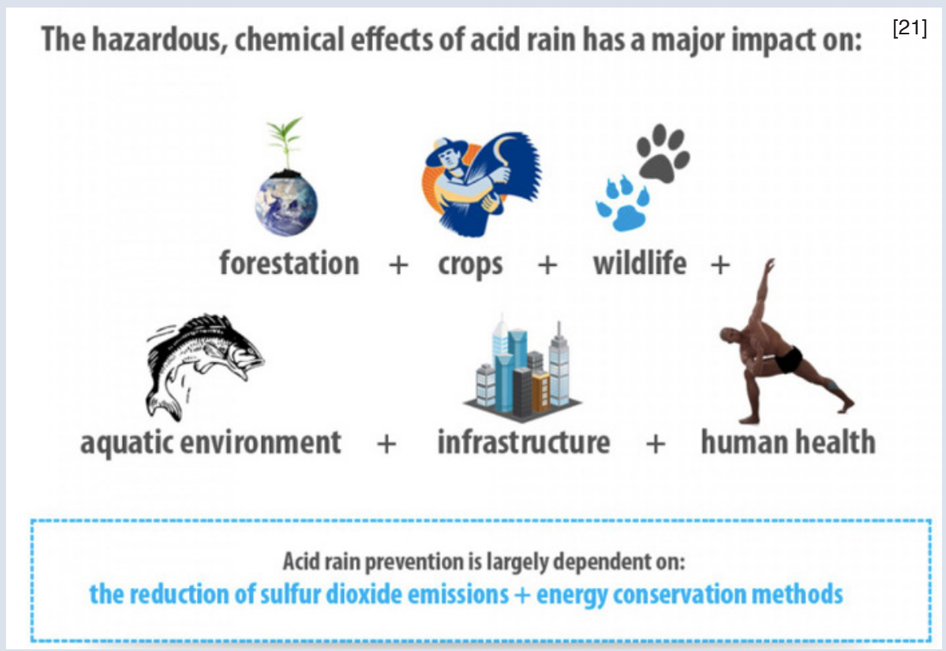


[21]

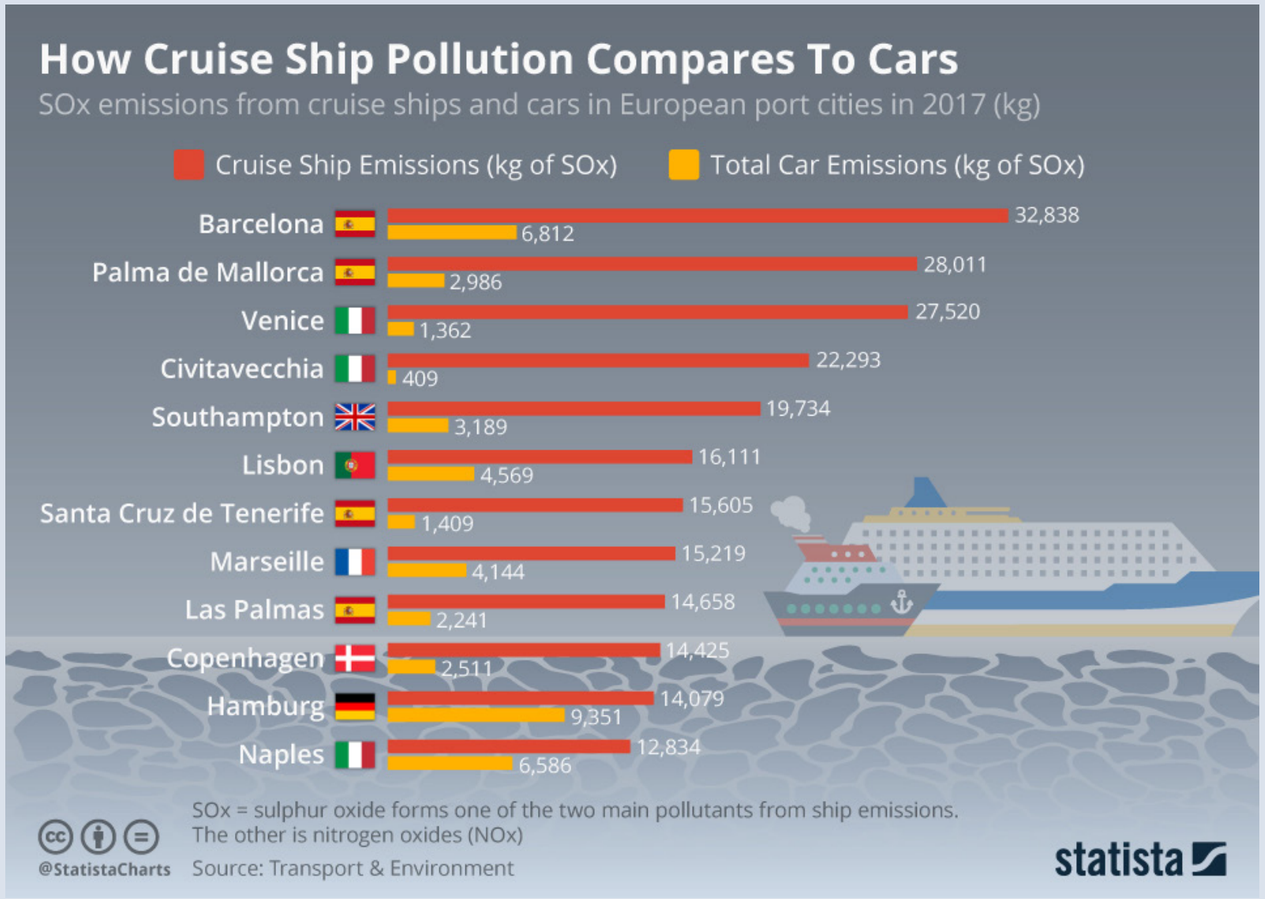
Ships account for:

90% of the world's commercial goods transport*

2% of global CO_2 emissions**

15% of global nitrogen oxide (NO_x) emissions**

6% of global sulphur oxide (SO_x) emissions**



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Cruise Pollution & Impact

Sulfur Dioxide SOx

SOx is the primary air pollutant that ships produce.

SOx is the short form of Sulfur Oxides, a family containing Sulfur Dioxide (SO2) and Sulfur Trioxide (SO3).

Regulated through MARPOL Annex VI

Description:
Colorless and odorless gas

Environmental Effects:
Injury of death of animals and plants; Acid Rain

Health Effects:
Damage to lungs; Respiratory disease; Narrowing of airways

Nitrogen Oxide NOx

NOx is the second major air pollutant that ships produce.

NOx gases are produced from the reaction of nitrogen and oxygen in the air during the combustion process.

Regulated through MARPOL Annex VI

Description:
Colorless and odorless gas

Environmental Effects:
Slows plant development; Fading of dyes

Health Effects:
Irritation of eyes, lungs, nose, and throat; Increased disease vulnerability

Particulate Matter PM

PM is the third air pollutant that ships produce.

PM is a complex mixture of extremely small particles & liquid droplets that get into the air

Description:
Small particles; Smoke, soot, dust

Environmental Effects:
Corrosion of metal; Tree and crop damage; Acid Rain

Health Effects:
Respiratory disease, Throat, lungs, and eye irritation

Carbon Monoxide & Carbon Dioxide CO & CO2

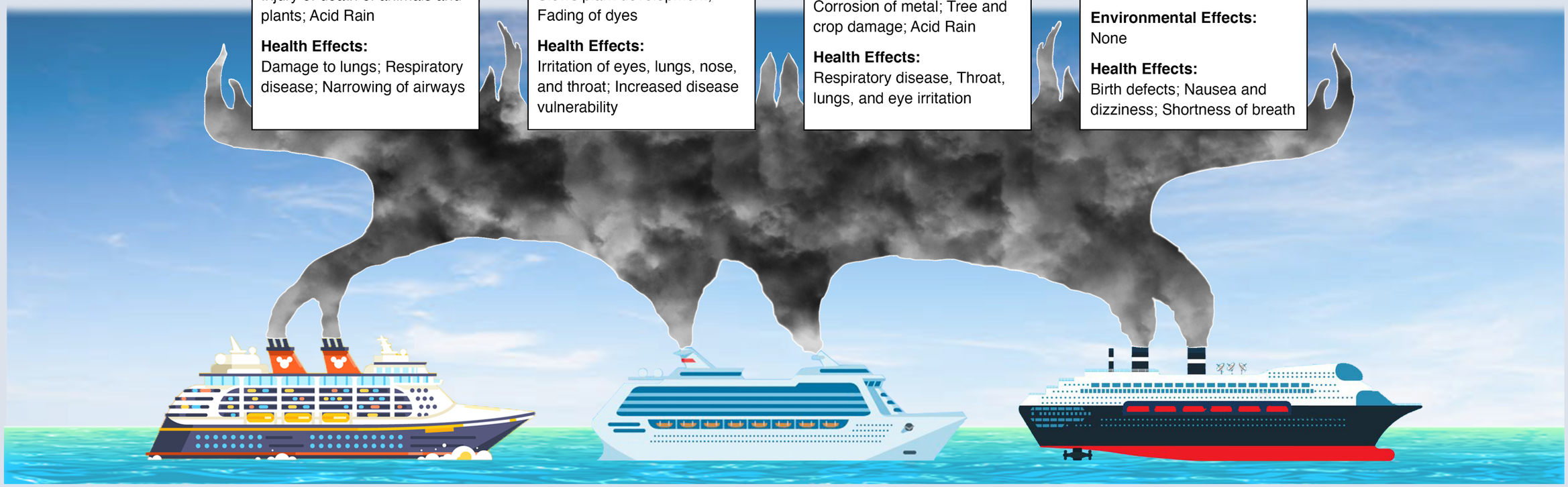
CO & CO2 are the last pollutants that ships produce.

CO2 is a common, naturally occurring gas required for all plant and animal life. CO is not common.

Description:
Colorless and odorless gas

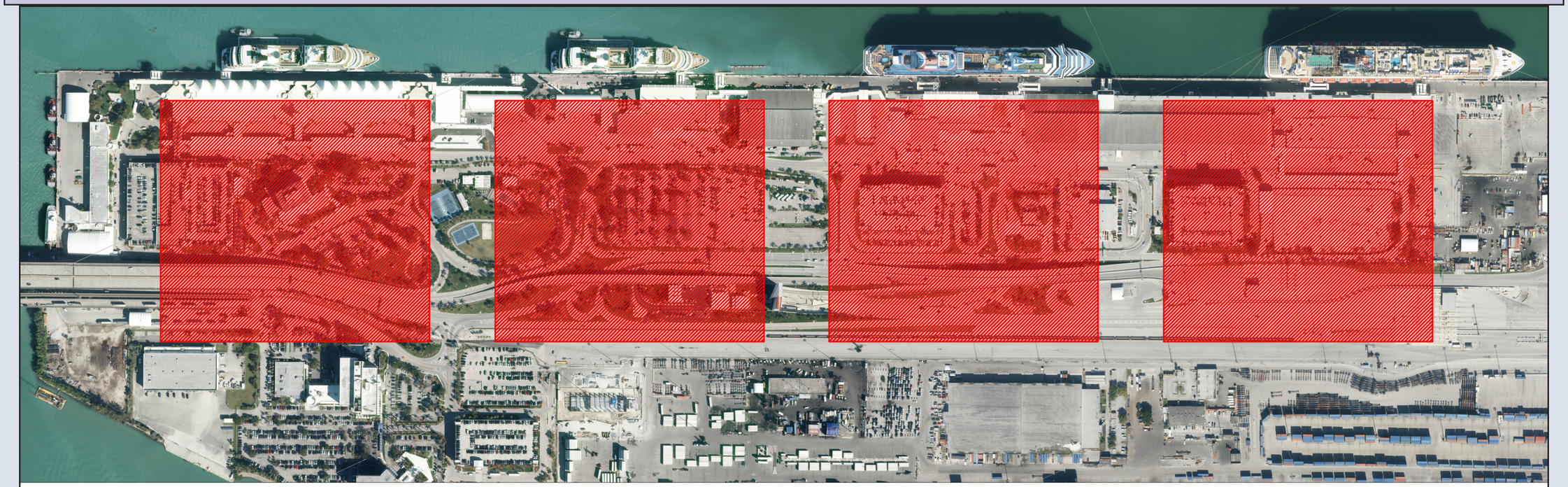
Environmental Effects:
None

Health Effects:
Birth defects; Nausea and dizziness; Shortness of breath



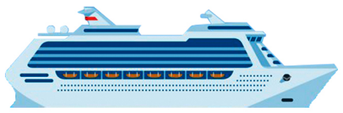
Impact at Port of Miami

A cruise ship at port creates as much pollution as 12,400 cars, per ship, per day. This diagram shows that four cruise ships are the equivalent of 49,600 cars idling at the Port of Miami.



0 1/4 mile 1/2 mile 1 mile

1 Cruise Ship = 12,400 Cars



6 ft

15 ft  = 90 sqft.

12,400 Cars
x 90 sq. ft.
= 1,116,000 sqft.

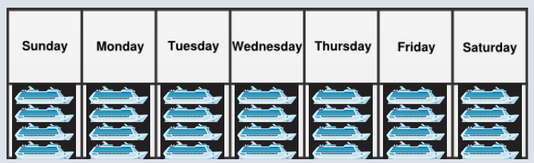
= 1,116,000 sqft.
or 12,400 cars

Impact at Port of Miami

Port of Miami Data

A cruise ship idles for an about 10 hours each visit.

About 4 ships visit every day.



Refrence Port

The Port of San Francisco estimates that the reductions in emissions for a 10-hour ship call are approximately:

- **140 pounds of diesel particulate matter (PM)**
- **1.3 tons of nitrogen oxides (NOx)**
- **0.87 tons of sulfur oxides (SOx)**
- **19.7 tons of carbon dioxide (CO2)**

Possible Daily Reduction

With shore power, The Port of Miami could see a daily reduction in emissions of approximately:

- **560 pounds of diesel particulate matter (PM)**
- **5.2 tons of nitrogen oxides (NOx)**
- **3.48 tons of sulfur oxides (SOx)**
- **78.8 tons of carbon dioxide (CO2)**

In 2019, cruise ships idled for about 11,800 hours at Port of Miami.

There are only 8,760 hours in a year.

11,800 hours
/ 8,760 hours
= 1.35 years of idleing.

1.35 years
x 365 days
= 492.75 days of idleing

493 * possible daily reduction
= possible yearly reduction

Possible Yearly Reduction

- **276,674 pounds of diesel particulate matter (PM)**
- **2,568.8 tons of nitrogen oxides (NOx)**
- **1,717.12 tons of sulfur oxides (SOx)**
- **38,927.2 tons of carbon dioxide (CO2)**

Data sourced from the “2019 Port of Miami Cruise Schedule” for top 12 cruise lines

Impact at Port of Miami

[21]

The Port of Miami accepts more cruise passengers and ships than any other port in the world.

Wouldn't that mean Miami receives the most air pollution as well?

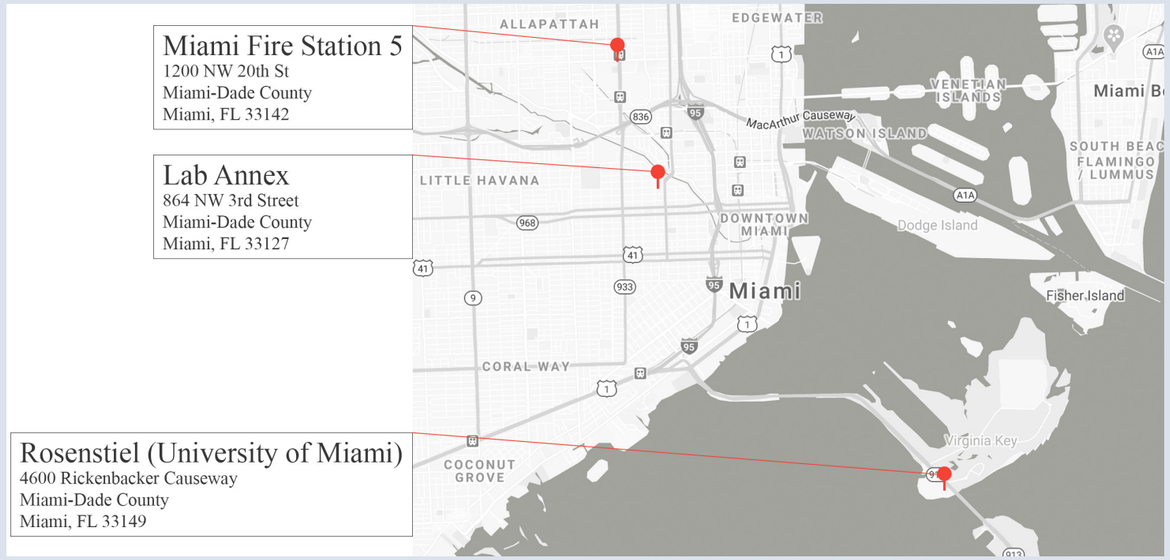
Air Monitering

Miami Dade Department of Regulatory and Economic Resources separate from the Environmental Protection Agency (EPA)

Miami Dade Department of Regulatory and

Economic Resources is responsible for ALL air monitoring in South Florida. These three stations collect data by monitoring the “ambient air”.

Air Monitoring Stations

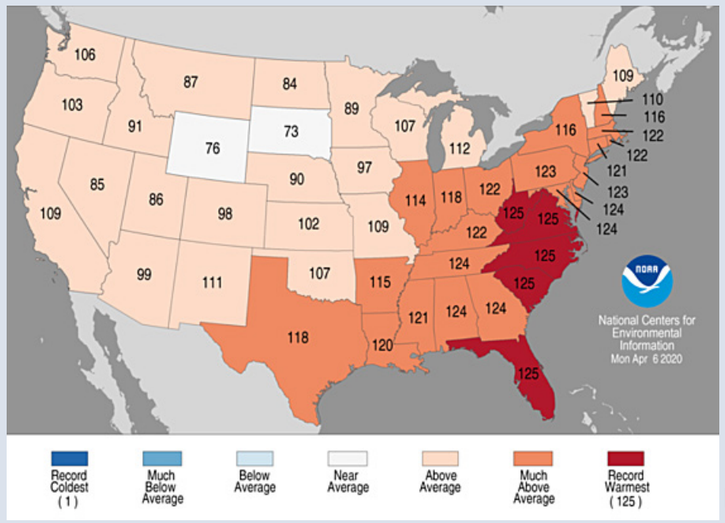


[23]

Temperature, cloudiness, humidity, frequency & intensity of precipitation, and wind patterns all affect air quality monitoring.

Are these stations close enough to the Port of Miami to accurately collect data on pollution generated by cruise ships?

Statewide Average Temperature Ranks



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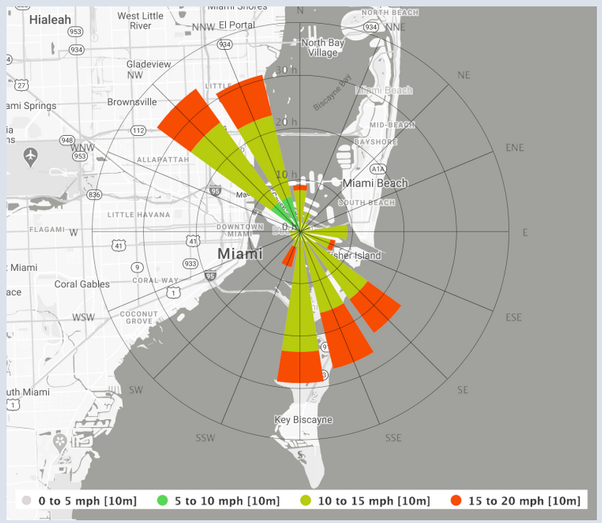
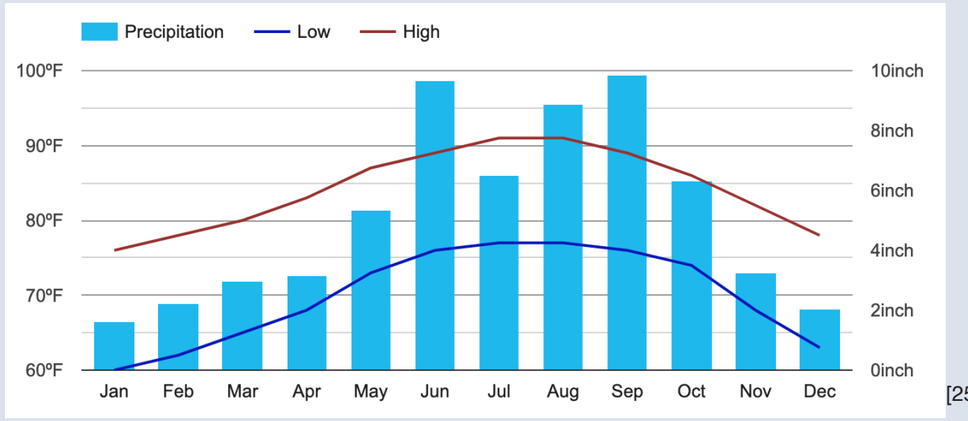
Wind Direction Map



[24]

Average Precipitation Graph



[25]

Affected Neighborhoods

The neighborhoods most affected by cruise pollution are Palm Island, Hibiscus Island, Star Island, Fisher Island, and the Venetian Island group. Ports are usually bordered by low income, industrial neighborhoods. These islands, in contrast to the norm, are some of the wealthiest areas in Miami.

Are these wealthy areas aware of the pollution being emitted so close to their homes?

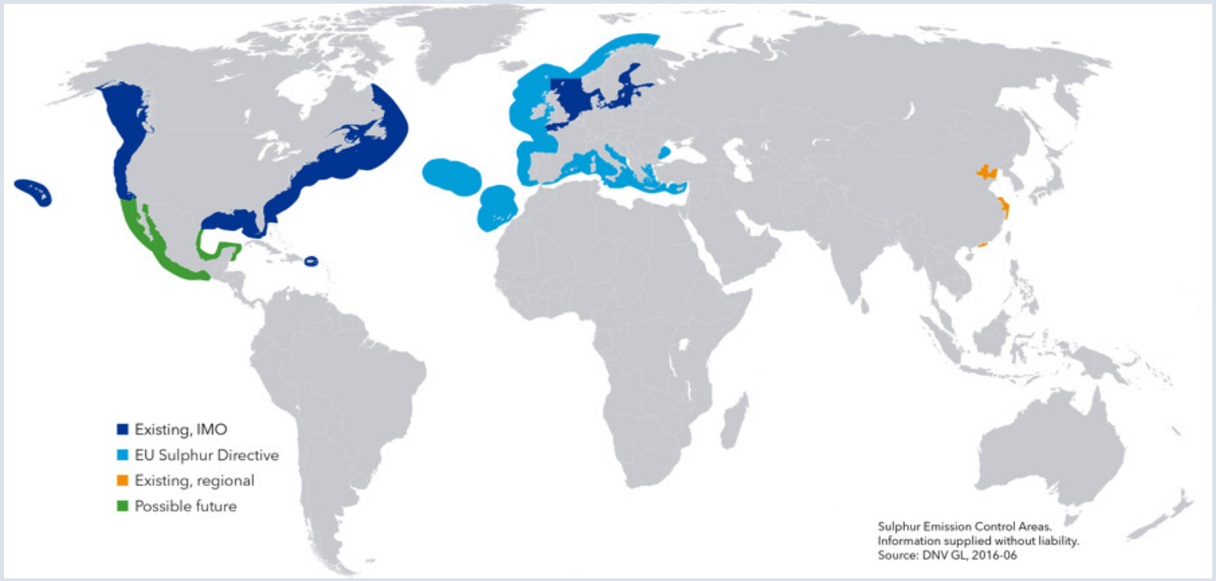
[43]

International Laws and Regulations

MARPOL Annex VI

Developed through the International Maritime Organization, MARPOL (Maritime Pollution) is the International Convention for the Prevention of Pollution from Ships. Annex VI of the MARPOL treaty, implemented in 1901-1905, is the leading international treaty addressing air pollution prevention requirements for ships.

Emission Control Areas



[30]

Annex VI establishes:

- Limits on NOx emissions from marine diesel engines with a power output of more than 130 kW. The standards apply to both main propulsion and auxiliary engines and require the engines to be operated in conformance with the Annex VI NOx emission limits.
- Limits on the sulfur content of marine fuels.
- Ships operating up to 200 nautical miles off of U.S. shores must meet the most advanced standards for NOx emissions and use fuel with lower sulfur content. This geographic area is designated under Annex VI as the ECA.

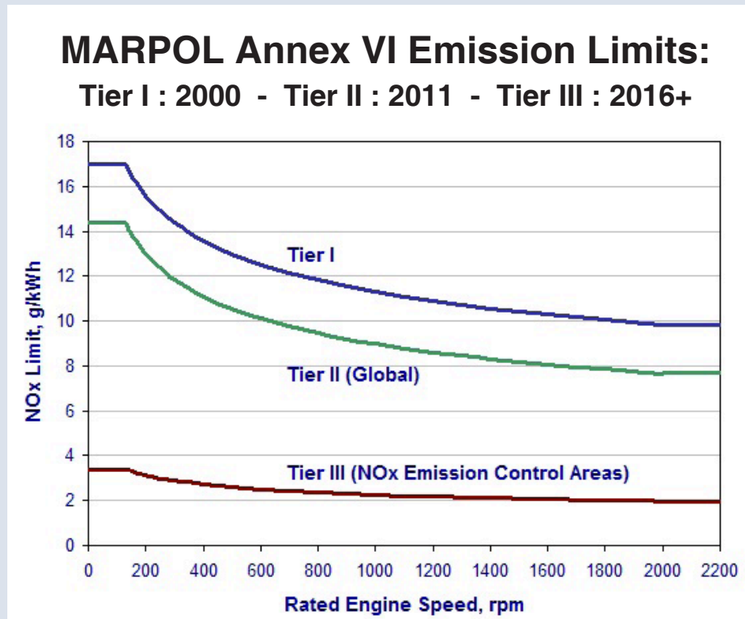
International Laws and Regulations

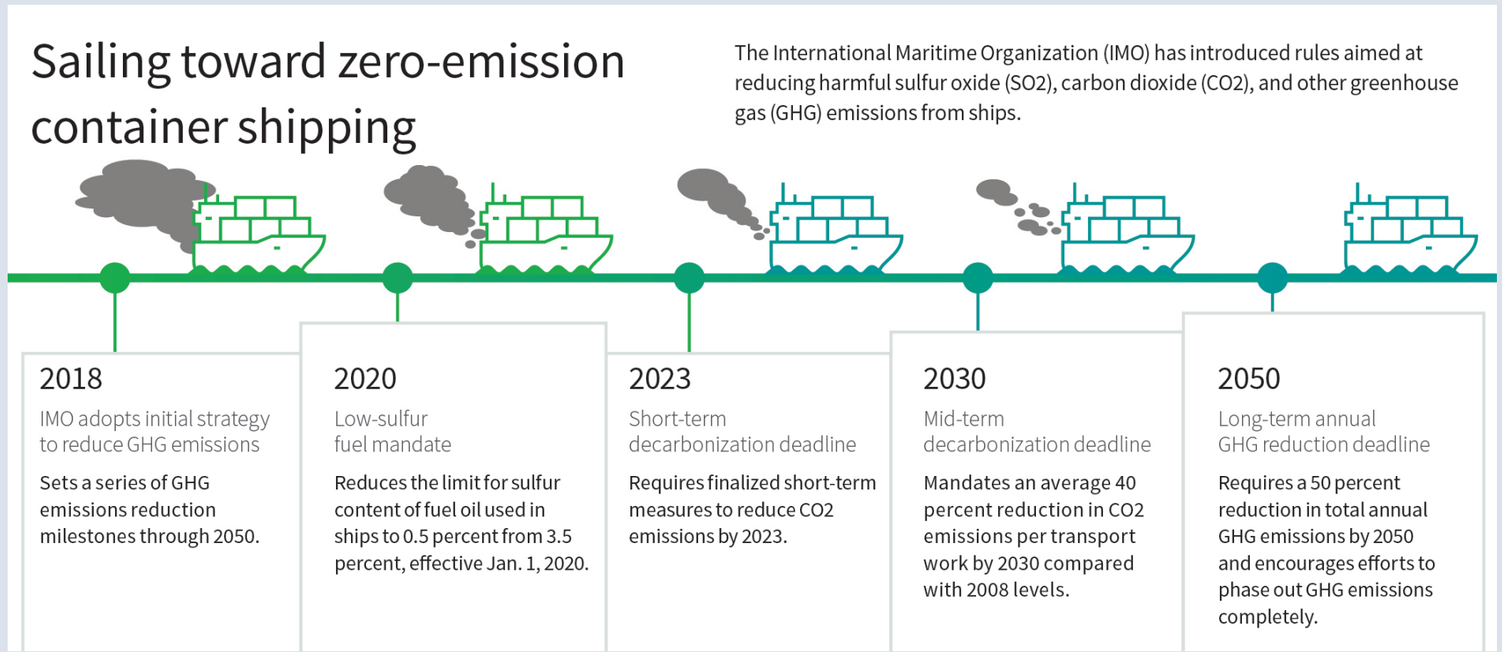
These graphs show the MARPOL limits and goals established by the IMO: On the top right is a chart comparing Annex 6 regulations to the EU Maritime fuel sulphur directive; On the bottom left is a graph displaying the NOx reduction regulations over the past two decades; On the bottom right is a time line that displays the future goals in reducing ship pollution.

Year	IMO MARPOL Annex 6		EU EU maritime fuel sulphur directive (2005/33/EC)	
	Average NO_x limit in fuel (g/kWh)	SO_2 limit in fuel (% m/m)		
	High sea and berth		SECA	Berth (1)
2009	11.8	4.5%	1.5%	1.5%
2010				
2010, July			1.0%	0.1%
2011	9.6			
2012		3.5%		
2015			0.1%	
2016				
2020		0.5%		
2021	2.3			

[28] & [29]

[28]





California Laws and Regulations

The California Air Resources Board (CARB) adopted a regulation in Dec. 2007 to reduce emissions from auxiliary engines on ships while at-berth for container, cruise and reefer vessels. The regulation requires that auxiliary diesel engines are shut down for specified percentages of fleet visits. As an alternative, vessel operators may employ any combination of technologies to achieve equivalent reductions.

The Port of Los Angeles adopted an international clean air program that pays a monetary reward to ocean carriers for bringing their newest, most efficient and lowest emission vessels to port. The port was the first seaport in North America and the Pacific Rim to agree to such a program, based on the Environmental Ship Index, a web-based tool developed by the World Ports Climate Initiative.

- Ships equipped with shore connection systems have been required to use them since January 1, 2010.
- The requirement is that, as of January 1, 2014, 50 percent of a fleet's vessel calls must plug into shore power.
- The requirements increase to 70 percent in 2017 and 80 percent in 2020.
- Fleets that fail to meet requirements will be penalized by the CARB.

The Port of Los Angeles reported that its cumulative emissions have dropped as much as 76 %, while container volumes increased 6 %, between 2005 and 2011. On a year-to-year basis, the port's 2011 Inventory of Air Emissions shows a decrease up to 7 percent of emissions.

CALIFORNIA AIR RESOURCES BOARD

[31]

California ports with shore power:

- San Francisco
- Long Beach
- Los Angeles
- San Diego

Europe Laws and Regulations

- Proposed environmental regulations, such as Directive 2005/33/EC, which restricts the sulphur content of marine fuel used by ships docked for more than two hours to no more than 0.1%.
- Adopted a Directive of Deployment of Alternative Fuels Infrastructures (DAFI) that establishes the implementation of Shore Connection in all ports by 2025 and makes the standard IEC/IEEE 80005 Mandatory.
- Reduced taxes in electricity to vessels at berth as stated by the Directive 2003/96/EC.
- Implemented subsidised programs such as Marco Polo and Trans European Network Transport (TENT T) to co-finance shore connection projects.

All ports in the European Union are required to have Shore Power technology by 2025.

In addition to the regulatory approach, the Commission has also identified the promotion of shore side electricity as a priority for transport investment. It is highlighted in the TEN-T Guidelines and the Commission has been supporting this through the Connecting Europe Facility since 2014. Moreover, alternative fuel infrastructure, such as on-shore power supply, is eligible under the General Block Exemption Regulation and can thus be funded with public support.

To further incentivise the deployment and use of cold ironing, Member States can also ask an authorisation to apply a reduced rate of taxation on electricity directly provided to vessels at berth in a port in accordance with Article 19 of the directive of the Energy Taxation Directive.

China Laws and Regulations

China may be taking the world's strongest stance on shore power requirements. Last year, the country adopted a measure requiring all cruise ships to use shore power by 2021. Cruise ships visiting China now must plug in if they have the ability to do so.

China has taken another important step to combat shipping pollution. On December 10th, the Ministry of Transport released a new regulation designating a coastal domestic emission control area (DECA) that extends 12 nautical miles off China's coastline

When the new regulations come into effect on January 1, 2019, all ships operating inside the coastal DECA must burn fuel with a sulfur content not exceeding 0.5 percent (0.5% sulfur fuel) at all times. Oceangoing ships that ply the inland river DECAs must use fuel with a sulfur content not exceeding 0.1 percent (0.1% sulfur fuel) on January 1, 2020. Beginning on January 1, 2022, a 0.1% sulfur cap will be applied to all ships operating inside Hainan waters.

Besides capping the sulfur content of fuel in the DECAs, the new regulations also start phasing in emission standards for nitrogen oxides (NOx) applicable to all China-flagged new-build or rebuilt ships, as well as requirements on the installation and use of onshore power.

In addition, China has been encouraging the use of shore power at ports. The government provides funding to subsidize the building of shore power infrastructure. By 2020, 493 berths across the country are expected to be equipped with onshore power equipment.

[29]

All cruise ships must plug into shore-side electric power beginning on January 1, 2021, if they dock at berths that are shore power capable. Similarly, shore power capable ships must be connected to shore-side electricity if they dock at shore-power equipped berths starting from July 1, 2019.

Cruise Tax Haven & Green Effort

International law requires every ship to register with a country and fly its insignia in open waters. A ship is only subject to the laws of the country it is registered in.

Under an obscure, 99-year-old section of the US tax code, cruise companies are able to register their ships with countries that have more lenient laws than the US — an act called flying a “flag of convenience” — and avoid paying into the US tax system.

“Cruise lines want to register somewhere where they pay no taxes, are exempt from labor and wage statues, and don’t have to follow health and safety codes,” says Jim Walker, a Miami-based maritime lawyer.

According to annual report filings, the major cruise lines pay an average tax rate of 0.8% — for below the 21% US corporate tax rate.

If cruise lines do not get taxed on the billions of dollars generated, should they be forced to retrofit their ships and finance it privately?

“Friends of the Earth” is the world’s largest federation of environmental groups with a presence in more than 75 countries.

Friends of the Earth

Criminal Violations: All Carnival Corporation companies committed criminal environmental violations in 2017 & 2018.

Sewage Treatment: Whether a cruise line has installed the most advanced sewage and wastewater treatment systems available instead of dumping minimally treated sewage directly into the water.

Air Pollution Reduction: Whether a cruise line has retrofitted its ships to “plug in” to available shoreside electrical grids instead of running polluting engines when docked.

Water Quality Compliance: To what degree cruise ships violated 2010-2018 water pollution standards designed to better protect the Alaskan coast.

Transparency: Did the cruise lines respond to our requests for information regarding their environmental practices.

CRUISE LINE	Sewage treatment	Air pollution reduction	Water quality compliance	Transparency	Criminal Violations	2019 FINAL GRADE
Disney	A	D+	A	A		A-
Princess	B	C	A-	F	✓	~~F~~
Norwegian	A	D-	A	F		C-
Holland America	B+	D-	A	F	✓	~~F~~
Seabourn	A	F	B+	F	✓	~~F~~
Celebrity	A	D-	N/A	F		D+
Cunard	A	F	N/A	F	✓	~~F~~
Regent Seven Seas	C-	F	A	F		D
Royal Caribbean	A	F	N/A	F		D
Carnival Cruise Line	F	D	A	F	✓	~~F~~
Silversea	D	F	A	F		D
Oceania	C-	F	C+	F		D-
MSC Cruises	C-	F	N/A	F		F
P&O Cruises	D-	F	N/A	F	✓	F
Costa	F	F	N/A	F	✓	F
Crystal	F	F	N/A	F		F

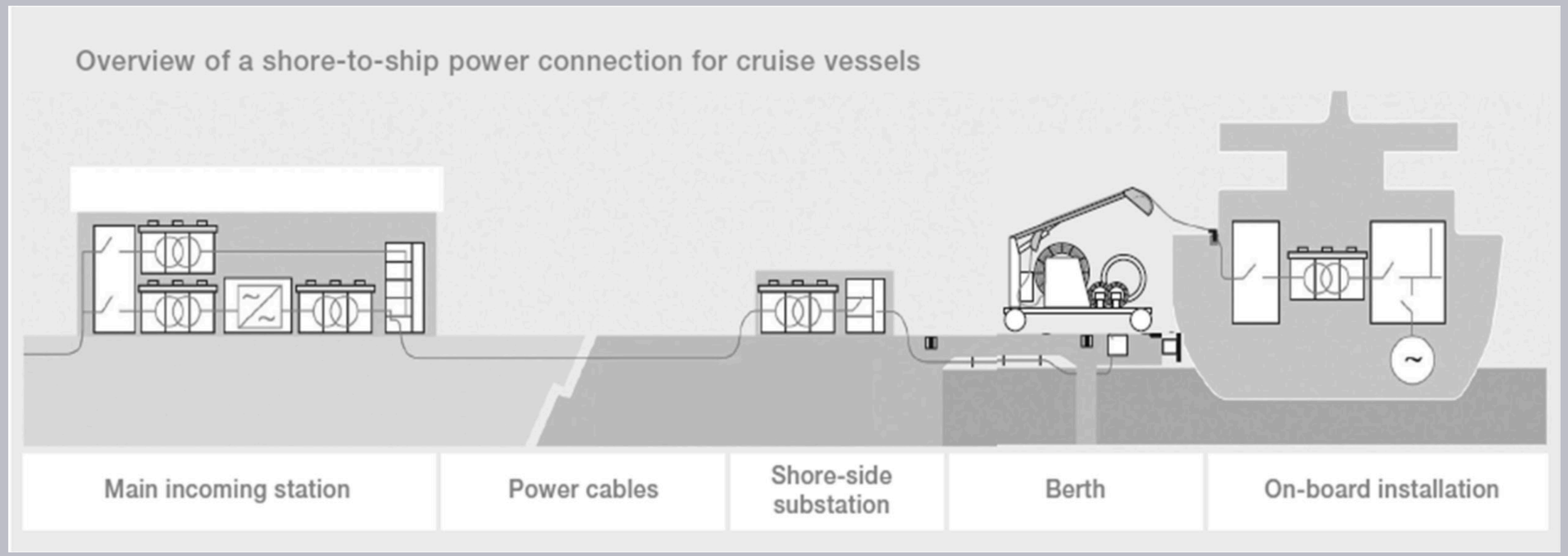
Royal Caribbean International - Carnival Corporation - Norwegian Cruise Line Holdings -

[32]

Every cruise company scored a grade of D or F in” Air Pollution Reduction,” making it the lowest scoring group.

With no intervention, cruise companies will continue to cause significant air pollution without consequence.

Shore Power



[34]

A somewhat new technology, shore power is making headlines around the world. Shore power systems help reduce and virtually eliminate all air pollution generated by cruise ships idling at port. Improving air quality, while at the same time generating incremental revenue for local communities, shore power is the next big idea for port cities.

What is Shore Power?

"Shore power" is a technology that creates a connection between a ship and the port's shoreside electricity grid, allowing a ship to turn off its idling, polluting engine.

Also known as:
- Shore-to-Ship Power
- Cold ironing
- Onshore power supply (OPS)
- Alternative Maritime Power (AMP)

- Power is transmitted from an onshore substation equipped with a dual voltage transformer that will supply power to ships.
- Internal shore side monitoring and protection is achieved with protection relays to insure safety and protection of both ships and shore electrical systems.
- Flexibility to connect either 11kV or 6.6kV ships is achieved by two independent secondary breakers with Kirk-Key interlocks.
- Power is carried to the ship through five flexible "Ship Cables" routed through a grounding switch.
- This grounding switch works in conjunction with the ships automation system to ensure safety and reliability during the cable handling from shore to ship.

[34]

Benefits of Shore Power

- No more burning of extra-dirty bunker fuel, creating carcinogenic emissions right next to dense residential populations
- Huge reduction or elimination of:
  - Dangerous SOx, NOx and particulates
  - Greenhouse gasses, including CO2
  - Soot or “black carbon”
- Health burden lifted from vulnerable residents, especially kids with asthma, the elderly, low-income and minority communities near ports
- Reduction of cancer, lung disease, heart disease, premature death, etc.
- Cruise and container operators contribute to local economy by purchasing electricity from local, domestic suppliers, rather than dirty fuel from multinational oil companies
- Reduction of noise and vibration on board ship (relief for ship workers)
- Investment in the industry will be more attractive as cruise ship visits increase in number, but the pollution does not increase.

Reported Reduction:

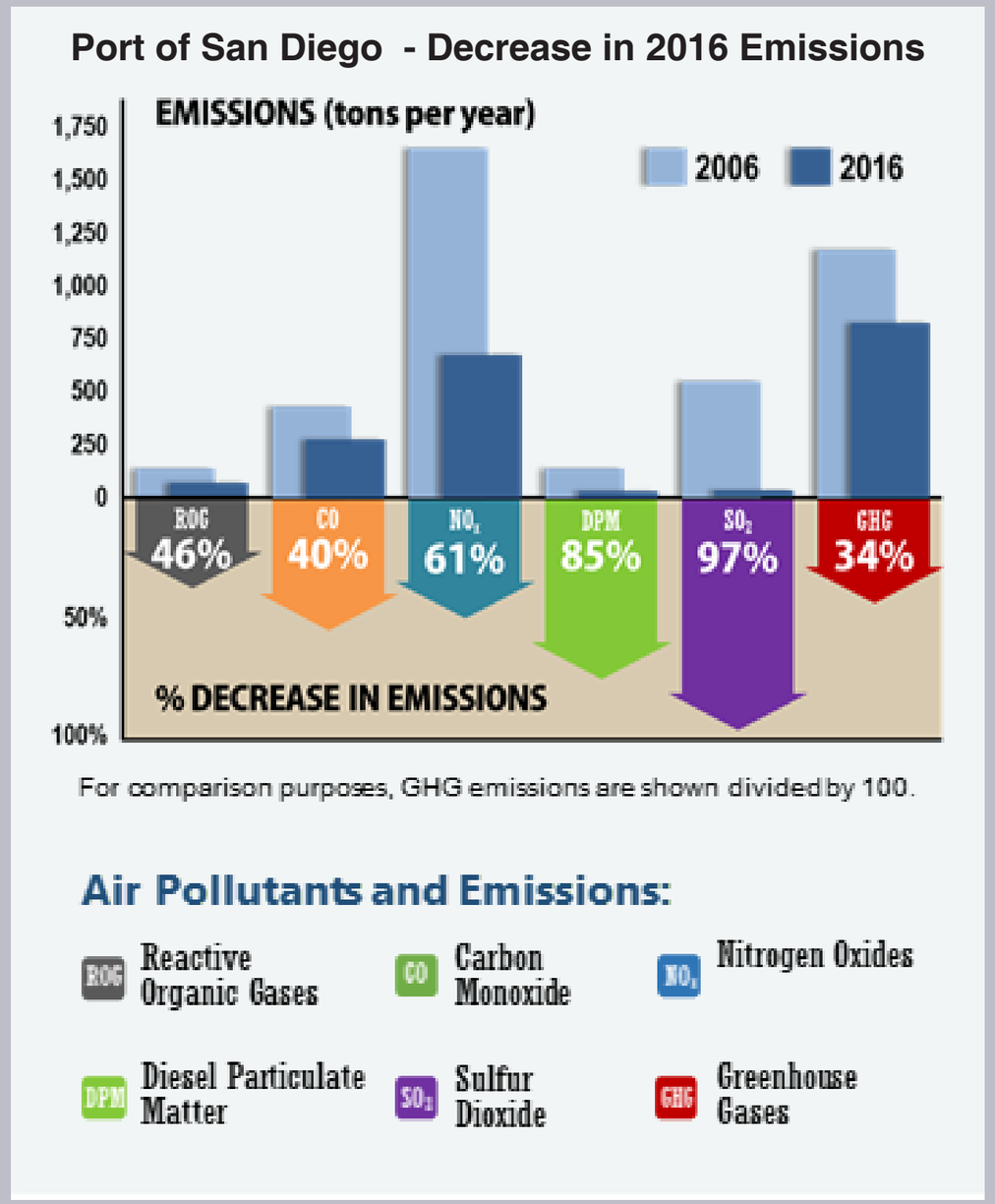
The Port of San Francisco estimates that the reductions in emissions for a 10-hour ship call are approximately:

- **140 pounds of diesel particulate matter (PM)**
- **1.3 tons of nitrogen oxides (NOx)**
- **0.87 tons of sulfur oxides (SOx)**
- **19.7 tons of carbon dioxide (CO2)**

The New York City Economic Development Corporation, the company that operates the Brooklyn terminal, estimates a yearly reduction of approximately:

- **6.5 tons of of diesel particulate matter (PM)**
- **95 tons of nitrogen oxide (NOx)**
- **1,500 tons of carbon dioxide**

Benefits of Shore Power



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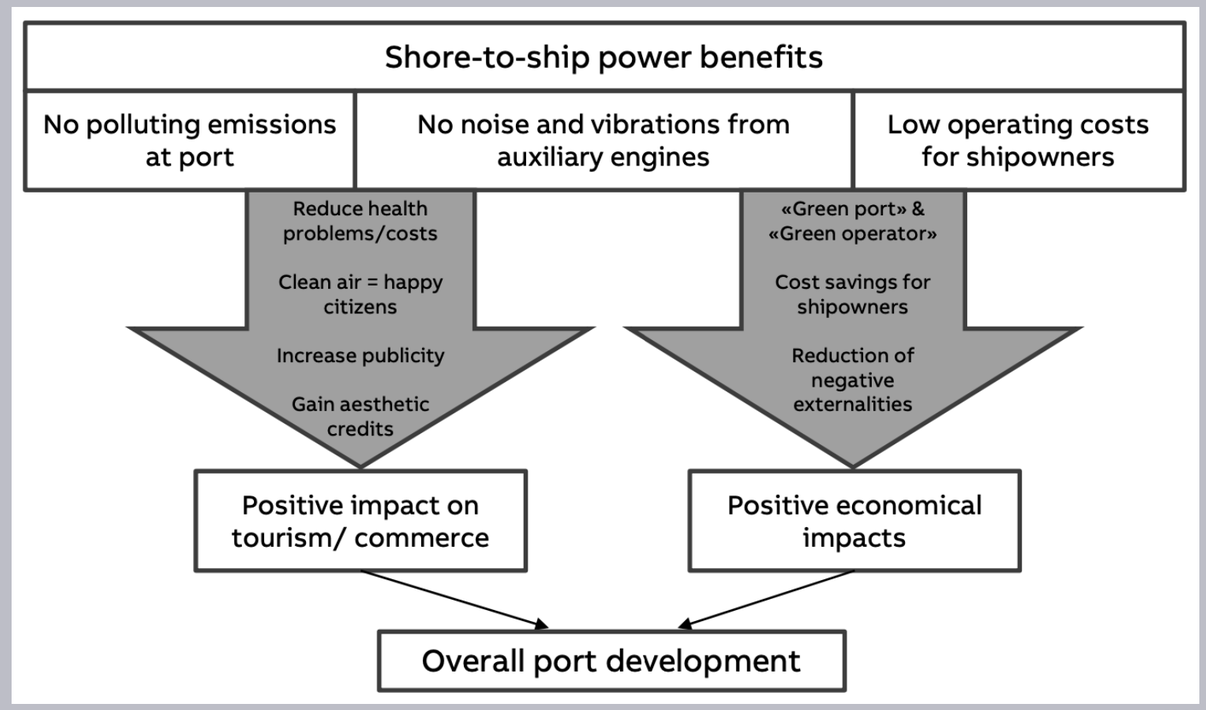

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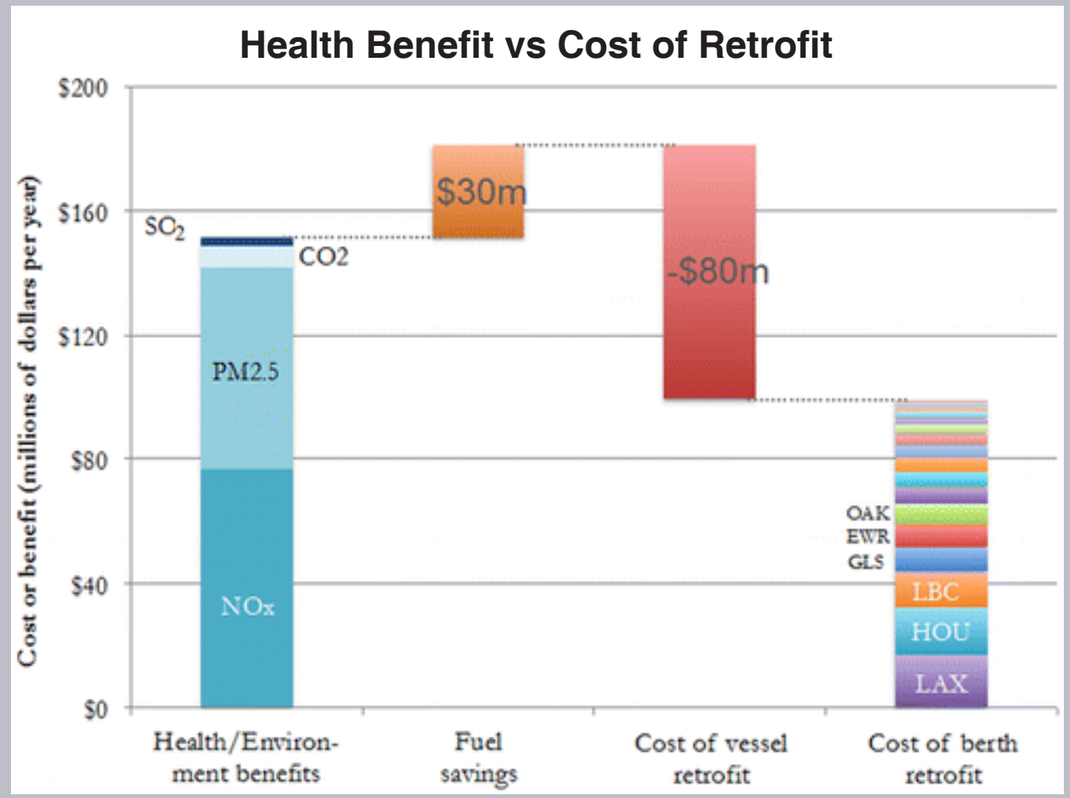


[42]

Shore Power

Steps for Shore Power:

1. Electrical Design
2. Procurement
3. Installation
4. Commissioning & Testing

Shore power eliminates almost all at-berth emissions. Plugging in a Cruise Ship for one day is the equivalent of taking more than 12,000 cars off of the roads.

Criteria for a Successful Shore Power Project:

- Availability of an adequate supply of electricity at a reasonable cost.
- Frequency of calls by cruise vessels equipped to connect to Shore Power.
- Availability of the same dock and pier facility for these vessels for every call.
- Adequate dock and uplands space for equipment.
- Willing partners including – utility, port and government agencies.

Most Important:

- Sufficient energy to be able to supply electricity to berths.

- Sufficient funding to be able to finance shore power projects.

$ Cost & Financing Options

Unless regulation is in place, ports are waiting for shipping & cruise companies to implement shore power, while ships are waiting on port infrastructure to be in place before adopting and using the new technology.

USA Shore Power Costs

Juneau, Alaska
$25.8 million for 2 berths

Seattle, Washington
$23 million for 3 berths

Brooklyn, New York
$21 million for 1 berth

San Francisco, California
$5.2 million for 1 berth

Long Beach, California &
Los Angeles, California
$185+ million for 16 berths

San Diego, California
$7.1 million for 1 berth

Financing Options

1. State/Port/Municipality
   Project is funded completely by capital from the State, the port, and the municipality,

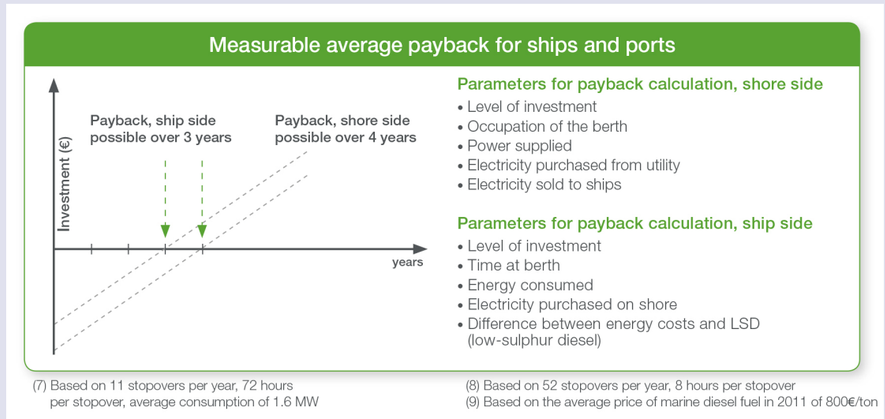
2. Port/Municipality & Loan
   Project is funded partially by the municipality & port, but a portion of investment is borrowed.

3. Passenger Tax
   The port can cancollecting the funds from cruise passengers arriving and leaving.

4. Electricity Tax
   The port and/or power company can collect a shore power charge from the ships based on their consumption of electricity. The costs to the port and the power company are covered by the profits from sales of electricity minus operating costs to run the plant.
   Best Option

Some ports have started to see a return on their investment in as soon as three years.

Payback time period is largely dependent on the price of fuel and electricity in the area.



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Shore Power Process & Components

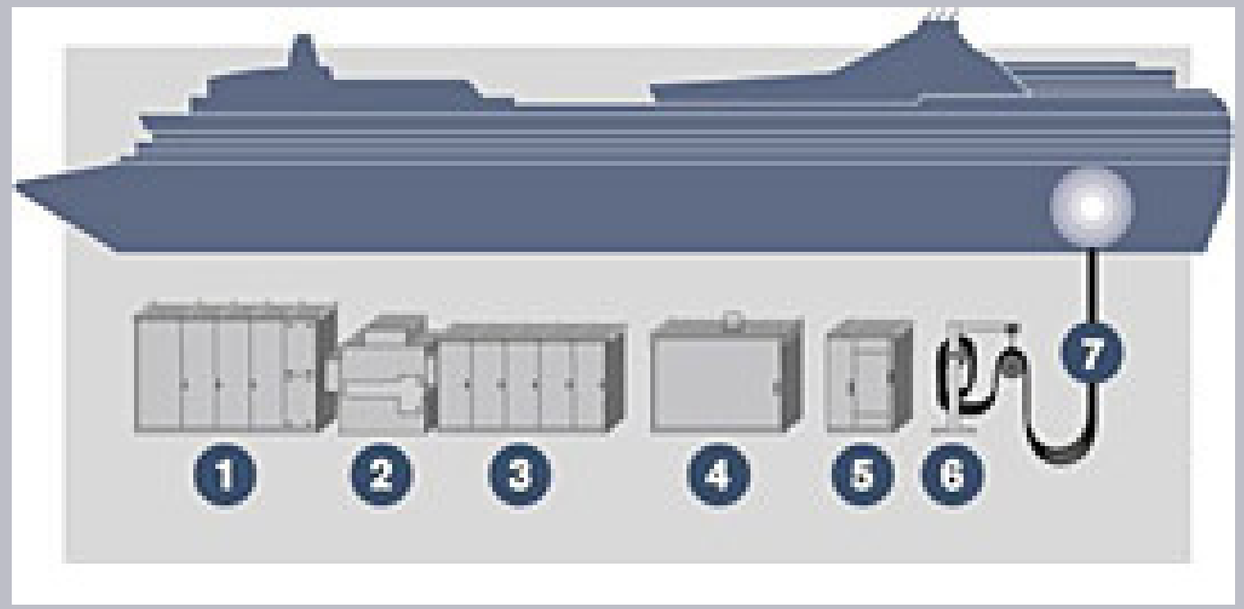
Design Process

1. Meet with the utility company to determine the source of power.
2. Field survey & agree on location of equipment.
3. Perform load calculations & place equipment on drawings.
4. Design is generated & forwarded to local jurisdiction for approval.

Nearly **28%** of the world's cruise ships are fitted with the technology to plug in to the electric grid, according to CLIA, and **30% of new ships** are being built with the technology.

System Components

1. Primary Metering Equipment
2. Transformer
3. Secondary Metering Equipment
4. Capacitor
5. Grounding Switch
6. Shore Power Cable Management Winch
7. Power Cables



[39]

Applicable Standards

International Electrotechnical Commission

International Organization for Standardization

IEEE Advancing Technology for Humanity

The universal, international standard defining shore connection systems:

Standard IEC/ISO/IEEE 80005-1 High-voltage Shore Connection (HVSC)

[39]

Main Standard :

IEC / ISO / IEEE 80005-1, High Voltage Shore Connection (HVSC)

IEC / ISO / IEEE 80005-2, Communication protocol between shore and Ship

IEC / ISO / IEEE 80005-3, Low Voltage Shore Connection (LVSC)

Plugs & Sockets Outlets :

IEC 62 613, Plugs & Socket Outlets

Voltage & frequency ratings (typical)

- Medium voltage : 6.6 / 11 kV, (+ 6% / - 3.5%)
- Low voltage: 400/440V/690 V, (+6%/-5%)
- Frequency: 50 / 60 Hz Power ratings
- Medium voltage : up to 20 MVA per vessel
- Low voltage : typical < 1MVA

Installation of Shore Power on Land

1. Excavation

2. Conduit Installation

3. Transformer Pad Installation

4. Equipment Installation

Transformer, Main & Secondary Metering Equipment

Grounding Switch

Cable Winch

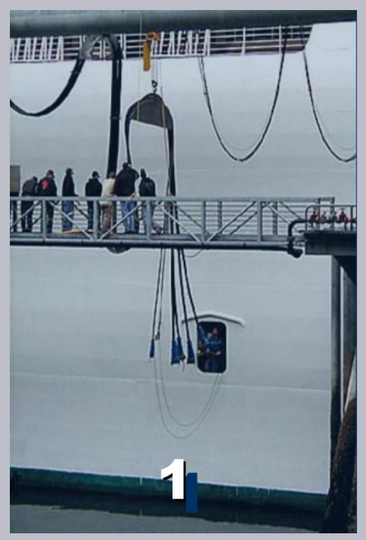
5. Cable Installation

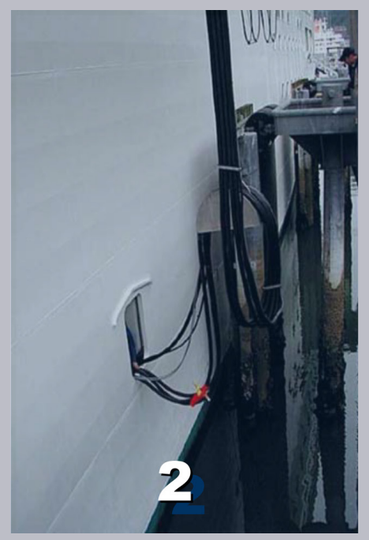
[39] [40] [41] [42]

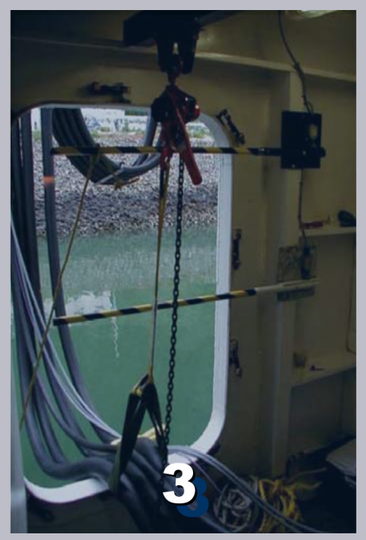
Installation of Shore Power on Ship

Retrofit Onboard Ship

Length of time needed to connect the electrical cables, parallel the ship's diesel generator to the shore power, synchronize, transfer the electrical load and then shut down the ship's diesel generator:
Approximately 40 minutes







[39] [40] [41] [42]

Ship-to-Shore Power in North America

Seven ports require cruise ships to use shore power in North America:

- Juneau, Alaska
- Seattle, Washington
- Brooklyn, New York
- San Francisco, California
- Long Beach, California
- Los Angeles, California
- San Diego, California

International ports:
(not shown)

- Hamburg, Germany
- Shanghai, China
- Hailfax, Canada
- Montreal, Canada

[43]

PRINCESS CRUISES Leading the Way

"Princess Cruises pioneered the use of shore power in the cruise industry in 2001 when Juneau, Alaska became the first city to create a shoreside power connection. This technology allows cruise ships to turn off their diesel engines and literally "plug in" to a power supply in port.

Princess has outfitted 14 of its ships with a custom-built electrical connection cabinet that automatically connects the ship's electrical network to the local electrical network ashore. The electrical power is transmitted from the transformer ashore to the vessel via 3 ½-inch diameter flexible electrical cables on the dock. (In Juneau, the cables hang festooning-style on a special gantry system designed to accommodate the 20-foot rise and fall of the tide and withstand the 100 mph Juneau winds during the winter.) The actual cable connection on the vessel is a traditional, though quite large, plug and socket.

Princess Ships Equipped:

Coral Princess
Crown Princess
Dawn Princess
Diamond Princess
Golden Princess
Grand Princess
Island Princess
Royal Princess
Regal Princess
Ruby Princess
Sapphire Princess
Sea Princess
Star Princess
Sun Princess

Since 2001, Princess has invested more than $7 million in equipment alone to enable its vessels to connect to shore power.

Shore Power - Alaska, USA

Port of Juneau, Alaska

Statistics:
Design: AEL&P, PN&D, ABB
Terminal 1 completed: 2001
Terminal 2 & 3 completed: 2017
Connection Duration:
~100,000 kilowatts/day
Total Power Used:
11 - 12 GWH Annually

Festooning System:
This shore power system is supported by a 36'x66' floating dock structure that can be accessed from a 50-ft long aluminum gangway, mounted on the south approach dock. This Festooning System allows for cable adjustment during tidal fluctuations

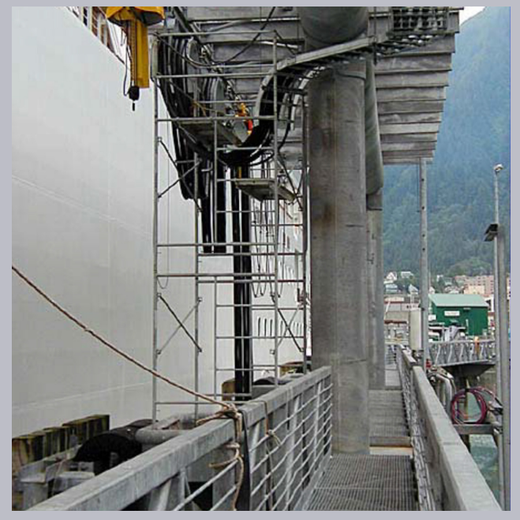
Pros & Cost: First High Voltage Shore Power Connection for Cruise Ships in the world

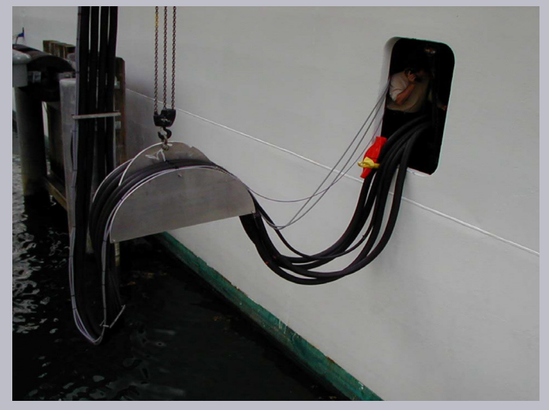
$12.9 million for South Berth
$12.9 million for North Berth.

Princess' shore power program made history in 2001 when it first began operations in Alaska. This ground-breaking technology has now grown to include systems all over the West Coast

Cons: Festooning System is an eyesore

[39] [40] [41] [42]





Shore Power - Washington & Canada

Port of Seattle, Washington

Statistics:
Design: Cochran Marine
Terminal 30 completed: 2005
Terminal 91 completed: 2009
Annual Connections:
2005-16: 757
2016: 75
Connection Duration:
2005-16: 5,084 hours
2016: 546 hours
Total Power Used:
2005-16: 36,424,368 KWH
2016: 3,575,680 KWH

Pros & Cost: First in continental United States, contracted by Princess Cruise Lines

$7M for 2 berths at T91
$16M for Pier 66 (extensive off-site improvements)

Electricity in Seattle is largely hydro-based (low-carbon and comparably cheap)

Cons: Fixed cable management system

[39] [40] [41] [42]

Port of Halifax, Nova Scotia

Statistics:
Design: Cochran Marine
Date Completed: 2014
Annual Connections:
2014-16: 54
2016: 31
Connection Duration:
2014-16: 275 hours
2016: 188 hours
Total Power Used:
2014-16: 1,498,768 KWH
2016: 1,011,957 KWH

Pros & Cost: Shore power for Cruise Ships at 3 terminals

Transport Canada - $5 million
Province of Nova Scotia & Port of Halifax - $2.5 million each.
Total $10 Million

This System is equipped with the same automation and cable positioning devices used at other Cochran Marine installations.

Cons: Fixed cable management system

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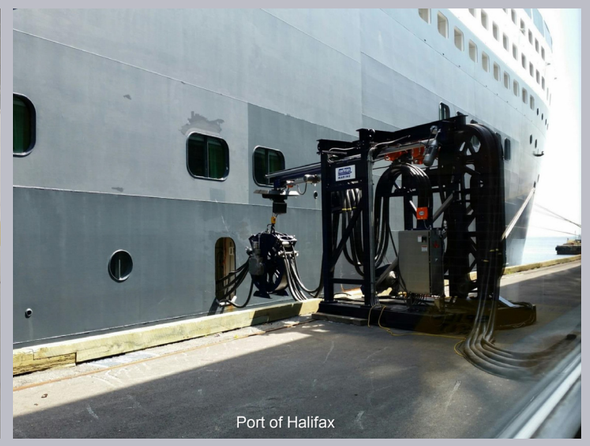


Shore Power - California, USA

Port of San Francisco, California

Statistics:
Design: Cochran Marine
Date Completed: 2011
Annual Connections:
2011-16: 88
2016: 33
Connection Duration:
2011-16: 728 hours
2016: 306 hours
Total Power Used:
2011-16: 6,310,237 KWH
2016: 2,769,081 KWH

Pros & Cost: First port in California to provide shoreside electrical power for cruise ships

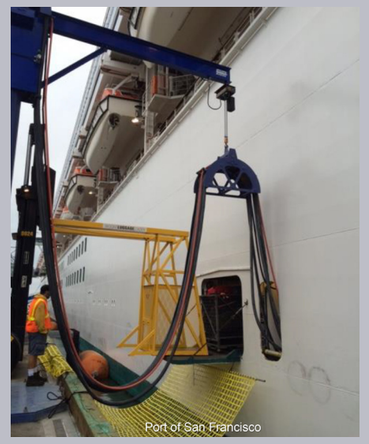
$5.2 million to facilitate shore power system

This dual voltage system can accommodate two cruise ships at separate berthing locations

Cons: Fixed cable management system

[39] [40] [41] [42]

Port of San Francisco


Port of San Francisco

Port of San Diego, California

Statistics:
Design: Cochran Marine
Date Completed: 2010
Annual Connections:
2010-16: 172
2016: 36
Connection Duration:
2010-16: 1,210 hours
2016: 256 hours
Total Power Used:
2010-16: 1,896,633 KWH
2016: 8,250,314 KWH

Pros & Cost: Second port in California and fifth port in the world with shore power for cruise ships

$7.1 million funded by the port's Capital Improvement Program

All air pollutants have decreased between 40% and 97% compared to 2006

Cons: Fixed cable management system

[39] [40] [41] [42]

Port of San Diego


Port of San Diego

Shore Power - California, USA

Port of Long Beach, California

Statistics:
Design: Cochran Marine & Schneider Electric
Date Completed: 2011
Annual Connections:
2011-16: 900
2016: 217
Connection Duration:
2011-16: 7,924 hours
2016: 2,296 hours
Total Power Used:
2011-16: 37,836,785 KWH
2016: 10,714,158 KWH

Pros & Cost: Dual voltage system is the next generation of Cochran: upgraded independent cable monitoring ability.

More than $185 million to facilitate shore power.

Free dockage for ships that hook up to shore power

Cons: Each terminal has its own account and rate structure with the local electricity provider.

Port of Los Angeles, California

Statistics:
Design: Schneider Electric & Cavotec
Date Completed: 2004
Annual Connections 2019: 919
95% reduction of PM, NOx and SOx emissions per vessel call

Adopted International clean air program that pays a monetary reward to ocean carriers for bringing their newest, most efficient and lowest emission vessels to port.

Best Example of Cruise Shore Power in USA.

16 shore power berths (5 Cruise & 11 Cargo)

Pros: This project is similar to the shore power program Princess debuted in Alaska

AMPMobile by Cavotec brings power cables to any point on the ship

Cons:
No cons - US Example Port

[39] [40] [41] [42]

Shore Power - New York, USA

Brooklyn, New York City

Statistics:
Design: Cochran Marine
Date Completed: 2015
Annual Connections 2015-2019:
30 connections out of 96 visits

By the end of 2019, 35 cruise ships will have docked at the Brooklyn terminal; 179 will have docked in Manhattan with no shore power.

Pros & Cost: This project is similar to the Cochran System in Long Beach.

$21 million to facilitate shore power system

Brooklyn is only the second Atlantic coast cruise terminal after Halifax, Nova Scotia, to install shore power.

System will eliminate a calculated 1,500 tons of carbon dioxide, 95 tons of nitrous oxide and 6.5 tons of particulate matter annually, according to the New York City Economic Development Corporation that operates the terminal.

System includes a removable Cable Positioning Device (CPD), so that it can be stowed during winter months when Cruise Ships aren't calling on the port.

The city's Economic Development Corporation, which runs the cruise terminals, said at the time that the Brooklyn plug-in system would save $99 million in health care costs over 15 years.

[39] [40] [41] [42]

New York, USA - Continued

Adam Armstrong is a musician, activist, and local resident of Red Hook Brooklyn. He started his movement in 2006 when a new cruise terminal was going to be built in his neighborhood. Worried about the immanent cruise pollution, Adam began blogging, going to community meetings, and putting pressure on local municipalities to implement shore power.

“A View From The Hook” is the title of Adam’s blog, which he updated weekly writing about all the progress made on shore power. He also did things like write letters to the mayor, put pressure on local representatives, contact the port authority to get all parties involved.

Adam worked with, Mayor Bloomberg, the NY & NJ Port Authority, the USA EPA, the NY Power Authority, Princess Cruises & Cunard Line, and NYCEDC (NYC Economic Development Cooperation) to make this project a success.

Though the shore power system is available, there is no law or regulation requiring cruise ships to use it. Also, the Queen Mary is the only boat that can easily access the shore power because the electrical socket on other ships does not line up with the shore-power crane.

In 2018, cruise ships connected to shore power just 30 of the 96 visits in Red Hook.

If no laws require a shore power connection and a fixed cable management system can not supply most ships, is this implementation actually beneficial?

“The biggest issue is lack of knowledge about the topic. It took me about three years to get everyone on board, and bring shore power to Brooklyn.” – Adam Armstrong

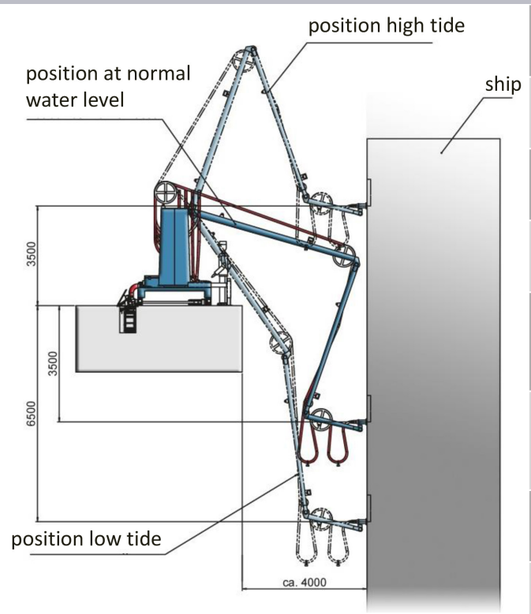
[27] [27] [48] [60] [61]

Shore Power - Hamburg, Germany

SAMPS Cruiser - Cruise Terminal Hamburg Altona

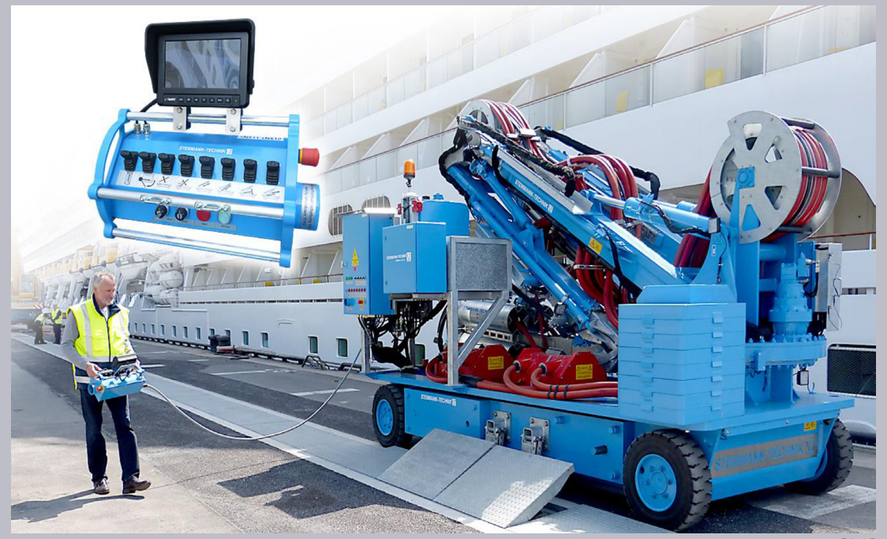
- Vehicle can be driven by only one person
- Safe plug delivery by means of telescopic arm and plug carrier
- Safe from flooding up to 1.3 m above quay edge (IP 67)
- Tidal range compensation up to 9 meters
- 20 MVA at 11 kV or 6.6 kV, 50/60 Hz
- Individually Modifiable to each port situation
- ICE/ISO/IEEE80005-1

Stemmann-Technik
A Wabtec Subsidiary



High tide, height difference hatch/quay: **3.5 m**
Low tide, height difference hatch/quay: **6.5 m**
Travel distance parallel to quay wall: **300 m**
Distance between ship and quay wall: **4 m**
Distance between SAMP-System and quay wall: **approx. 2.5 m**
Distance between hatch and socket: **approx. 3.5 m**
Hatch dimensions (h x w): **1.2 x 0.8 m**
Transmittable voltage: **12 MVA**

“Cable Channel” sections lift and feed power cables to cruiser as it drives.



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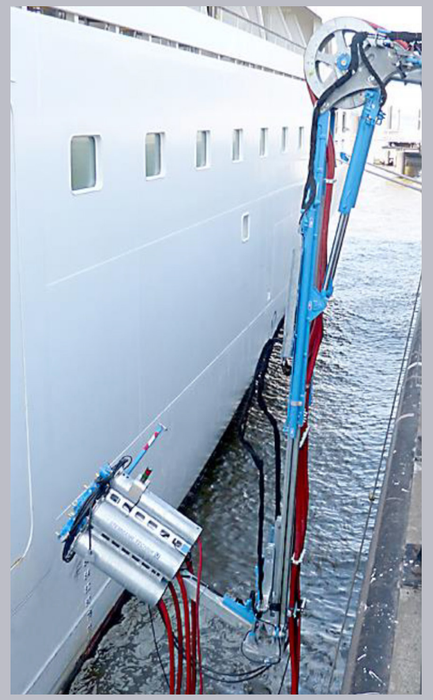
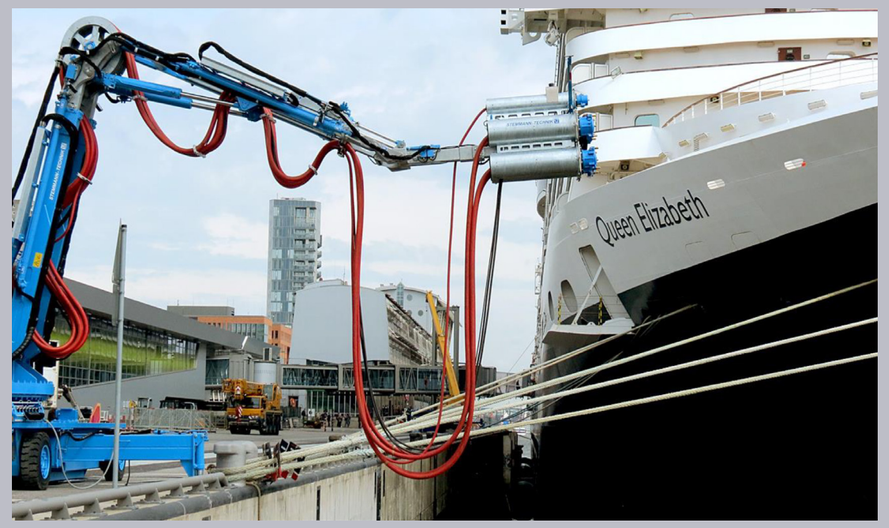
Hamburg, Germany - Continued

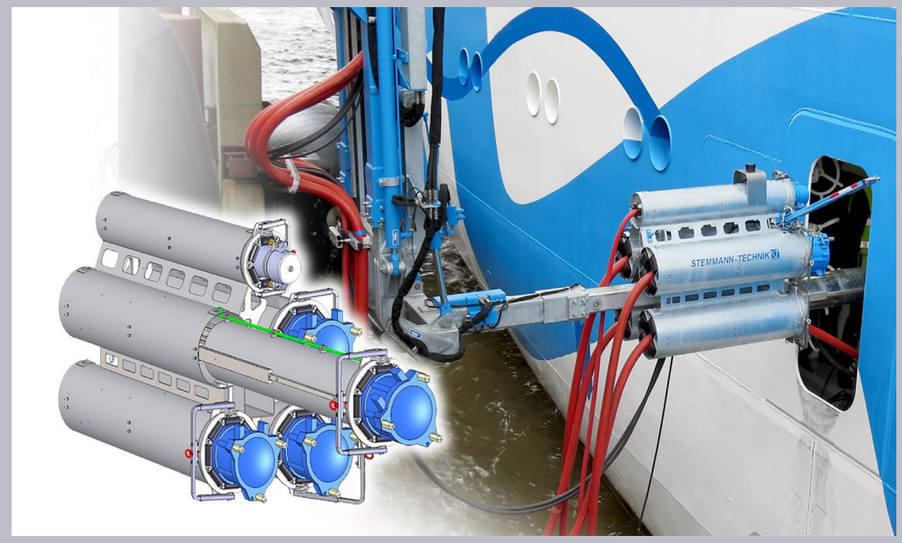




[38]

The power and data transmission to the cruise ship is affected by means of our onshore power supply-vehicle which can be moved along an underfloor cable channel with a length of 300 m. By means of the underfloor supply it is granted that the medium voltage cable is not damaged and that the port operations are not negatively influenced by cabled lying about. This system has a large coverage range, from the long travel distance and the tidal range compensation of up to 9 m.

Pros:	Cons:
Cable is covered & protected	Ducting on terminal required
Large coverage range	Chance of duct flooding
Tidle range compensation of 9 meters	Cruiser has fixed travel path
All cables delivered as single unit	

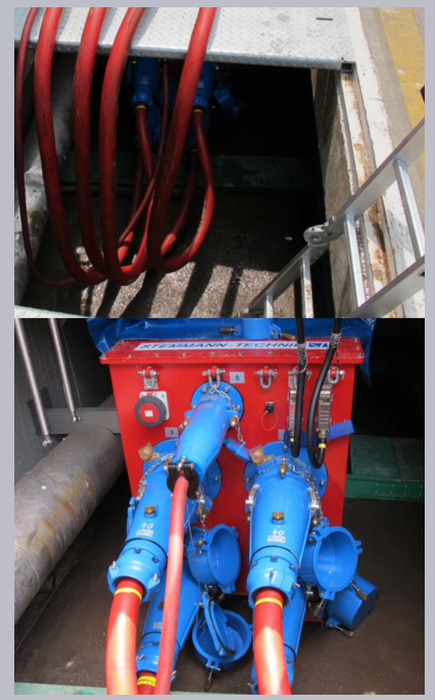


Shore Power - Shanghai, China

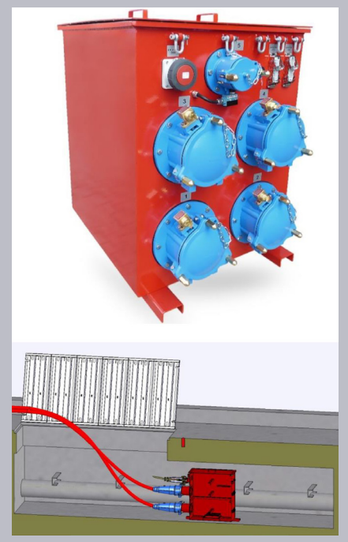
SAMPS Cruiser - Cruise Terminal Wusongkou

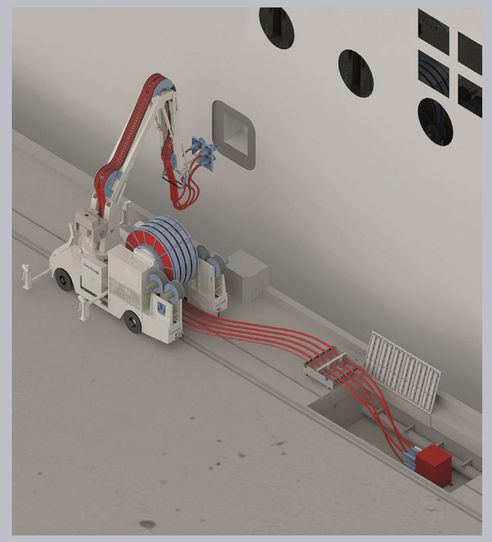
- Vehicle can be driven by only one person
- Safe plug delivery by means of articulated arm and plug carrier
- Battery operation for self-sustained travel movements
- Tidal range compensation up to 6 meters
- 20 MVA at 11 kV or 6.6 kV, 50/60 Hz
- Individually Modifiable to each port situation
- ICE/ISO/IEEE80005-1

Stemmann-Technik
A Wabtec Subsidiary



Cruiser is driven to one of multiple connection points, allowing one vehicle to serve multiple berths





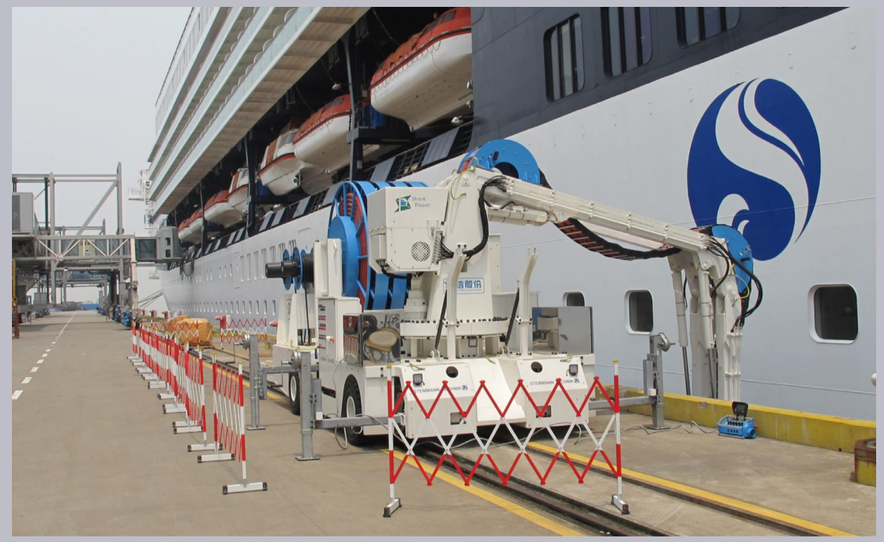
[38]

Shanghai, China - Continued

The onshore power supply-vehicle is moved to the pier by a battery-operated drive and there it is coupled with an underfloor connection system. The SAMPS Cruiser has a flexible travel distance of up to 70 m from this supply point. This system also has tidal range compensation and can, corresponding to the requirements of the particular ship, supply different frequencies and voltages.

Pros:
A single cruiser can serve multiple terminals
Easy storage hidden when not in use
Multiple connections points can extend cruiser's range

Cons:
Need multiple connection points
Cable management on dock
Shorter travel distance if single connection point



[38]

Industry Leaders

Equipment - Design - Installation:

ABB

Full Service Installation

Majority of shore power installations outside of USA

Refrences:
Juneau, Alaska

Schneider Electric

Full Service Installation

Compatable Product:
ShoreBOX

Refrences:
Los Angeles, California
Long Beach, California

Cochran Marine

Full Service Installation

Majority of shore power installations in the USA

Refrences:
Seattle, Washington
San Francisco California
San Diego, California
Long Beach, Califonia
Brooklyn, New York
Halifax, Nova Scotia

Stemmann - Technik

Full Service Installation

Compatable Product:
ShoreCONNECT

Refrences:
Hamburg, Germany
Shanghai, China

Cable Management Vehicle:

Stemmann - Technik

Product: SAMPS Cruiser for Hamburg, Germany
SAMPS Cruiser for Shanghai, China

Cavotech

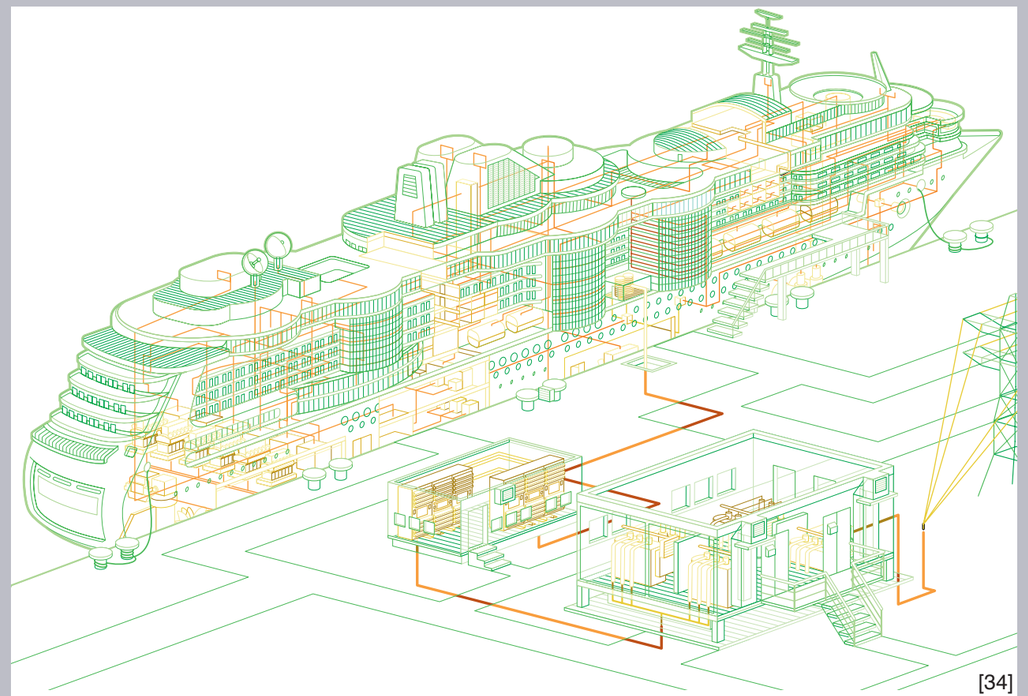
Product: AMPMobile for Port of Los Angles

Every port has specific needs, so companies work hand and hand with each other.

For example, ABB could facilitate the installation of a ShoreBOX, by Schneider Electric, and a SAMPS Cruiser, by Stemmann Technik.

ABB

ABB offers fully engineered and integrated shore-to-ship power solutions ensuring reliable power supply from the public grid and port network to ships while in port. The systems comprise all power, control and protection equipment for the automatic and safe transfer of the ship's load from onboard generation to the shore-side power supply.



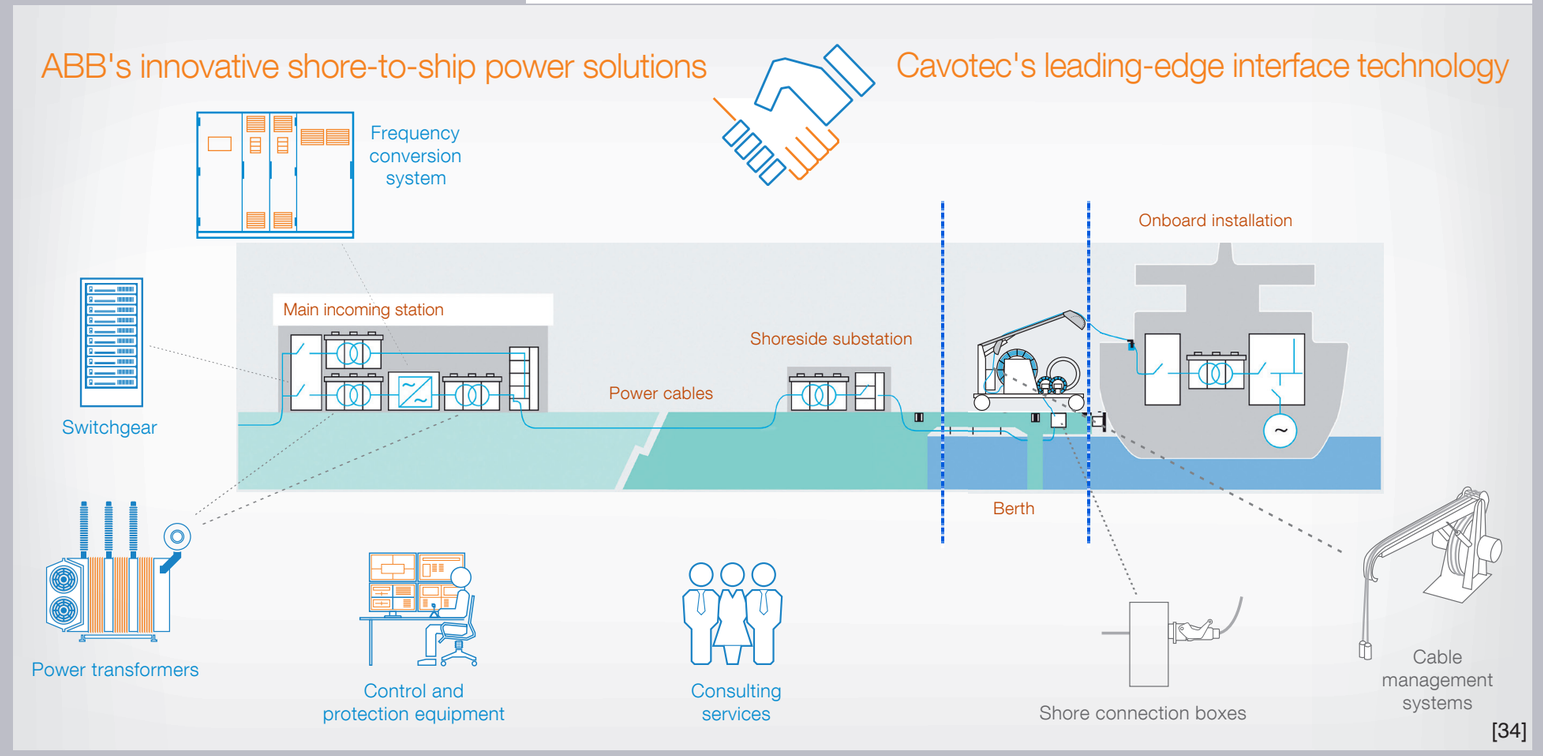
[34]

ABB's solutions encompass:

- Electrical infrastructure to fit all types of ports
- Connection and control solutions to ensure personnel safety and seamless power transfer
- Electrical infrastructure on ships – retrofits or new installations

Benefits:

- Enhanced environment for passengers, crew, dockworkers and local residents
- Minimized greenhouse gas emissions, noise and vibrations
- Reliable and high-quality power supply
- High operational and maintenance efficiency
- Proficient project management



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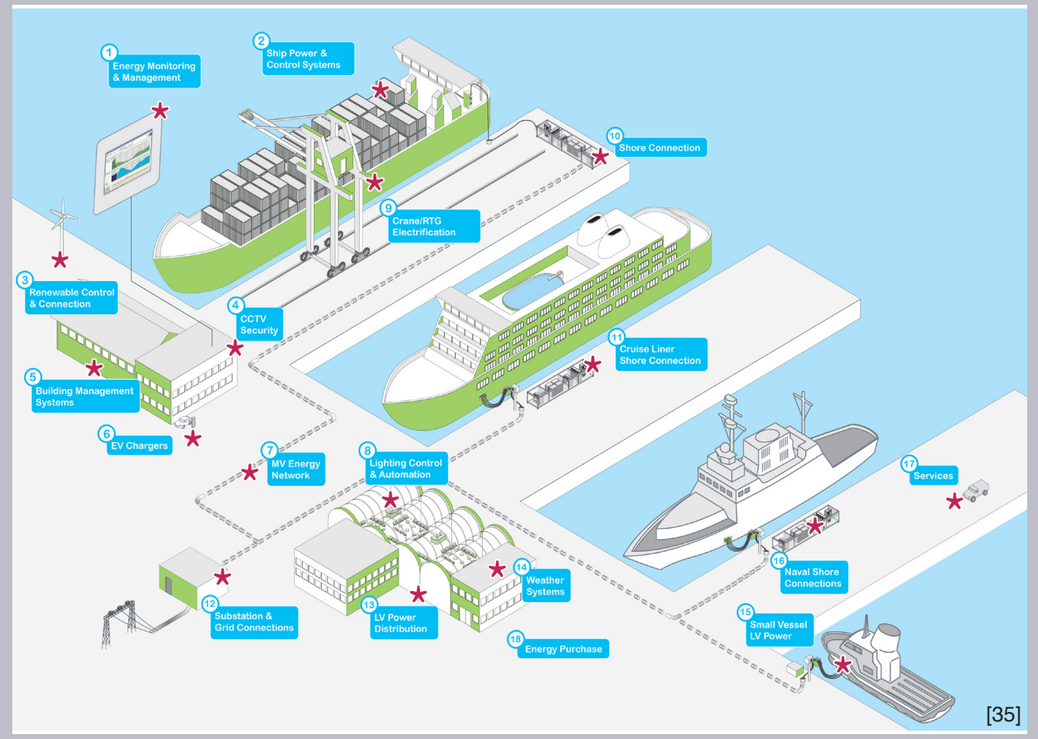
Schneider Electric

ShoreBOX, by Schneider Electric, is a system that appeals to a wide market because it is portable and modular, making it well suited for urban ports and those with limited space. This new technology could see clients break even after three years. ShoreBOX uses a Static Grid Frequency Conversion system and can be installed and used for cruise ships, containerships, tankers, and even smaller vessels.



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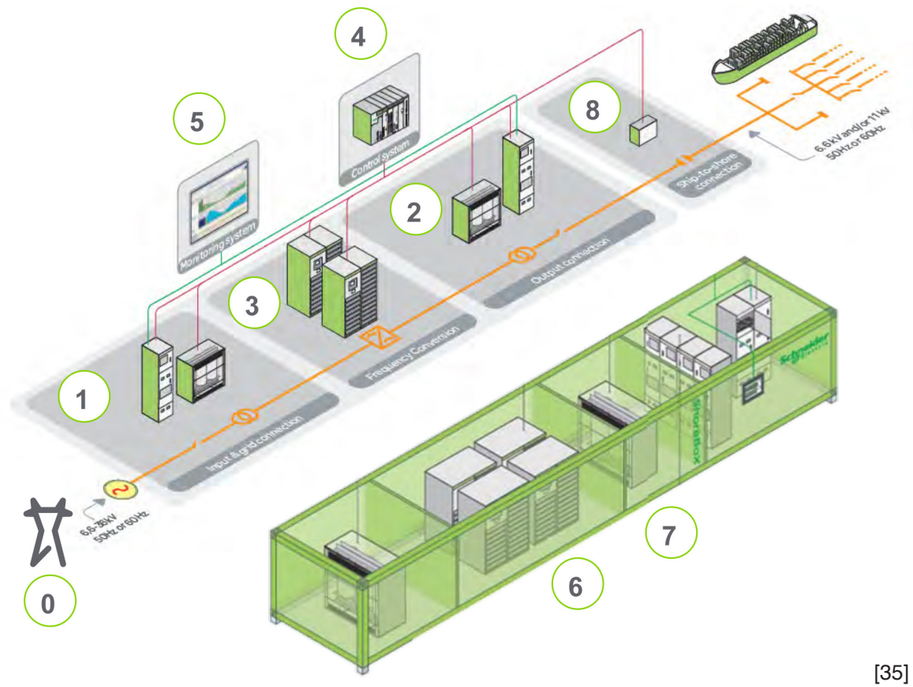
Benefits:

- Ready to use all-in-one system
- Best-In-Class Energy quality and Efficiency
- Can be relocated
- Can be installed in parallel for further extension
- Manufactured and tested in a controlled factory environment
- Reduced project costs and execution time
- Minimized disturbance to berth's activity
- Cost effective standard components

0. Supply from energy provider
1. Input & grid connection
2. Output
3. Grid Conversion frequency
4. Load Management
5. Monitoring
6. Thermal Management
7. Enclosure box
8. Ship to shore connection (HV or LV)

The ShoreBoX is made of defined component "bricks" that can be **adapted and installed in an existing building** as well



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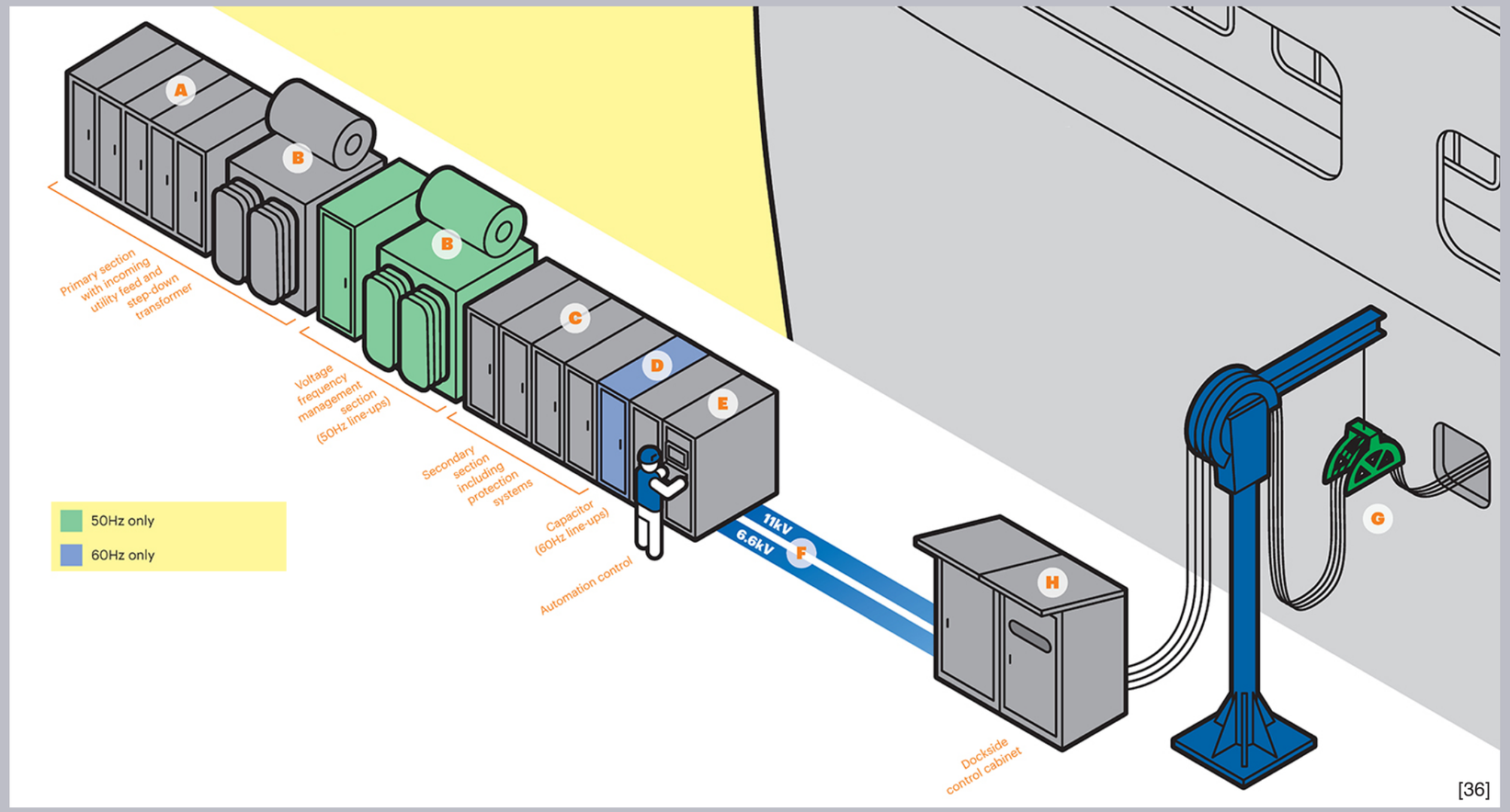
Cochran Marine

Cochran Marine has installed the majority of the shore power systems in North America. Their system was one of the first to hit the market and can be scaled to fit any port senario. Cable management systems are designed port by port, but all are fixed.



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A
The primary section contains metering and the MV main isolating breaker. AC supply is converted to DC and stored for an uninterrupted supply to the control systems.

B
The custom transformer steps down the MV circuit to voltages compatible with designated vessels. In 50 Hz systems, the frequency management section converts to 65 Hz power when required.

C
Our patented system includes multiple breakers and safety procedures to safeguard the ship's crew and assets throughout the shore power process.

D
The automated control system verifies readiness and determines the correct operating parameters for the incoming vessel. One Cochran Marine electrician manages the entire process from a dockside control station.

E
We help your crew position the vessel, then physically connect it to the line-up, either via a specifically retrofitted container on a deck or directly to the vessel using out cable management system.

F
At the dockside control station, we await final go-ahead from the vessel before closing the breaker and sending power to the ship.

G
We help your crew position the vessel, then physically connect it to the line-up via our unique cable positioning device.

H
At the dockside control cabinet, we await a go-ahead from the ship's chief electrical engineer before racking in the breaker and sending power to the ship.

Cable Management Vehicles

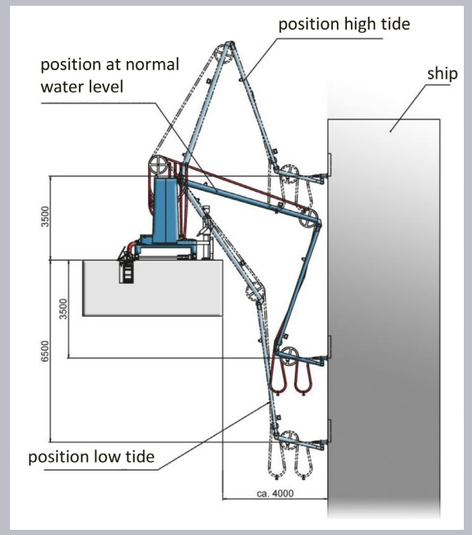
Stemmann-Technik
A Wabtec Subsidiary

SAMPS Cruiser in Hamburg Altona

Safe plug delivery by means of telescopic arm and plug carrier

Cable channel protects power cables and concels them from view.

Battery operated cruiser



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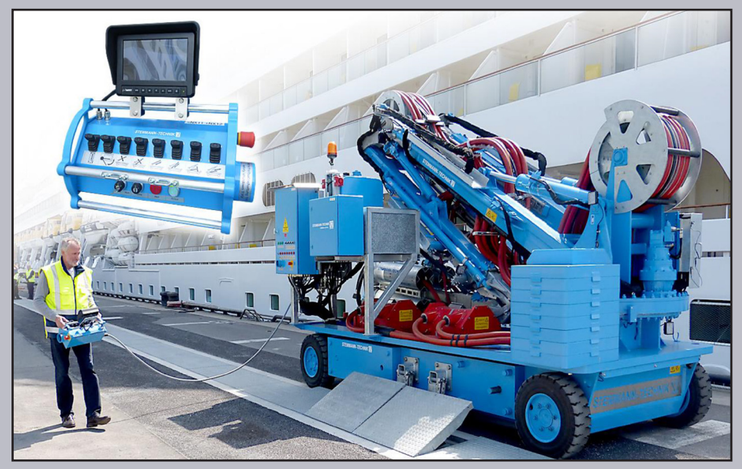
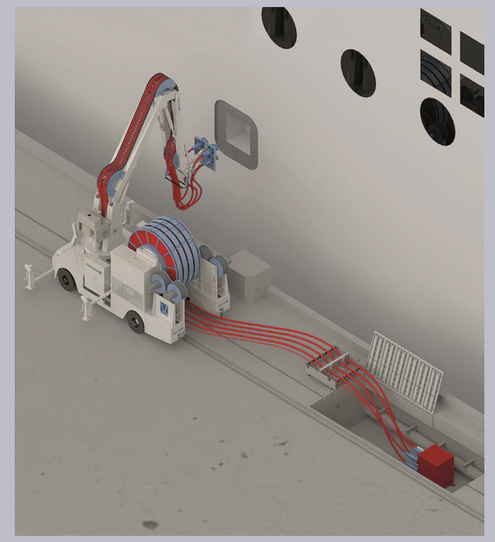


SAMPS Cruiser in Shanghi

Safe plug delivery by means of articulated arm and plug carrier

One Cruiser can serve multiple berths if multiple connection points are available.

Can be stowed away completely out of sight.



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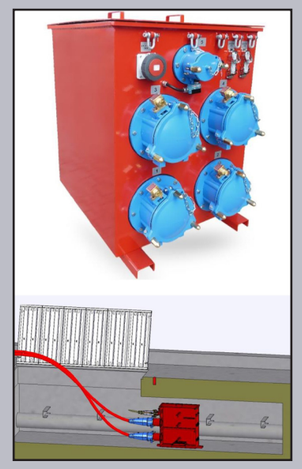


Cable Management Vehicles

AMPMobile in California

[36]

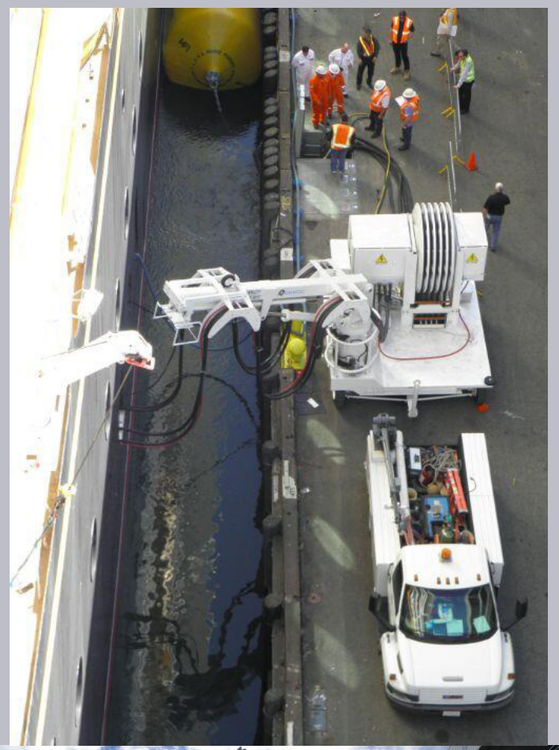
Reliability: proven technology with a large number of units successfully operating for many years at cruise terminals worldwide.

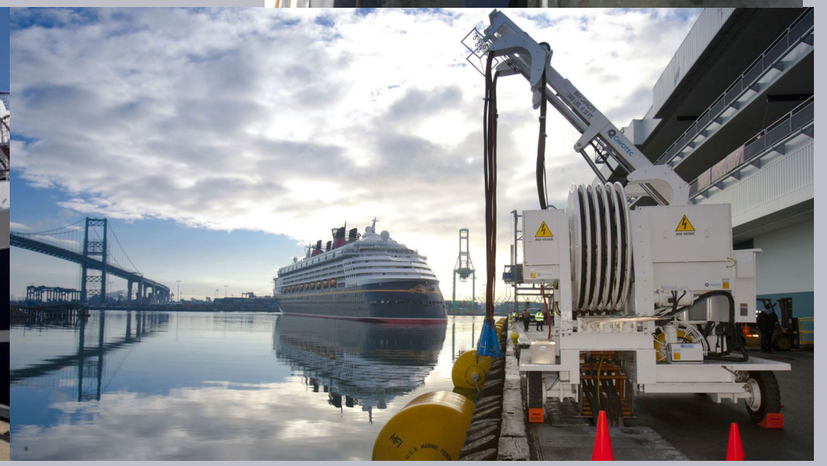
Limited civil works costs: this above ground solution does not require the digging of trenches along the quayside.

High operational flexibility along the berth: accommodating a wide range of vessels, regardless of connection point location.

Easy storage: when not in use, AMPMobile can be moved from the quayside and parked elsewhere.

One such unit costs $600,000 to $800,000



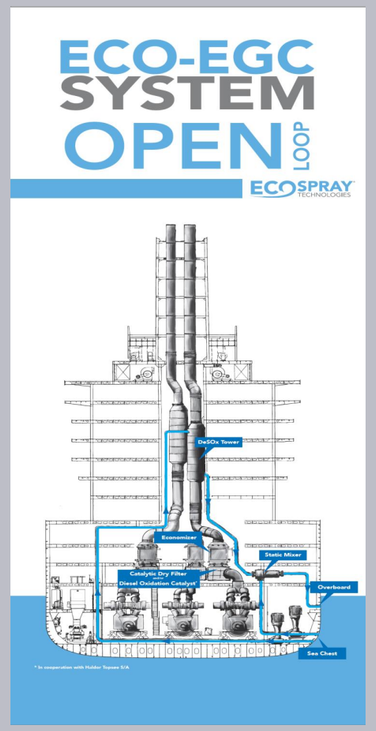


Cable Management Vehicles are custom made to fit the needs of the port. While they are expensive, they are extremely versatile, having the ability to serve any size ship at any point on the dock.

Fixed cable management delivery has a limited range and connectability, making it an outdated system.

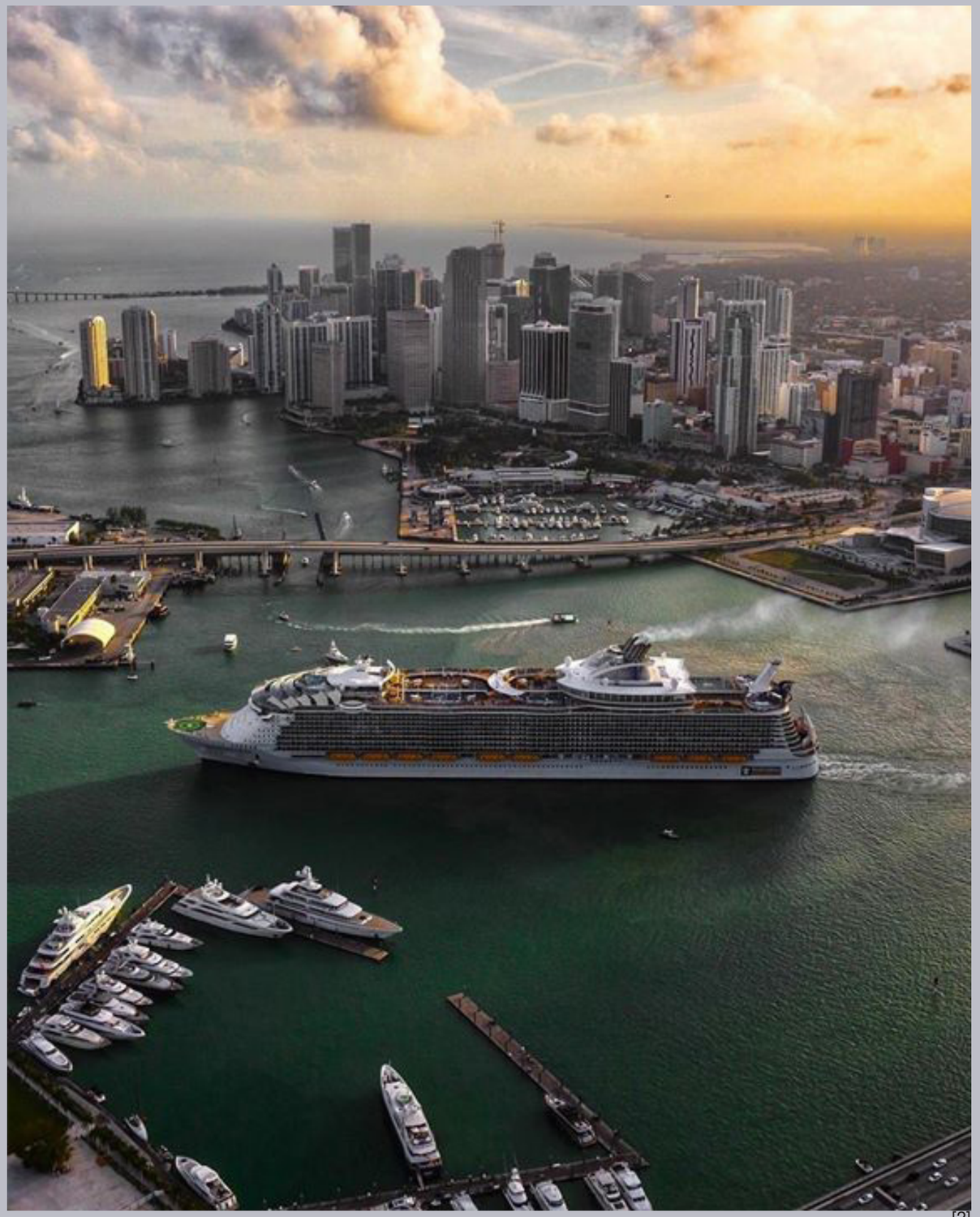
Other Options to Reduce Emissions

Switching from heavy fuel oil to cleaner liquefied natural gas (LNG) is one way cruise ships can limit their emissions. This is the most used option to comply with emission laws, but it has little to no impact on total pollution reduction long term.



An Exhaust Gas Cleaning System is a pollution filter that is installed onboard a ship. This system does not filter for CO2 and it is not as efficient as shore power in the reduction of other pollutants. 68% of the global capacity currently utilizes EGCS and 75% of non-LNG new-builds will have EGCS.

A baghouse, bag filter, or fabric filter is an air pollution control device that removes particulates out of air or gas released from commercial processes or combustion for electricity generation. This is the least effective option for air pollution reduction.



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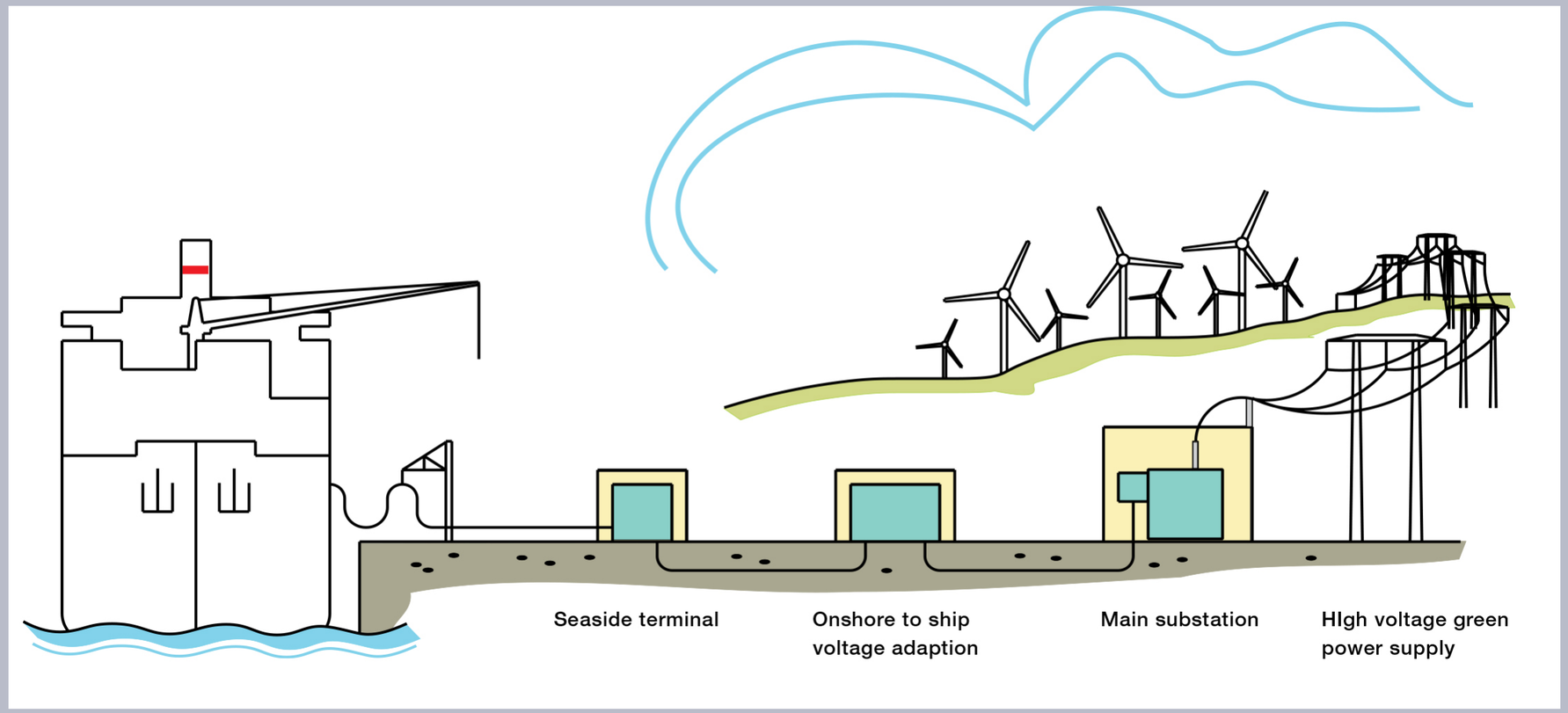
Port of Miami Shore Power



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Implementing a shore power system before the terminal is built can significantly reduce the cost of installation. I intend to show how shore power duct channels could be laid before the MSC Terminal is built. I also propose a possible retrofit option for the two terminals neighboring MSC, with the least impact to the berths as possible.

Factors Unique to Miami

Weather

The year-round climate in Miami is warmer than most US States.

Warmer weather calls for more electricity to power the cooling systems.

Compared to places like NYC or California where the HVAC system might not always be running, Miami calls for air conditioning 24 hours a day

Ownership

The Port of Miami is governed by the Port Authority of Miami Dade County. Florida Power and Light is a governmental monopoly, supplying power to all of South Florida.

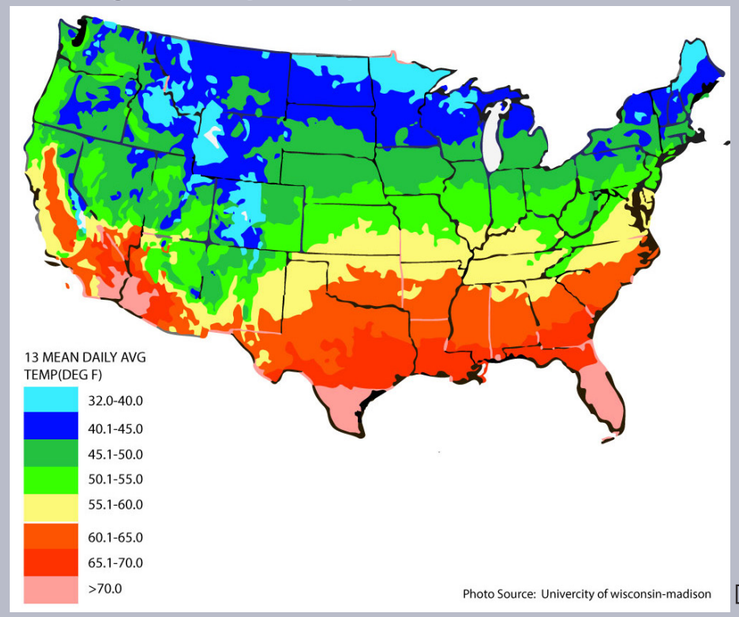
With both entities operated by the government, projects can be streamlined and electricity deals can be subsidized.

Investment

Miami Dade County has invested over 700 million dollars into new cruise terminals at the Port of Miami. It expects a return on investment of more than $5.8 million dollars over the next few decades.

Some of this money should be allocated for shore power technology.

Average Yearly Temperature



[25]

“Cruise Captal of the World”

The Port of Miami is the busiest cruise port in the world by number of passengers. The weather makes Florida a prime location to cruise from year round.

As less busy ports with shore power technology report significant reduction in emissions, why hasn’t the Port of Miami taken action to implement?

MSC Terminal

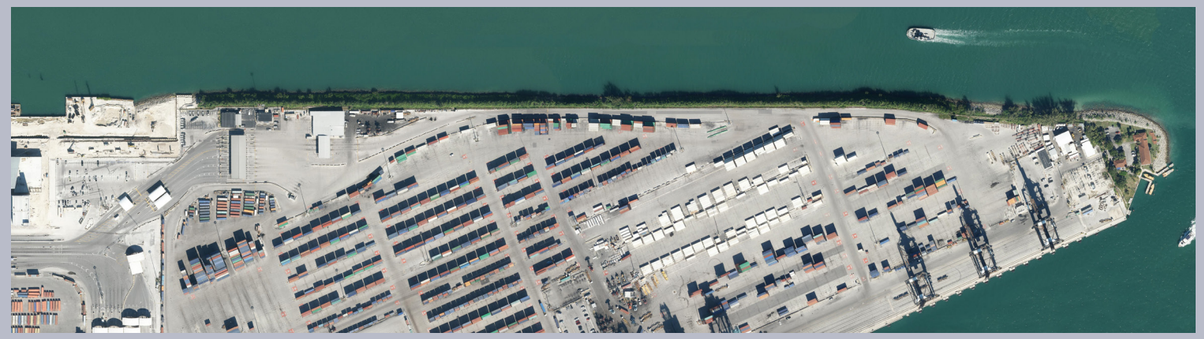
While interning at Arquitectonica, I worked on their MSC cruise terminal project. Once completed in October 2022, this terminal and office building will be the largest cruise project at The Port of Miami. The MSC terminal is one of six new projects being built at the port.

None of the existing terminals, nor the newly designed terminals, have shore power technology. Designing in accordance with guidelines that the port gave MSC, I am proposing a 1 berth Shore Power system for this terminal.

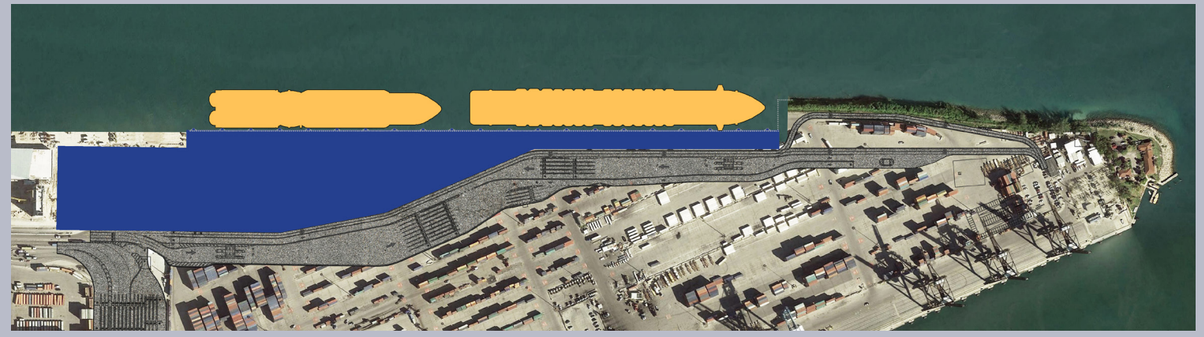
MSC terminal is still in the construction documents phase and has not yet broken ground. Installing Shore Power in a new terminal costs significantly less than retrofitting an existing terminal.

[15]

Existing Conditions



MSC Lot & Dredge



Future Berth Phasing

MSC Terminal

Factors Considered

- Mobile cable cruiser delivery
- Ability to park cruiser in covered garage
- All-in-one modular equipment package
- Equipment package modular
- Future expansion of shore power
- Power cable duct bank placed under road
- Least impact on berth to retrofit
- Green energy options

**Port of Halifax equipment .
Best existing precedent system, able to power 3 cruise berths simultaneously.**

Two best cruiser precedents

Stemmann Technik SAMPS Cruiser at Terminal Wusongkou, China.

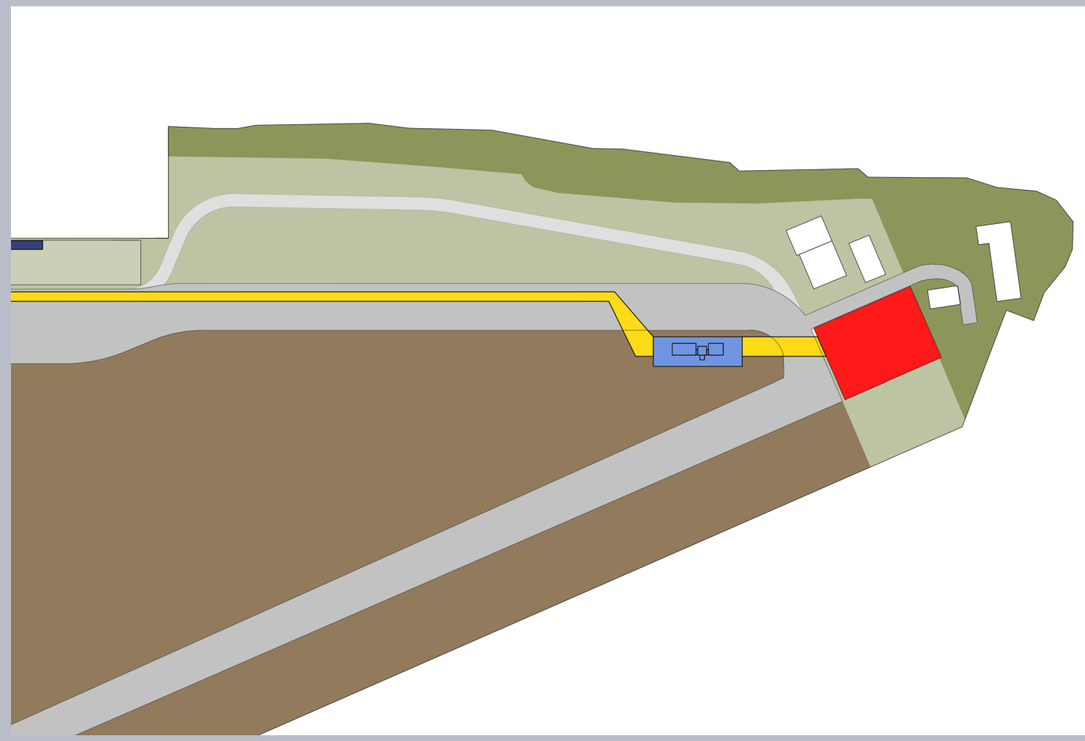
[38]

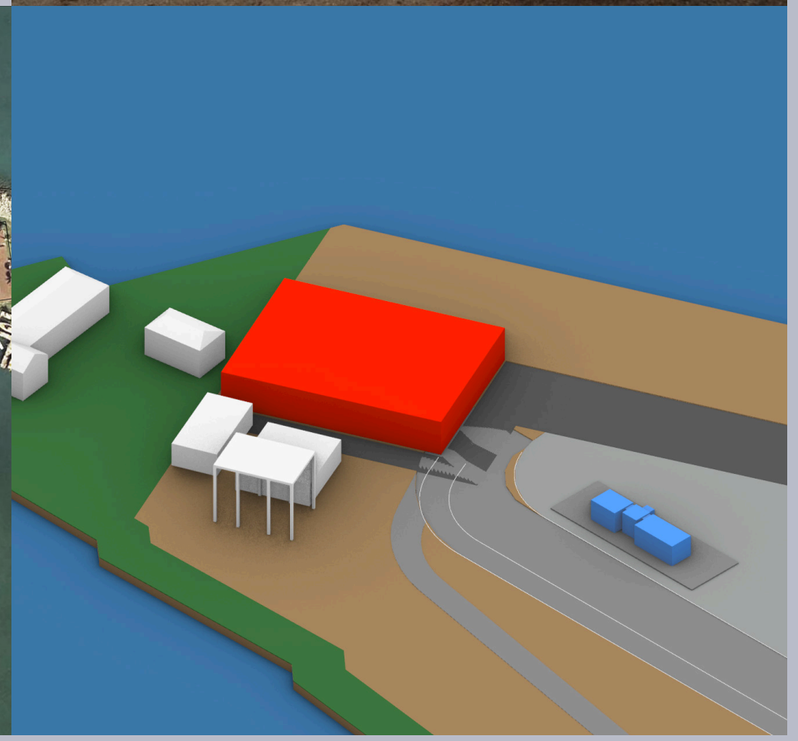
Cavotec Cruiser at The Port of Los Angeles, California

Equipment Location

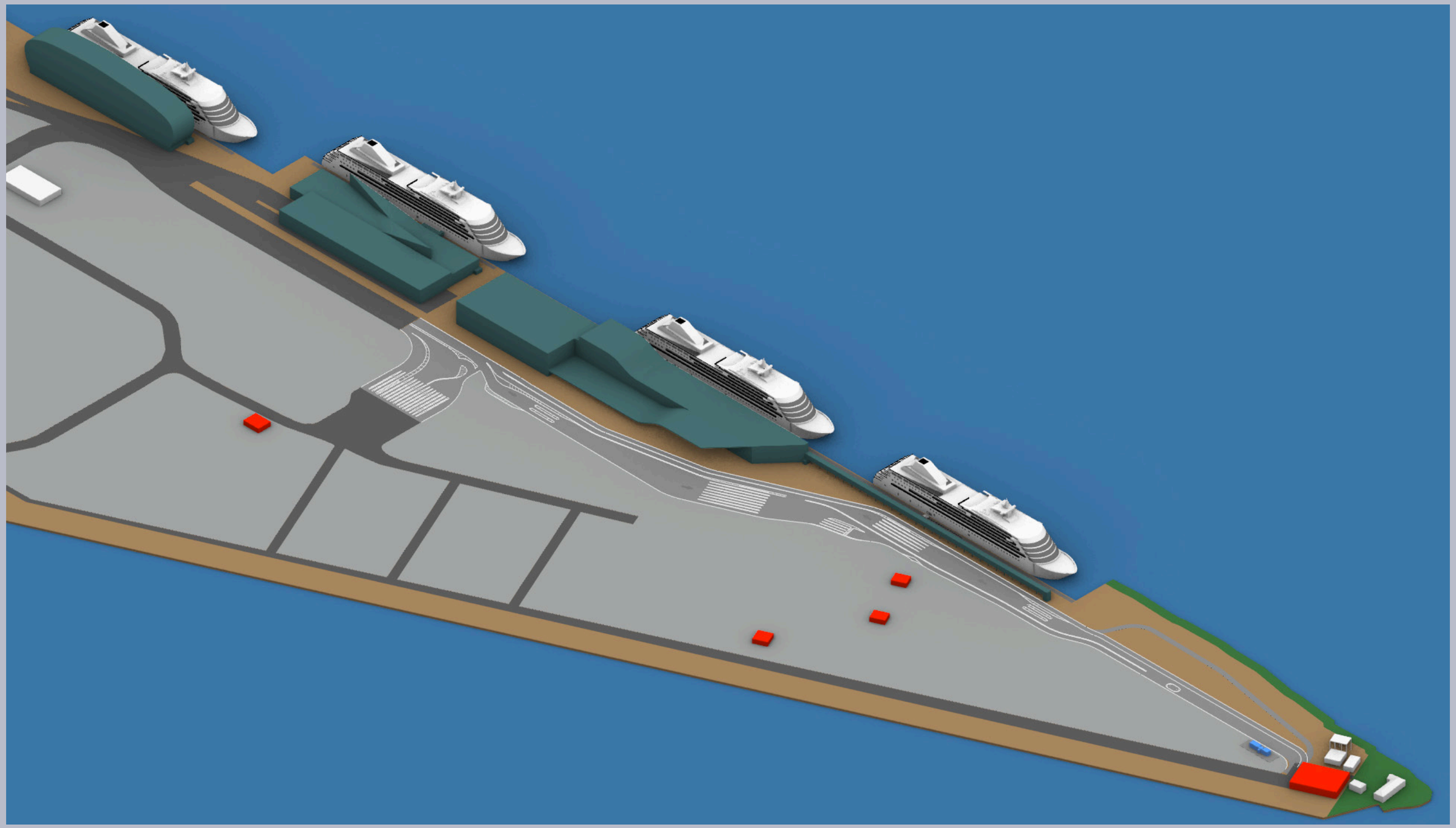
Shore power equipment will be placed next to the existing FPL Substation. Resting atop an existing parking lot, the transformer pad and housing for the equipment would not be disruptive. The duct bank will be placed beneath the road extension planned by the Port of Miami.

ShoreBOX by Schneider Electric is the preferred equipment option because it is portable, modular, and it can be placed in parallel for expansion.



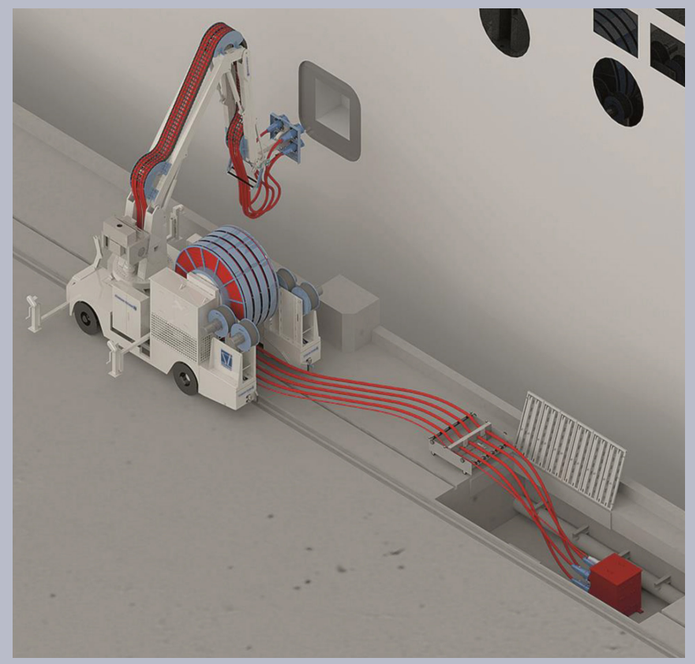


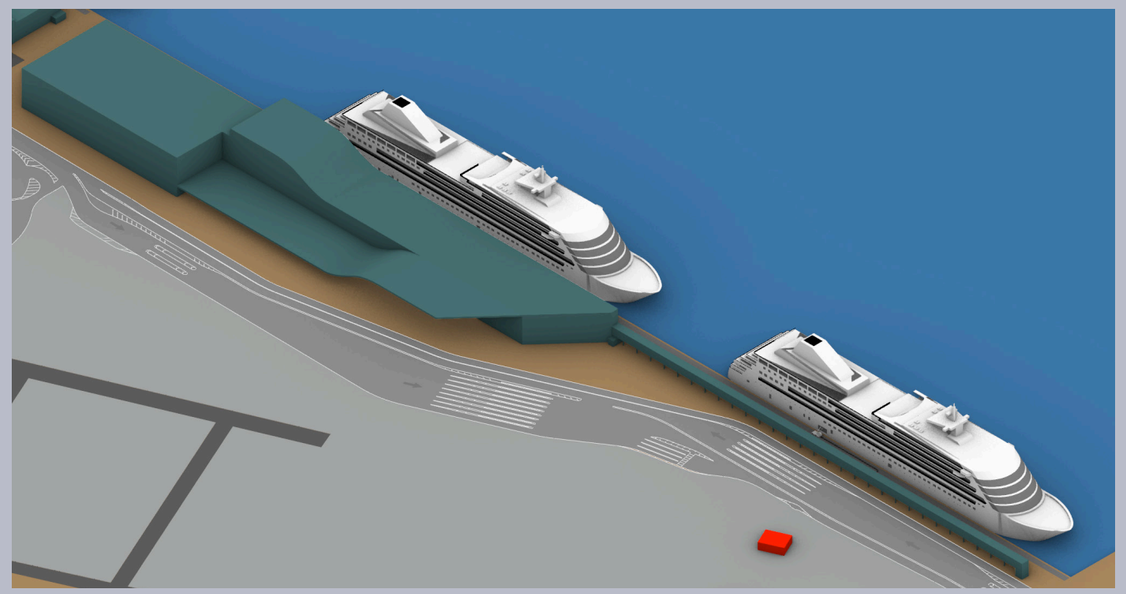
North East Axonometric

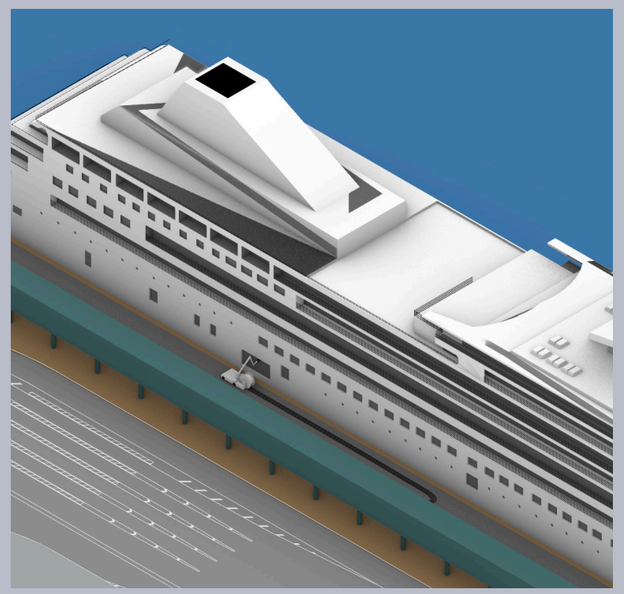


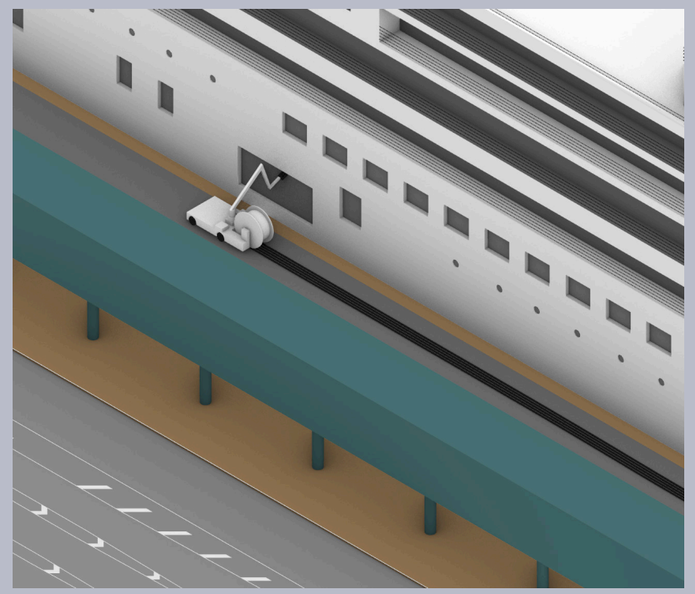
MSC Terminal Shore Power

The best time to implement a shore power system is during the design process. This is due to costs being significantly less if retrofit isn't required. Adding a duct bank under the road before it is paved is an important step if shore power is to be implemented in the future.

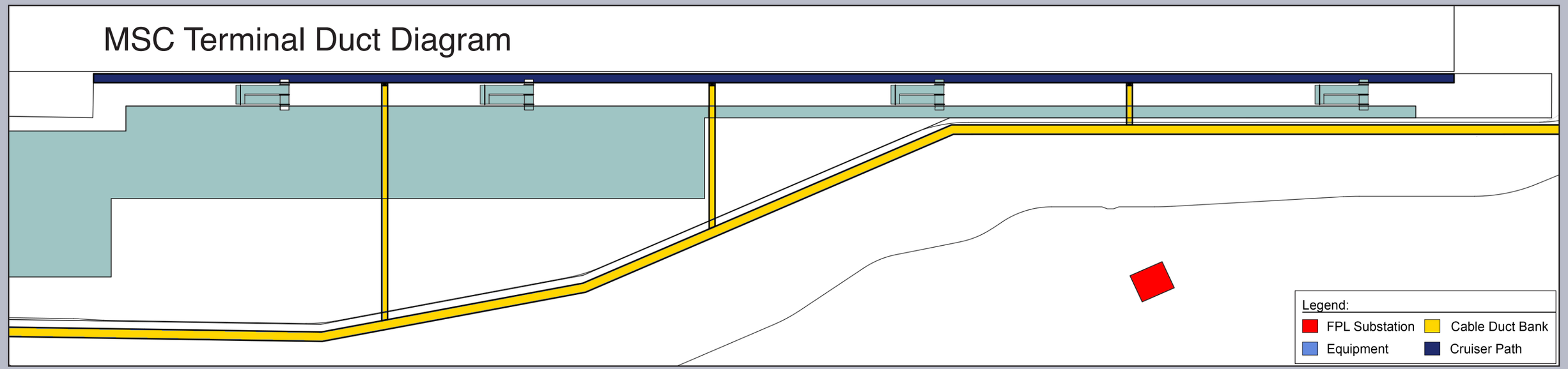


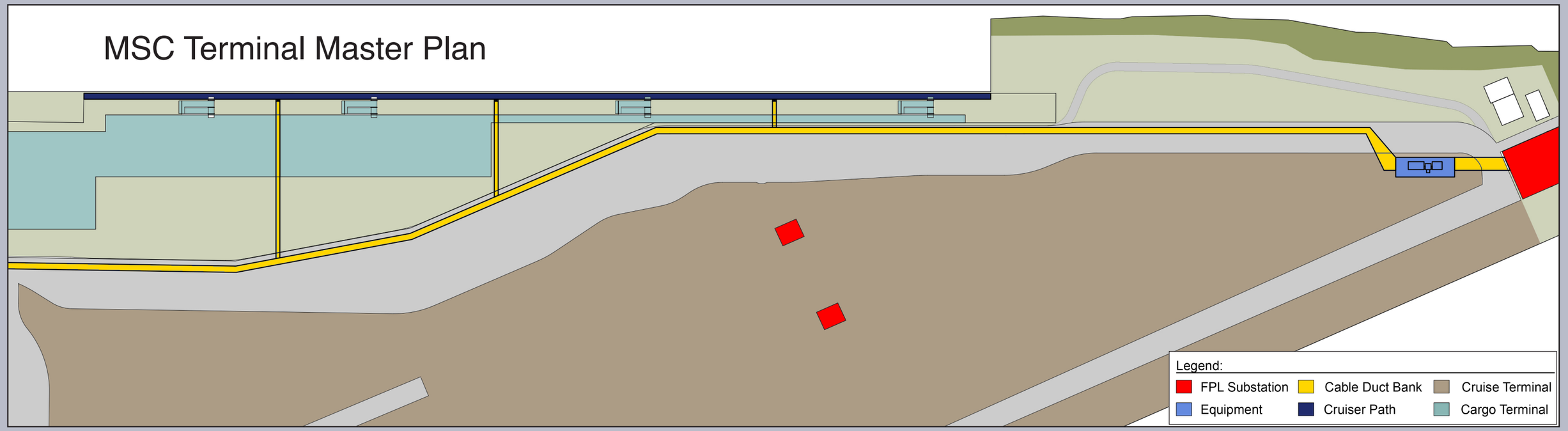






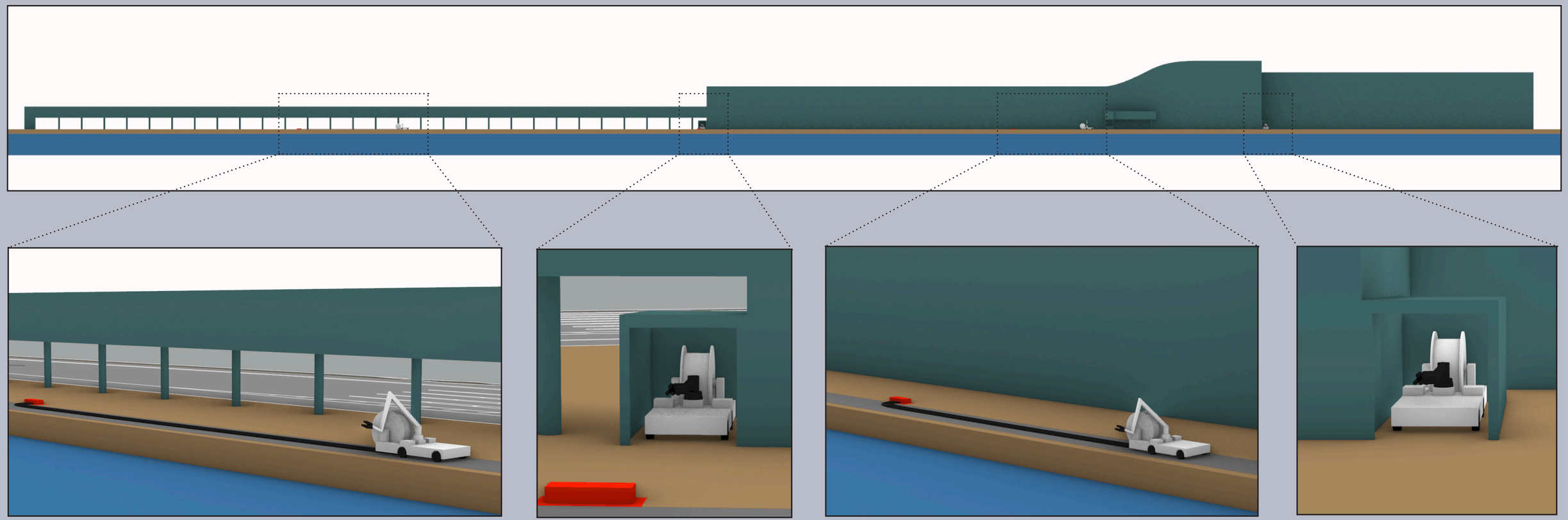
MSC Terminal Duct Diagram & Master Plan





MSC Terminal Cruiser & Garage Locations

The two cable delivery cruisers are able to attach to any of the three connection points placed along the berth. Two covered garages will house and hide the cruisers when they are not in use. This layout allows for maximum flexibility in connection, adaptation, and expansion options.



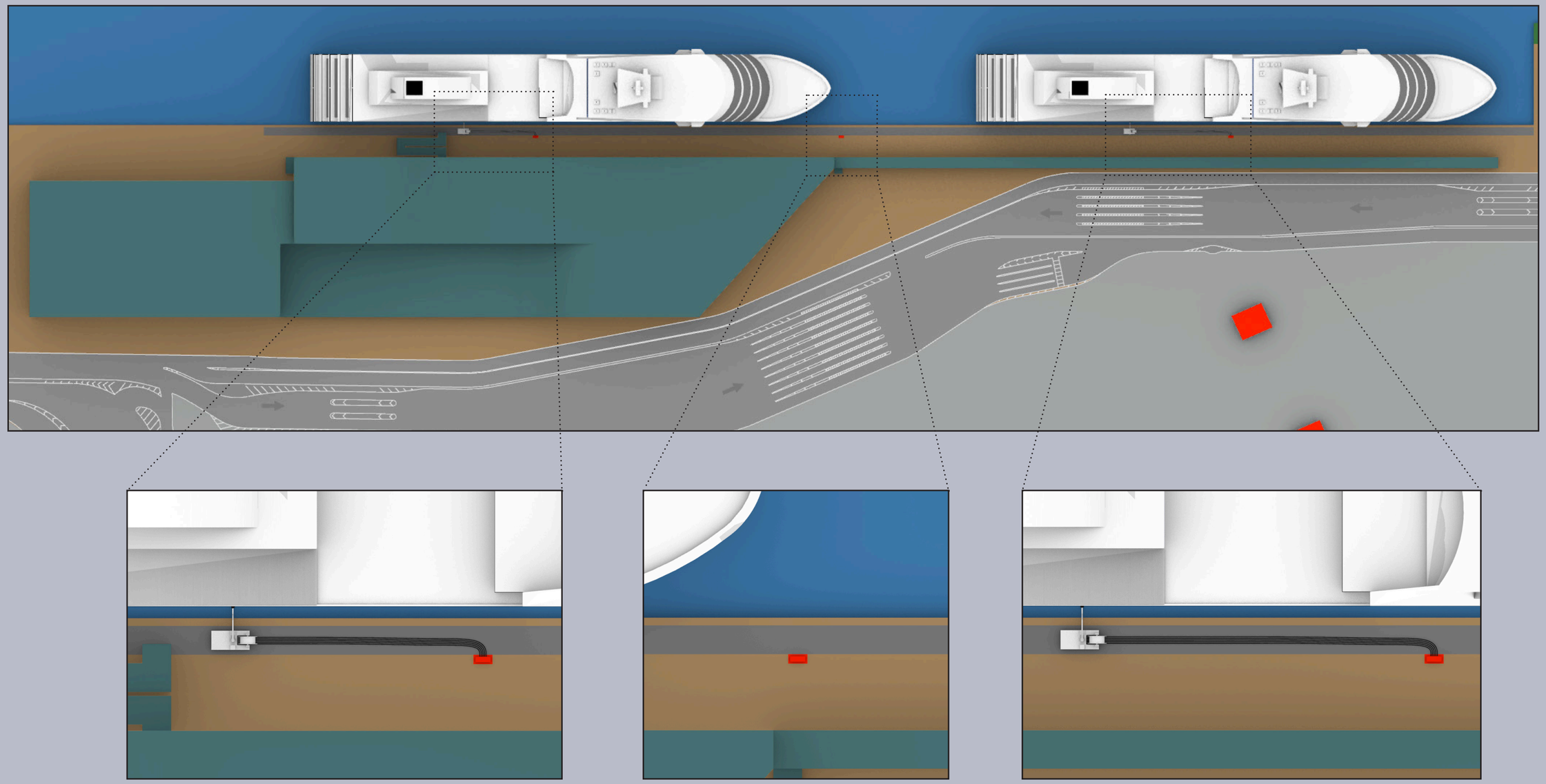
MSC Cruiser One

Cruiser Garage One

MSC Cruiser Two

Cruiser Garage Two

MSC Terminal Connection Point Locations



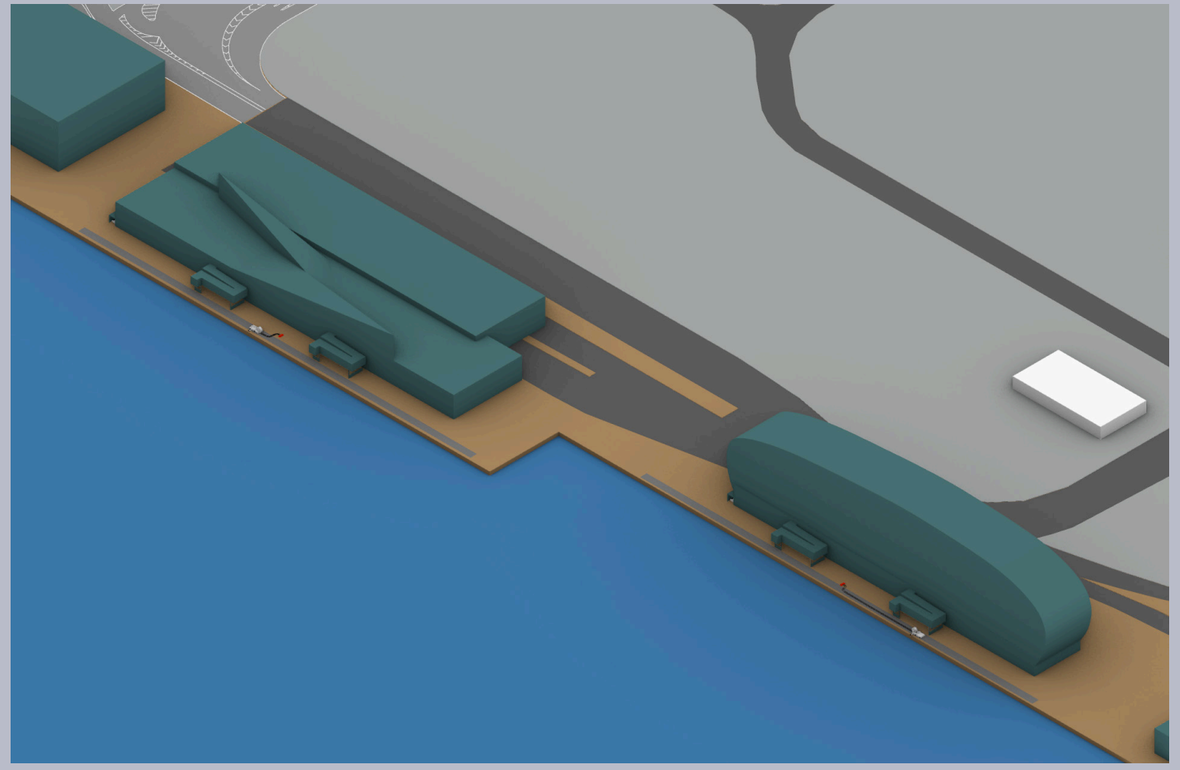
Connection Point One

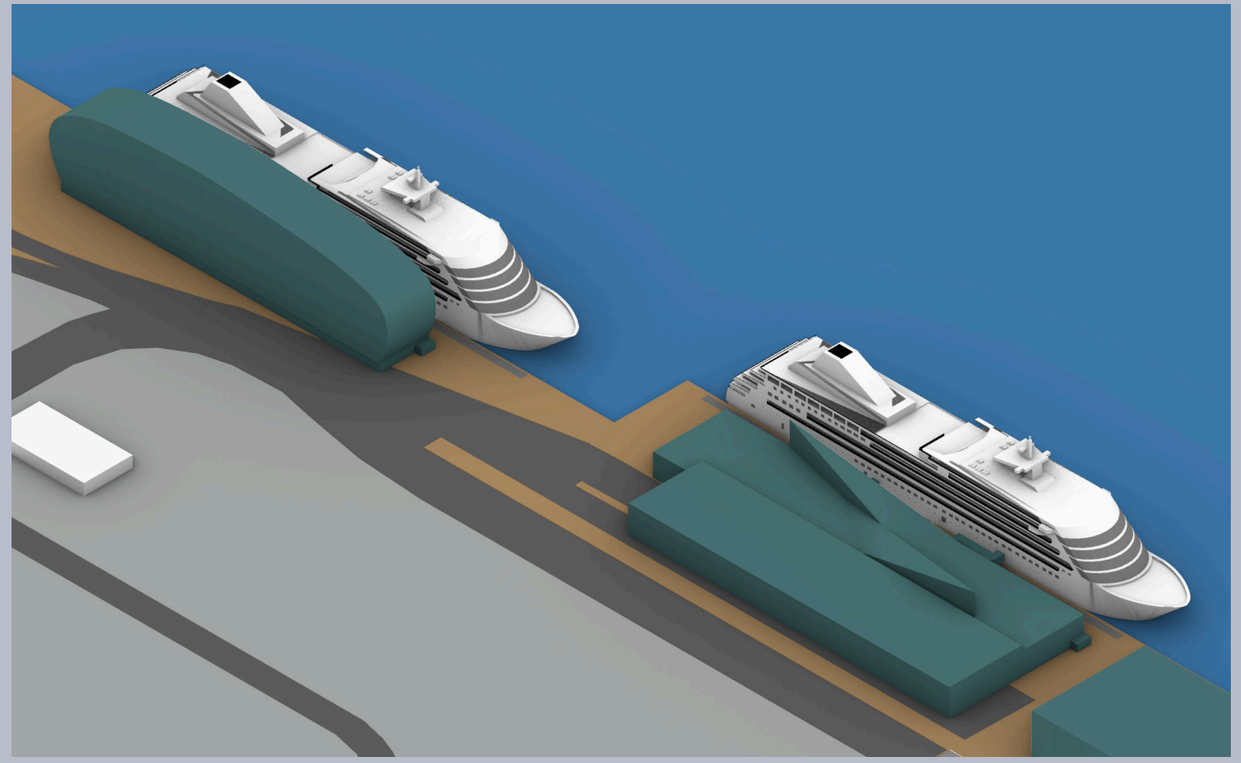
Connection Point Two

Connection Point Three

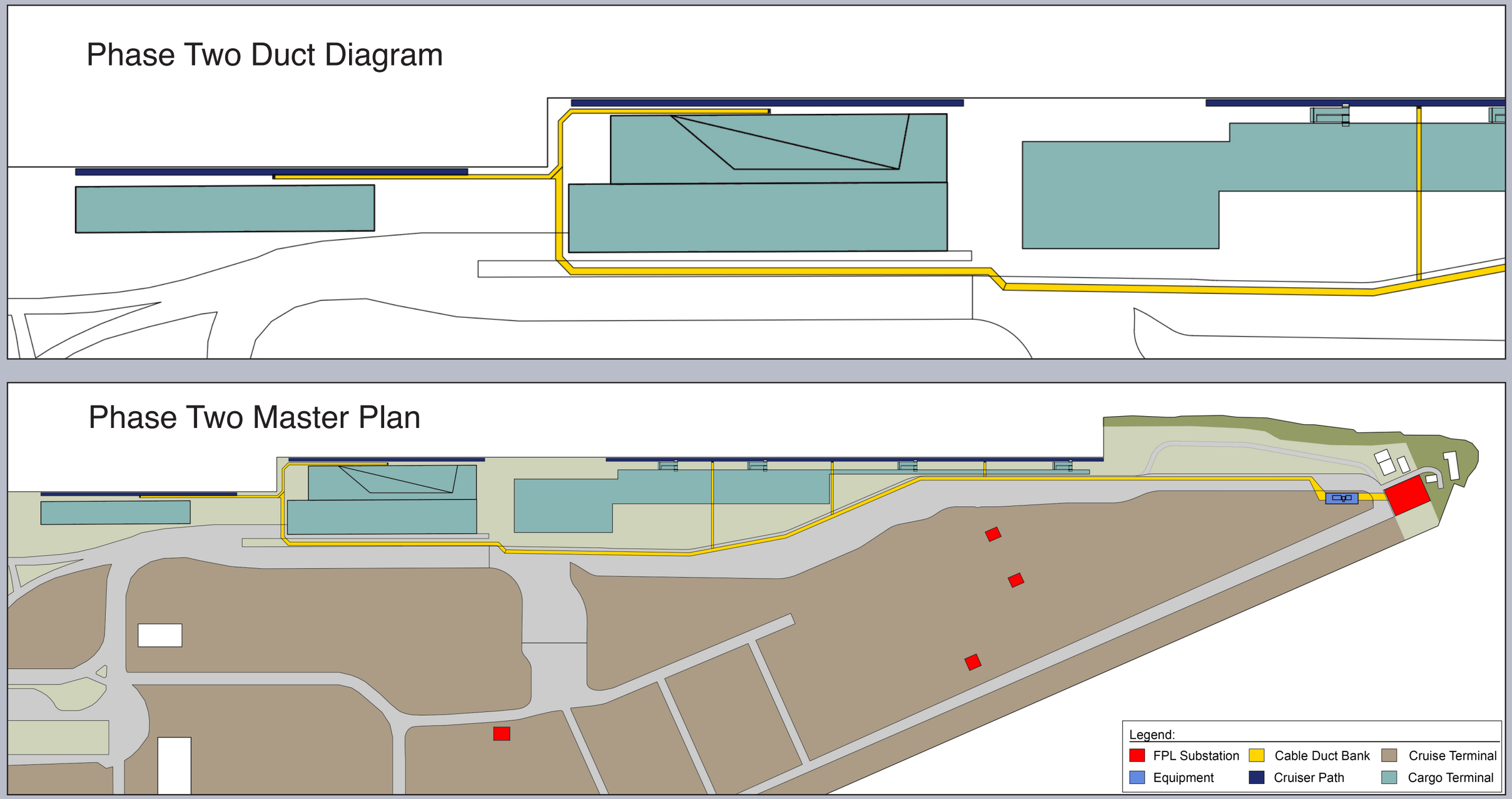
Royal Caribbean & NCL Shore Power

The Royal Caribbean Terminal and the NCL Terminal each have only one berth to serve. Each terminal has its own connection point and cruiser to facilitate shore power. The duct bank established for the MSC terminal would be expanded to serve these two terminals.



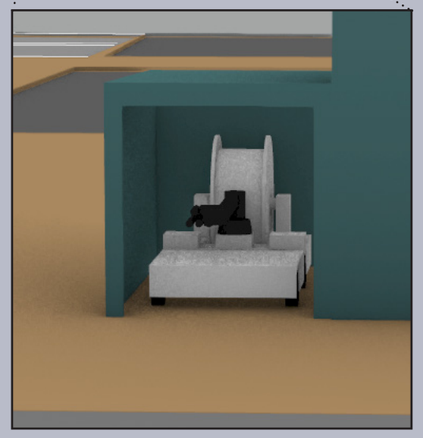


Phase Two - Duct Plan & Diagram

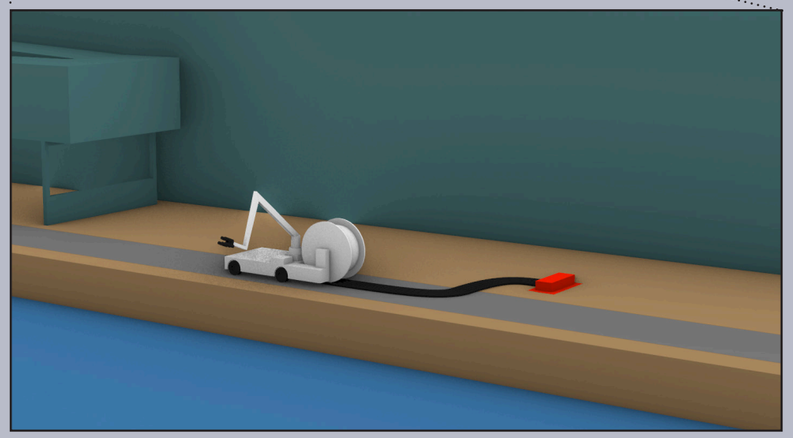


Phase Two Cruiser & Garage Locations

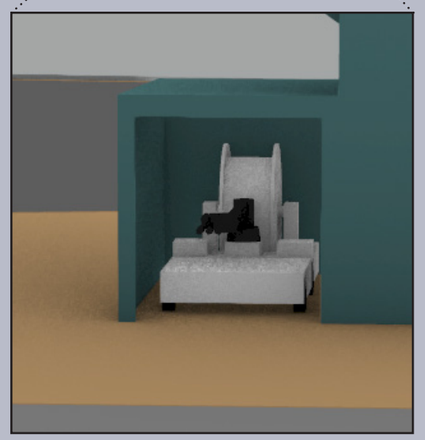
Each terminal will have a connection point placed at the berth's center. The cable delivery cruiser's also would have a garage to conceal them when not in use. Maximum flexibility, both lengthwise along the berth and height wise along the ship, is achieved by these cruisers.



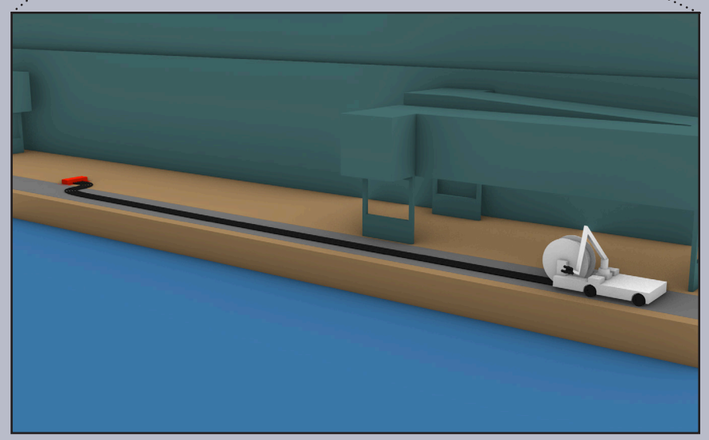
Cruiser
Garage Three



Royal Caribbean Cruiser

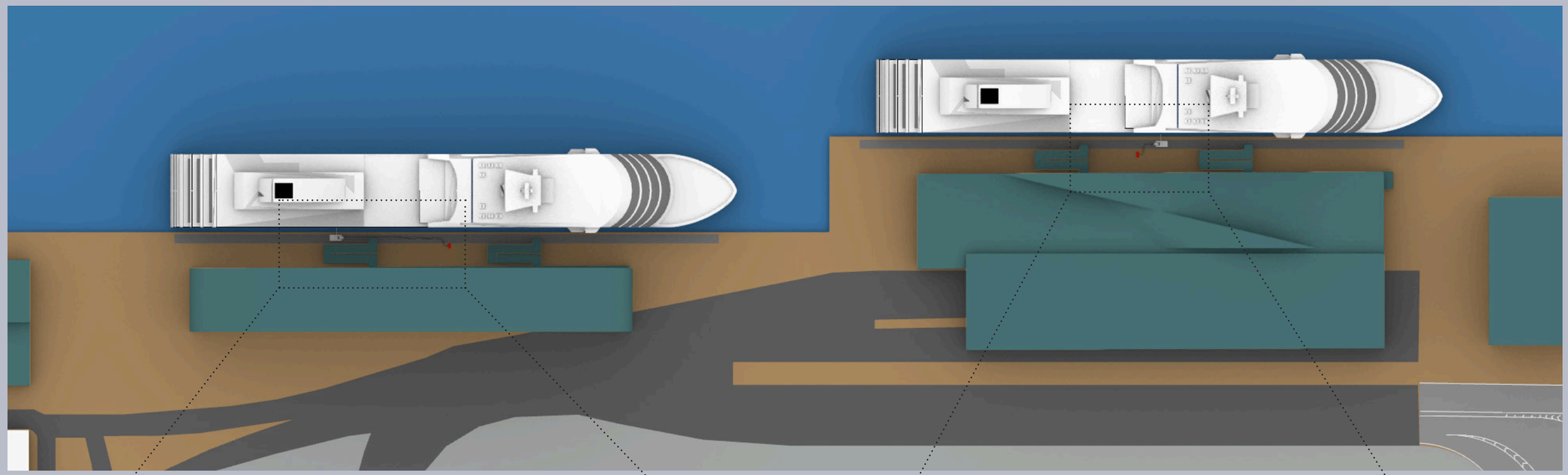


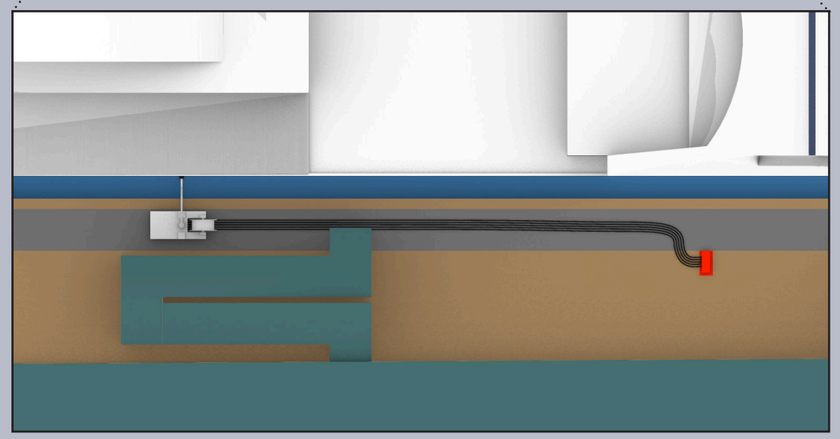
Cruiser
Garage Four



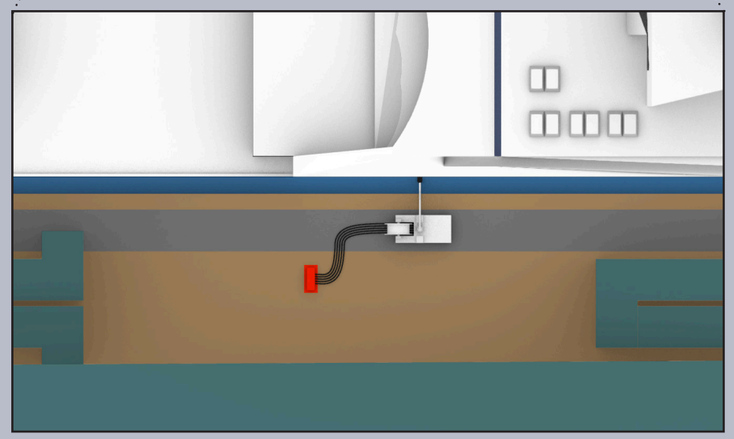
NCL Cruiser

Royal Caribbean & NCL Shore Power





Connection Point Four



Connection Point Five

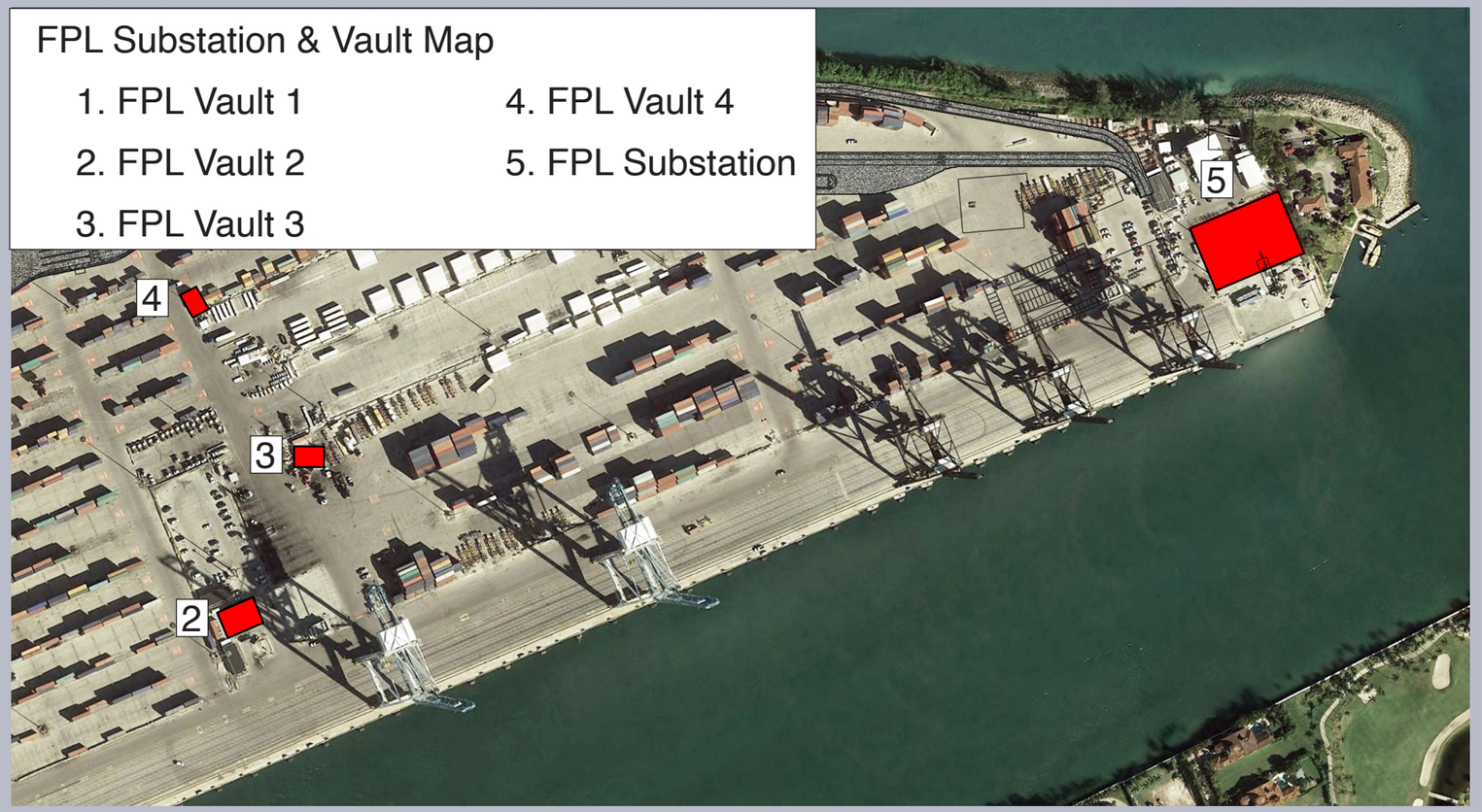
Existing FPL substation & Expansion

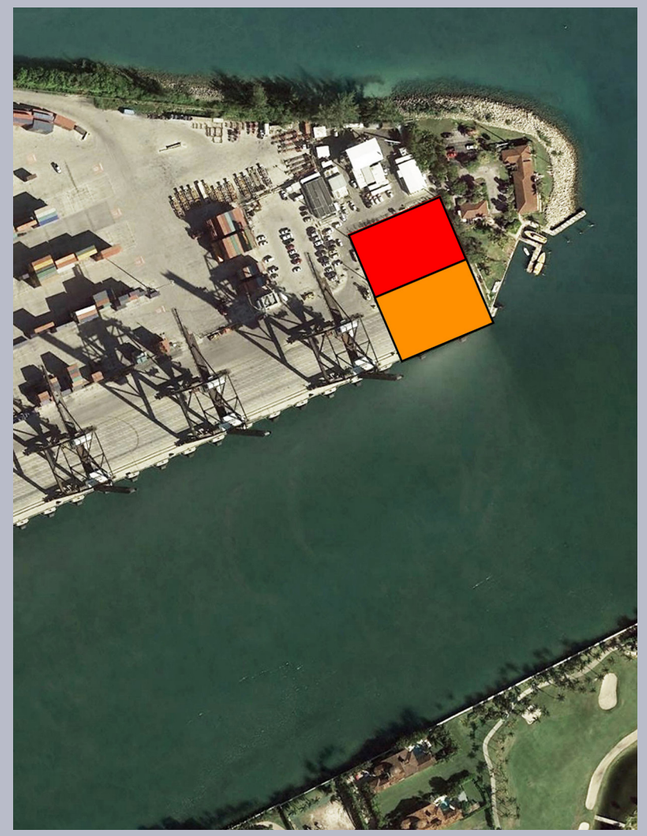
There is an existing FPL substation located on the east tip of the island. Four FPL vaults also exist and connect to this substation. Assuming it has the capacity to supply enough energy for shore power, the equipment could attach to the substation directly

Substation expansion is expected in order to generate the amount of power needed to supply multiple berths. The substation expansion is proposed to replace an area that is currently a parking lot.

FPL Substation & Vault Map

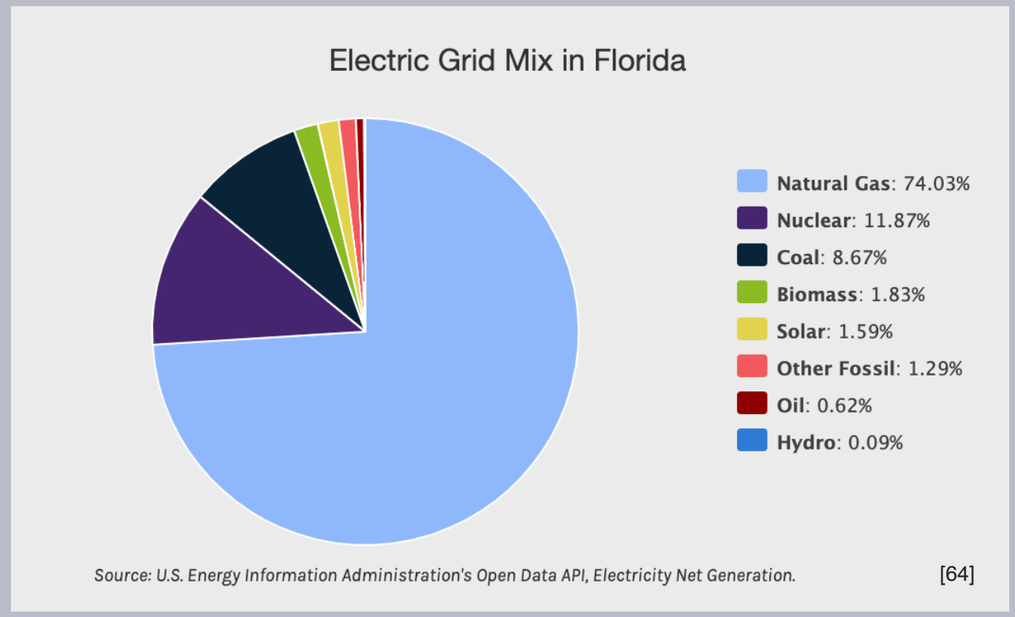
1. FPL Vault 1
2. FPL Vault 2
3. FPL Vault 3
4. FPL Vault 4
5. FPL Substation





Florida Electricity Production & Consumption

- Florida is the fourth-largest energy-consuming state, and it uses almost eight times as much energy as it produces.
- Florida is the second-largest producer of electricity after Texas, and natural gas was primary source: 70% of net generation in 2018.
- Coal consumption in Florida's electric power sector has fallen from about 29 million tons in 2008 to about 12 million tons in 2018, as natural gas-fired power plants replaced older coal-fired units.
- In 2018, solar energy accounted for more than one-third of Florida's renewable-sourced electricity generation, with solar power generation increasing from 429,000 megawatthours in 2016 to about 2.9 million megawatthours in 2018.



Source: U.S. Energy Information Administration's Open Data API, Electricity Net Generation. [64]

FPL

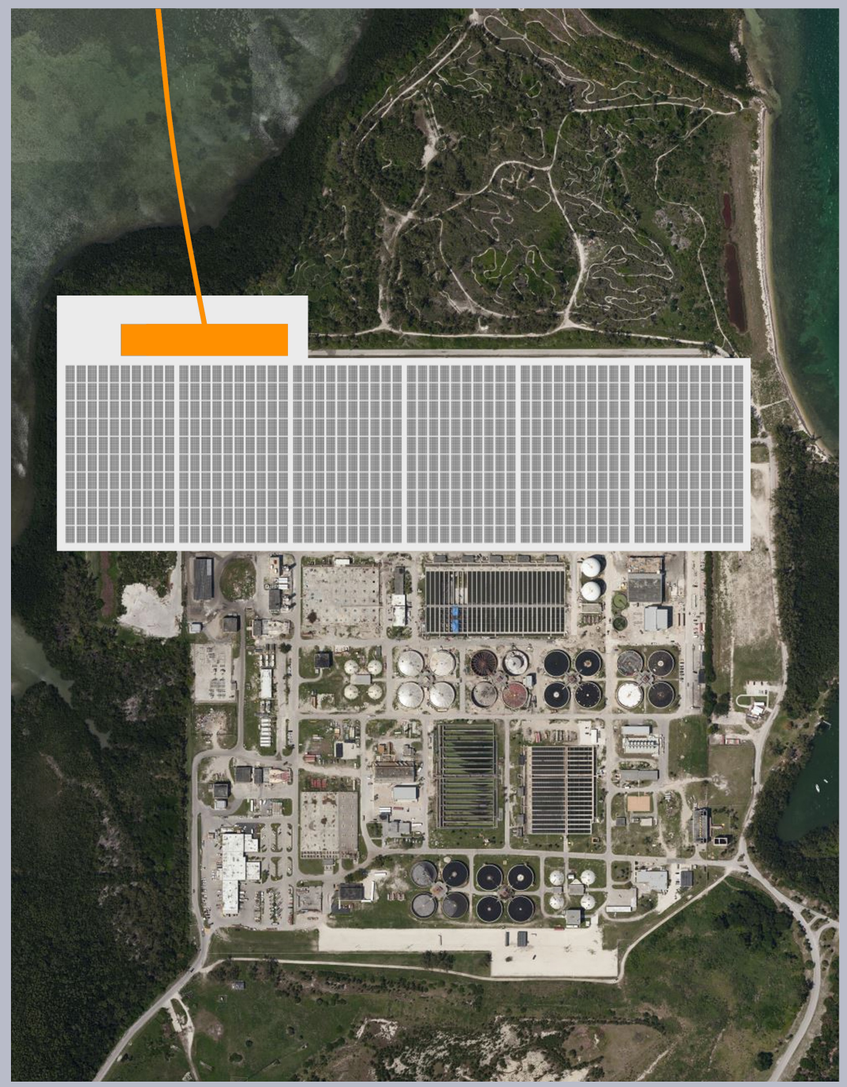
Florida Power & Light is the largest utility in Florida. It is a vertically integrated, regulated monopoly generating and delivering electricity to all of South Florida.

If electricity supplied to the shore power system is generated by a dirty energy source, total emission reduction would be offset and be insignificant.

Solar Power

Solar is currently the best “Green” option

Under current conditions, solar panels can supply required, but the storage and capacity haven’t made them efficient. A solar array of over 60,000 solar panels is needed to generate enough power to supply one ship, maybe two. Though a viable option, solar panels are expensive, and this project would require a large number of them.



Cruise ships typically use between 6 - 11MW while they are at port.

1 panel (average) = 256 watts
60,000 solar panels = 14.76 MW

14.76 MW / 6 MW = 2.45 boats
14.76 MW / 11 MW = 1.3 boats

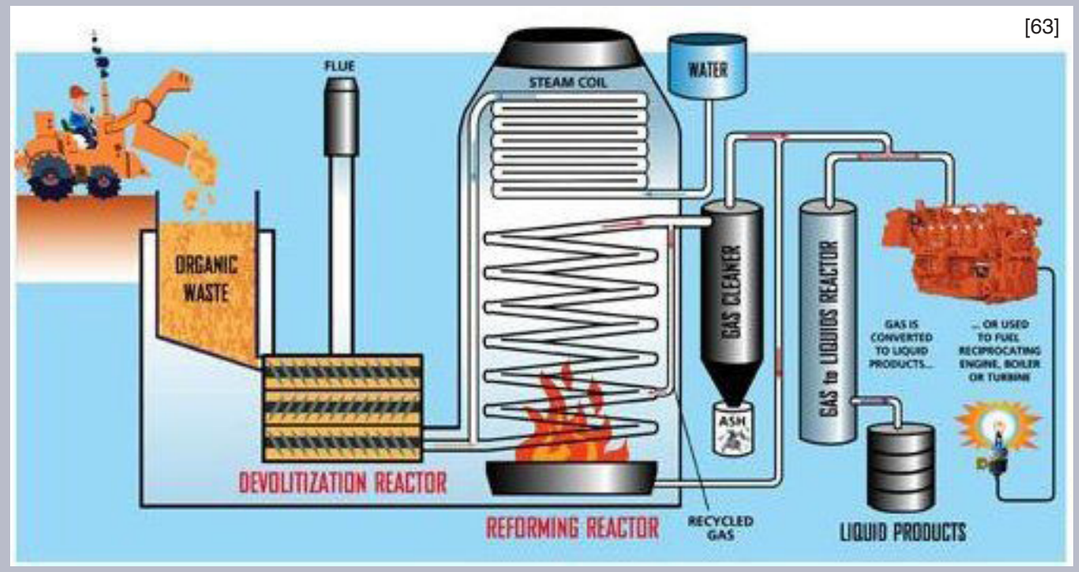
Depending on size, each ship requires a different amount of power.

Extremely expensive and inefficient

Biomass Power

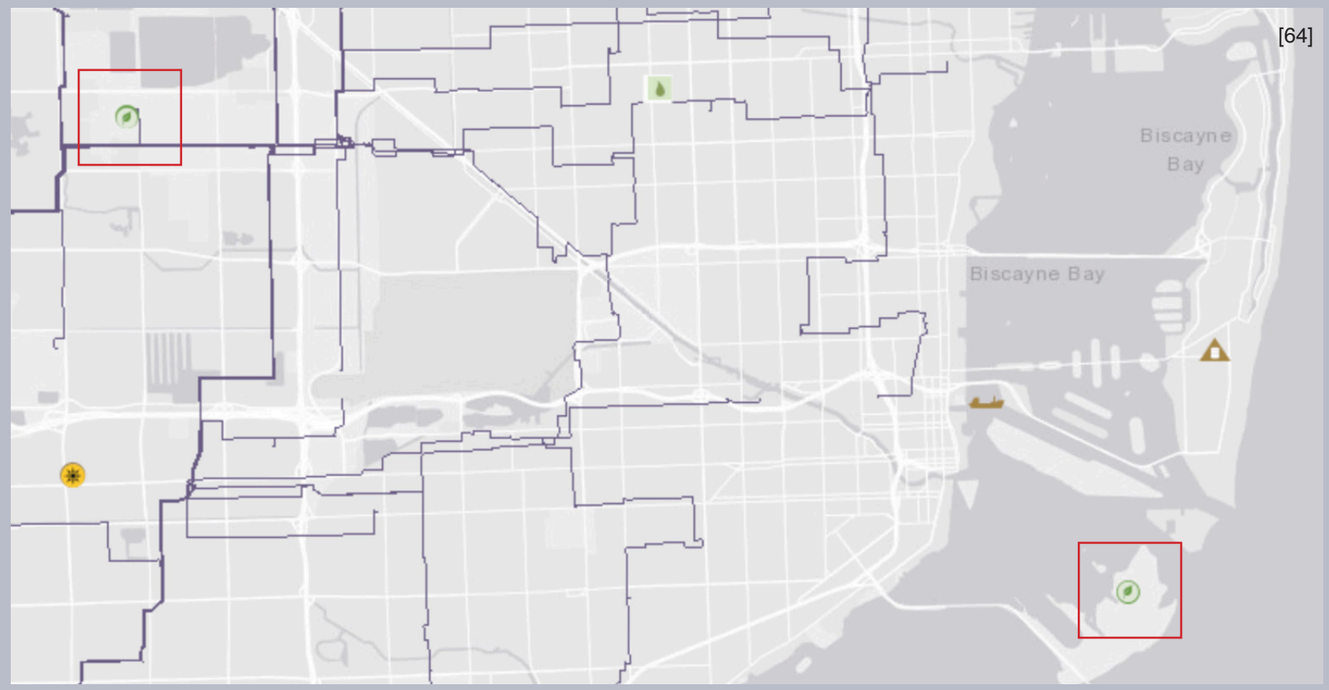
Biomass power is generated from burning renewable organic waste that would otherwise be dumped in landfills, openly burned, or left as kindling for forest fires. This process is not completely emission free, but it is a carbon neutral sustainable energy source.

[63]



Florida has more biomass resources than any other state, and it also produces more biomass electricity than any other state.
Virginia Key generates 4.8 MW of electricity from biomass but uses more than that for the water treatment plant.
The biomass plant located in Hialeah generates 72.6 MW of renewable electricity.
If energy comes from a biomass source, shore power can be sustainable.

[64]



Wind Power

Wind is NOT an efficient option for Florida

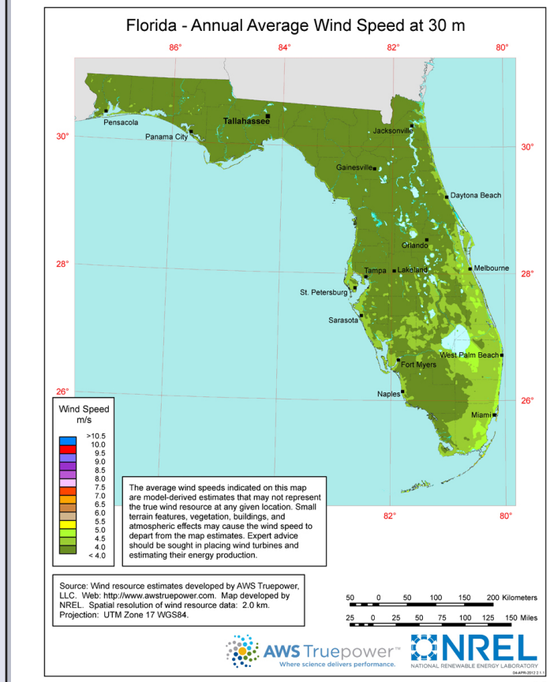
According to the U.S. Department of Energy, for wind energy to be a viable option, an area needs to see wind speeds with an annual average of 6.5 meters per second at a height of 80 meters. Florida does not meet this measurement, averaging just 4 meters per second.

According to a 2015 Energy Department report, for a Florida turbine to be efficient, the heights would have to be enormous — up to 460 feet tall, and with 200-foot blades, for a total height of 660 feet when one of the blades is pointing up.
This is the equivalent to three time the height of the Statue of Liberty.

Wind in Florida is not strong enough to make wind power an efficient option.

Little to no data on wind power generation capacity in Florida is available. This is due to the fact that there are little to no turbines in the entire state.

NextEra Energy, the parent company of FPL, claims to be the biggest owner of wind energy in North America. But FPL declined to conduct a major test of wind energy and has not opted to import wind-generated electricity.



[65]

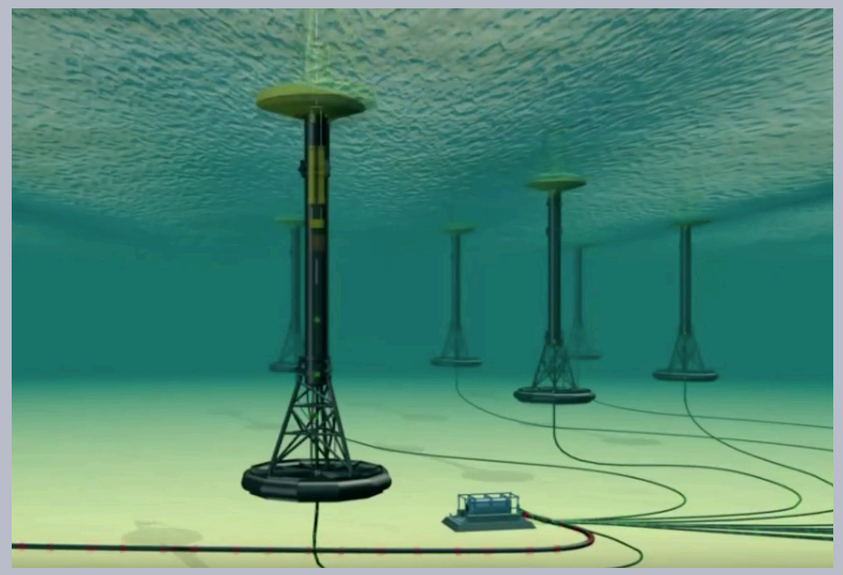
Water Power

Water is the best option for the future

Wave Power

Florida's thousands of miles of coastline has the potential to generate 5.1 gigawatts of power. Power Buoy's are systems that generate electricity as they rise and fall, following the wave current. About 20 Buoys (5000 sf) has the ability to generate 50 Kilowatts. This is a generally new technology, planning to see more commercial applications over the next 5 years.

Installing wave power systems offshore could be a viable option to generate sustainable electricity for shore power.



Tidal Power

Tidal energy is generated by using naturally flowing ocean currents to spin turbines. Recently, Florida Atlantic University was granted permission to install the world's first ocean current energy test site. They estimate that the Gulf Stream could yield as much energy as several nuclear plants. Installing multiple anchored floating test berths 13 miles offshore from Broward County, this is an important step in research. If successful, a single 100-foot turbine could generate 13.5 megawatts of power.

A single tidal wind turbine could generate enough electricity to power one maybe two cruise berths. Multiple turbines have the potential to generate enough electricity to power 1/3 of Florida.

$ Financing

Passenger Tax

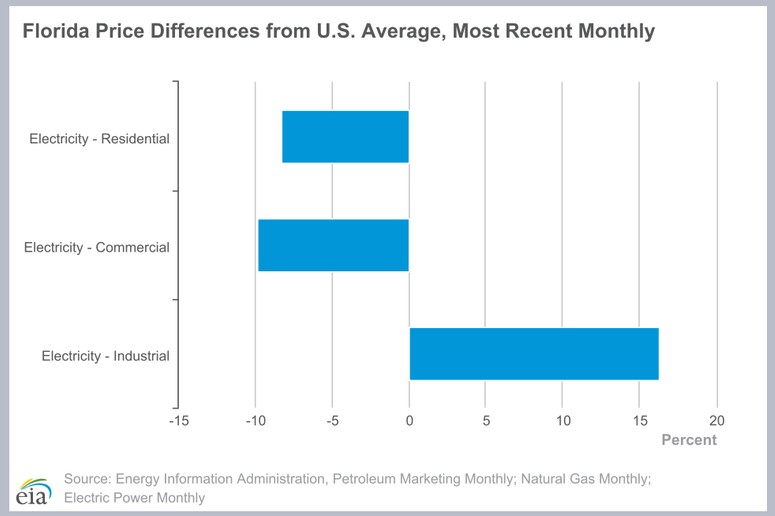
Charging a passenger tax on all people who arrive and depart on cruise ships is an easy way to generate funding for shore power. The Port of Miami generates more cruise traffic than any other port in the world.

Charging each passenger 1 dollar could generate over $5 million dollars annually. This can be implemented to fund the project before starting, and continue to generate income for the port after it is completed.

Electricity tax

The port could buy electricity from FPL at a discounted rate, and sell it to the cruise lines at a premium rate. Both governed by Miami Dade, deals can be struck easily compared to a privately owned port or utility. After the shore power project is complete, it begins to pay for itself. Other states with higher electricity costs have already received a return on their investment. Cost of electricity in Florida is relatively cheap, and cooperation between both parties can be streamlined through the government.

Shore power costs ranges from $1 to $4 million per berth.



Next Steps

Put pressure on the Port of Miami, FPL, and Miami Dade County to implement shore power.

Spread awareness in local neighborhoods and organizations about Ship pollution

Contact local representatives and get them on board.

Contact congress & Florida State to establish pollution laws.

Attend council and local meetings.

Contact unions to ensure no opposition.

Implement green technology as the advancements catch up

Begin charging passenger or electricity tax to raise funding for shore power

Corona Virus

While conducting my research for this project, the COVID-19 pandemic struck the world. The cruise industry is experiencing a major negative impact from this unexpected disease. The passengers of cruise ships, due to their densely packed population, have experienced numerous cases of Coronavirus. Now being turned away by ports, these cruise ships have gained an immensely negative perception over the last few months.

Effects:

- No financial contribution from the cruise industry
- Cruise industry reputation will take years to recover
- Boats that are turned away from ports are forced to idle at sea

Conclusion

While working on the MSC Cruise Terminal project. I noticed millions of dollars being invested into a number of other new terminals. All cruise ships that visit the Port of Miami idle their auxiliary engines while at port, across all terminals. These engines emit harmful pollutants directly into the adjacent residential neighborhoods and are significant contributors to air pollution. As an alternative, Shore Power can be used by these ships, allowing them to turn off their auxiliary engines while at-dock and plug into the local electricity grid.

Based on functioning precedents, the most efficient layout for shore power at the Port of Miami is shown in the solution chapter. Each terminal having a centralized connection point and a mobile cruiser, allows any ship with shore power ability to connect. Laying a duct channel before the MSC Terminal is built will save a significant amount of installation cost.

My research has shown that the auxiliary engines running at berth, are creating significant emissions that are major contributors to air pollution. More specifically, the exposure to air pollution associated with emissions from these cruise ships can contribute to significant human health problems. However if implemented correctly, overall pollutant emissions from ships can be reduced by up to 98% when using shore power from a green energy source. This technology is a viable option for the Port of Miami.

Works Cited

[1] Miami-Feelings, Jake @jakerybu. “Miami, Florida .” *Miami Feelings*, 12 Nov. 2019, images.miamifeelings.com/post/189010315041/miami-florida-jake-jakerybu.

[2] Miami-Feelings, Tom Roche @offshoretom. “Miami, Cruise Capital of the World .” *Miami Feelings*, 7 Nov. 2019, images.miamifeelings.com/post/188875819771/miami-cruise-capital-of-the-world-tom-roche.

[3] “Port of Miami at Sunset Calder in 2020: Places to Travel, Miami Sunset, Beautiful Sunset.” *Pinterest*, 17 Mar. 2020, www.pinterest.com/pin/729583208369800844/.

[4] “Prinzessin Victoria Luise.” *Wikipedia*, Wikimedia Foundation, 15 July 2019, en.wikipedia.org/wiki/Prinzessin_Victoria_Luise.

[5] “State Of The Cruise Industry Outlook 2020.” *Cruise Line Industry Association*, 2020, cruising.org/news-and-research/research/2019/december/state-of-the-cruise-industry-outlook-2020.

[6] Richter, Felix. “Infographic: Where Cruise Ship Passengers Are From & Where They Go.” *Statista Infographics*, 7 Sept. 2017, www.statista.com/chart/10994/origin-of-cruise-ship-passengers-and-primary-destination-of-ocean-cruises/.

[7] “The Economics of Cruise Ships.” *The Hustle*, 7 Apr. 2020, thehustle.co/the-economics-of-cruise-ships/.

[8] “Miami Cruise Ship Terminal Photography” *Getty Images* www.gettyimages.com/photos/port-of-miami?mediatype=photography&phrase=port%2Bof%2Bmiami&sort=mostpopular

[9] *2019-2020 BUDGET AND MULTI-YEAR CAPITAL PLAN*. 2019, www.miamidade.gov/budget/library/fy2019-20/proposed/volume-1.pdf.

[10] kgnadmin. “Analysis: Florida Cruise Statistics by Ports in 2017: Crew Center.” *Analysis: Florida Cruise Statistics by Ports in 2017 | Crew Center*, 2017, crew-center.com/analysis-florida-cruise-statistics-ports-2017.

[11] “Port Miami 2035 Masterplan.” *Port Miami 2035 Masterplan*, 2011, www.miamidade.gov/portmiami/library/2035-master-plan/complete-master-plan.pdf.

[12] “DOWNTOWN Miami, Bayfront Park and Port of Miami Historical Photos Gallery - All Years - Click on Image to View by Don Boyd.” *PBase*, pbase.com/donboyd/memories_downtown.

[13] Dugdale, Magdalena. “The World's Busiest Cruise Ports in Terms of Passenger Volume.” *Ship Technology*, 4 Feb. 2020, www.ship-technology.com/features/worlds-busiest-cruise-ports/.

[14] “Port Miami 2019 Cruise Guide.” *Port Miami 2019 Cruise Guide*, 2019, www.miamidade.gov/portmiami/library/2019-cruise-guide.pdf.

[15] Dolven, Taylor. “PortMiami Is Remaking the City's Skyline for $1.5 Billion, One Cruise Terminal at a Time.” *Miamiherald*, Miami Herald, 4 Nov. 2019, www.miamiherald.com/news/business/tourism-cruises/article236564698.html.

[16] jozo. “Port of Miami Cruise Ship Schedule January-April 2019: Crew Center.” *Port of Miami Cruise Ship Schedule January-April 2019 | Crew Center*, 2018, crew-center.com/port-miami-cruise-ship-schedule-january-april-2019.

[17] Whitefield, Mimi. “Smooth Sailing for PortMiami as It Sets Records for Both Cargo and Cruise Passengers in Fiscal 2018.” *Miamiherald*, Miami Herald, 24 Oct. 2018, www.miamiherald.com/latest-news/article220536140.html.

[18] Kaye, Ken. “Sailing Back in History: A Look at South Florida's Ports.” *Sun*, South Florida Sun-Sentinel, 15 June 2018, www.sun-sentinel.com/local/broward/fl-south-florida-cruise-history-20150821-story.html.

[19] “DOWNTOWN Miami, Bayfront Park and Port of Miami Historical Photos Gallery - All Years - Click on Image to View by Don Boyd.” *PBase*, pbase.com/donboyd/memories_downtown.

[20] “Each Day A Cruise Ship Emits As Much Pollution As A Million Cars.” *Green World Warriors*, 3 May 2019, greenworldwarriors.com/2019/04/19/each-day-a-cruise-ship-emits-as-much-pollution-as-a-million-cars/.

[21] “Air Pollution.” *APES Air Pollution Review - Home*, noair-rors.weebly.com/air-pollution.html.

[22] McCarthy, Niall, and Felix Richter. “Infographic: How Cruise Ship Pollution Compares To Cars.” *Statista Infographics*, 14 June 2019, www.statista.com/chart/18351/emissions-from-cruise-ships-and-cars-in-european-port-cities/.

[23] “Miami-Dade County Air Monitoring.” *Florida Department of Environmental Protection*, floridadep.gov/air/air-monitoring/content/miami-dade-county-air-monitoring.

[24] “Wind Rose Miami.” *Meteoblue*, www.meteoblue.com/en/weather/archive/windrose/miami_united-states-of-america_4164138.

[25] “Data.org.” *Climate*, en.climate-data.org/north-america/united-states-of-america/florida/miami-1641/.

[26] “Oh, and Another Thing .... Greenhouse Gases and Black Carbon (UPDATED: w/ Link to NY Times Article).” *Oh, and Another Thing .... Greenhouse Gases and Black Carbon (UPDATED: w/ Link to NY Times Article)*, www.aviewfromthehook.com/2010/12/oh-and-another-thing-greenhouse-gases.html.

[27] Armstrong, Adam. “‘NO IDLING’ - Facts about Ship Pollution.” *"NO IDLING" - Facts about Ship Pollution.*, 2010, www.aviewfromthehook.com/2010/06/no-idling-facts-about-ship-pollution.html.

[28] “Technical-and-Operational-Measures // .” *Energy Efficiency Measures*, www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Technical-and-Operational-Measures.aspx.

[29] “Air-Pollution Air Pollution // .” *Air Pollution*, www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx.

[30] Comer, Bryan, and Naya Olmer. *The International Council on Clean Transportation*, theicct.org/blogs/staff/end-of-crystal-serenity-voyage.

[31] California Air Resources Board. “Shore Power for Ocean-Going Vessels.” *California Air Resources Board*, ww3.arb.ca.gov/ports/shorepower/shorepower.htm.

[32] “2019 Cruise Ship Report Card.” *Friends of the Earth*, 16 July 2019, foe.org/cruise-report-card/.

[33] “National Port News and Trends.” *A Clean Air Strategy*, cleanports-nynj.com/?tx_category=all.

[34] “Shore-to-Ship Power - Shore-to-Ship Power and Smart Ports.” *ABB*, new.abb.com/substations/port-electrification-and-shore-to-ship-power/shore-to-ship-power.

[35] “ShoreBoX.” *Schneider Electric*, www.se.com/ww/en/product-range-presentation/61396-shorebox/#tabs-top.

[36] “Home.” *Cavotec SA*, www.cavotec.com/en/your-applications/ports-maritime/shore-power/shore-power-systems-for-ports.

[37] “Our ShoreBoX™ Solution: Plug in to Green Power.” *Our ShoreBoX™ Solution: Plug in to Green Power | Schneider Electric*, www.se.com/ww/en/work/solutions/for-business/marine/shorepower.jsp.

[38] “STEMMANN TECHNIK.” *STEMMANN*, www.stemmann.com/en/products/onshore_power_supply/shore_connect_for_cruise_line_ships.

[39] DOW, TOM. *AAPA CRUISE SEMINAR*. 2005, aapa.files.cms-plus.com/2017Seminars/17Cruise/Dow_Thomas.pdf.

[40] BROWN, DEAN, et al. “CRUISE SHIP SHORE POWER PROJECTS.” *CRUISE SHIP SHORE POWER PROJECTS*, 2006, cmanc.com/web/presentations/ShipOwnersPerspective/Brown-Watts-Thunem.pdf.

[41]“AAPA CRUISE SEMINAR.” *CARNIVAL CORPORATION*, 2017, aapa.files.cms-plus.com/2017Seminars/17Cruise/Dow_Thomas.pdf.

[42] Hall, William J. “Assessment of CO2 and Priority Pollutant Reduction by Installation of Shoreside Power.” *Resources, Conservation and Recycling*, Elsevier, 7 Nov. 2009, www.sciencedirect.com/science/article/abs/pii/S0921344909002262.

[43] “Free Styles for Google Maps.” *Snazzy Maps*, snazzymaps.com/build-a-map.

[44] Cruises. “Princess Cruises: Princess Ships Clear the Air with Shore Power Connections.” *Www.princess.com*, 31 July 2019, www.princess.com/news/backgrounders_and_fact_sheets/factsheet/Princess-Ships-Clear-the-Air-with-Shore-Power-Connections.html.

[45] “Port Strategy: Making a Connection.” *Port Strategy. Insight for Marine Technology Professionals*, 2014, www.portstrategy.com/news101/port-operations/planning-and-design/breaking-boundaries-in-shoreside-power.

[46] Sciberras, Edward A., et al. “Electrical Characteristics of Cold Ironing Energy Supply for Berthed Ships.” *Transportation Research Part D: Transport and Environment*, Pergamon, 25 June 2015, www.sciencedirect.com/science/article/pii/S1361920915000796.

[47] “Shore-Port-To-Ship Power Converter Systems.” *Ports Using Cold-Ironing - Shore Port to Ship Power Converter Systems*, 2007, www.shoreportshippower.com/portsusingcoldironing.html.

[48] “Cold Ironing.” *United States Cold Ironing - Cold Ironing Electric Power Converters*, www.coldironing.us/unitedstatescoldironing.htm.

[48] “From the EPA: IMO Adopts Proposal for USA ECA ... Let Me Explain.” *From the EPA: IMO Adopts Proposal for USA ECA ... Let Me Explain.*, www.aviewfromthehook.com/2010/03/from-epa-imo-adopts-proposal-for-usa.html.

[49] “Vessel Shore Power • Friends of the Earth.” *Friends of the Earth*, 26 Apr. 2019, foe.org/vessel-shore-power/.

[50] “Port Strategy: Making a Connection.” *Port Strategy. Insight for Marine Technology Professionals*, www.portstrategy.com/news101/port-operations/planning-and-design/breaking-boundaries-in-shoreside-power.

[51] Grey, Eva. “Shore-Side Power: a Key Role to Play in Greener Shipping.” *Ship Technology*, 10 Nov. 2017, www.ship-technology.com/features/featureshore-side-power-a-key-role-to-play-in-greener-shipping-4750332/.

[52] “The Motorship: Taking Shore Side Power to the next Level.” *The Motorship | Taking Shore Side Power to the next Level*, www.motorship.com/news101/industry-news/taking-shore-side-power-to-the-next-level.

[53] “The Progress of Cold Ironing Worldwide.” *GreenPort*, 2013, www.greenport.com/news101/Products-and-Services/the-progress-of-cold-ironing-worldwide.

[54] Norsworthy, Marcelo. “Researchers Highlight Air Quality Ideas for Ports.” *Texas Clean Air Matters*, 25 Jan. 2016, blogs.edf.org/texascleanairmatters/2016/01/25/researchers-highlight-air-quality-ideas-for-ports/.

[55] “CBJ-Dock-Electrification-POJ-Cruise-Ship-Berths-Shore-Tie-Power-Study-Fi... (1).Pdf.” *Google Drive*, Google, 2016, drive.google.com/file/d/1UAIJRSqlY5ucXYZY4Q8Zu8WGhva0-DOJ/view.

[56] “Alternative Maritime Power® (AMP®).” *Alternative Maritime Power (AMP) | Air Quality | Port of Los Angeles*, www.portoflosangeles.org/environment/air-quality/alternative-maritime-power-(amp).

[57] Hardcastle, Jessica Lyons. “Ports Power Docked Ships with Electricity.” *Environment + Energy Leader*, 23 May 2013, www.environmentalleader.com/2013/05/ports-power-docked-ships-with-electricity/.

[58] “Port Strategy: Making a Connection.” *Port Strategy. Insight for Marine Technology Professionals*, 2014, www.portstrategy.com/news101/port-operations/planning-and-design/breaking-boundaries-in-shoreside-power.

[59] Lisa. “How Cruise Ships Bring 1,200 Tons of Toxic Fumes to Brooklyn a Year.” *The New York Times*, The New York Times, 26 Dec. 2019, www.nytimes.com/2019/12/26/nyregion/cruise-ship-exhaust-shore-power-nyc.html.

[60] Nandan, Gita. “Shore Power.” *Resilient Red Hook*, Resilient Red Hook, 21 Apr. 2018, www.resilientredhook.org/initiatives/shore-power.

[61] Collins, Lisa. “State Stalls on Brooklyn Air Pollution.” *South Brooklyn Post | News & Culture in Carroll Gardens, Cobble Hill, Boerum Hill, Gowanus, Red Hook and Points Nearby*, 2014, southbrooklynpost.com/2010/11/cruise-ship-air-pollutio/.

[62] January 13, 2020·45 Comments. “Ships Docked At PortMiami Are Spewing Thousands Of Tons Of Pollution Into Miami's Air, But Shore Power Still Isn't Being Built.” *The Next Miami*, 13 Jan. 2020, www.thenextmiami.com/ships-docked-at-portmiami-are-spewing-thousands-of-tons-of-pollution-into-miamis-air-but-shore-power-still-isnt-being-built/.

[63] Laumer, John. “Tallahassee Florida USA Plans 35MW Wood Powered Gas & Electric Plant.” *TreeHugger*, Treehugger, 11 Oct. 2018, www.treehugger.com/renewable-energy/tallahassee-florida-usa-plans-35mw-wood-powered-gas-electric-plant.html.

[64] “U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” *Florida - State Energy Profile Overview - U.S. Energy Information Administration (EIA)*, www.eia.gov/state/?sid=FL#tabs-4.

[65] Sweeney, Dan. “Why Doesn't Florida Use More Wind Energy?: You Asked, We Answer.” *Sun*, South Florida Sun-Sentinel, 7 Jan. 2019, www.sun-sentinel.com/news/sound-off-south-florida/fl-ne-hk-wind-energy-20190103-story.html.