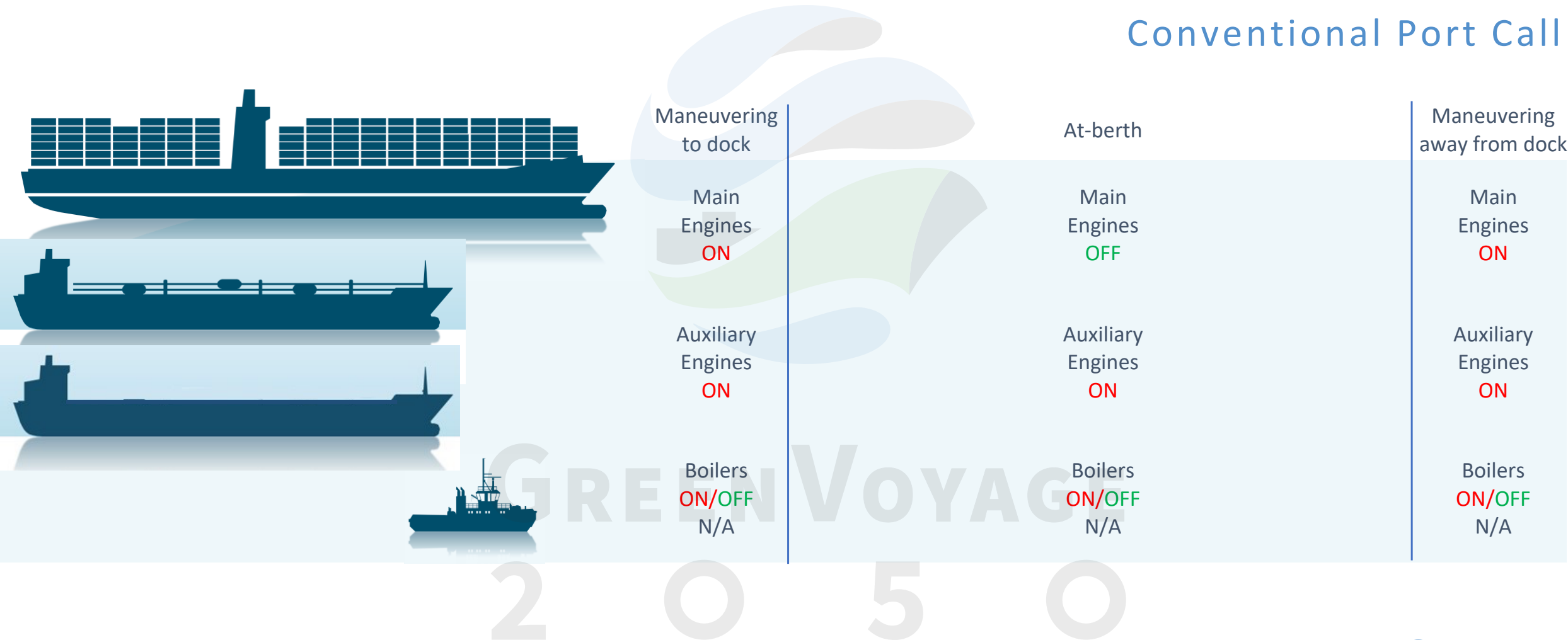
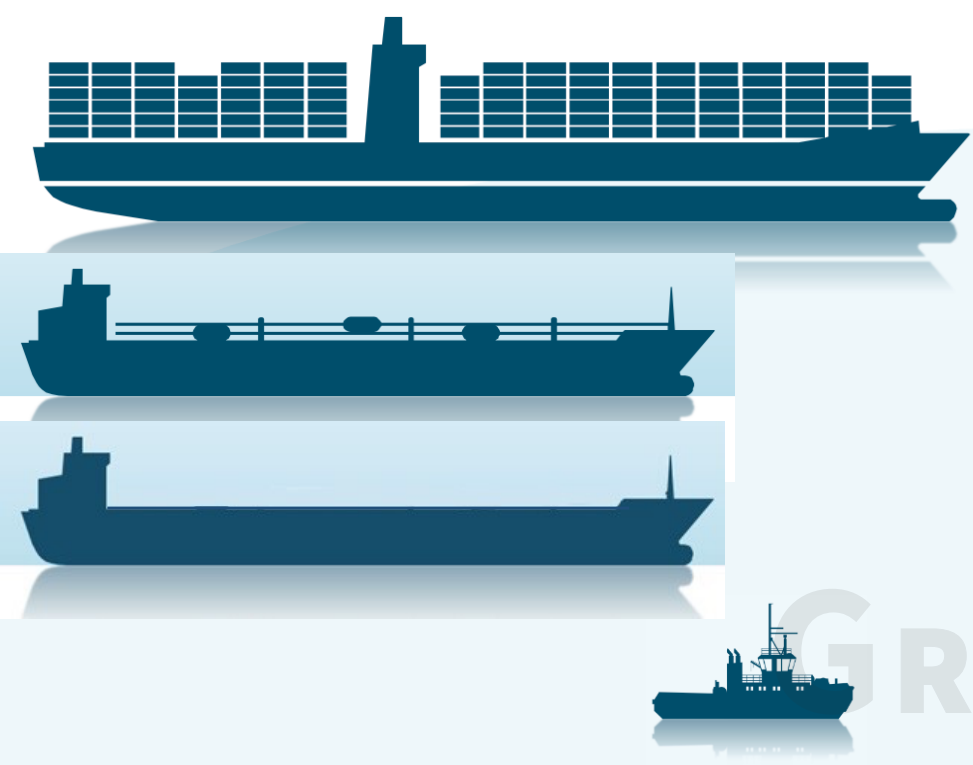


What's the basic concept?



What's the basic concept?

OPS Port Call



Maneuvering to dock	Connect	At-berth Connected	Disconnect	Maneuvering away from dock
Main Engines ON	Main Engines OFF	Main Engines OFF	Main Engines OFF	Main Engines ON
Auxiliary Engines ON	Auxiliary Engines ON	Auxiliary Engines OFF - Energy from Grid	Auxiliary Engines ON	Auxiliary Engines ON
Boilers ON/OFF N/A	Boilers ON/OFF N/A	Boilers ON N/A	Boilers ON/OFF N/A	Boilers ON/OFF N/A

GREEN VOYAGE
2050



Brief history

- Has its origins with military & commercial ships that spend long periods of time at berth
- First regulated in 2001 in Alaska related to opacity limits from the funnels of cruise ships berth in Alaska
- Was a condition agreed to in the settlement of a law suit for a terminal expansion project at the Port of Los Angeles → first container ship application
- Was put in by cruise lines Seattle in 2005 because of the favorable business case (cost of shore-side electricity was well below equivalent fuel costs at the time)
- Was first broadly regulated as an air quality emission reduction strategy for container, reefer, & cruise by the California Air Resources Board (CARB) in 2007; amended & expanded to RoRo (2025) & tankers (2027)
- Has since blossomed in North America, Europe, & Asia in both regulatory & voluntary emission control strategies
- China will require its use since October 2022, if the ship has OPS onboard & calls in Domestic Emission Control Areas (DECAs)
- Has more recently become a GHG emissions reduction strategy, which can have mixed results depending on how clean the grid/energy generation fuel

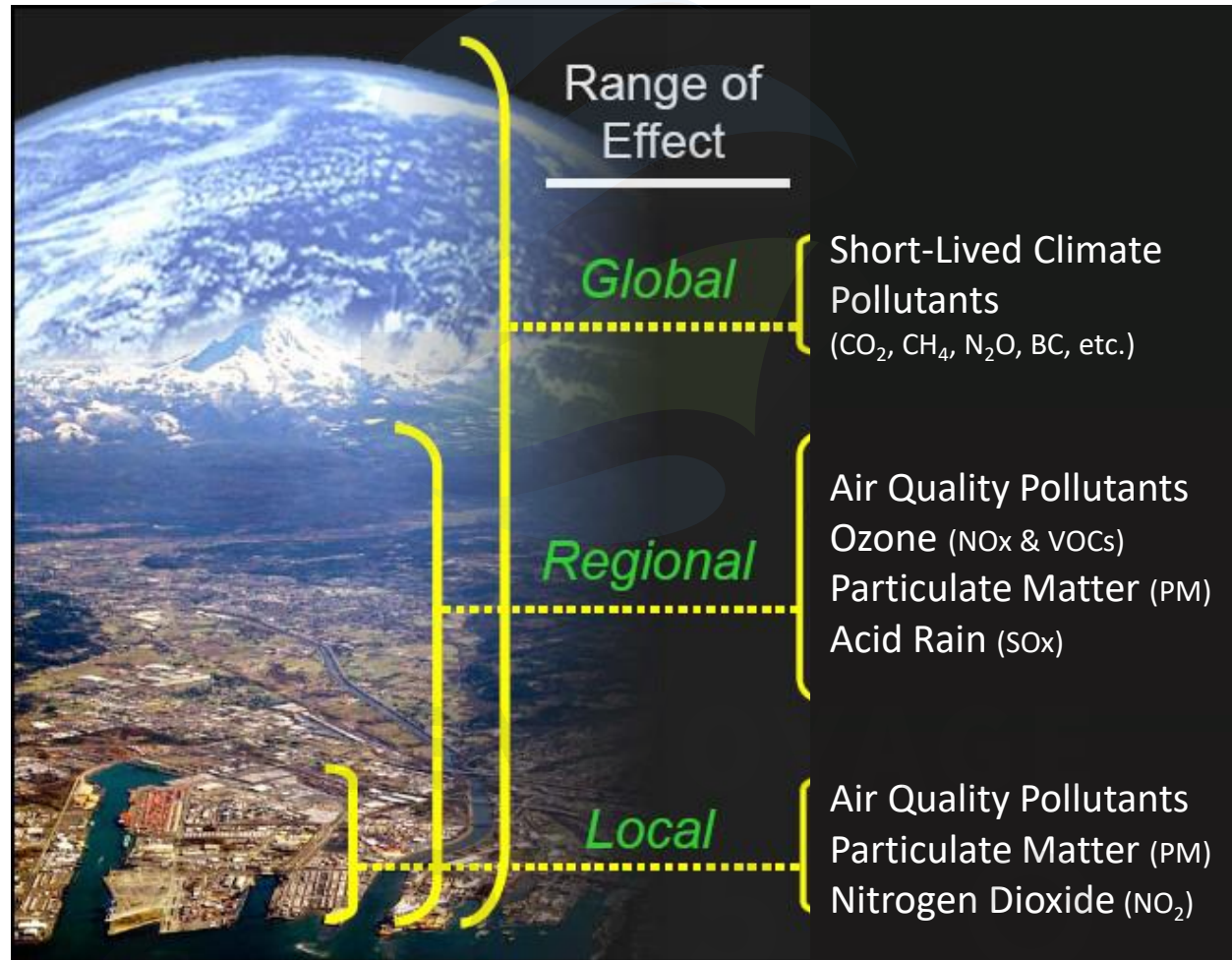
IMO does not mandate or have any regulations related to OPS



©Rinske van der Meer, Port of Rotterdam, 2022



Air Quality & Greenhouse Gases 101



Common drivers

- Regulation
- Business case
- Stakeholders
 - Public/neighbours
 - Government
 - Local
 - State
 - Regional
 - National
 - Multinational
 - NGOs
 - Tenants
 - Ship owners/operators
 - Port boards
- Proactive reduction in impacts/social responsibility/license to operate
-



What's involved?

- OPS is considered a vessel + port-based emission reduction strategy
 - For OPS to work, both the vessel & port/terminal need to have equipment
- Port/terminal side OPS types
 - Grid-based – requires port infrastructure to connect the vessel to the electrical grid
 - Non Grid-based – can be a variety of options including: alternative fuelled generators, battery banks, fuel cells, battery swapping, etc.
- Vessel side OPS
 - Both types require infrastructure on-board a vessel to connect to land side OPS to transfer power, recharge batteries, or replace batteries to/on the vessel



©Port of Los Angeles, 2021



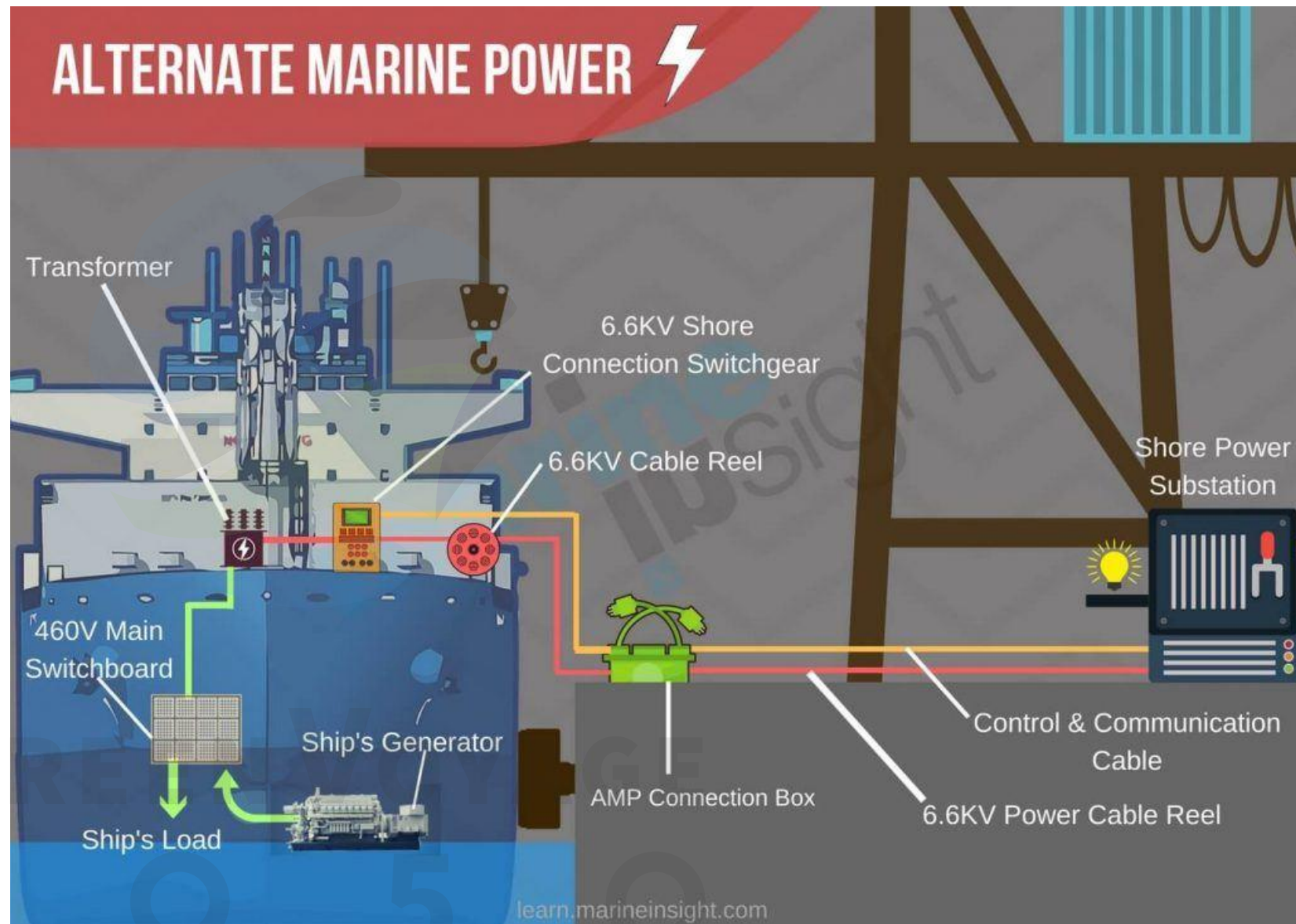
<https://www.becker-marine-systems.com/products/product-detail/becker-lng-powerpac.html>



What's involved?

Grid-based

- Port/terminal Infrastructure
 - Low/high voltage grid connection to port
 - Low/high voltage power substation at port
 - Frequency and voltage converters
 - Transformers & power conditioning equipment
 - Control panels & connection vaults
 - Cable connectors (fixed, mobile, barged mounted, etc.)
- Ship Infrastructure
 - Control panels
 - Conduit access
 - Transformers
 - Connection switch gear
 - Cable reel /management system



<https://www.marineinsight.com/marine-electrical/what-is-alternate-marine-power-amp-or-cold-ironing/>



Technical standards

- Low voltage shore connection (LVSC) systems **220-480 V** **Loads <1 MW**
 - Applicable ISO Standard: IEC/PAS 80005-3:2014 Standard is in the process of being updated
- High voltage shore connection (HVSC) systems **6.6 kV or 11 kV up to 20MVA** **Loads ≥1 MW**
 - Applicable ISO Standard: IEC/IEEE 80005-1:2019 Standard is published with two amendments:
IEC/IEEE 80005-1:2019/Amd 1:2022 Published
IEC/IEEE 80005-1:2019/AWI Amd 2 Underdevelopment
- Ship onboard frequencies 50 or 60 Hz
 - Most ships are 60 Hz
 - Frequency converter to 60 Hz for Ports supplied by 50 Hz grid power

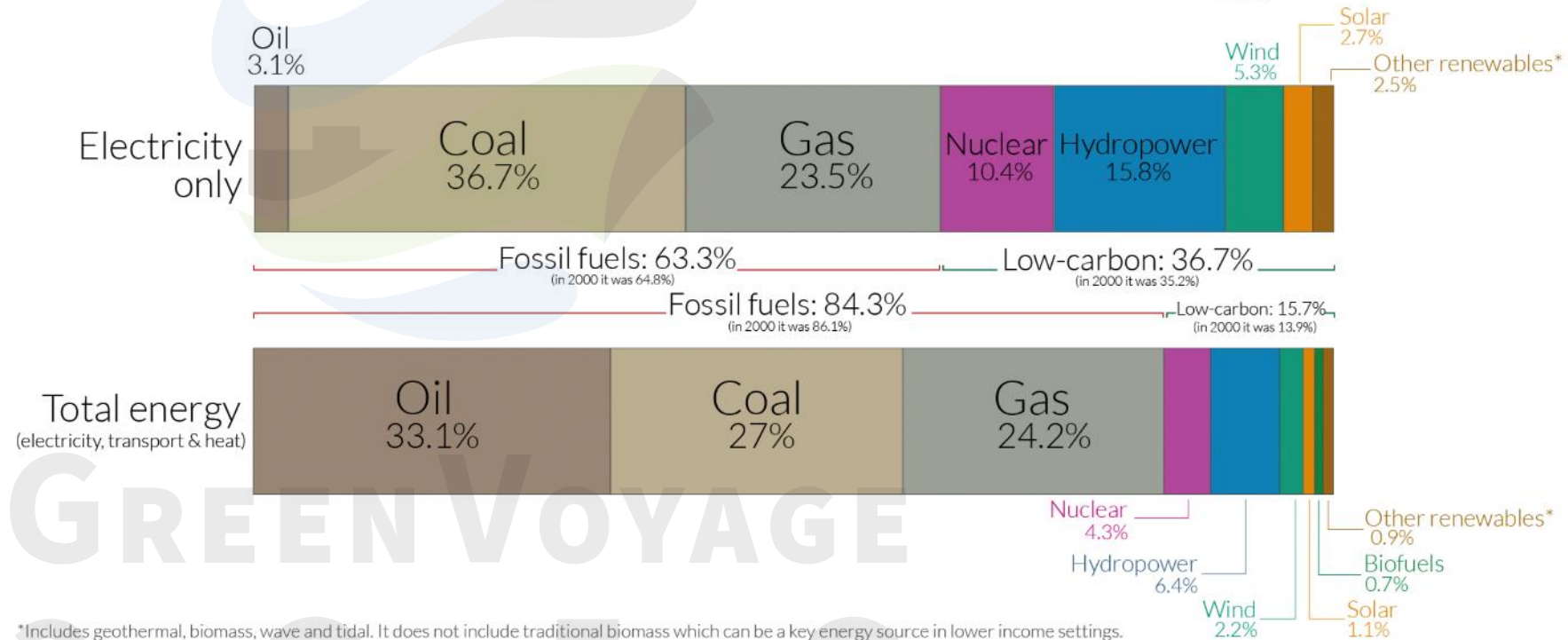


How clean is your grid?

- Grid emissions
 - How clean is the grid that will power the ships?
 - The grid is not always cleaner than onboard generation.
 - Depending on the target pollutant or GHG, it is important to determine the emission rates.
 - Utility/power providers may provide their generation mix & emission rates for pollutants + GHGs

More than one-third of global electricity comes from low-carbon sources; but a lot less of total energy does

Our World
in Data



*Includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Our World in Data based on BP Statistical Review of World Energy (2020). Based on the primary energy and electricity mix in 2019.

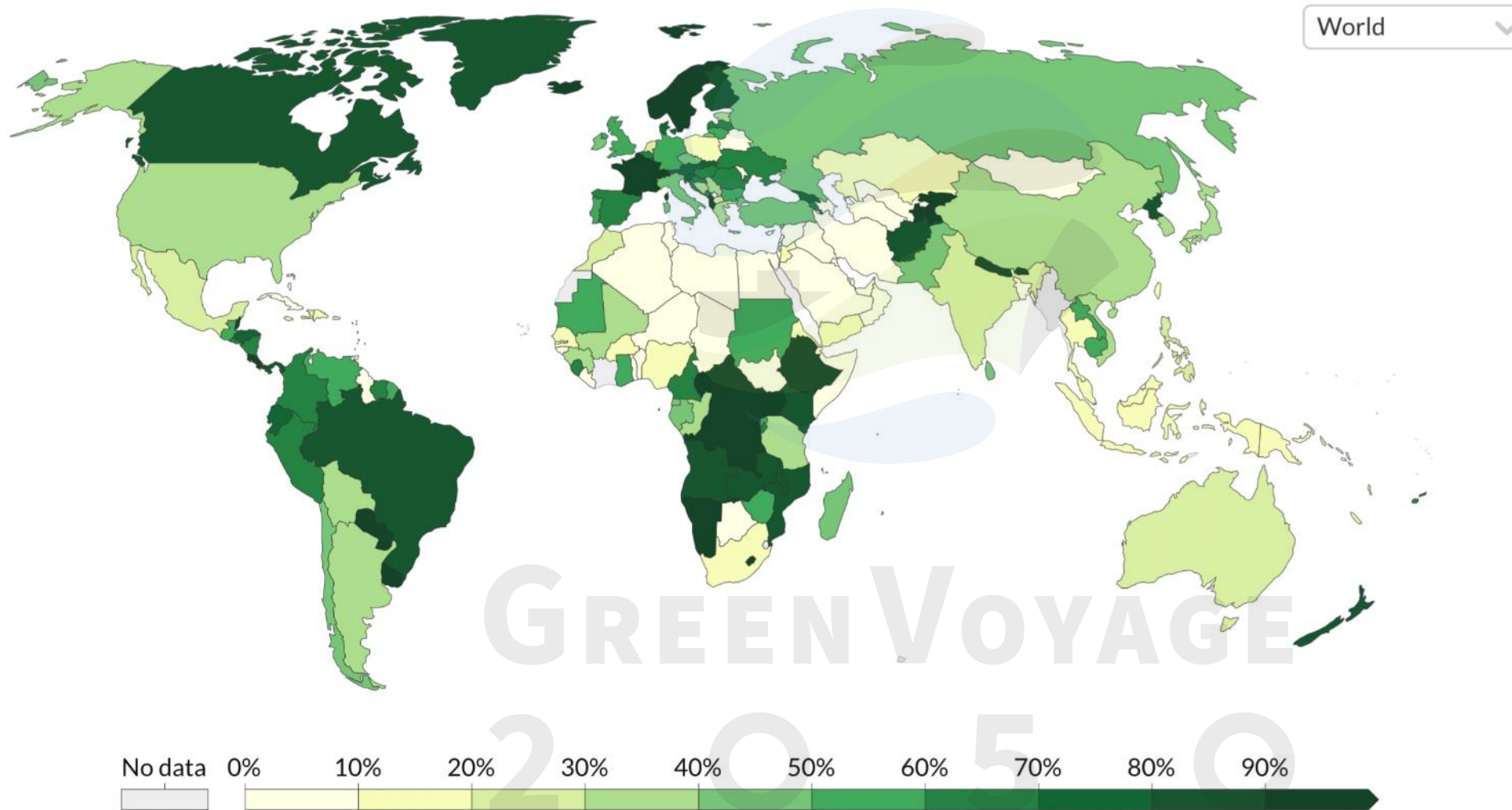
Licensed under CC-BY by the author Hannah Ritchie.



Share of electricity from low-carbon sources, 2020

Low-carbon electricity is the sum of electricity from nuclear and renewable sources (including solar, wind, hydropower, biomass and waste, geothermal and wave and tidal).

Our World
in Data

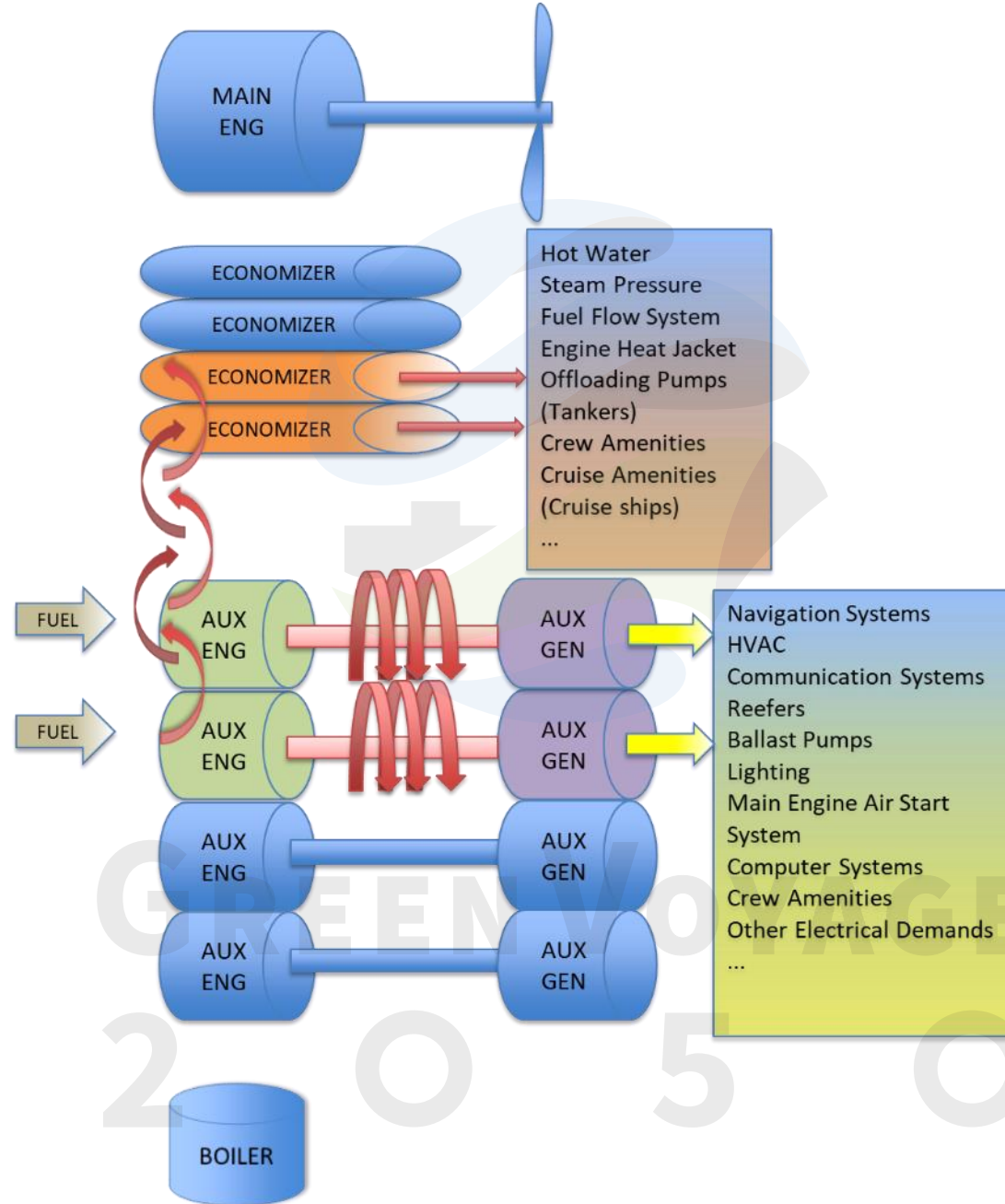


Source: Our World in Data based on BP Statistical Review of World Energy & Ember (2021)

CC BY



What is the emission reduction premise?

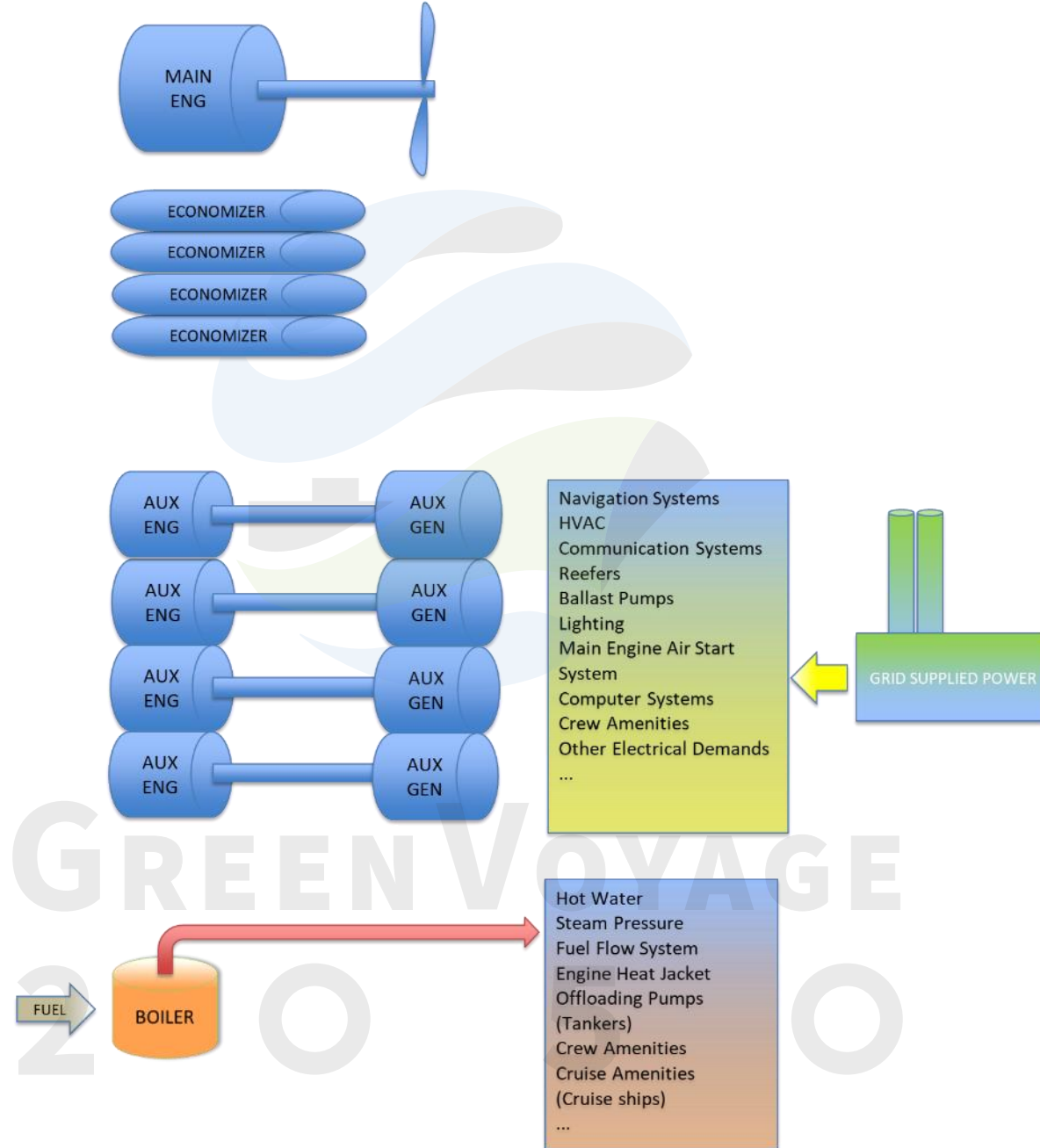


Conventional Port Call

Blue – equipment off
Colored – equipment on



What is the emission reduction premise?



OPS Port Call

Blue – equipment off
Colored – equipment on



Strengths & limitations

Grid-based

Strengths

- ◎ Reduces all auxiliary engine emissions while connected to OPS at-berth
- ◎ Technical standards exists for OPS which minimized compatibility uncertainty
- ◎ OPS has been in use for nearly two decades for cruise & a broadening number of ship types
- ◎ Low voltage systems are significantly less expensive than the high voltage systems
- ◎ Works well with frequent calling ships
- ◎ Benefits depend on how clean the grid supplying the power is compared to onboard generation

Limitations

- ◎ Does not eliminate ship emissions while at-berth (aux engines run during c/d time & boilers operate)
- ◎ High voltage systems can typically be one of the most expensive emission reduction strategies for ships (both capital & O&M)
- ◎ Port & Ship-based strategy, which means both Ports & ships need to have the equipment in place prior to arrival in order for the strategy to work
- ◎ Does not work for non-frequent calling ships
- ◎ Benefits depend on how clean the grid supplying the power is compared to onboard generation



Strengths & limitations

Non grid-based vs grid-based

Strengths

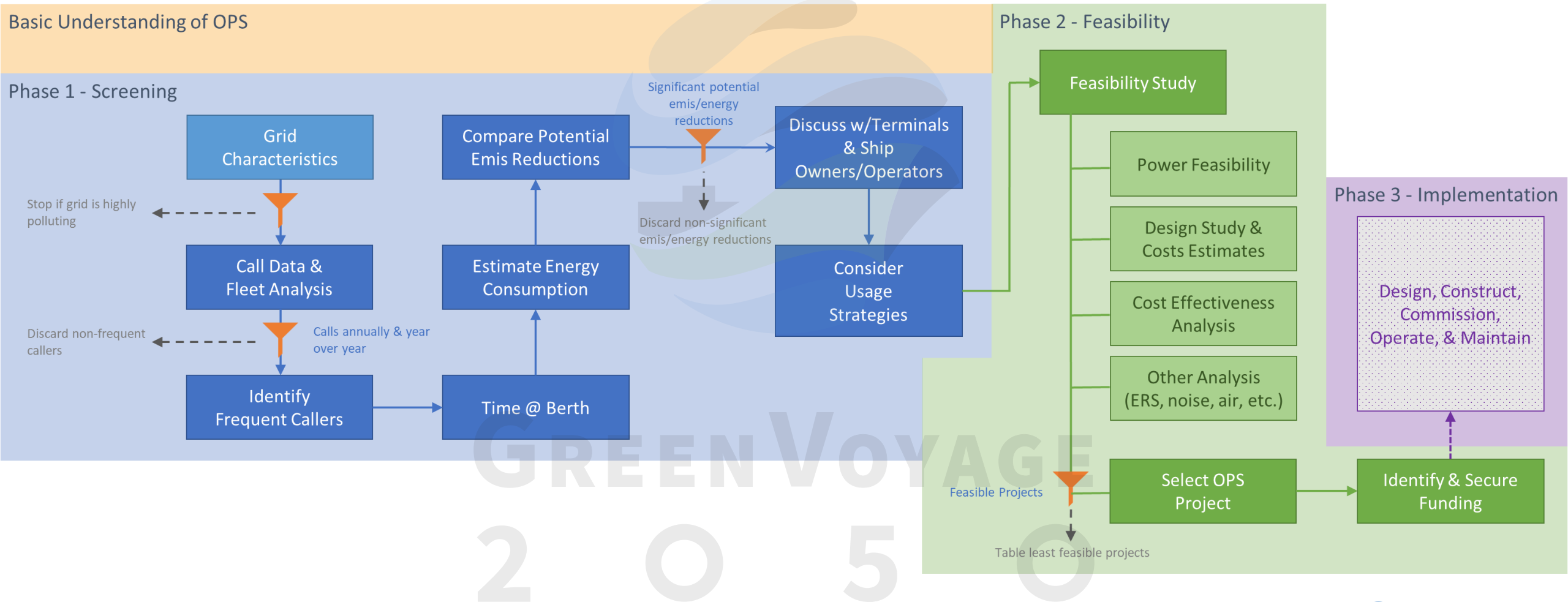
- © Can significantly reduce infrastructure capital costs compared to grid-based OPS
- © Benefits depend on how clean the non grid power source is compared to onboard generation
- © Can be relatively easily repositioned on the terminal or to another terminal
- © The system could be maintained by the equipment provider
- © The system could potentially leased instead of purchased

Limitations

- © Requires a dependable supply of alternative energy source/fuel to power generators, recharge batteries, etc.
- © Benefits depend on how clean the non grid power source is compared to onboard generation
- © Terminal space may not be available for the system
- © Noise on terminal from power generation
- © Third-party costs maybe uncertain over time & market is just emerging

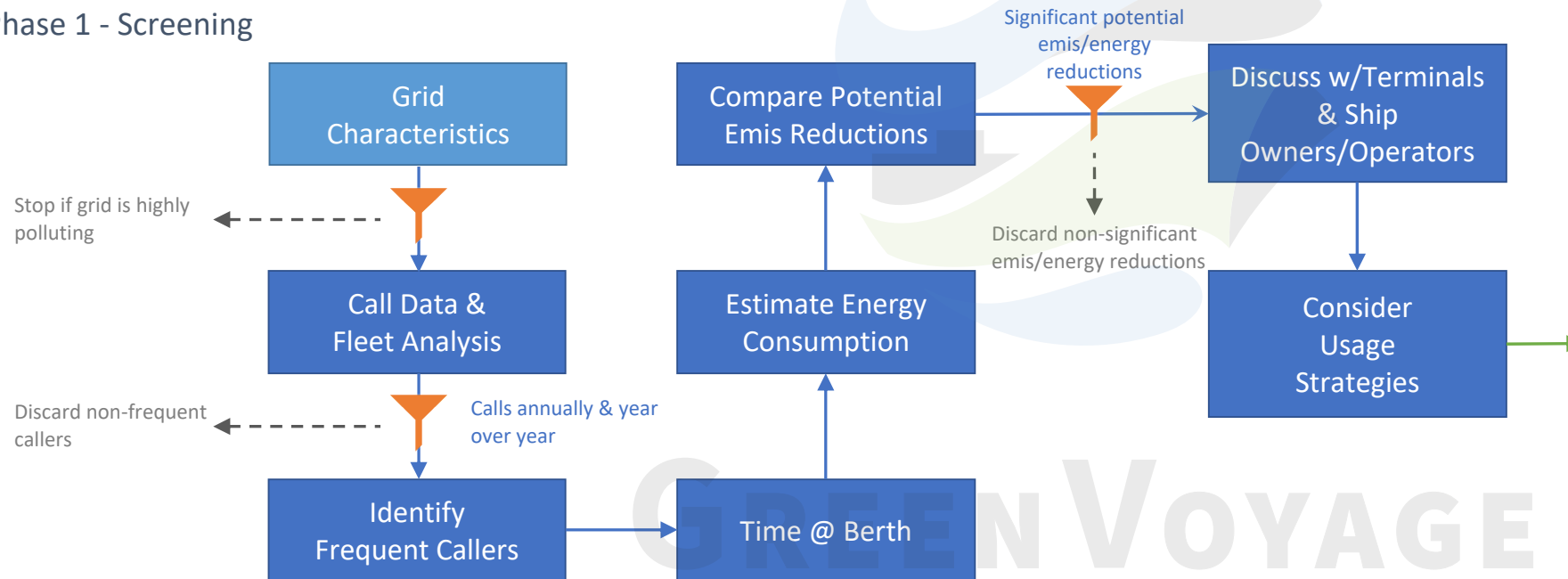


Phased port/terminal approach



Phase 1 - Screening

Phase 1 - Screening



- How clean is your grid?
- Are there any frequent calls?
- What are the characteristics of the fleets calling your port?
- What are the potential emission reductions?
- What are the terminals & shipping lines thinking?
- Which implementation options are available?



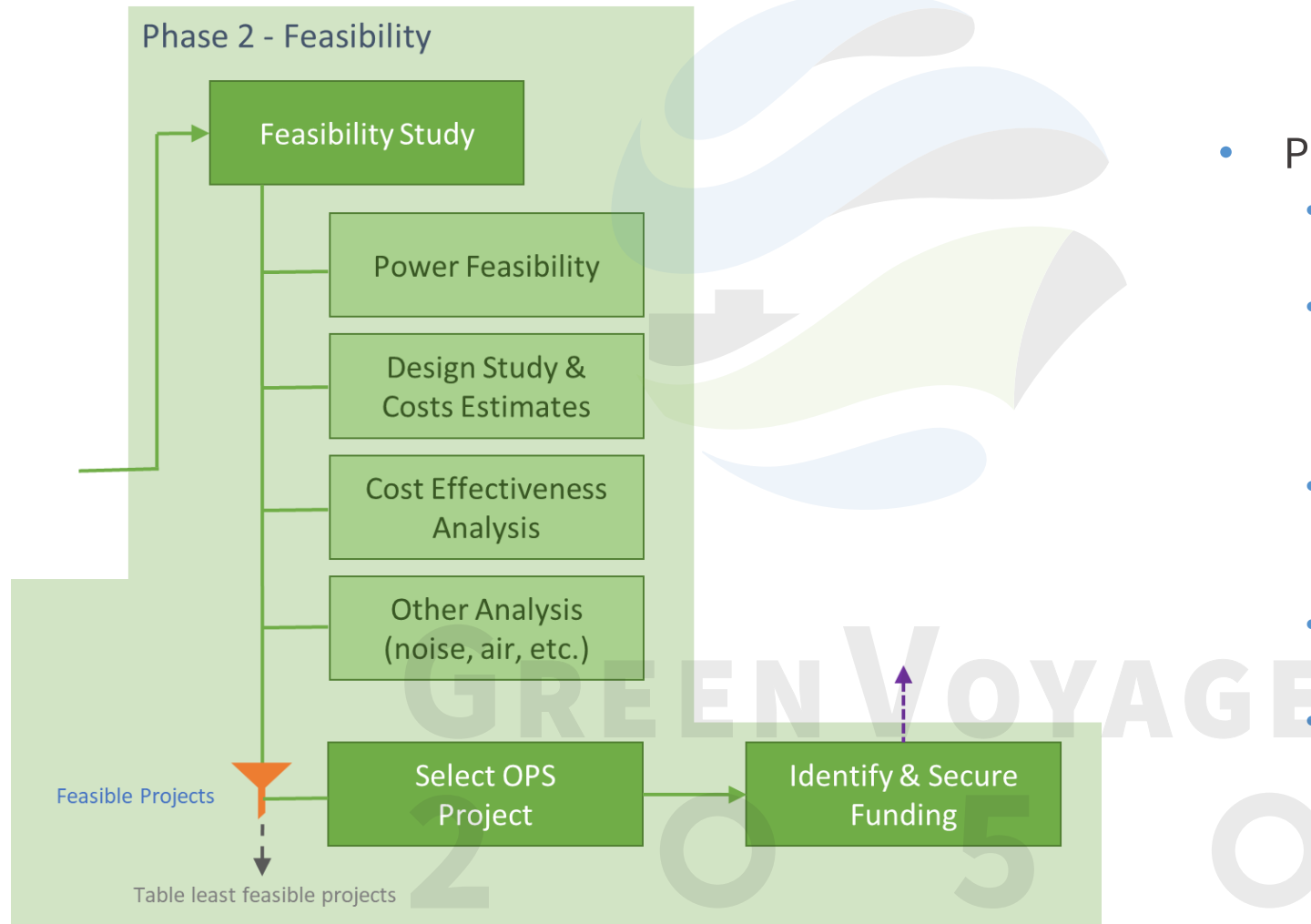
Usage strategies

- How do you ensure OPS usage?
 - *Regulations*
 - *Incentives*
 - *Port requirements*
 - *Appeal to the business case*
 - *Appeal for environmental stewardship*
 - ...



©Rinske van der Meer, Port of Rotterdam, 2022

Phase 2- Feasibility



- Phase 2 – Feasibility
 - Select various project scenarios
 - Discuss project scenarios with terminals & shipping lines associated with frequent calling ships
 - Identify which feasibility studies are needed to evaluate projects
 - Evaluate costs on both port-side & ship-side
 - Baby steps



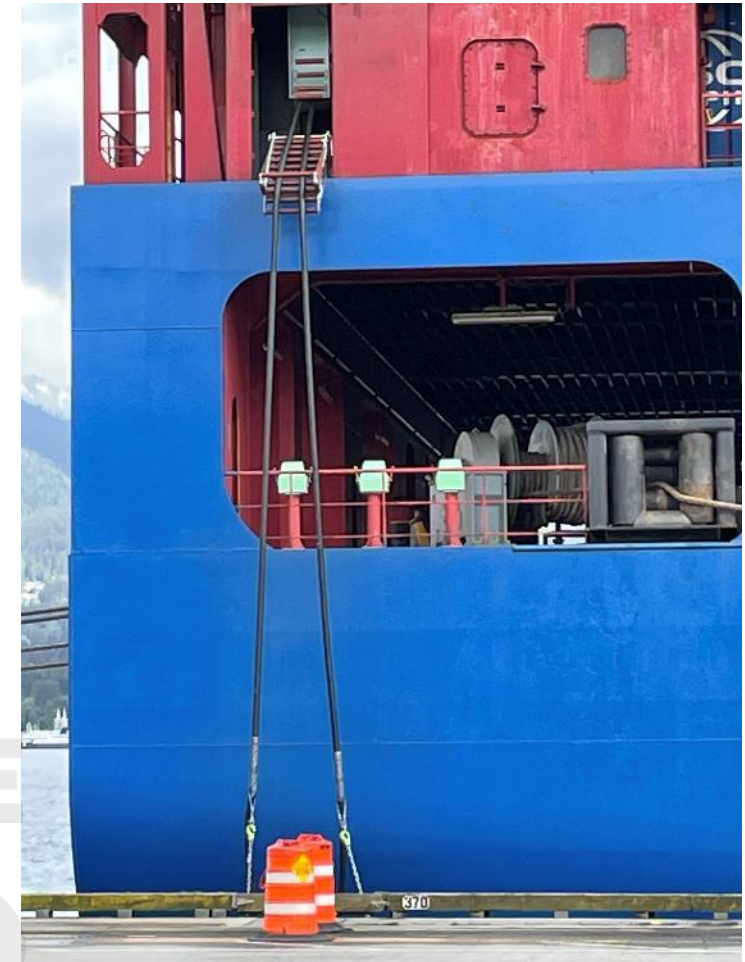
Phase 3 - Implementation

- Phase 3 - Implementation

- Final Designs
- Permitting
- Construction
- Commissioning
 - Land side
 - Ship side
- Operations
- Maintaining
- Staffing
-

Phase 3 - Implementation

Design, Construct,
Commission,
Operate, & Maintain



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All

LNG

LPG

Methanol

Ammonia

Hydrogen

Shore Power

Usage around the world

DNV GL
Alternative
Fuel Insight
Portal

<https://afi.dnvgl.com/>

GREEN VOYAGE



**WPCAP
Power2Ship
Portal**

A vertical map of the West Coast of North America, showing the coastline from Juneau, Alaska, down to San Diego, California. Major ports are marked with blue icons and labeled: Port of Juneau*, Port of Prince Rupert*, Port of Vancouver, Port of Tacoma*, Port of Seattle, Port of Oakland*, Port of San Francisco*, Port of Eugene*, Port of Los Angeles, and Port of San Diego*. An orange rectangular box highlights the coastal region of British Columbia, Canada, encompassing the Port of Vancouver and the Port of Tacoma*.

A satellite map of the eastern coast of North America, showing the Great Lakes and the Atlantic Ocean. Three ports are highlighted with blue circular icons containing a white ship. The icons are labeled: 'Port of Quebec*' at the top, 'Port of Montreal*' in the middle, and 'Port of New York & New Jersey' at the bottom. The text 'North America East Coast' is overlaid in large white font. The entire map is framed by a thick orange border.

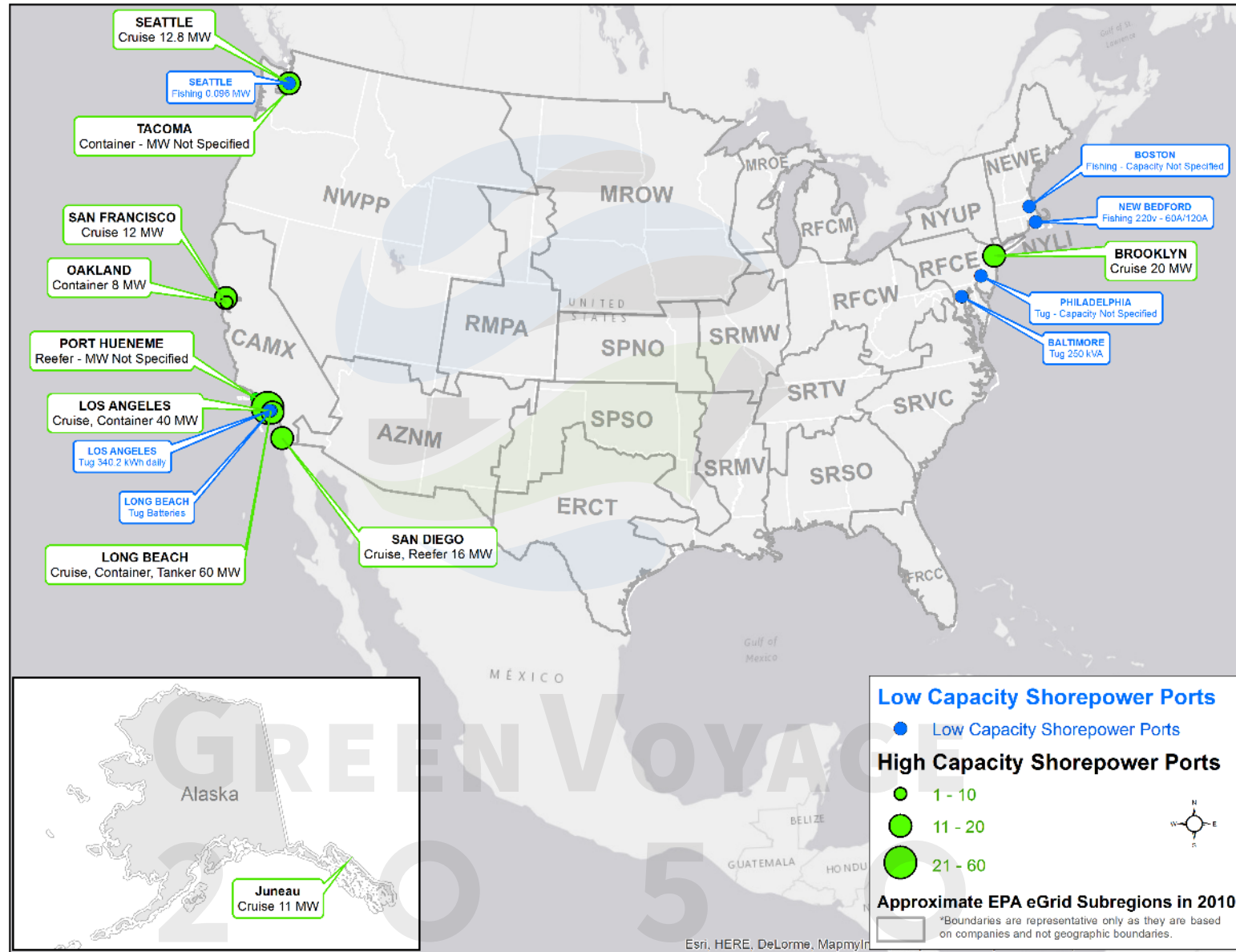
India
Southern Tip

Port of Tuticorin (Chidambaram)*

A map of the Asia East Coast, specifically the eastern coast of China and the surrounding waters. The map is framed by an orange border. The landmass is green, and the water is blue. Several ports and cities are marked with blue dots and labeled with text. The labels are: 'Port of Dalian' at the top, 'Port of Lianyungang*' below it, 'Port of Ningbo-Zhoushan*' further south, 'Qin Huangdao*' below that, 'Port of Shenzhen*' on the southern coast, and 'Port of Guangzhou*' at the bottom. The text 'Asia East Coast' is written in large, bold, white letters across the center of the map. The island of Taiwan is visible in the bottom right corner.



Usage around the world



US EPA, <https://www.epa.gov/ports-initiative/shore-power-technology-assessment-us-ports>

