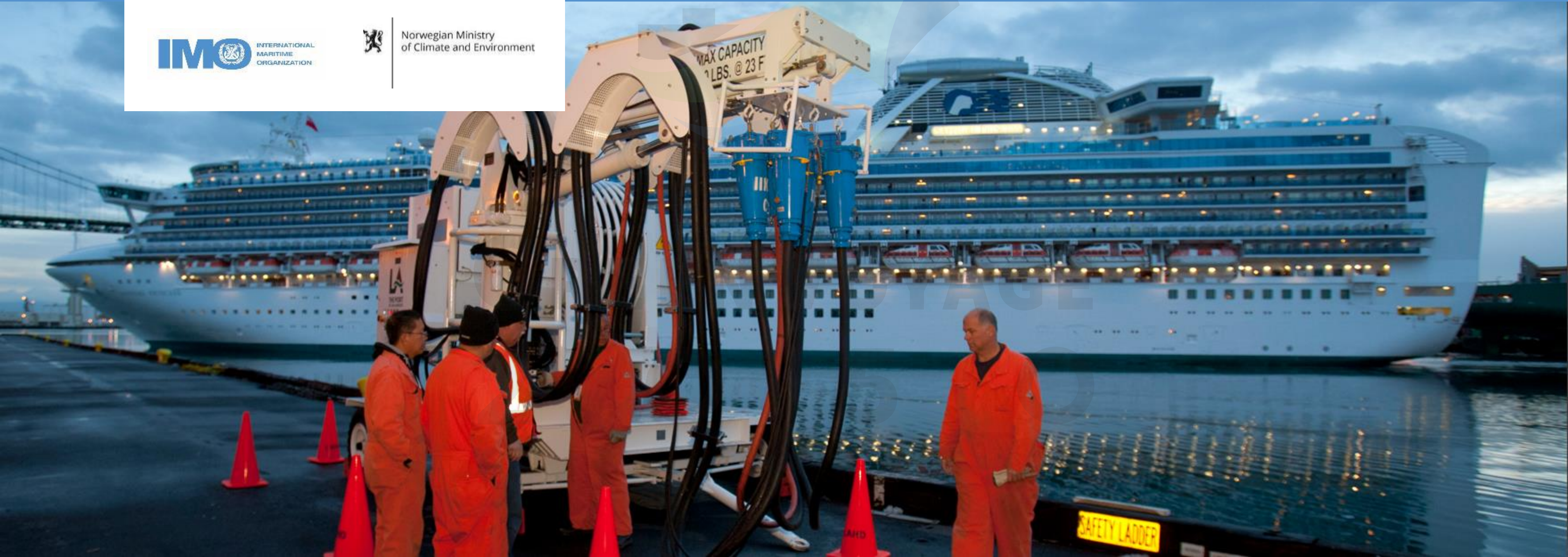
Onshore Power Supply Workshop

Session 3: Phase 1 Screening - OPS Emission Analysis, Outreach & Usage

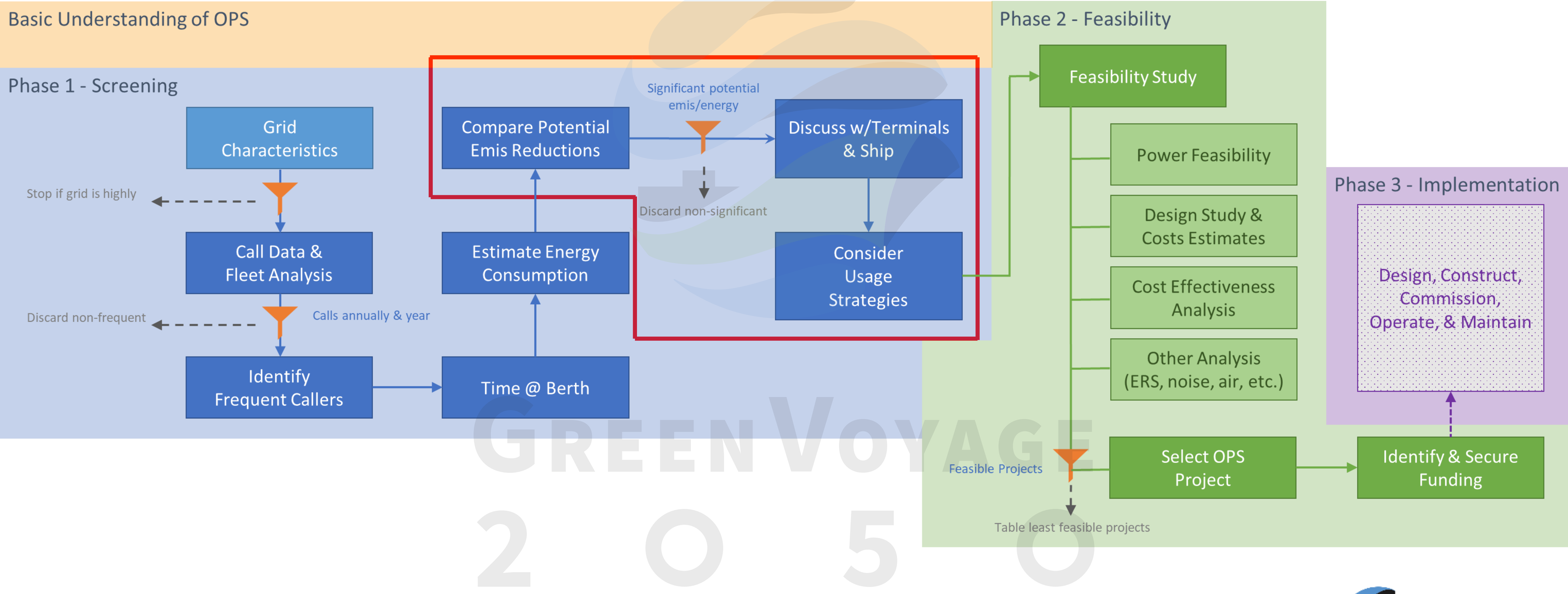
GreenVoyage 2050

International Maritime Organization

Norwegian Ministry of Climate and Environment



Decision pathway



Session 3 – Phase 1 Screening (Part 2) OPS Emission Reductions, Stakeholder Outreach, & Usage Strategies

Learning Objectives

- Understand how to calculate potential emission reductions under various scenarios.
- Understand the perceptions and concerns of stakeholder entities instrumental in the success of OPS – terminal operators (if applicable) & ship owners/operators
- Identify various policy approaches to help support the deployment & usage of OPS

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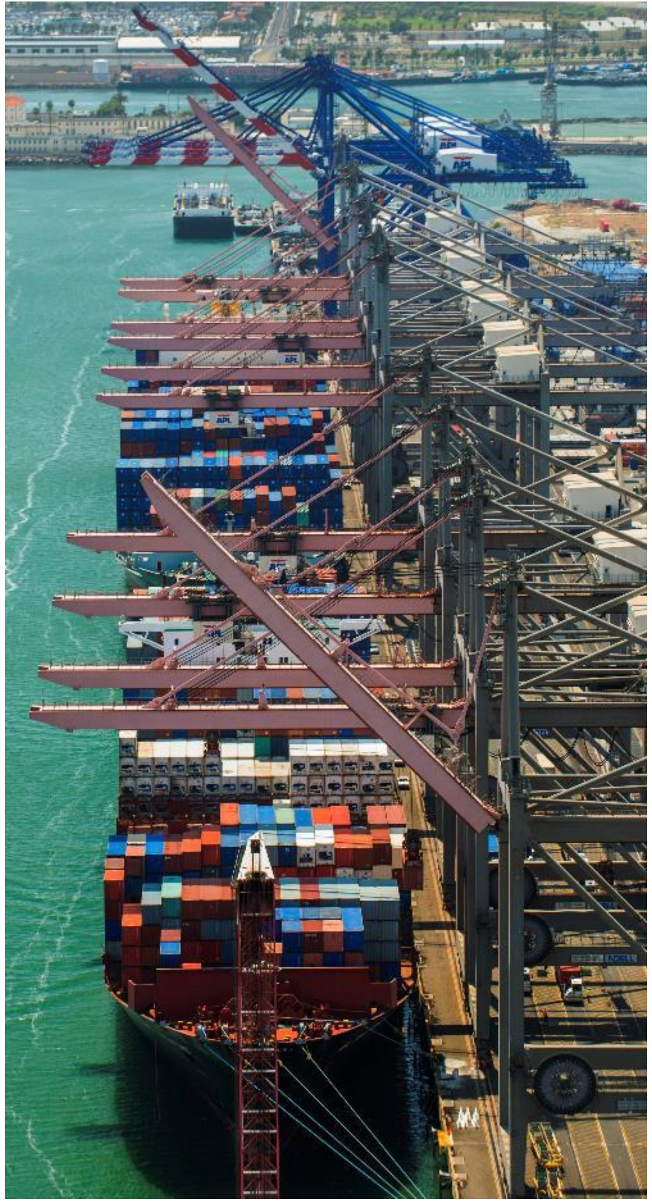
Compare potential emission reductions

- Why conduct an emission reduction analysis?
  - Estimate emission reductions between conventional calls vs OPS calls
  - Compare terminals/scenarios to determine which the most effective approach
- Evaluating future operations
  - Building on work done in Screening Part 1, which focuses on existing operations:
    - Identified terminals & frequent callers
    - Evaluated conventional call (CC) time at-berth & understood call context
    - Estimated energy consumption at-berth ($EC_{at\text{-}berth}$) for both CC & OPS calls
  - Future considerations for candidate terminals
    - Future call schedules, if available
    - Forecasting calls
- Typical GHGs & air quality pollutants quantified
  - CO_2, N_2O, CH_4, CO_2e NOx, PM_{10}, $PM_{2.5}$, SOx, HC, CO, VOC, etc.



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Compare potential emission reductions

- Pollutant & greenhouse gas (GHG) emission estimates
  - Convert energy consumption to tonnes of pollutants & GHGs of interest (typically NOx, PM, SOx, & CO_2e), using latest emission factors (EFs)
    - Fourth IMO GHG Study is a good resource for both EFs and global warming potential (GWP) values for GHGs
  - *Basic equations - pollutants*

Ship

$$\text{Auxiliary}_{CC}\text{Emissions}_i \text{ (tonnes)} = [\ EC_{CC} \text{ (kWh)} \times EF_i \text{ (g pollutant}_i\text{/kWh)}\ ] \ /\ 10^6 \text{ g/tonne}$$

$$\text{Auxiliary}_{OPS}\text{Emissions}_i \text{ (tonnes)} = [\ EC_{OPS} \text{ (kWh)} \times EF_i \text{ (g pollutant}_i\text{/kWh)}\ ] \ /\ 10^6 \text{ g/tonne}$$

$$\text{Auxiliary Reductions}_i \text{ (tonnes)} = \text{Auxiliary}_{CC}\text{Emissions}_i \text{ (tonnes)} - \text{Auxiliary}_{OPS}\text{Emissions}_i \text{ (tonnes)}$$

$$\text{Boiler}_{CC}\text{Emissions}_i \text{ (tonnes)} = [\ EC_{CC} \text{ (kWh)} \times EF_i \text{ (g pollutant}_i\text{/kWh)}\ ] \ /\ 10^6 \text{ g/tonne}$$

$$\text{Boiler}_{OPS}\text{Emissions}_i \text{ (tonnes)} = [\ EC_{OPS} \text{ (kWh)} \times EF_i \text{ (g pollutant}_i\text{/kWh)}\ ] \ /\ 10^6 \text{ g/tonne}$$

$$\text{Boiler Reductions}_i \text{ (tonnes)} = \text{Boiler}_{CC}\text{Emissions}_i \text{ (tonnes)} - \text{Boiler}_{OPS}\text{Emissions}_i \text{ (tonnes)}$$

Fourth IMO GHG Study, 2020
https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20-%20Full%20report%20and%20annexes.pdf

Compare potential emission reductions

- Pollutant & greenhouse gas (GHG) emission estimates
  - *Basic equations - GHGs*

Ship emissions

$Auxiliary_{CC}Emissions_y$ (tonnes) = [EC_{CC} (kWh) x EF_y (g GHG_y/kWh) x GWP_y] / 10^6 g/tonne

$Auxiliary_{OPS}Emissions_y$ (tonnes) = [EC_{OPS} (kWh) x EF_y (g GHG_y/kWh) x GWP_y] / 10^6 g/tonne

$Boiler_{CC}Emissions_y$ (tonnes) = [EC_{CC} (kWh) x EF_y (g GHG_y/kWh) x GWP_y] / 10^6 g/tonne

$Boiler_{OPS}Emissions_y$ (tonnes) = [EC_{OPS} (kWh) x EF_y (g GHG_y/kWh) x GWP_y] / 10^6 g/tonne

Grid related OPS emissions

$Grid_{OPS}Emissions_y$ (tonnes) = [EC_{grid} (kWh) x [$EFgrid_y$ (g GHG_y/kWh) x GWP_y]] / 10^6 g/tonne

Reductions in Emissions from OPS

Auxiliary $Reductions_y$ (tonnes) = [$Auxiliary_{CC}Emissions_y$ (tonnes) - $Auxiliary_{OPS}Emissions_y$ (tonnes)] – $Grid_{OPS}Emissions_{CO2}$ (tonnes)

Boiler $Reductions_y$ (tonnes) = $Boiler_{CC}Emissions_y$ (tonnes) - $Boiler_{OPS}Emissions_y$ (tonnes)

Compare potential emission reductions

- *Example – bulk ship call in Argentina*

NOx, assuming Tier I NOx for auxiliary engines

Auxiliary_{CC} Emissions_{NOx} (tonnes) = [26,000 kWh x 12.98 g NOx /kWh] / 10^6 g/tonne = 0.34 tonne NOx

Boilers_{CC} Emissions_{NOx} (tonnes) = [5,400 kWh x 1.97 g NOx /kWh] / 10^6 g/tonne = 0.01 tonne NOx

Auxiliary_{OPS} Emissions_{NOx} (tonnes) = [1,950 kWh x 12.98 g NOx /kWh] / 10^6 g/tonne = 0.03 tonne NOx

Boilers_{OPS} Emissions_{NOx} (tonnes) = [5,400 kWh x 1.97 g NOx /kWh] / 10^6 g/tonne = 0.01 tonne NOx

Auxiliary NOx reductions = 0.34 - 0.03 tonne NOx = 0.31 tonne NOx reduced or ~93%; no change for boilers

CO_2

Auxiliary_{CC} Emissions_{CO2} (tonnes) = [26,000 kWh x [593.1 g CO_2 /kWh x 1]] / 10^6 g/tonne = 15.42 tonnes CO_2

Boilers_{CC} Emissions_{CO2} (tonnes) = [5,400 kWh x [962 g CO_2 /kWh x 1]] / 10^6 g/tonne = 5.20 tonnes CO_2

Auxiliary_{OPS} Emissions_{CO2} (tonnes) = [1,950 kWh x [593.1 g CO_2 /kWh x 1]] / 10^6 g/tonne = 1.16 tonnes CO_2

Boilers_{OPS} Emissions_{CO2} (tonnes) = [5,400 kWh x [962 g CO_2 /kWh x 1]] / 10^6 g/tonne = 5.20 tonnes CO_2

Grid_{OPS} Emissions_{CO2} (tonnes) = [24,050 kWh x [407.1 g CO_2 /kWh x 1]] / 10^6 g/tonne = 9.79 tonnes CO_2

Auxiliary CO_2 reductions = (15.42 - 1.16) – 9.79 tonnes CO_2 = 4.47 tonne CO_2 reduced or ~29%; no change for boilers

Compare potential emission reductions

- *Example – cruise ship call in Argentina*

NOx, assuming Tier I NOx for auxiliary engines

$\text{Auxiliary}_{CC}\ \text{Emissions}_{NOx}\ (\text{tonnes}) = [\ 60{,}000\ \text{kWh} \times 12.98\ \text{g NOx/kWh}\ ] / 10^6\ \text{g/tonne} = 0.78\ \text{tonne NOx}$

$\text{Boilers}_{CC}\ \text{Emissions}_{NOx}\ (\text{tonnes}) = [\ 0\ \text{kWh} \times 1.97\ \text{g NOx/kWh}\ ] / 10^6\ \text{g/tonne} = 0\ \text{tonne NOx}$

$\text{Auxiliary}_{OPS}\ \text{Emissions}_{NOx}\ (\text{tonnes}) = [22{,}500\ \text{kWh} \times 12.98\ \text{g NOx/kWh}\ ] / 10^6\ \text{g/tonne} = 0.29\ \text{tonne NOx}$

$\text{Boilers}_{OPS}\ \text{Emissions}_{NOx}\ (\text{tonnes}) = [\ 8{,}000\ \text{kWh} \times 1.97\ \text{g NOx/kWh}\ ] / 10^6\ \text{g/tonne} = 0.02\ \text{tonne NOx}$

Auxiliary NOx reductions = 0.78 - 0.29 tonne NOx = 0.49 tonne NOx reduced (~63% reduction)

Boilers NOx reductions = 0.00 – 0.02 tonne NOx = -0.02 tonne NOx reduced (slight increase in NOx from OPS)

Total NOx reductions = 0.49 + (-0.02) tonne NOx reduced = 0.47 tonne NOx reduced (net ~60% reduction in NOx from OPS)

Compare potential emission reductions

- *Example – cruise ship call in Argentina*

CO_2

$Auxiliary_{CC}$ $Emissions_{CO2}$ (tonnes) = [60,000 kWh x [593.1 g CO_2/kWh x 1]] / 10^6 g/tonne = 35.59 tonnes CO_2

$Boilers_{CC}$ $Emissions_{CO2}$ (tonnes) = [0 kWh x [962.0 g CO_2/kWh x 1]] / 10^6 g/tonne = 0 tonnes CO_2

$Auxiliary_{OPS}$ $Emissions_{CO2}$ (tonnes) = [22,500 kWh x [593.1 g CO_2/kWh x 1]] / 10^6 g/tonne = 13.35 tonnes CO_2

$Boilers_{OPS}$ $Emissions_{CO2}$ (tonnes) = [8,000 kWh x [962.0 g CO_2/kWh x 1]] / 10^6 g/tonne = 7.70 tonnes CO_2

$Grid_{OPS}$ $Emissions_{CO2}$ (tonnes) = [37,500 kWh x [407.1 g CO_2/kWh x 1]] / 10^6 g/tonne = 15.27 tonnes CO_2

Auxiliary CO_2 reductions = (35.59 – 13.35) – 15.27 tonnes CO_2 = 6.97 tonnes CO_2 reduced (~20% reduction)

Boilers CO_2 reductions = 0.00 – 7.70 tonnes CO_2 = -7.70 tonnes CO_2 reduced (increase in CO_2 from OPS)

Total CO_2 reductions = 6.97 + (-7.70) tonnes CO_2 reduced = -0.73 tonne CO_2 reduced (net increase in CO_2 from OPS)

Example comparison

Bulk ship	Cruise ship
• 93% reduction in NO_x	• 60% reduction in NO_x
• 29% reduction in CO_2	• INCREASE in CO_2

Are you surprised by the results?

Why or why not?

What accounts for the differences?

Emission reduction analysis

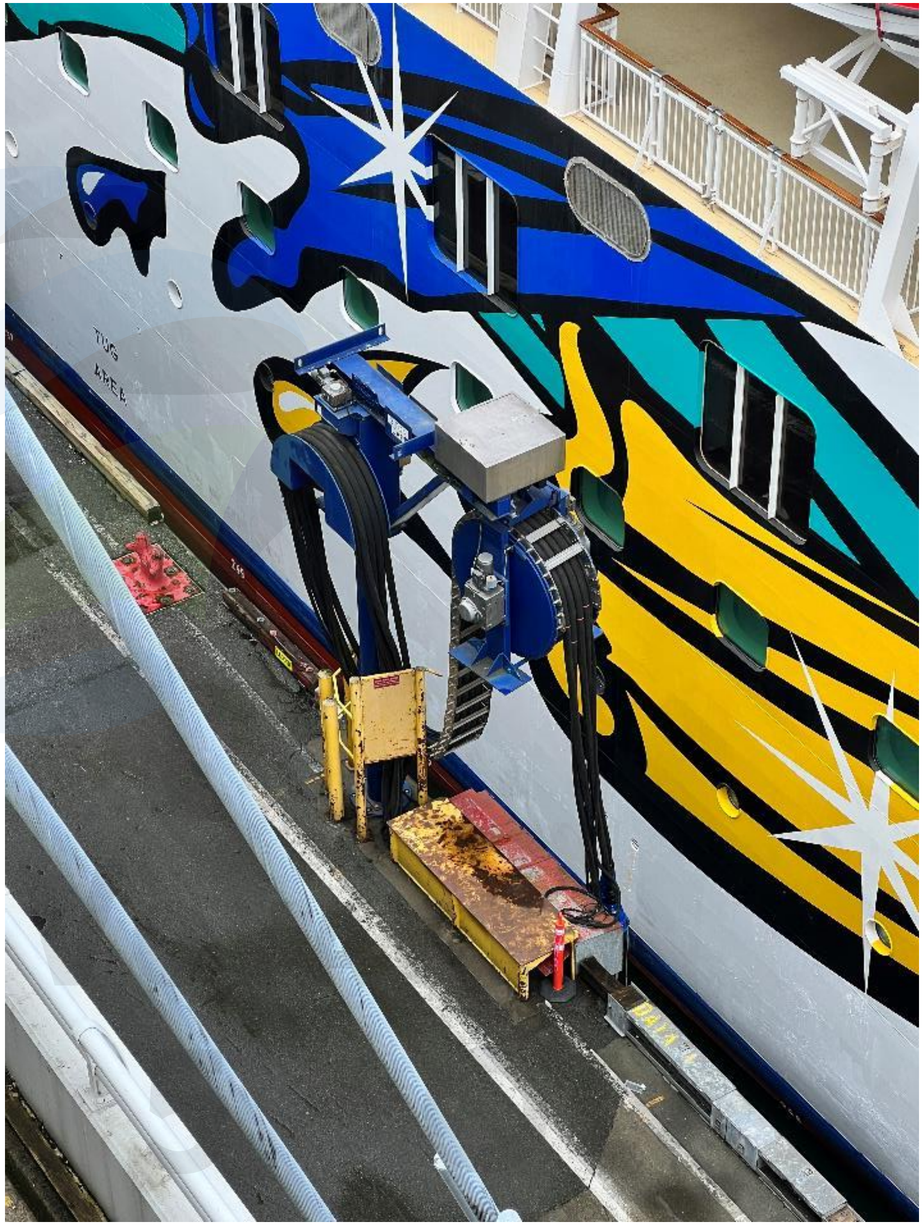
- Net emission reduction comparisons
  - Comparisons are typically focused on looking at annual benefits
  - Compare OPS results to business as usual
    - This is typically done by terminal, with the rolled up netted results by terminal & ship type (if more than one ship type calls the terminal)
  - Compare with various fleet usage scenarios for OPS
    - What percent of ship calls targeted will actually utilize OPS?
    - That's dependent on the usage strategy in place to encourage/require use of OPS.
    - Best case scenario is 100% of selected frequent callers.
    - What happens to the emissions benefits (business case) if only a third or half of the frequent callers actually use OPS?
  - Compare other emission reduction strategy scenarios to business as usual & OPS
    - The call data, context, & energy consumption information compiled in Phase 1 can be used to assess other emission reduction strategies that might target the same emissions
      - Cleaner fuels
      - Non-grid OPS
      - Capture & control systems
      - Having IMO NOx Tier III ships (very rare) use Tier III at ports not in NECA
      - …

Discuss with terminals & ship owners/operators

- Identify the level of interest
  - How does the terminal operator/port view OPS? Does OPS fit into their future plans?
    - Terminal owners/operators typically see OPS as an expense without a cost benefit. This is changing slightly with corporate sustainability goals that include Scope 3 emissions.
  - How do the ship owners/operators view OPS at the candidate terminal? Does it align with their sustainability goals & future plans?
    - Shipping owners/operators can view OPS either as part of the sustainability efforts or as an added cost.
    - They typically base decisions on business case, with more progressive companies giving sustainability efforts a high value.
  - Are any of the co-benefits like noise reduction (above & below water), opacity, work efficiency, etc. of interest?
- Understand the future plans for port, terminal & ship owners/operators
  - Terminals can sometimes change focus, which could mean the ships and/or ship types targeted by OPS may not call in the future
  - Find out what type of ship services operate at the candidate terminals and if those conditions may change; understand how ships are rotated into strings (for liner services)
- If there is interest, share assumptions & findings related to your OPS analysis
  - This can be done earlier if there is interest.

Usage strategies
How do we ensure it is used?

- *Regulatory*
  - *Alaska – opacity regulation*
  - *California – air toxics & air quality (ozone & particulates)*
  - *Europe - emerging (TenT, etc.)*
- *Incentives*
  - *Ports*
  - *Local & state government agencies*
  - *National government agencies*
  - *Incentive programs*
- *Port requirements*
  - *Tariff*
  - *Lease conditions*



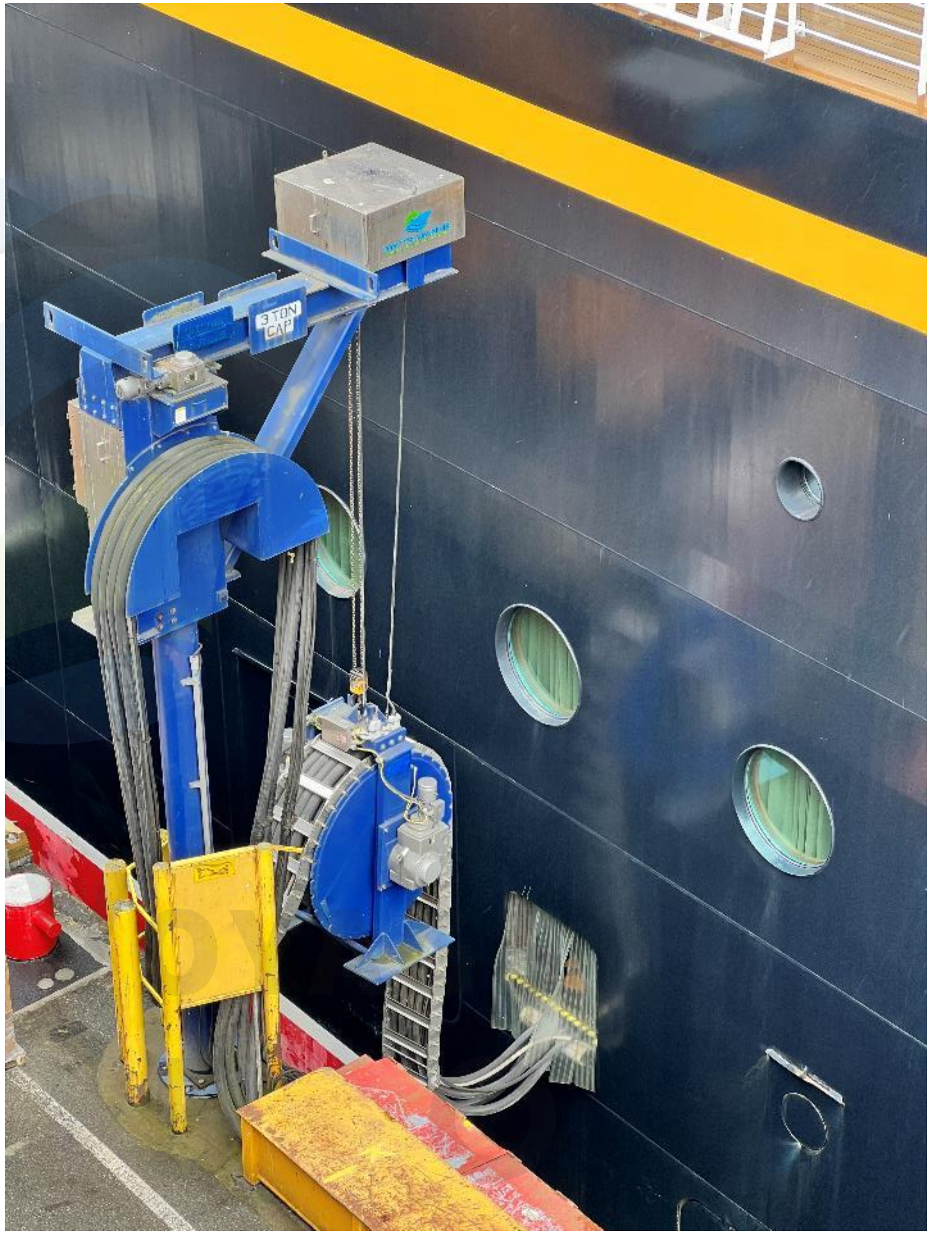
Usage strategies
How do we ensure it is used?

- *Business case*
  - *Princess Cruise lines Seattle*

- *Environmental stewardship*
  - *Port Authority of New South Wales*

- *Other innovative strategies to emerge*

- Based on input from terminal, ship owners & operators, one can adjust the emission reduction analysis to cover potential ranges of participation based on the various policy options the port is considering.



Case Study: Port of Long Beach, California, US

Drivers: pressure from community, environmental groups, and regulatory agencies to reduce emissions

- 2006 – Port requires International Transportation Service to use shore power through lease conditions
- 2007 – California adopts regulation requiring shore power (50% of fleet in 2014 up to 80% by 2020); applies only to cruise, container, and reefer ships
- 2008 – Shore power begins at ITS → 2% calls per year
- 2009-2013 – Port installs shore power at two additional terminals (container and tanker) under lease conditions
- 2014 – California regulation goes into effect → 26% of calls per year

  – Port launches financial incentive designed to encourage shore power usage
- 2020 – California amends regulation, requiring 100% shore power beginning in 2021; adds tankers and RoRo vessels → 46% of calls per year