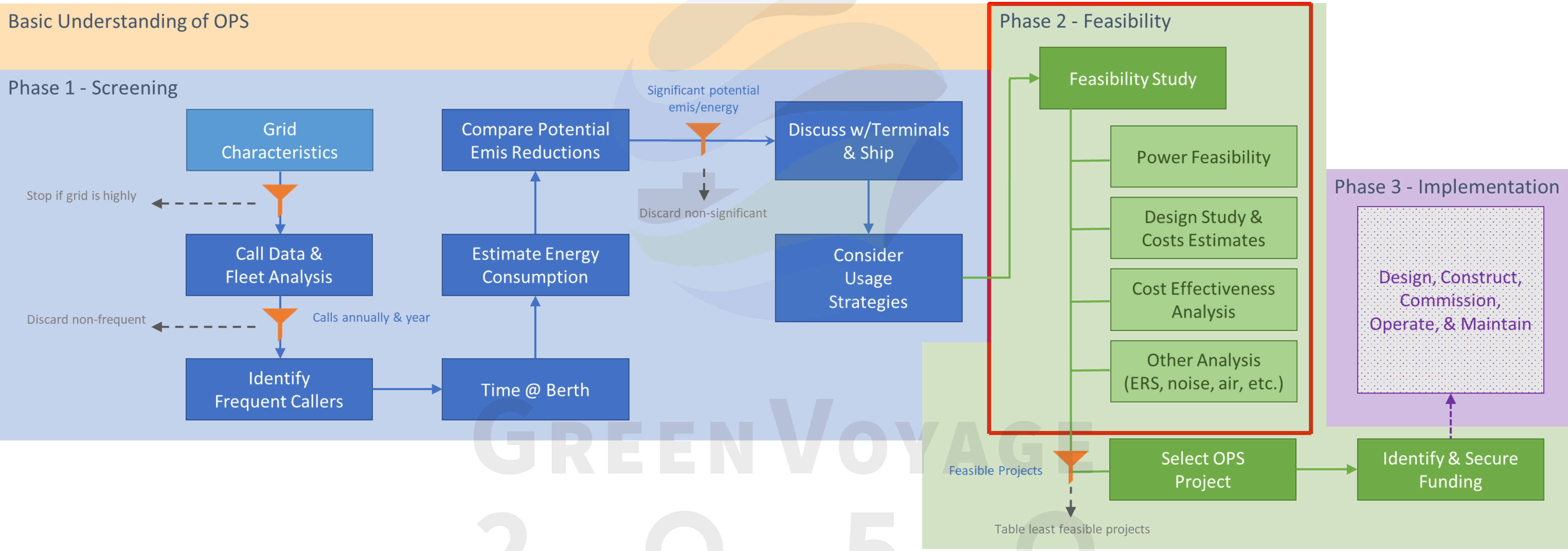
Onshore Power Supply Workshop

Session 4: Phase 2 Feasibility - Feasibility Analysis for Ports & Case Studies

GreenVoyage 2050

Decision pathway



Session 4 – Phase 2 Feasibility Analysis for Ports

Learning Objectives

- Understand the importance of conducting a feasibility study including the following components:
    - Power feasibility & design study
    - Cost analysis
    - Cost-effectiveness analysis
    - Other analyses as needed

- Understand the importance of stakeholder engagement in developing an OPS strategy

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Feasibility Study

- Purpose of a feasibility study
  - Determine if a candidate OPS terminal project scenario(s) is (are) viable & how effective are they
  - Findings are used to rank feasible scenarios

- Scope of a typical feasibility study includes
  - Power feasibility
  - Design & cost estimates
  - Emissions & cost-benefits
  - Alternative emission reduction strategy comparisons

- The scope can be expanded based on the drivers to implement OPS
  - Noise study
  - Ambient air quality analysis

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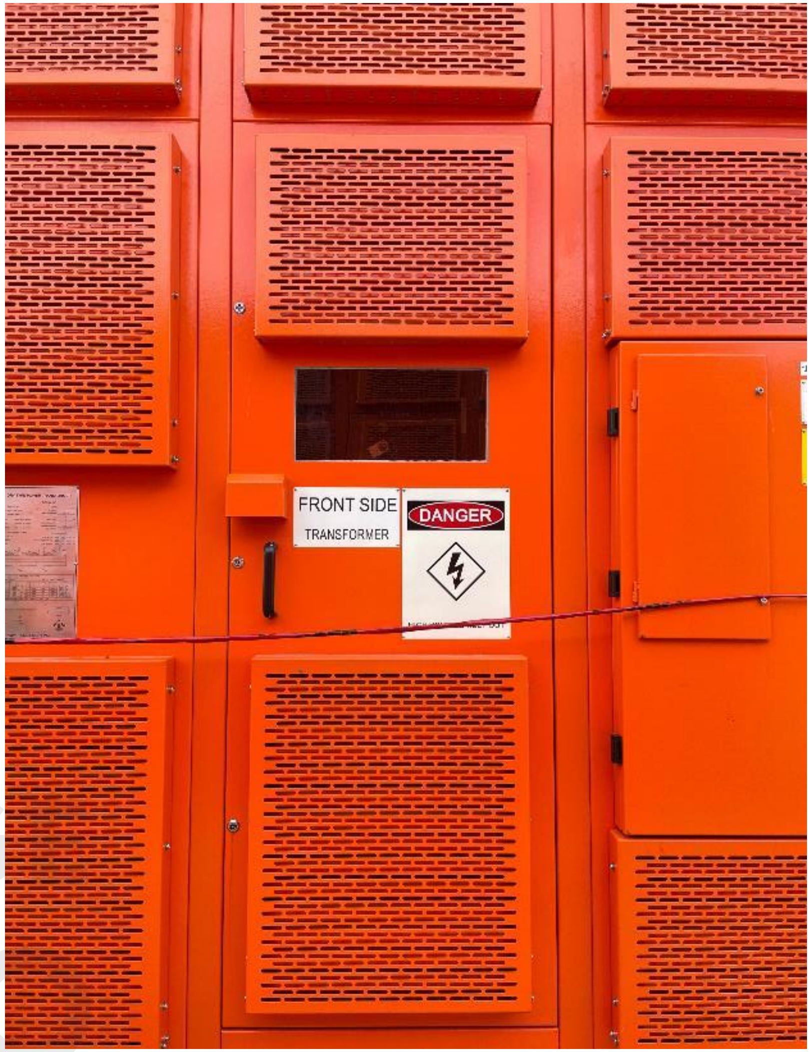
Power feasibility

- Key considerations
  - For grid-based OPS
    - Identify service needs LVSC or HVSC
    - Determine average & peak loads for targeted ships
    - Determine if there is sufficient grid power available at the terminal for OPS scenarios
    - If sufficient grid power is not available, determine what's involved bringing it to the terminal for meeting OPS scenario requirements
    - Identify the power characteristics of nearest tie point
    - Determine if a new substation is needed
    - Determine if frequency conversion equipment is needed
    - Determine what power conditioning equipment is needed
    - Determine who is responsible for operation & maintenance of OPS equipment



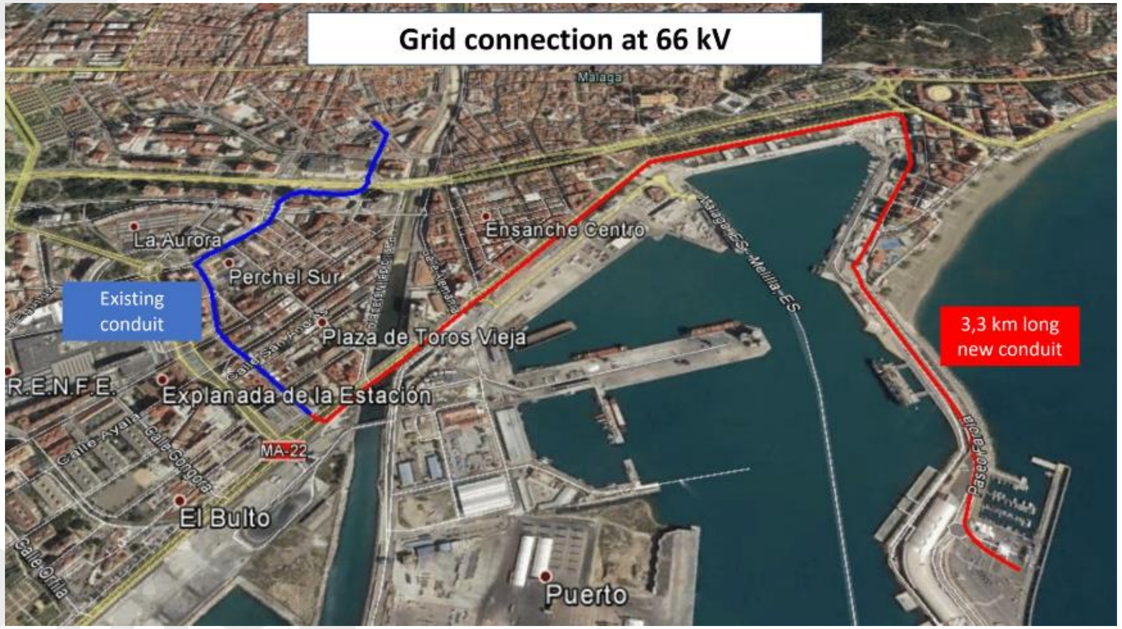
Power feasibility

- Key considerations
  - For non-grid based OPS units
    - Identify service needs LVSC or HVSC
    - Determine average & peak loads for targeted ships
    - Determine number of units needed to support each scenario
    - Identify power frequency of unit
    - Determine if additional power frequency or conditioning equipment is needed
    - Identify unit refuelling frequency
    - Identify refuelling equipment (truck, ISO-tainer, train, pipeline, etc.)
    - Identify any safety requirements related to unit's fuelling or refuelling siting and/or operations
    - Determine who is responsible for operation, maintenance, & refuelling
    - Determine costs including: unit(s) costs, operating, maintenance, & refuelling costs

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

Design study & cost estimates

- Key considerations
  - For grid-based OPS
    - Design & identify siting for new substation, as needed
    - Identify power equipment needs related to grid-to-terminal OPS connection
    - Design & site grid-to-terminal OPS power equipment, vaults & conduit systems
    - Design & site terminal-to-berth OPS power equipment, vaults & conduit systems
    - Identify civil works needed to complete the project
      - Conduits, equipment pads, equipment vaults, fencing, etc.
      - Berth & terminal modifications to support cable management systems & cabling conduits, etc.
    - Determine construction disruptions to terminal/port operations
    - Determine & review ship characteristics for existing & future operations
    - Identify & select berth cable management systems options
    - Design berth vault locations based on cable management systems & ship characteristics



©Courtesy of Ports of Spain-OPS MASTERPLAN EU funded project

Design study & cost considerations

- Key considerations
  - For non-grid based OPS
    - Identify footprint needs for system(s)
    - Determine available space & siting of system(s)
    - Determine if sites can carry the unit(s) weight load
    - Identify & resolve any fire/emergency considerations of non grid-based unit
    - Determine local sourcing of fuel/energy for the system
    - Determine if additional fuel tankage is needed
    - Identify how fuel transported to the system (pipeline, vessel, rail, truck, etc.)
    - Engage grid energy provider
      - Determine electrical grid rate
      - Determine if the grid power service is interruptible or guaranteed
    - Determine operational personnel (from provider or port/terminal operator?) & associated training
    - Identify schedule/cost for having unit delivered, sited, & installed

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Design study & cost considerations

- Key considerations
  - Estimate capital & operational/maintenance (O&M) cost for terminal scenarios
  - Estimate capital & O&M costs for ship side
  - Estimate construction operational impact costs
  - Estimate energy consumption costs
  - Determine funding source(s)
  - Determine applicable interest rate
  - Compare cost estimate findings to determine range of costs

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Cost effectiveness analysis

- Cost-effectiveness analysis shows how cost effective each scenario is
- Merge the various scenario emissions benefits calculations with the associated scenario project costs, to:
  - Determine costs per emissions reduced ($/tonne) for pollutants & GHGs of concern
    - If needed, you can use global warming potentials (GWPs) to convert GHGs to CO_2e
    - Same can be done for air quality pollutants
      - California uses a factor of 20 to compare particulate matter to NOx
  - Cost-effectiveness shows how cost effective a scenario is helps rank various scenarios by ‘biggest bang for the buck’
    - Ranking emission reduction strategies is a common evaluation tool used when selecting a strategy
- Each country may have their own approach & guidelines in determining cost effectiveness for capital projects

Cost effectiveness analysis example

PORT AUTHORITY OF NEW SOUTH WALES

FINAL
White Bay Cruise Terminal Shore Power Analysis Report

1. From Table 6.6, the annual reductions for S5 compared to S1 were used for both fuel types and both domains (regional and local)
2. Evaluation periods: [38] 10-years 20-years
3. The total project costs include:
   a. On-shore infrastructure[39]

	10-years	20-years
low:	$20,700,000	$20,700,000
high:	$36,400,000	$36,400,000

   b. On-shore O&M[40]

	10-years	20-years
low:	$931,500 per year	$931,500 per year
high:	$1,638,000 per year	$1,638,000 per year

   c. Cruise ship infrastructure retrofit costs[41]

	10-years	20-years
# of ships:	10	20
low:	$700,000 per ship	$700,000 per ship
high:	$2,750,000 per ship	$2,750,000 per ship

4. Interest rate for CRF[42]:

	10-years	20-years
low:	4.5%	4.5%
high:	8.0%	8.0%

5. CRF (calculated):

	10-years	20-years
low:	0.1264	0.0769
high:	0.1490	0.1019

6. Exchange Rate: 0.76 AUD$: 1.00 US$
7. Energy costs for shore power supplied electricity were not considered due to the future uncertainty of fuel oil costs and future costs of energy supplied by the grid.

S2 – Compliance with EPA and AMSA Fuel Sulphur Regulations: 0.1%/0.001% S Fuels

S5 – Shore Power

As stated above, cost-effectiveness is calculated using annualised emissions reductions typically for PM_{10} and NO_x, with PM_{10} being weighted 20 times compared to NO_x due to its disproportionate health effects, using the equation below: [43]

Cost-Effectiveness ($/weighted tonne) =
Total Project Costs x CRF / ((20 x PM_{10} annual reductions) + NO_x annual reductions)

Comparison	Condition		Annual Reductions, tonnes PM_{10}	$PM_{2.5}$	NOx	CO_2	On-shore Infrastructure	On-shore O&M	Ship Infrastructure	Total	Incremental Cost Eff. $/wgt tonne
Low - 10 year											
Scenario 5 w/2a	0.1% S & Shore power	Local	1.1	1.1	73.1	na	$20,700,000	$9,315,000	$7,000,000	$37,015,000	$48,924
		Regional	0.7	0.8	63.8	-990					$59,565
Scenario 5 w/2a	0.001% S & Shore power	Local	0.9	0.9	73.1	na	$20,700,000	$9,315,000	$7,000,000	$37,015,000	$50,794
		Regional	0.6	0.7	63.8	-990					$62,361
High - 10 year											
Scenario 5 w/2a	0.1% S & Shore power	Local	1.1	1.1	73.1	na	$36,400,000	$16,380,000	$27,500,000	$80,280,000	$125,126
		Regional	0.7	0.8	63.8	-990					$152,343
Scenario 5 w/2a	0.001% S & Shore power	Local	0.9	0.9	73.1	na	$36,400,000	$16,380,000	$27,500,000	$80,280,000	$129,910
		Regional	0.6	0.7	63.8	-990					$159,492
Low - 20 year											
Scenario 5 w/2a	0.1% S & Shore power	Local	1.1	1.1	73.1	na	$20,700,000	$18,630,000	$14,000,000	$53,330,000	$42,878
		Regional	0.7	0.8	63.8	-990					$52,204
Scenario 5 w/2a	0.001% S & Shore power	Local	1.1	1.1	73.1	na	$20,700,000	$18,630,000	$14,000,000	$53,330,000	$44,517
		Regional	0.7	0.8	63.8	-990					$54,654
High - 20 year											
Scenario 5 w/2a	0.1% S & Shore power	Local	1.1	1.1	73.1	na	$36,400,000	$32,760,000	$55,000,000	$124,160,000	$132,258
		Regional	0.7	0.8	63.8	-990					$161,025
Scenario 5 w/2a	0.001% S & Shore power	Local	1.1	1.1	73.1	na	$36,400,000	$32,760,000	$55,000,000	$124,160,000	$137,314
		Regional	0.7	0.8	63.8	-990					$168,582

Other analysis

- Depending on the Port's drivers, other companion analysis might need to be conducted

- Typically these include
  - Evaluating other emission reduction strategy(ies) scenarios, examples:
    - Operational efficiencies for ships &/or other port emissions sources
    - Cleaner fuels targeting air pollutants for ships & other port emission sources (cargo handling equipment, harbor craft, locomotives, trucks, etc.)
    - Green/blue fuels targeting GHGs for ships &/or other port emission sources
    - Accelerated fleet turnover for other port emission sources
    - Emission reduction technologies targeting air pollutants &/or GHGs for other port emission sources & ships
  - Noise reduction benefits study – to determine how the above and/or below water noise levels are affected
  - Ambient air quality assessment - to determine change in the concentrations of targeted air pollutants in & around the berth/terminal
  - Terminal efficiency analysis – to determine if there are any operational efficiency improvements associated with the use of OPS

Stakeholder engagement

- Stakeholder engagement can be critical to the success of the deployment of OPS
  - Getting buy-in from shipping lines
  - Getting buy-in from terminals
  - Getting buy-in from Port Authority Boards
  - Getting buy-in & advocacy from local & regional stakeholders

- The level of engagement with stakeholders depends on the drivers
  - Focus the messaging around the various stakeholders
  - Identify funding streams for the project
  - Identify usage policies
  - Connect how the project helps the port meet its sustainability goals & what are the primary & co-benefits
  - Be transparent with the process & updates on project status
  - Provide summary usage statistics & emissions reduced annually

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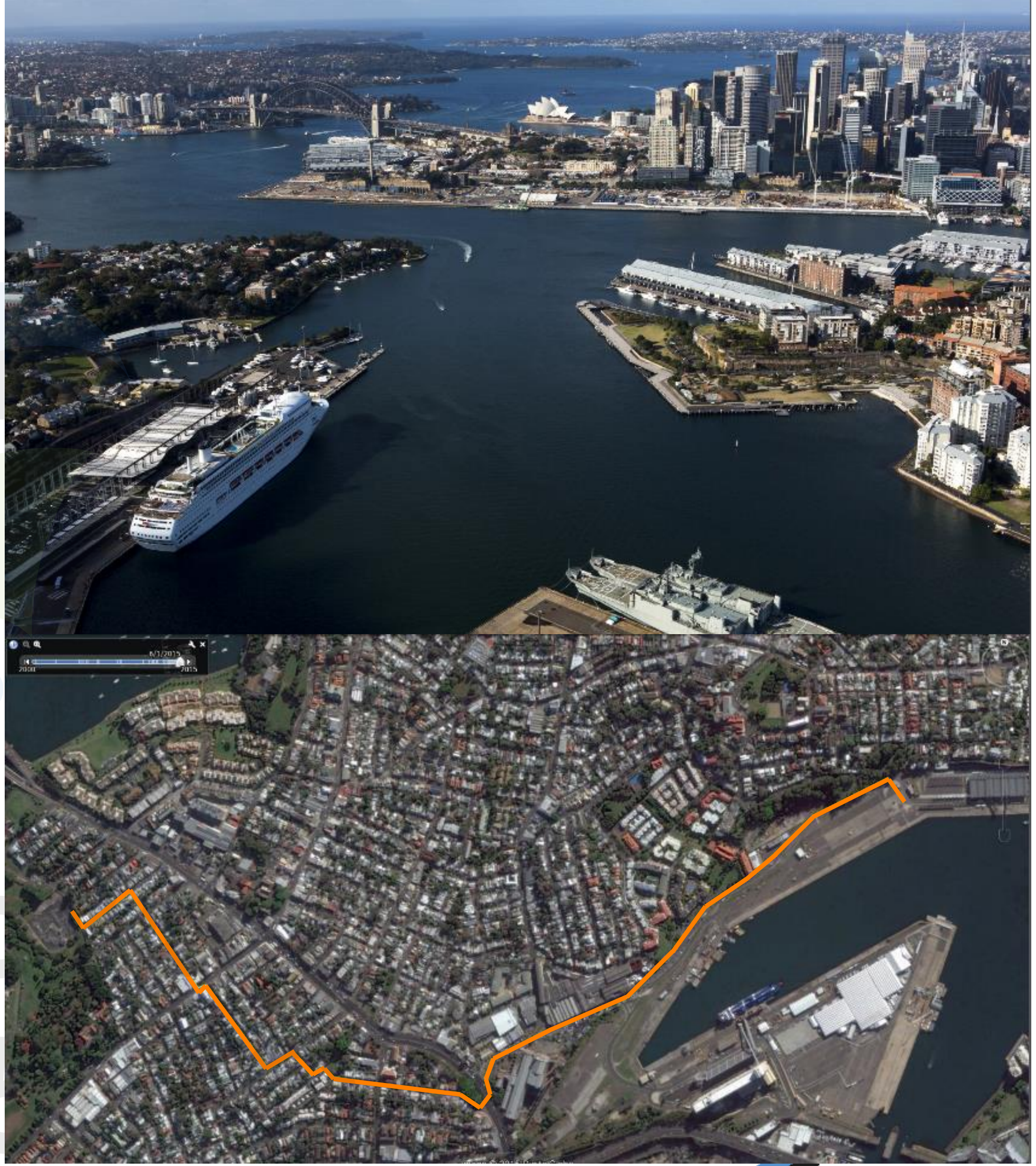
Case Study
Port Authority of New South Wales
White Bay Cruise Terminal &
Glebe Island Bulk Precinct (Bays Port)

- Drivers
  - Neighbours homes impacted from cruise ship emissions (air quality & noise)
  - Stakeholder pressure – including local port communities, local, and state governments
  - Port & terminal license to operate
- Conducted an initial feasibility study for cruise in 2017, which included:
  - Power feasibility
  - Design study & cost estimates - $36.4 million AUD – landside
  - Emission reduction estimates for each scenario
  - Costs & benefits study/cost effectiveness
    - Evaluated alternative strategies including various fuel switch options, exhaust gas clean systems, & grid based OPS
  - Ambient air quality analysis
  - Noise assessment
- Initial findings
  - Power not available – need to bring power to terminal
  - At that time, not the most cost effective strategy
  - Other strategies reduced more emissions
  - Grid generation capacity Not implemented; but noted would review again



©Port Authority New South Wales, 2017

Case Study
Port Authority of New South Wales
White Bay Cruise Terminal & Glebe Island Bulk Precinct (Bays Port)

- Port continued to track conditions related to the viability of OPS after the initial feasibility study
- 2020 Port developed a sustainability plan
- 2021 established a net-zero target for Scopes 1&2 by 2040
- 2021 Port identified a unique opportunity related to the bulk terminals & cruise terminal
- 2021 Port conducted an updated feasibility & analysis of potential CO_2e emission reductions from OPS for both cruise & bulk
    - Bulk actually has the greater potential for reductions due to limited number of ships, longer stays, operating year round
- 2022 Port announces OPS solutions for both cruise & bulk
    - $60 million AUD
    - Will be the first bulk & cruise OPS terminal in the Southern Hemisphere powered by renewable electricity
    - Operational by end of 2024

Case Study
Port Authority of New South Wales White Bay Cruise Terminal & Glebe Island Bulk Precinct (Bays Port)

PORT AUTHORITY
OF NEW SOUTH WALES

SHORE POWER
LETTER OF INTENT

Port Authority of New South Wales, the owner and operator of Bays Port Precinct and each of the major operators within the Precinct, being Monday 21 of March 2022 today, commit to working collaboratively towards a shared goal of ensuring that ships visiting Bays Port Precinct utilise certified renewable energy supplied at berth.

Each of the signatories to this letter of intent are committed to achieving sustainable outcomes, and our collective goal will achieve demonstrable reduction in greenhouse gas emissions helping to achieve NSW's emission reduction targets. Allowing visiting ships to shut down their engines while at berth will also ensure that ships can continue the century-long tradition of berthing within Sydney Harbour to deliver passengers and essential goods to Sydney as part of a broader approach to further improving the Bays Precinct.

By signing this letter of intent, Port Authority intends to progressively install shore power infrastructure at the White Bay Cruise Terminal and each of the four major commercial berths at Glebe Island. Further, Port Authority will arrange for the electricity consumed by the ships to be 100% certified renewable energy. Each of the operators intend to equip ships regularly visiting these berths to receive shore power supplied to the commercial berths at Bays Port Precinct.

Each of the signatories will endeavour to achieve these commitments as soon as possible, with the first shore power installation expected to be utilised by 2024.

Philip Holliday
CEO & Director
Port Authority of NSW

Allen Dobie
Vice-President Commercial
Australia & Asia
CSL

Rob Davies
CEO
Cement Australia

Lissa J Landis
Director
RCL Ltd.

Peter Little
Senior Vice President,
Guest Experiences
Carnival Australia

Lynne Clarke
Chairman
MSC Cruises (Australia) Pty Ltd.

Case Study: Mauritius Ports Authority

- Drivers
  - Reduce emissions while cruise ships are at-berth
  - Be a green cruise destination
  - Demonstrate innovation leadership in the region
- Conducted a feasibility study for cruise in 2022, which included:
  - Power feasibility
  - Design study & cost estimates
    - $11.5 million USD construction
    - $3.5 million USD for solar panel installation
  - Emission reduction estimates
  - Cost effectiveness
- Findings
  - Power grid is dirtier than ship's - cruise lines were concerned with condition of grid
  - However, Mauritius intends to progressively reduce its carbon emission from its electricity grid by 2030. In that regard, energy transition ambition has been furthered by increasing the target of share of renewables in the electricity mix from 40% to 60% by 2030. OPS will make sense then.
  - If MPA installs sufficient solar panels to produce electricity required by the cruise berth each year, CO_2 emissions effectively become zero. The estimated investment is $3.5 million USD.
  - Two year build horizon from agreement on project

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COMMISSION DE L'OCÉAN INDIEN

SWIOFISH 2

THE WORLD BANK

CENTRAL ELECTRICITY BOARD

Case Study: Mauritius Ports Authority

- Key challenges
  - Cost of installations compared with cost of operation, cost of electrical power (which is currently from fossil fuels mostly) & economic viability of the service, lack of pricing and taxing framework
  - Status & capacity of the electricity grid (reliability, power constraints, etc.)
  - Assessment of renewable energy generation potential using the grid as a buffer/ store
  - Technical and operational expertise for implementation shore side electricity for ports
  - Definition of role, responsibility, expectations of stakeholders and split incentives
  - Regulatory measures for OPS installation and operation
  - Sources of funding
  - Training for OPS operations
    - For Port Authorities
    - For the Operator of the OPS

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- SWIOFISH2
- THE WORLD BANK
- CENTRAL ELECTRICITY BOARD

Challenges for SIDS

- Most SIDS have historically been net energy importers of fossil fuels
- Fuel imports take a significant portion of the national budgets
- Energy utilization is primarily for power generation & transport sectors
- Many islands with tourism & hospitality dependent economies require significant energy to sustain these sectors
- Crucial for SIDS to improve their access to sustainable & renewable energy sources to increase energy security & potentially move to energy provider for the maritime sector