Cruise Vessel Emission Reduction Technologies

Feasibility Study

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Executive Summary

The environmental impact of emissions from berthed vessels is a significant challenge faced by city ports worldwide. To understand the range of technologies available for mitigating these, POAL engaged WorleyParsons/Advisian to complete a feasibility study. This sought to investigate options for reducing noise, pollutant and greenhouse gas emissions from berthed cruise vessels and determine the preferred solution(s) using a triple bottom line approach.

The study reflects the POAL sustainability commitment and represents a proactive step to assist in reducing emissions within the Auckland airshed. It also follows growing global trends to address shipping emissions, such as incentive schemes and MARPOAL Annex VI regulations.

At berth, cruise ships run generators to provide electrical power for on-board amenities, typically fuelled with high sulphur, heavy fuel oil (HFO). In addition to the noise impacts, considering the terminal's central city setting, studies have highlighted direct correlations between some of the emission components and adverse public health outcomes.

Cruise ships were selected for the study as the industry has been proactive at addressing environmental issues over the past decade and these vessels are more frequently fitted with the onboard infrastructure required by a number of the potential solutions (particularly shore power). This, combined with high individual electricity demand while at berth (compared to other vessel types), is expected to increase utilisation and deliver the highest emission reduction return.

2015-2017 cruise schedules indicated annual hoteling generation capacity totalled approximately 9,900 MWh across all cruise vessels. Approximately 3,300 MWh was generated from vessels identified with existing capacity to accept shore power. This represents the current size of the opportunity for reduction of associated noise and pollutant emissions.

The broad range of technologies available in the current market to potentially reduce in-berth emissions included:

- Shore Power (grid supplied, local generation including renewables, hybrid),
- Fuel switching (methanol, LNG, Low Sulphur Diesel),
- Land/barge based exhaust capture systems and
- Ship based scrubbers.

Viable solutions were assessed using a weighted criteria evaluation matrix which considered a range of social and environmental attributes in addition to whole of life cost. This holistic approach was adopted to provide a balanced assessment of the alternatives with consideration of the stakeholder values. Potential methods of funding were not explored.

The three highest scoring solutions were determined as follows:

1. Conventional shore power – supply from the national grid
2. Hybrid shore power – supply from national grid with a 400kW (4,000 m^2) solar array (compensation for 20% non-renewable grid generation mix on annual output basis)
3. Fuel switching to low Sulphur content diesel for on-board generators

Further analysis was performed on these three options using more detailed capital and annualised operating cost estimates.

The analysis resulted in the following recommendations for POAL consideration:

- Implement fuel switching as a low cost and interim solution. This has an estimated total installed cost of $2.2 million (±30%) which allows for local storage upgrades, if required. The associated operating cost is estimated at $1 million per annum and primarily represents the additional cost of low sulphur fuel against HFO (based on current consumption estimates).

  Considering that not all vessels are capable of connecting to a shore power system, fuel switching delivers the highest pollution reduction with minimum capital cost requirement. Sulphur dioxide and particulate matter reductions in this solution are in the order of 96% and 83% respectively. Greenhouse gas emission reductions are, however, marginal at approximately 4%. Under this initiative, ship based emissions treatment systems producing equivalent emissions may also be accepted as an alternative means of compliance (similar to the options available in the MARPOL Annex VI regulations).
- Plan for implementation of grid supply shore power system in the next 5 years, particularly once anticipated additional shore power enabled vessels begin berthing. This has an estimated total installed cost of $18.3 million (±30%) and has the potential to reduce sulphur dioxide emissions by 33% and greenhouse gas emissions by 31%.

  Pursuit of this option will help POAL move towards its 2040 zero emission goals and support Auckland Council's Low Carbon Auckland Strategy. Supplementing this with renewable solar generation would reduce emissions further but represents a separate investment decision.
- Following implementation of grid supply shore power, continue with fuel switching (or equivalent emission reduction using on-board scrubbers) on vessels that are not capable of receiving shore power.

All solutions above will present implementation challenges. A business case should be developed for each, involving all key stakeholders, to determine an appropriate means of funding and managing the programme. Potential adverse impacts from any mandatory regulations will need to be considered. The benefits of the programme can then be measured fairly against the costs and resources required to implement it.

1 Introduction

This report canvases a variety of specific technologies available in the current market to reduce the emissions from ships hoteling at Ports of Auckland, Queens Wharf cruise terminal. The aim is to determine the preferred solution(s) for Ports of Auckland Limited (POAL) to deliver against the required social, financial and regulatory criteria listed in this report.

The introduction section provides the background, purpose, scope, and methodology used to complete the study. It also includes a discussion of the key project drivers.

The practices and standards section follows with a review of the global trends and methods that other ports have implemented to reduce hoteling emissions. This is followed by a discussion of the related international and local standards on emissions and emission reduction technologies.

The project information section discusses the project details. This includes analysis of the POAL cruise schedules along with capacity of the local utilities (natural gas and electricity) to better understand the feasibility of each emission control technology. This is followed by a discussion on possible government funding options available to POAL to implement such an initiative.

The following two sections of the report; “concept options” and “solutions evaluations” review different possible emission control technologies. Using an evaluation matrix, possible technologies are narrowed down to three (3) shortlisted options. The advantages and disadvantages of each option are discussed in detail.

Finally, the report provides an assessment of the three preferred options, including costs, and wraps up with a conclusion and recommendations to be considered by POAL.

1.1 Background

In recent years, worldwide attention has increased on the environmental impacts of port operations on their nearby communities. This is more important when considering the location of these ports, many of which are situated at the heart of major cities. One of the main environmental challenges that major ports, including POAL, are facing is the pollutant and noise emissions from the hoteling activities of different vessels such as cruise, container, break bulk, dry bulk and vehicle carrier ships when at berth.

Hoteling vessels typically run their on-board generators on heavy fuel oil (HFO) to provide electrical power for their on-board amenities, equipment and passengers. Studies have highlighted direct correlations between some of the emission components and public health implications (Corbett, 2007), (World Health Organization, 2013) (Broome, et al.).

With the goal of becoming a global leader in sustainable port operations, and in-line with its sustainability strategy (including 2040 zero emissions target), POAL has commissioned this study to define the preferred approach for reducing emissions from hoteling cruise vessels. The initiative has resulted from an appreciation of increasing public concerns regarding the potential health and environmental implications. It is POAL's intention to act as the pioneer on this path and drive change in New Zealand towards an emission free port industry.

Cruise vessels were selected as the focus of this study as initiatives are expected to offer the highest return in terms of emission reductions. This approach also appears to be consistent with installations and initiatives at other ports worldwide (refer section 2.1).

The cruise industry has demonstrated a commitment to be at the forefront of developing responsible environmental practices and innovative technologies that lead the world's shipping sector in reduction of air emissions. This is evidenced in vessel operators' proactive measures to install the onboard infrastructure required to control pollutant emissions, operate on alternative fuels and accept shore power. Accordingly, cruise vessels have an increased likelihood of being compatible with potential initiatives and may be more willing to adopt voluntary schemes.

Cruise vessels also have the highest individual power demand at berth (and associated air emissions) when compared with other vessel types and represent a growing proportion of POAL's emissions inventory. Between 2006 and 2010 emissions from hoteling cruise vessels grew from approximately 13% to 17% despite representing only 3% of hours at berth in each year (Peeters, 2010). The high draw will serve to maximise utilisation for any berth-based solution.

It is intended that the study be expanded to other berths and vessel types in 2018.

1.2 Location

The POAL Cruise Terminal consists of three deep water berths on two pile and deck structure finger wharfs; Queens, and Princes. Queens Wharf East, including Shed 10, is the primary cruise ship berth. Queens Wharf has a berthing length of 290 metres while Princes wharf has a berthing length of 320 metres (Ernst & Young, June 2016). Figure 1-1 shows the layout of the current cruise terminal.

Figure 1-1 Ports of Auckland Cruise Terminal Layout

1.3 Purpose and Scope

The objective of this feasibility study is to evaluate the available options for in-berth cruise vessel emission reductions at POAL. The output of the study will provide POAL with recommendations to help deliver on its 2040 zero emission target and long-term sustainability goals. The scope is intentionally broad; aiming to cover a wide range of options to ensure the best available method is selected and implemented. In particular. the scope includes:

- Review of all available emission reduction schemes and technologies to determine their suitability for POAL.
- Analysis of each option with respect to defined evaluation criteria.
- Development of a weighted criteria evaluation matrix to assess different options based on their indicative cost, pollutant reductions, greenhouse gas reductions, noise reductions and constructability risk.
- Compilation of preliminary cost estimates associated with shortlisted options.
- Analysis of three shortlisted options and final recommendations.

While overall cost of options is considered, investigation of potential funding avenues is outside of the study scope. This would be subject to separate review in close consultation with all stakeholder groups.

1.4 Study Drivers

POAL has outlined a commitment to reduce the impact of operations on people and the environment by conducting its activities in the most sustainable way possible. This extends to assisting visiting vessels reduce their environmental footprint. In alignment with this, key drivers for this study are:

Improved Air quality in the Auckland City Airshed:

Improving the air quality in the Auckland city airshed will contribute to the health and well-being of its citizens. The emissions associated with shipping are known to have negative health impacts. Emissions of particulate matter (PM), nitrogen oxides (NO_x), sulphur oxides (SO_X), and carbon monoxide (CO) can increase the risk of respiratory diseases, cardiovascular diseases, premature death and cancer (World Health Organization, 2013) (Broome, et al.), (Corbett, 2007). Using higher grade fuels or options to replace or minimise use of on-board generators for powering the berthed vessels may reduce the health impacts.

Reduced Noise from Cruise Operations:

In addition to improving air quality, noise impacts can also be reduced. Problems related to noise include stress related illnesses, high blood pressure, speech interference, hearing loss, sleep disruption, and lost productivity (European Commission 2015). Given the cruise terminal's proximity to residential buildings and frequency of overnight berthing, reductions in the noise generated at the berth will improve outcomes for neighbours.

Compliance with government regulation and legislation:

Currently there are no regulations for berthed vessel emission levels for cruise ships visiting New Zealand. However, judging by precedents set by other developed countries, it is probable that government regulation and legislation will be introduced in future. By proactively investigating optimal, economical solutions, POAL will be in a strong position to influence adoption of practical emission reduction procedures in future regulations and legislation.

Regulatory measures may include the ratification of IMO MARPOL Annex VI and/or the implementation of a local Emission Control Area, similar to those already implemented in North America, the US Caribbean, North Sea and Baltic Sea (refer section 2.2.1).

Investment and Operating costs:

The capital investment and ongoing operating costs of any emission reduction technology will need to be viable for the long-term port operations.

1.5 Project Stakeholders

Table 1-1 summaries the key project stakeholders their interests and role in the development of this study.

Table 1-1 Project Stakeholders Interest and Priorities

Company	Name	Position	Project Role
Ports of Auckland	Tony Gibson	Chief Executive Officer	Project Sponsor
Ports of Auckland	Rosie Mercer	Manager Sustainable Business Improvement	Project Lead
Cruise Lines International Association	Dimity McCredie	Advocacy Director	Stakeholder
Carnival Australia	Sandy Olsen	Vice President Corporate Affairs	Stakeholder
RCL Cruise Ltd	Neil Linwood	Director, Operations	Stakeholder
Ponant	Sarina Bratton	Chairman Asia Pacific	Stakeholder
Norwegian Cruise Lines	Jason Worth	Sr Director of Finance	Stakeholder
Holland America Group	Keith Taylor	EVP, Fleet Operations	Stakeholder

1.6 Methodology

The key steps of the project methodology are shown in Figure 1-1 and discussed below.

Figure 1-2 Project Methodology Key Steps

The methodology adopted combines the technical expertise of the study team with the key POAL objectives. The project was started with a kick-off meeting to establish the baseline outcome of the study, including expected deliverables, schedule and project objectives.

The original emission reduction technology options were discussed and developed in the initial kick-off meeting. To confirm the success and availability of each of these options the study team conducted online research of other similar installations, feasibility studies and other global port installations. A high-level viability assessment was carried out on all identified options to determine their feasibility for POAL. No option was removed at this stage.

In parallel, analysis was completed on the cruise ship schedules (2015 to 2017) to broadly quantify current in-berth generation and reductions available under each of the options.

The study team reviewed the project drivers and developed a set of selection criteria which were weighted in accordance with the project objectives to short-list the options. The criteria were reviewed with POAL and agreed upon in a workshop where the proposed evaluation concept was introduced and discussed. During this workshop POAL had the opportunity to validate the alternatives (with potential to add any others identified) and assessment criteria before confirming the overall evaluation and shortlist of options.

Finally, cost analysis was completed on each of the shortlisted options and final recommendations were derived.

2 Practices and Standards

This section provides an overview of current emission reduction technologies that ports and shipping companies are adopting around the world. This overview is used to identify available emission reducing options for the study. The details are discussed in subsequent sections.

Additionally, this section provides an update of the international and local regulations applicable to ship emissions.

2.1 Global Developments

To combat emissions resulting from ships burning heavy fuel oil (HFO) to power their electrical systems while at berth, various technologies are adopted by ports around the world with different results. Greatest uptake of the implemented technologies has occurred where either supported by regulation, such as Emission Control Areas (ECAs), State legislation, or incentives where subsidies are provided to the shipping companies to adopt the technology (e.g. Vancouver and, previously, Hong Kong).

Fuel switching or scrubbers are implemented by numerous vessel operators who sail throughout the current ECAs, including the Atlantic and Pacific coasts of North America, the North Sea and the Baltic Sea as a means of complying with the emission targets in these regions. Additionally, Hong Kong implemented a voluntary fuel switching program to marine gas oil (0.5% sulphur) in 2012 for vessels berthed at the port. Hong Kong port authorities offered a reduction in port facility dues for ships that switch to low sulphur fuel. This voluntary program has now been superseded by legislation that has made the use of low sulphur fuel mandatory there. In October 2015 Sydney Harbour implemented a requirement for all ships to burn low sulphur fuel (0.1%) while at berth (Cruise Shipping Legislation, 2017). This was subsequently replaced by AMSA Marine Notice 21/2016 (refer Section 4.2.3.2).

The Chinese government in 2016 agreed to implement an ECA in the Pearl River Delta, the Yangtze River Delta and the Bohai Bay rim area. The new regulations stipulate by 2019 all ships entering these ECAs will be required to use fuel with a sulphur content below 0.5%. (Chinese Emission Control Areas (ECAs) effective from 1 January 2016, n.d.)

The Port of Los Angeles in the United States of America has implemented a barge mounted emission capturing system. This system was the first of its kind and developed by Advance Maritime Emission Control System team as an alternative to shore power and is an approved technology by the California Air Resource Board. Current operating versions of this system appear to be aimed at cargo/container vessels only.

The Port of Hamburg has been pioneering the use of a mobile Liquefied Natural Gas (LNG) fuelled shore power barge. The barge generates the required electricity for the cruise ships by burning the on-board LNG and connects to the local berth electrical infrastructure to provide power to berthed vessels. The advantage of this system is the mobile power barge has the flexibility to provide external energy to ships at other berths without requiring extensive infrastructure investment. The Port of Rotterdam is following a similar approach and announced in October 2016 that it will employ a floating barge LNG powered shore power system by June 2017 (Rotterdam could get LNG Hybrid Barge, 2017). The barge will initially serve cruise ships at this port.

The most common practice to reduce hoteling emissions adopted by many ports around the world is a grid supply shore power system. In California, the use of shore power is listed by the California Air Resource Board (CARB) as a way to reduce at berth emissions by 80% by 2020. This has resulted in the implementation of shore power systems in many other ports around the world. As an example, the Chinese government released its air pollution prevention action plan, which indicates shore power facilities must be either installed or required space be provided in all new port developments (Natural Resources Defense Council, 2014).

In Canada, five ports have now been installed with shore power infrastructure (including cruise vessels) under a government sponsored initiative. The most recent installation on a cruise berth is at the Port of Montreal, completed August 2017. This had a published capital cost of CAN$11 million (approx. NZ$12.5 million), excluding any frequency conversion, and was delivered using a combination of funding from federal government (CAN$5 million), provincial government (CAN$3 million) and Montreal Port Authority (CAN$3 million).

A listing of current shore power installations is provided in Table 2-1.

Table 2-1 Shore Power Enabled Ports. (World Ports Climate Initiative, n.d.) (Port of Montreal, 2017) (Watts, 2017)

Year	Port	Country	Size (MVA)	Freq. (Hz)	Voltage (kV)	Vessel Type
2000	Gothenburg	Sweden	1.25-2.5	50 & 60	6.6 & 11	RoRo, RoPax
2000	Zeebrugge	Belgium	1.25	50	6.6	RoRo
2001	Juneau	U.S.A.	16	60	6.6 & 11	Cruise
2004	Los Angeles	U.S.A.	7.5	60	6.6	Cruise, Container
2005	Seattle	U.S.A.	20	60	6.6 & 11	Cruise
2006	Seattle	U.S.A.	16.25	60	6.6 & 11	Cruise
2006	Kemi	Finland	N/A	50	6.6	RoPax
2006	Kotka	Finland	N/A	50	6.6	RoPax

Year	Port	Country	Size (MVA)	Freq. (Hz)	Voltage (kV)	Vessel Type
2006	Oulu	Finland	N/A	50	6.6	RoPax
2008	Antwerp	Belgium	0.8	50 & 60	6.6	Container
2008	Lubeck	Germany	2.2	50	6	RoPax
2009	Vancouver	Canada	20	60	6.6 & 11	Cruise
2009	Vancouver	Canada	20	60	6.6 & 11	Cruise
2010	San Diego	U.S.A.	20	60	6.6 & 11	Cruise
2010	San Francisco	U.S.A.	20	60	6.6 & 11	Cruise
2010	Karlskrona	Sweden	2.5	50	11	Cruise
2011	Long Beach	U.S.A.	20	60	6.6 & 11	Cruise
2011	Oakland	U.S.A	7.5	60	6.6	Container
2011	Oslo	Norway	4.5	50	11	Cruise
2011	Prince Rupert	Canada	7.5	60	6.6	N/A
2012	Rotterdam	Netherlands	2.8	60	11	RoPax
2012	Ystad	Sweden	6.25	50 & 60	11	Cruise
2013	Trelleborg	Sweden	3.5-4.6	50	11	N/A
2014	Halifax	Canada	20	60	6.6 & 11	Cruise
2015	Hamburg	Germany	12	50 & 60	6.6 & 11	Cruise
2015	Brooklyn	U.S.A.	20	60	6.6 & 11	Cruise
2017	Montreal	Canada	TBC	60 (TBC)	6.6 & 11 (TBC)	Cruise, Container

2.1.1 Trends for Ship Emission Reduction Infrastructure

MARPOL Annex VI has been introduced to regulate pollution from ships. It restricts NO_X emissions and nominates sulphur limits for marine fuels - 0.5% worldwide (starting in 2020) and 0.1% within Emissions Control Areas (ECAs). Alternative technologies producing equivalent emissions are also accepted. Accordingly, operators have options to achieve compliance.

For existing vessels, one option is to install scrubbers on-board and benefit from the cheaper costs of Heavy Fuel Oil compared to low sulphur marine diesel (MGO). Carnival Cruise lines made the decision in 2014 to install scrubbers in 70 of their existing fleet (Environmental Leader, 2014). Additionally, Royal Caribbean Cruises Limited announced in 2014 it would install scrubbers on 19 of its vessels (World Maritime News, 2014) and committed to having scrubbers fitted to all vessels visiting New Zealand by September 2019 (Linwood, 2017).

As the price difference between HFO and MGO has reduced, many shippers have postponed the scrubber investment and made the switch to MGO as their main fuel (den Boer & Hoen, 2015). However, the cost difference between HFO, MGO and electricity in New Zealand may motivate operators to upgrade vessels with shore power systems and capitalise on potential cost savings. The main advantage of scrubbers over shore power is that they are also effective at reducing emissions under propulsion, not just at berth.

For new vessel builds, engine manufacturers such as Rolls-Royce, MAN, Wärtsilä, Mitsubishi and Caterpillar have already delivered LNG capable engines. The trend of engine manufacture appears to focus on dual fuel engines capable of running on both LNG and low sulphur diesel, negating the need for scrubbers (Helfre & Boot, 2013).

2.2 Regulatory Requirements

2.2.1 International Regulations

The International Maritime Organisation (IMO) is a United Nations funded organisation responsible for developing and maintaining a regulatory framework for global shipping. It executes emission reduction methods through the International Convention for the Prevention of Marine Pollution from Ships (MARPOL). Annex VI specifically deals with the prevention of air pollutants (NO_x and SO_x) from vessels and prohibits the deliberate emissions of ozone depleting substances. The Convention also regulates shipboard incineration and the emissions of volatile organic compounds (VOCs) from tankers.

MARPOL Annex VI:

- Affects main propulsion engines, auxiliary engines and auxiliary boilers
- Will alter the limit for sulphur content in fuel used by oceangoing vessels from 3.5% to 0.5% by January 2020.
- Limited fuel sulphur content within an ECA to 0.1% from January 2015.

- Established Tier III NO_x emission standards for new engines on larger ships constructed after January 2016 and operating in ECAs. This is equivalent to an 80% reduction on Tier I emission levels.
- Annex VI allows signatory countries to apply to the IMO for the designation of an ECA with more stringent control of ship emissions. ECA designation must be accompanied with a detailed assessment of how SO_x emissions from shipping in the area are adversely contributing to air pollution. Existing ECAs include:
  - Baltic Sea (SO_x);
  - North Sea (SO_x);
  - North America ECA, including most of US and Canadian coast (NO_x and SO_x);
  - US Caribbean ECA, including Puerto Rico and the US Virgin Islands (NO_x and SO_x).

New Zealand became a signatory to MARPOL in 1998. New Zealand has not ratified Annex VI (prevention of air pollution from ships). The Ministry of Transport is, however, currently reviewing policy regarding this and expects to make a recommendation in early 2018 on whether to adopt Annex VI. It is understood that vessels flagged to a signatory State must comply with the Annex regardless of whether the country they are calling at is a signatory.

2.2.2 Local Standards

2.2.2.1 Air Quality

The Air Quality in New Zealand is primarily governed by the Resource Management Act 1991 (RMA) and is managed by a number of agencies. The Ministry for the Environment is responsible for protecting the health of the public by recommending national air quality standards. In addition, regional councils and local authorities are responsible for ensuring that the air quality standards are met in their regions.

In 2004, the National Environmental Standards for Air Quality (NESAQ) were published, and have gone through several amendments. In essence, NESAQ align with sections 43 and 44 of the RMA (Ministry for the Environment 2011) and include:

- Seven standards banning activities that discharge significant quantities of dioxins and other toxics into the air.
- Five ambient air quality standards for carbon monoxide (CO), particulate matter less than 10 micrometres in diameter (PM_{10}), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ozone (O_3)

The NESAQ are set for the specified contaminants above so that they do not exceed a prescribed threshold concentration in an airshed unless the exceedance is permissible. Table 2-2 outlines Schedule 1 of the NESAQ for the five contaminants listed above.

Table 2-2 Schedule 1 of the National Environmental Standards for Air Quality

Contaminant	Threshold concentration	Exceedances allowed in a 12-month period
Carbon monoxide (CO)	10 mg/m^3 expressed as a running 8h mean	1
Nitrogen dioxide (NO_2)	200 µg/m^3 expressed as a 1h mean	9
Ozone (O_3)	150 µg/m^3 expressed as a 1h mean	None
PM_{10}	50 µg/m^3 expressed as a 24h mean	1
Sulphur dioxide (SO_2)	350 µg/m^3 expressed as a 1h mean	9
	570 µg/m^3 expressed as a 1h mean	None

The RMA specifically addresses air emissions related to shipping in the following sections:

- Section 15, subsection 2
- Section 15B: Discharge of harmful substances from ships or offshore installations
- Regulation 15 of the Marine Pollution Regulations

These regulations only address abnormal operations (fire, excessive exhaust smoke etc.) and do not address the emissions from vessels under normal operation (i.e. hoteling at berth, propulsion etc.)

In addition to the NESAQ, New Zealand has ambient air quality guidelines. The guidelines promote the sustainable management of the air resource in New Zealand. As such, the guideline values are minimum requirements that all outdoor air quality should meet to protect people and ecosystems from adverse effects.

Key differences between the national ambient air quality guidelines and the NESAQ are that the guidelines:

- Cover a wide range of pollutants, including toxins, whereas the national environmental standards include only five priority pollutants.
- Promote the protection of both ecosystems and human health, whereas the national environmental standards only focus on human health.

- Recognise and promote the maintenance and enhancement of air quality through the use of environmental indicators (e.g. establishment of action and alert levels below the guideline values).

For more information on the national ambient air quality guidelines please refer to: http://www.mfe.govt.nz/air/ambient-air-quality-guidelines

It should be noted that, while emissions from the normal operation of ships (including at berth) is not expressly regulated under the RMA, it is implied that any fixed (or floating) installations at the berth would need to comply and be granted resource consent.

2.2.2.2 Noise Standards

Specific noise limits for the Port Precinct have been nominated in the Auckland Unitary Plan. These are summarised as follows:

- Exemption from noise standards for the operational requirements of commercial vessels within the costal marine area
- Limit of 60dB L_{Aeq} and 85dB L_{AFmax} 11pm to 7am measured at 1m from the façade of any building on the southern side of Quay Street, beyond the inner control boundary (reflections excluded)
- Limit of 50dB L_{Aeq} and 75dB L_{AFmax} 11pm to 7am measured at 1m from the façade of any residential building located beyond the outer control boundary (reflections excluded)
- Limit of 55dB L_{Aeq} 7am to 11pm measured at 1m from the façade of any residential building located beyond the outer control boundary (reflections excluded)

According to the World Health Organization (WHO) sound pressure levels at the outside facades of living spaces should not exceed 45 dB(A) with an L_{max} of 60 dB(A), so that people are able sleep with bedroom windows open. These values are obtained assuming the noise reduction from outside to inside with the window partly open is 15 dB.

2.3 Emission Reduction Standards

At present, there are no international standards specifically relating to emission reduction technologies or methods for oceangoing vessels (e.g. scrubbers).

An international standard has, however, been established for shore power installations - ISO/IEC/IEEE 80005-1:2012. A summary of the general requirements based on Part 1 of the standard is provided below:

- Equipotential bonding between ship's hull and shore earthing electrodes shall be established;
- Typical onshore HV supply nominal voltage is 6.6kV or 11kV. Note, 11kV is typical for cruise ships longer than 200m while 6.6kV may be utilised by other vessels including cruise ships shorter than 200m, container ships, break bulk and dry bulk ships;

- A short circuit and load analysis study shall be performed and provided for the shore side;
- Operating frequency (Hz) of the vessel and shore electrical systems (supply) shall match (typically 60 Hz) otherwise a frequency converter on the shore side is required;
- A dedicated HV shore supply installation is required to provide galvanic isolation from other connected ships and consumers typically using an isolation or power transformer;
- A delta-wye transformer with load tap changer and neutral earthing resistor will be utilised (in case no frequency conversion is required);
- The Neutral Earthing Resistor rating will be not less than 1.25 times the rated charging current. The current rating will be a minimum of 25A and the resistor rating will be 200 Ω (continuous);
- Ship to shore connection interface for cruise ships will follow a specific design (hardwired);
- Maximum short-circuit current for plugs and sockets to be 25kA for 1sec. or 40kA peak.

3 Project Information

The following sections establish the specifications for different emission control technologies. It considers berth utilisation to determine the extent of the required infrastructure for each option and identifies which berths are to be upgraded. Additionally, upstream utility infrastructure (electricity and natural gas) is assessed to determine if the extra capacity needed is available.

Finally, potential government funding opportunities to assist POAL implement the emission reduction method is assessed and summarised.

3.1 Vessel Demand

In the absence of direct data from vessel operators, Table 3-1 (Wang, Mao, & Rutherford, 2015) was used to estimate the power demand based on each vessel's length.

Table 3-1 Typical Hoteling Power Load for Cruise Vessels

Vessel Type	Average Power (MW)	Peak Power (MW)	Peak Power - 95% of Vessels (MW)
Cruise Ship <200 m	4.1	7.3	6.7
Cruise Ship >200 m and <300 m	7.5	11	9.5
Cruise Ship >300 m	10	20	12.5

The table in Appendix 1 extends this to all cruise vessels that berthed during 2015, 2016 and 2017 using lengths established online (Cruise New Zealand, 2013). This also includes a determination on whether the vessel has the capacity to accept shore power in accordance with the IEC/ISO/IEEE 80005 standard, established from a published list of compatible cruise vessels (City & Port Development, CMP and the City of Copenhagen, 2015). The list was also ratified against the Princess Cruises website (Princess Cruises, n.d.) and information received directly from cruise lines.

Limited information was available on the delivery voltage for shore power enabled vessels. This was generally expected to be a mix of 6.6kV and 11kV, again, primarily driven by vessel length.

The exception to this is PONANT who nominated shore power capability for their ships with a delivery voltage of 690V. This aligns will a smaller vessel category of the IEC/ISO/IEEE 80005 standard and would likely require the inclusion of additional step-down transformers. POAL may consider accommodating this supply voltage in any system installed, however, it has been excluded from the analysis (and system capital costs) given the limited utilisation.

All vessels were assumed to operate at 60Hz.

3.2 System Capacity

To ensure the peak draw of all potential vessels can be accommodated, any prospective shore power solution would need to be able to deliver 20MW of electricity (per berth). A capacity of 15MW, however, would be expected to accommodate the vast majority of visiting vessels (>95%) and represents double the average draw of sub 200m vessels (most common vessel) in case this needed to be divided. Accordingly, a minimum 15MW capacity was nominated for all potential shore power solutions. This also aligns with the IEC/ISO/IEEE Standard requirement for 16-20 MVA per berth.

3.3 Cruise Schedule Analysis

Analysis was completed using the schedules provided by POAL for 2015, 2016 and 2017 to quantify annual in-berth generation by hoteling cruise vessels. This also provided insight into capacity specifications and likely utilisation of prospective solutions.

Vessels were allocated a notional berth for each visit. The intent was to maximise utilisation of Queens Wharf East (i.e. highest priority for shore power system), then Princes Wharf followed by Queens Wharf West.

The following priority sequence was used to determine the berth allocation:

1. Ability to accept shore power;
2. Total power draw during visit.

For simplicity, it was assumed that once a vessel was berthed, it would not be moved (i.e. if staying multiple nights, a vessel would not be moved to make way for a large vessel arriving).

When looking at all ships on the cruise schedule the results shown in Table 3-2 were obtained:

Table 3-2 Berth and Power Draw of all Vessels

	Queens Wharf East (Berth 1)		Princes Wharf (Berth 2)		Queens Wharf West (Berth 3)		Total	
	Days Utilised	Energy (MWh)	Days Utilised	Energy (MWh)	Days Utilised	Energy (MWh)	Days Utilised	Energy (MWh)
2015	90	8,503	16	1,469	3	121	**109**	**10,093**
2016	86	8,115	15	1,509	4	192	**105**	**9,817**
2017	74	7,178	25	2,241	5	372	**104**	**9,792**
Total	**250**	**23,796**	**56**	**5,219**	**12**	**685**	**318**	**29,701**

Revising the analysis to only account for vessels identified with the ability to accept shore power (either currently or within 5 years) delivered the results in Table 3-3.

Table 3-3 Berth and Power Draw of Shore Power Enabled Vessels

	Queens Wharf East (Berth 1)		Princes Wharf (Berth 2)		Queens Wharf West (Berth 3)		Total	
	Days Utilised	Energy (MWh)	Days Utilised	Energy (MWh)	Days Utilised	Energy (MWh)	Days Utilised	Energy (MWh)
2015	40	3,818	2	165	0	0	**42**	**3,983**
2016	30	2,820	0	0	0	0	**30**	**2,820**
2017	32	2,981	2	173	0	0	**34**	**3,154**
Total	**102**	**9,619**	**4**	**338**	**0**	**0**	**106**	**9,956**

3.4 System Demand and Utilisation

Table 3-2 indicates that, on average, approximately 9,900 MWh of electricity is generated annually by berthed cruise vessels for hoteling loads (across roughly 106 days of utilisation). The percentage of this electricity that could be generated in the Queens East berth ranged between 73% and 85% of the total.

Table 3-3 demonstrates that a suitable shore power system installed on a single berth (Queens East proposed) would be expected to deliver approximately 3,200 MWh per year and accommodate between 94% and 100% of all shore power enabled vessels. Even when accommodating growth, utilisation of a system installed on a secondary berth would be poor. Accordingly, a single berth installation was assumed for all infrastructure oriented solutions.

While the analysis was deemed to be adequate for the purposes of the feasibility study, the following key points should be noted:

- The analysis is entirely based on a nominal assumed power consumption derived from each vessel's length. The analysis should be revised using typical hoteling power consumption specific to each vessel when available. WorleyParsons/Advisian was, however, unable to obtain this information from the respective vessel operators within the timeframe of the study.
- The study team was not able to validate which vessels were to be fitted with shore power capability in the near future.
- The 2017 schedule appeared to extend as far as mid-December only. No adjustment was made to account for potential visits through until the end of the calendar year. This will act to underestimate the 2017 figures marginally.
- The power consumption is based on the nominated average draw and total duration at berth. No reduction was made for time taken to connect and disconnect to the system. This process is expected to take around half an hour each resulting in a reduction of approximately 8% on the power draw of a typical 12h stay.

3.5 Future Trends and Growth

Global trends have seen cruise holiday demand grow steadily over recent years. A combination of increased diversity of services in the sector and a drive by operators to satisfy the growing demand for cruise holidays has resulted in a worldwide trend for larger vessels. These require more power to cater for the additional amenities, like water parks, theatres, restaurants etc. as well as additional passenger numbers. This said, some counteractive measures are also being implemented to improve energy efficiency on-board (e.g. insulation, double glazing, energy efficient heating/cooling).

Overall cruise ship trends are anticipated to have the following results:

- Passengers numbers increase beyond 5000,
- More amenities to support the stay aboard customers,
- Vessel length may increase beyond 350 m.

It is expected that growth in passenger numbers will primarily be accommodated through the arrival of larger vessels. Increases in the number of vessels visiting and duration of stays is expected to be relatively marginal. Given global trends and IMO regulations, these new vessels are more likely to be fitted with shore power infrastructure and will consequently increase system utilisation.

Indicative visit frequencies for a larger, shore power capable vessel from the Princess Lines from late 2019 (Majestic Princess) would potentially increase shore power system utilisation by 40%.

3.6 Utility System Capacity

3.6.1 Electrical Utility System Capacity

Options involving shore power delivered from the local electricity network will require a dedicated, high capacity supply from nearby grid connection point. Discussions with the local distribution company (Vector) identified three potential sources:

- Option 1: Supply from the local 11kV substation situated near Queens Wharf,
- Option 2: Supply via a new 22kV supply from Hobson Street Substation,
- Option 3: Supply via a new 22kV supply from Quay Street Substation.

Details of the available capacity are listed in Table 3-4.

Table 3-4 Electrical Network Supply Options and Available Capacities

Substation	Spare Capacity (Substation)		Distance to Queens Wharf (meters)
	Substation Peak	Substation N-1	
Queens Wharf Substation (11kV)	2 MVA	0	80
Hobson Street Substation (22kV)	> 30 MVA	> 30 MVA	750
Quay Street Substation (22kV)	> 30 MVA	10 MVA	650

The option to supply from the local Queens Wharf 11kV substation was discounted due to a capacity limitation of 2MVA. This capacity is insufficient to meet the minimum shore power electrical capacity nominated at 15MW.

Supply from both Quay and Hobson Street substations was available at a capacity greater than 30MVA under normal operating conditions. Redundancy to a level of N-1 is available at the bus level at each of these substations, although there is a capacity limitation of 10MVA at this redundancy from the Quay Street substation. As on-board generation remains available for cruise ships, however, it would be unlikely that the supply agreement between Vector and POAL would require a guaranteed redundancy. Furthermore, N-1 redundancy in final supply to Queens Wharf is also limited by the number of supply cables provided to the electrical equipment terminals at Queens Wharf.

Hobson Street substation was initially nominated as the preferred option as the cable route would pass Princes wharf on its way to Queens Wharf, allowing for minimum future excavation should POAL also elect to enable shore power on Princes wharf. However, following further consideration, supply from Quay Street substation was selected as the final preferred option due to both minimised impact to public by cable routing within POAL controlled land and a subsequent lower overall cost.

An aerial mark-up of the proposed options is provided in Appendix 2. A summary of the capacity and cost options considered for Queens Wharf (Option 1), Hobson Street (Option 2) and Quay Street (Option 3) substations is provided per Table 3-5. Note that in this table, "a" and "b" correspond to parallel and single cables between the upstream substation and the Queens Wharf Substation for each option respectively.

The installation cost of supply options from the Hobson Street substation could potentially be reduced if combined with works under the City Rail Link (e.g. installation of a conduit). This, however, would only apply to a portion of the route and Quay Street supply options remained the preference.

Table 3-5 Utility Upgrade Cost Summary for Shore Power

Option	Description	Normal Cable Capacity (MVA)	N-1 Cable Capacity (MVA)	Estimated Cost ($ M NZD)
1	Queens Wharf (11 kV)	Not applicable. Does not have capacity		
2a	Hobson St (2 x 22kV)	30	15	4.2
2b	Hobson St (1 x 22 kV)	20	0	2.5
3a	Quay St (2 x 22 kV)	30	15	3.2
3b	Quay St (1 x 22 kV)	20	0	1.9

Due to the limited benefit of additional redundancy and ability to deliver the nominated capacity, a single supply cable was nominated for the infrastructure upgrade requirements (i.e. Option 3b selected).

3.6.2 Gas Utility System Capacity

Options involving local generation for shore power using natural gas delivered from the local reticulation network will require a dedicated supply from a suitable nearby tie-in point. Discussions with the local distribution company (Vector) identified two potential sources. These included:

- Option 1: Supply from the local 4 bar(g) medium pressure network near Queens Wharf
- Option 2: New high capacity supply from the 20 bar(g) intermediate pressure transmission line.

Table 3-6 Gas Network Supply Options Summary

Tie in Location	Maximum Available Supply Capacity (Sm^3/h)	Distance to Queens Wharf (meters)
4 bar(g) (MP4) Network	3,000	220
20 bar(g) (IP20) Network	> 10,000	2,000

The option to supply from the 20 bar(g) network is sufficient to meet the required electrical demand for all generating technologies, however, due to prohibitive distance to the nearest network tie-in location resulting in indicative order of magnitude costs of greater than $5 million, this option was discounted.

Local supply from the 4 bar(g) network is sufficient to support the Natural Gas generation option only at a maximum supply rate of 3,000 Scm^3/h. It is expected that this flow could support approximately 16MW of local generation. Estimated order of magnitude costs for this supply option returned at a value of $900k. This was based on a supply network extension from Quay Street/Lower Albert Street for a distance of 220m to the POAL connection point.

A summary of the capacity and cost options for both gas supplies is provided per Table 3-7 below.

Table 3-7 Queens Wharf Supply - New Gas Supply

Description	Supply Capacity (Sm^3/h)	Estimated Cost ($NZD)
Install 220m of 6" steel mains extension from Quay Street/Lower Albert Street intersection to new ICP at Queens Wharf. Inclusive of one new IP20/MP4 DRS.	3,000	900k

Description	Supply Capacity (Sm^3/h)	Estimated Cost ($NZD)
Connection to IP20 network. Located remote from Queens Wharf Site.	>5,000	> 5m

3.7 Funding Options

A brief review was completed on available grants and potential funding contributions applicable to a project targeting urban air emission reductions. In particular, this included investigation into public grants advertised through the Ministry for the Environment (MFE), the Ministry for Business, Innovation and Employment (MBIE) and their subsidiaries, principally the Energy Efficiency and Conservation Authority (EECA). These Ministries also highlighted publicly sponsored funds currently available.

3.7.1 Ministry for the Environment (MFE)

Funding sources available through MFE appeared to exclusively target freshwater improvement, site remediation, waste minimisation and community outreach/education programmes. Additional funding sources highlighted from other, related, government departments were similar and typically targeted specific community/tangata whenua initiatives or industries (e.g. agriculture). Unfortunately, none of the identified funds appeared to target a corporate initiative targeting air emissions.

3.7.2 Ministry for Business, Innovation and Employment (MBIE)

Funding sources advertised directly through MBIE are targeted at fostering science, research and innovation as well as helping develop organisations operating in this field. Again, application to an air emissions project seems limited, especially if the technology to be applied was established and not locally developed.

3.7.3 Energy Efficiency and Conservation Authority (EECA)

Although the stated objective of EECA is around energy reduction and increasing efficiency, the application appears to be slightly flexible and may be considered for a project targeting improvements in air emissions. Funding would be particularly relevant if there was a renewable generation component to the proposed system.

Unfortunately, all EECA funding programmes identified appear to have a contribution limit of $100,000 to a maximum of 40% of the cost. While it may be possible to apply for multiple grants for different stages or components of the proposed project, the overall contribution could still have limited influence on a multi-million-dollar capital investment. The exception to this is the potential for interest free crown loans.

Core EECA funds expected to have relevance to the project are provided in Table 3-8.

Table 3-8 Relevant EECA Funding Programmes

Programme	Eligibility	Financial Support
Feasibility Studies and Business Cases		
Assessment of the technical and financial feasibility of an energy efficiency or renewable energy project at design phase.	Public sector facilities and businesses with annual energy spend of more than $500,000	Up to 40% of the cost of writing a feasibility study or business case up to a maximum of $50,000
Crown Loans		
Interest free loans to fund energy efficiency and renewable energy projects for publicly funded organisations. Fees apply.	All public sector organisations	EECA BUSINESS has $2million to allocate to Crown Loans each year
Technology Demonstrations		
Support for the implementation for proven underutilised technologies and process improvements that with wider adoption could improve sector energy performance.	Available to all businesses	Up to 40% of the cost of the technology demonstration to a maximum of $100,000
Systems Optimisation		
Optimisation of all commercial and industrial systems. This includes process heat, pumps and motors, compressed air, refrigeration, HVAC and lighting controls.	Annual energy spend of more than $150,000	Up to 40% of the cost of optimisation measures to a maximum of $100,000
Industrial Systems Design Advice		
Design advice on the energy efficiency of a proposed industrial system or process in the design phase. This includes process heat, pumping and fans, compressed air, industrial refrigeration and manufacturing process.	Annual energy spend of more than $500,000	Up to 40% of the agreed quotation up to a maximum of $100,000

WorleyParsons/Advisian understands that Ports of Auckland is in the process of setting up a collaboration agreement with EECA and recommends discussing funding opportunities for any potential project or initiative directly.

4 Concept Options

A number of potential solutions were identified to help improve emissions from in-berth generation. These are outlined in the section below. For the options considered viable, discussion on the advantages and disadvantages for that option is included. The concept options reviewed are separated into two main categories; shore power and alternative methods.

- Shore Power
  - Grid Supplied
  - Local Generation using Diesel
  - Local Generation using LNG
  - Local Generation using Natural Gas (NG)
  - Local Generation using Methanol
  - Renewable Generation
  - Grid Supply with Supplementary Renewable Generation (hybrid)
- Alternative Methods
  - Vessel Fuel Switching
    - Fuel Switching to Methanol
    - Fuel Switching to LNG
    - Fuel Switching to Low Sulphur Diesel.
  - Land/Barge based Exhaust Capture Systems (Scrubber)
  - Ship Based Scrubbers

4.1 Shore Power Options

A primary method to mitigate in-berth emissions is to supply electrical power from the shore instead of generating this on-board. Any shore power system typically consists of the following electrical units:

- Step up/Step down transformers - to alter the supply voltage to that required by the vessel (6.6 or 11 kV).
- Distribution switchgear and circuit breakers.
- Frequency converter (if required) - to alter the supply frequency to that required by large cruise vessels (60 Hz).
- Cabling and connection pits.
- Cable management system - to handle the cables between the connection pit and the vessel.

With all shore power options, it is also important to consider the operational requirements and health and safety risks associated with connecting and disconnecting the high voltage supply to the ships.

A typical shore connection layout is illustrated in Figure 4-1

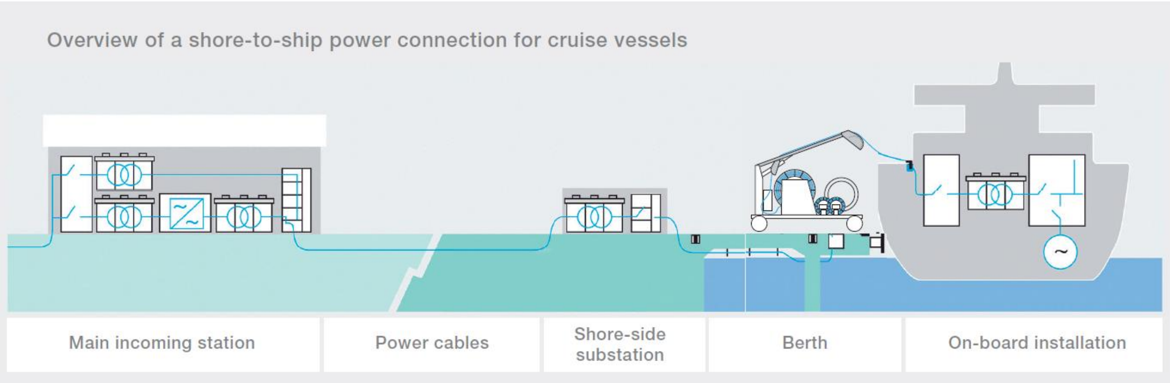

Figure 4-1 Typical Shore Power Connection (ABB, 2016)

Various options are available to supply the required electricity to the system. These are discussed below.

4.1.1 Shore Power - Grid Supply

The most common source of electricity for shore power systems is through a connection to the local power grid. For POAL, this option would involve receiving power from a local substation (operated by Vector) at 22kV, 50 Hz and converting this to the required 6.6kV or 11kV, 60 Hz required by the vessel.

In line with section 3.6.1, power would be supplied from the Quay Street substation via a single 400mm^2 Cu 22kV cable. This would be routed along Quay Street through POAL owned land to the shore side substation adjacent the Queens East cruise berth. Where possible, this cable will be suspended below the dock in a suitable cable tray or conduit. The shore side substation at the berth will house the transformers, switchgear and frequency converters required to change the voltage from 22kV @ 50Hz to 6.6 or 11kV @ 60Hz for supply to the vessels (in accordance with Standard). Cables will be run from the shore side substation underneath the wharf deck to three shore power connection pits. A cable car with an extendable arm is proposed to connect the cables between the connection pit and the ship.

Figure 4-2 shows the assumed shore power equipment layout. It is worth noting that the POAL licence to operate on the Queens Wharf is currently limited to a 7 meters strip from the water front. However, based on the current agreement, it is understood that there is provision for POAL to negotiate for additional space.

Figure 4-2 POAL Assumed Shore Power Layout

Grid power in New Zealand is predominantly generated from renewable sources. Since 2015, this has typically accounted for over 80% of the national supply (Ministry of Business, Innovation & Employment, 2017). While the renewable generation still produces some emissions (predominantly associated with geothermal plants, particularly older, open cycle systems) these are significantly lower than thermal generation and, overall, grid electricity carries comparatively low direct emissions factors (both GHG and pollutants). Release also occurs outside the Auckland airshed, generally in regions with relatively low population density. Accordingly, a grid supplied shore power system will likely deliver significant emission reductions on both a local and overall basis.

Some of the advantages and disadvantages of this method are summarised in Table 4-1.

It should be noted that the system can only be utilised by vessels with on-board infrastructure installed which is required to receive the power supply.

Table 4-1 Advantages and Disadvantages of Grid Supply Shore Power

Advantage	Disadvantage
▪ Grid supplied power is approximately 80% renewable energy. ▪ Reduces emissions of NO_x, SO_x and PM by approximately 33% compared to running auxiliary engines on HFO. ▪ Reduces GHG emissions by approximately 31% compared to running auxiliary engines on HFO. ▪ Removes virtually all residual emissions from the Auckland airshed (for connected vessels). ▪ Proven technology with an international install base. ▪ Modular construction can be completed offsite to allow for reduced site disruption. ▪ Operating cost (Energy cost) is cheaper than HFO. ▪ Reduction in noise and vibration as vessels' auxiliary engines are not running. ▪ May encourage further use of shore power equipped vessels.	▪ Cannot be used by all vessels. Only reduces emissions for shore power enabled vessels. ▪ Requires frequency convertors and associated chillers for cooling.

4.1.2 Shore Power - Local Generation

This suite of options involves generating the power required by the shore power system locally (at the berth). This can be produced from a variety of fuel sources including Low Sulphur Diesel, LNG, Natural Gas and Methanol. Each fuel and generator combination produces a different emissions profile (primarily driven by the fuel).

For the purpose of our study, it is assumed that any reciprocating power generation units are installed on the north-east corner of the Queens Wharf. This will supply power to the shore power connection pits via a medium voltage substation. Local power generation will supply power at the frequency required by the vessels (60Hz) and therefore there is no need for the 50 to 60 Hz frequency convertors. A typical layout for local generation at POAL is shown in Figure 4-3.

It is also possible to employ renewable generation technologies.

Figure 4-3 POAL Shore Power Local Generation layout

4.1.2.1 Shore Power – Local Generation - Low Sulphur Diesel

In this option, diesel fuel with a sulphur content of 8 ppm (0.0008%) was assumed based on the specifications of product available within New Zealand. It should be noted that this is significantly below the fuel sulphur content of 0.1% nominated by MARPOL Annex VI within an ECA.

POAL infrastructure will be required to store and supply low sulphur diesel for the generators. This requires storage tanks and a transfer system. For the purpose of this study it is assumed that POAL's existing infrastructure (used to supply the straddle cranes and other equipment) has sufficient capacity to also supply fuel to these generators. Refuelling the generators would be completed using trucks, eliminating the need to run fuel lines along the wharf.

Table 4-2 Advantages and Disadvantages of Low Sulphur Diesel Generators

Advantage	Disadvantage
▪ Reduces emissions of SO_x and PM by approximately 33% and 23% respectively compared to running auxiliary engines on HFO. ▪ Reduces GHG emissions by approximately 1% compared to running auxiliary engines on HFO. ▪ Proven technology with an international install base. ▪ Modular construction can be completed offsite to allow for reduced site disruption. ▪ Not reliant on the availability of the grid supply.	▪ Cannot be used for all vessels. Only reduces emissions for shore power enabled vessels. ▪ Additional costs to maintain rotating machinery. ▪ Operating cost (energy cost) is more expensive than HFO. ▪ Requires installation of generators on Queens Wharf

4.1.2.2 Shore Power – Local Generation - Natural Gas

Natural Gas is an inexpensive, clean burning fuel that is available via the local reticulation network (delivered directly from Taranaki gas fields). The overall emissions (NO_x, SO_x, $PM_{2.5}$ and PM_{10}) are considerably reduced compared to HFO. The nature (molecular structure) of its primary constituent, methane, means that carbon dioxide (greenhouse gas) emissions are significantly reduced when compared with longer chain hydrocarbon fuels.

Power generation using natural gas is considered a well-established technology which is supplied by all main producers of power generation packages.

A major condition is the availability of adequate capacity in the gas pipeline in the vicinity of the generation equipment. The cost and construction complications of a new pipeline can be a deterring factor for this option. As mentioned in section 3.4, Vector's existing 4 bar(g) gas pipeline can be extended to the generation location and is capable of supplying natural gas required to produce up to 16MW of electrical power.

Table 4-3 Advantages and Disadvantages of Natural Gas Generators

Advantage	Disadvantage
▪ Reduces emissions of NO_x, SO_x and PM by approximately 32%, 33% and 33% respectively compared to running auxiliary engines on HFO. ▪ Reduces GHG emissions by approximately 23% compared to running auxiliary engines on HFO. ▪ Proven technology with an international install base. ▪ Modular construction can be completed offsite to allow for reduced site disruption. ▪ Not reliant on the availability of the grid supply. ▪ Operating cost (energy cost) is cheaper than HFO.	▪ Cannot be used for all vessels. Only reduces emissions for shore power enabled vessels. ▪ Additional costs to maintain rotating machinery. ▪ Requires installation of generators on Queens Wharf

4.1.2.3 Shore Power – Local Generation- Liquefied Natural Gas (LNG)

LNG is natural gas that has been converted to liquid form to facilitate storage and transportation. LNG's volume compared to natural gas is reduced around 600 times. During the process of liquefaction, certain components such as heavy hydrocarbons, helium, acid gasses and dust are removed from natural gas prior to condensation and refrigeration.

Considering there are currently no LNG facilities in New Zealand and the transfer of LNG from elsewhere (e.g. Australia) is not feasible in the quantities required by POAL, this option was not considered as part this study.

4.1.2.4 Shore Power – Local Generation - Methanol

Methanol is another clean burning alternative fuel. The emissions profile is relatively similar to Natural Gas with comparable greenhouse gas reductions. SOx, NOx and PM emission values are also similarly reduced when compared to HFO. It also has the added benefit of being a liquid at ambient temperature and pressure (for storage and transport), however, commands a cost premium.

At the time of writing this report, the availability of generators to power 15MW required for this application could not be verified by the vendors. Israel Electric Company has, however, successfully implemented a methanol power generation facility in the city of Eliat. Accordingly, this option was considered viable in this study.

Table 4-4 Advantages and Disadvantages of Methanol Generators

Advantage	Disadvantage
▪ Reduces emissions of NO_x, SO_x and PM by approximately 30%, 33% and 33% respectively compared to running auxiliary engines on HFO. ▪ Reduces GHG emissions by approximately 22% compared to running auxiliary engines on HFO. ▪ Modular construction can be completed offsite to allow for reduced site disruption. ▪ Not reliant on the availability of the grid supply.	▪ Cannot be used for all vessels. Only reduces emissions for shore power enabled vessels. ▪ Additional costs to maintain rotating machinery. ▪ Operating cost (energy cost) is more expensive than HFO. ▪ Requires installation of generators on Queens Wharf ▪ Additional on-site storage is required.

4.1.3 Shore Power - Renewable Generation

The electricity supply for a shore power system can also, conceivably, be generated locally via renewable technologies. Options considered include wind, solar and tidal generation.

Photovoltaic solar was deemed to offer the only viable solution as there a number of technical and regulatory issues associated with the alternative options. In particular, there is a restriction preventing the installation of wind generation within Auckland City under the Unitary Plan. Local tidal generation system would also likely encounter a number of regulatory and technical limitations, particularly as this is a relatively immature technology.

There are also issues with renewable generation delivering the instantaneous power demand given the space constraints. By way of example, to deliver the nominated 15MW peak load capacity, a photovoltaic array of approximately 150,000m^2 (roughly 18 rugby fields) would be required.

The electricity output from all nominated technologies is also dictated by external conditions (sunlight, wind, tide movement, etc.) and unlikely to suit the relatively constant demand profile from the visiting vessels. This manifests as both insufficient energy available when a ship is in berth and surplus generation potential when no load is connected.

While it is possible to address both issues above by installing batteries to store the generated energy, the size and cost of the bank required was assessed to make this option unfeasible. This would also offer limited benefit in terms of capitalising on surplus generation potential.

Accordingly, it was determined that any renewable generation would be best paired with a connection to the grid under a 'hybrid solution'. This concept is explored separately in Section 4.1.4 below.

4.1.4 Shore Power - Hybrid Grid and Renewable Supply

A number of the issues identified with renewable generation can be addressed by installing a parallel connection to the electricity grid under a 'hybrid' solution. This provides a vehicle to export (and sell) surplus electricity when a ship is not connected or supplement the local generation if demand exceeds supply. This also largely removes the requirement for battery storage.

In evaluating alternative options, it was established that the best outcomes could be achieved if a full capacity (15 MW) grid connection was installed. This was largely due to the marginal conductor cost in relation to trenching and installation. Here, the core emission reduction objectives are delivered through the grid connection with the flexibility to supplement with renewable generation at any ratio.

One option that found particular favour is a hybrid connection featuring a photovoltaic solar array with the capacity to deliver 20% of the total vessel load (on an annual output basis). This offsets the typical non-renewable grid generation mix to deliver a notional, 100% renewable power supply.

To deliver the 600 MWh annual output requirement, a 4,000 m^2 (400 kW peak output) photovoltaic array would be needed. This area translates to approximately 60% of the Shed 2 footprint.

The system could also be supplemented with battery storage to assist with peak shaving under a 'micro grid' solution, however, it is expected that this infrastructure would be installed within the grid network. The renewable generation capacity could also be increased further to help offset POAL's operational electricity demand (and associated emissions).

It should also be noted that, with a full capacity grid connection in place, the investment in renewable generation becomes somewhat separate. It is also conceivable that the generation infrastructure be installed remotely where available space or consent factors are more favourable.

Table 4-5 Advantages and Disadvantages of Hybrid Supply Shore Power

Advantage	Disadvantage
▪ Possibility of 100% renewable energy. ▪ Reduces emissions of NO_x, SO_x and PM by approximately 33% compared to running auxiliary engines on HFO. ▪ Reduces GHG emissions by approximately 33% compared to running auxiliary engines on HFO.	▪ Cannot be used for all vessels. Only reduces emissions for shore power enabled vessels ▪ Requires frequency convertors and associated chillers for cooling. ▪ Additional cost to maintain solar array performance (i.e. cleaning)

Advantage	Disadvantage
▪ Proven technology with an international install base. ▪ Modular construction can be completed offsite to allow for reduced site disruption. ▪ Operating cost (energy cost) is cheaper than HFO. ▪ Reduction in noise and vibration as vessels' auxiliary engines are not running. ▪ Solar array will continuously provide renewable energy to the grid regardless of vessel requirements.	

4.2 Alternative Emission Reduction Solutions

4.2.1 Scrubbers (Vessel Based)

Scrubbers can be installed on vessels to capture and reduce the amount of some of the ships exhaust pollutants (SO_x and PM). By adding scrubbers on the ships, the ships can burn a lower grade fuel (HFO) and still meet the emission requirements in an ECA. There are 3 main types of scrubber technologies available in the market: wet, dry, and hybrid.

Use of scrubbers was initially considered as one of the emission reduction options for POAL. Since POAL does not have any influence over the ship owners to request the installation of the scrubbers on the ships, this option was discounted in the final evaluation. Information gathered during the study indicated scrubber installation costs varied between $1 million and $5 million USD per vessel (den Boer & Hoen, 2015).

Use of this technology by vessel operators is, however, considered as an acceptable alternative under the fuel switching options. Anecdotally, vessels that have scrubbers currently do not operate these when berthed at Auckland. There is an operating cost associated with the scrubbers and it is fair to expect that lines would not self-impose those costs unless there was an incentive based scheme available or a mandatory requirement to do so.

The costs associated with operating scrubbers was not investigated in this study. POAL should undertake to establish this as part of any subsequent work. If use of scrubbers is an acceptable alternative to fuel switching or shore power, then the cost of operating the scrubbers should be determined and included in any annualised cost estimate.

4.2.2 Ship Emission Capturing System

Ship Emission Capturing systems collect exhaust emission at the ship stack, directing the exhaust through a ducting network to an external scrubber which removes harmful pollutants prior to being exhausted into the surrounding environment. The current available systems can be shore based or barged based. Barge based systems have the advantage that they can be used when a vessel is in an anchorage area and minimise use of valuable dockside space.

In general, these types of systems require a large crane and support system. The main benefit of this method is it can be used for all types of vessels regardless of their shore power connection capability. A typical system is illustrated in Figure 4-4.

Figure 4-4 Typical Emission Capture System (Picture courtesy of AMECS website)

At the time of writing this report, however, the vendors of this technology had not responded to inquiries. The team's research indicates that this system has only been trialled on container/cargo vessels in the Port of Los Angeles. The lack of information makes the assessment of this concept difficult. As a result, this option has been considered not commercially viable in our analysis. It is recommended that this option be revisited if/when vendor information becomes available.

4.2.3 Fuel Switching

Fuel switching involves changing from HFO to cleaner burning fuels such as LNG, methanol or low sulphur diesel when the ship is in the berthed at the port

4.2.3.1 Fuel Switching - LNG and Methanol

Both LNG and methanol are viable options for new ship builds. For existing ships, however, substantial investment by the ship owner is required to convert the engines to either dual fuel or dedicated operation on the alternative fuel. Neither fuel supports compression ignition so either a spark source or pilot volume of diesel/fuel oil is required for operation. DNV (Lasselle & Abusdal, 2016) has approximated the costs to convert to a Methanol fuel engine at $10.5M USD.

Currently, neither of these fuel types are used by the cruise ships visiting New Zealand nor are they stored or bunkered on site. For LNG and methanol to be used as a fuel, storage and bunkering systems would need to be established. This would require substantial investment by POAL.

Finally, as POAL has no authority to enforce ship owners to complete the required conversion this option has not been evaluated.

4.2.3.2 Fuel Switching - Low Sulphur Diesel

Under this option it is proposed that POAL implement an arrangement to limit the Sulphur content of fuel used for generation in berth to 0.1% (or equivalent emissions treatment). As mentioned in Section 2.1, regional and local restrictions on sulphur content are a growing trend globally, however, the means of implementation differs globally. Some regions have ECA's imposed by the IMO, others have State imposed restrictions such as the direction issued by the Australian Maritime Safety Authority for cruise vessels with more than 100 passengers berthed in Sydney harbour (Carr & Corbett, 2017). Incentive based schemes are also in place such as in Vancouver. Hong Kong introduced an incentive-based voluntary programme subsidised by the Government until legislation was introduced making low sulphur fuel mandatory.

It should be noted that all diesel available in New Zealand has a significantly lower sulphur content of 8 ppm (0.0008%) to ensure compliance with the 10 ppm limit for automotive diesel. Vessels utilising this fuel would be expected to produce significantly lower SO_X emissions, however, vessels may carry 0.1% fuel on-board (sourced elsewhere). Accordingly, emissions reductions assume 0.1% sulphur. Due to the difficulty of establishing a local cost for 0.1% sulphur diesel without an existing supply, New Zealand pricing for automotive diesel (8 ppm sulphur) has been used in the study.

Switching from HFO to low sulphur diesel is considered a viable option. Many of the ships which visit POAL also transit through the ECA of North America, where using low sulphur fuel is mandatory. Hence the study team assumed all ships which visit POAL are capable of operating on a low sulphur diesel (0.1%) without major investment.

It is anticipated that approximately 2 million litres of low sulphur diesel would be required annually to meet the current at berth generation requirements of all visiting vessels. This represents a marginal increase in national demand and it is expected that adequate supply would be available. It is also expected that existing bunkering and refuelling infrastructure facilities at POAL would generally be adequate.

In the absence of significant engine modifications, supply constraints or regulations mandating its use, the key consideration is addressing the cost premium of the low sulphur fuel. As discussed previously, an holistic approach was taken in the analysis whereby the differential between HFO was included as an annual operating cost. It is recommended that POAL explore how this cost might be met by stakeholders.

Table 4-6 Advantages and Disadvantages of switching to Low Sulphur Fuel

Advantage	Disadvantage
▪ Reduces emissions of NO_x, SO_x and PM by approximately 5%, 96% and 84% respectively compared to running auxiliary engines on HFO. ▪ Reduces GHG emissions by approximately 4% compared to running auxiliary engines on HFO. ▪ Not reliant on the availability of the grid supply. ▪ Available for vast majority of vessels. ▪ Limited capital investment required by POAL. ▪ Adopted at other ports around the world including Sydney Harbour. ▪ Has the potential to be extended to include vessels under propulsion.	▪ Low Sulphur fuel is more expensive than HFO. Cost premium must be addressed. ▪ Additional on-site storage is possibly required. ▪ Operational management, storage and transfer of separate fuel is required

5 Solution Evaluation

This section outlines the procedure and criteria used to shortlist the emission reduction options. For this purpose, only the options which were recognised as viable and within POAL control in Section 4 were evaluated:

1. Shore Power - Grid Supply
2. Shore Power - Renewable Hybrid Supply
3. Shore Power - Local Generation - Diesel Fuel
4. Shore Power - Local Generation - Natural Gas Fuel
5. Shore Power - Local Generation - Methanol Fuel
6. Fuel Switching to Low Sulphur Diesel
7. Emission Capturing System

5.1 Approach

A weighted evaluation matrix was used to assess each of the alternative options against the status quo (i.e. on-board generators operating on HFO). The options were scored based on the identified assessment criteria discussed in the following sections. All criteria except for 'commercial availability' where scored between one (1) and three (3). The 'commercially availability' was scored between zero (0=No) and one (1=Yes), and was used to avoid POAL investing in technologies that are not currently viable.

Scores for each of the criteria were totalled for each option to establish a ranking. Solutions with the highest total score represented the best performance against the evaluation criteria.

Following the initial development of these criteria by the study team, they were all systematically reviewed and agreed upon by the key project stakeholders in a workshop held on Feb 6, 2017. At the start, stakeholders were also given the opportunity to propose additional solutions.

5.2 Weighting and Criteria

5.2.1 Commercial Availability

Commercial availability of the chosen technology was a key driver for the study. POAL decided they should only focus on commercially available solutions, proven in current applications to reduce emissions.

Commercial availability was determined by the study team, through discussion with industry experts, vendors and review of their installation references.

5.2.2 Capital Costs

Order of magnitude capital cost estimates were developed for each option. Equipment prices were based on budget pricing received from vendors or available historical information. Installation allowances were considered for the major equipment only. Costs were ranked high, medium or low depending on the capital investment required. Ranking criteria was as follows:

- Low (3) – Cost less than $5 M NZD.
- Medium (2) – Cost between $5 M NZD and $20 M NZD.
- High (1) – Cost greater than $20 M NZD.

5.2.3 Operating and Maintenance Costs

Operating and maintenance costs were identified as important criteria and were assessed to determine the ongoing viability of each solution.

Base maintenance costs were assumed to be a percentage of the equipment capital. These ranged between 0.5% for fixed electrical equipment to 3% for generators and scrubbers.

Operating costs were based on the cost differential between the proposed fuel for the particular option and on-board generation using HFO.

Annual fuel costs were based on historical, inflation adjusted data from MBIE ($/$GJ_{LHV}$). Trend lines were used to avoid market shifts and sharp price reductions.

The historical fuel and electricity price trends are shown in Figure 5-1 below (based on lower heating value). These represent raw costs. For fuels, an estimated generation efficiency was used to derive the cost of the electrical energy ultimately delivered. These are presented in Table 5-1.

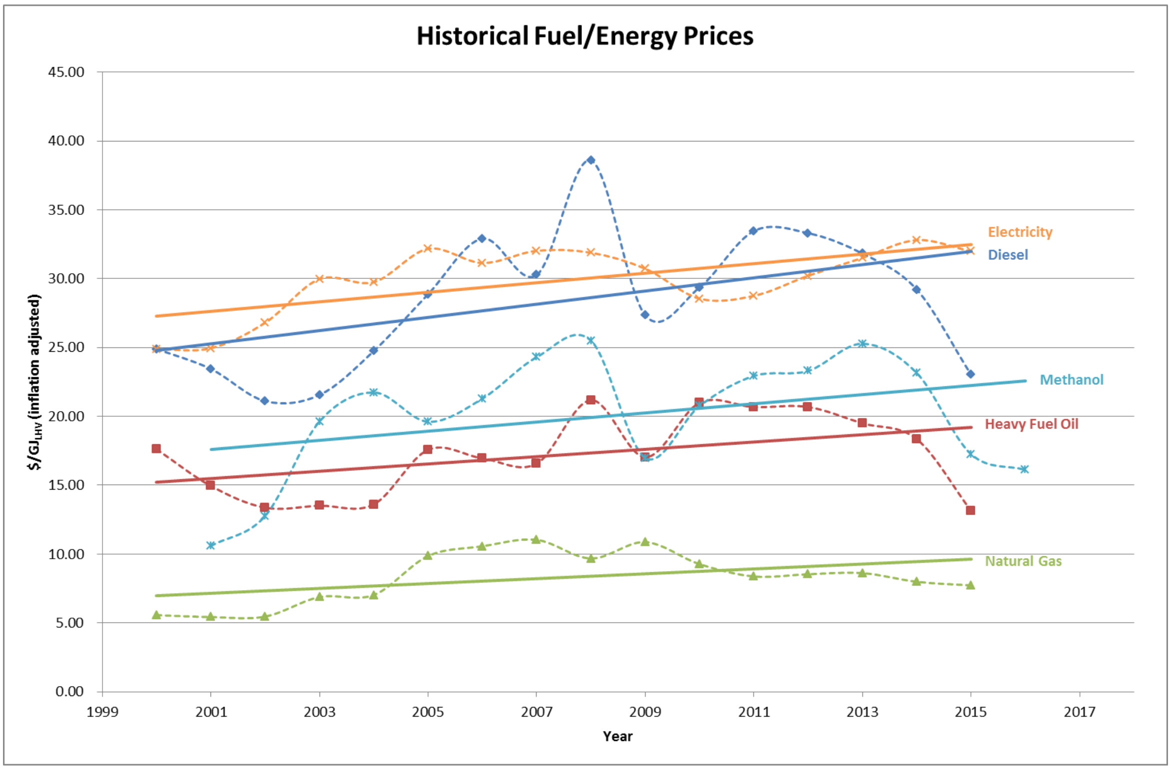

Figure 5-1 Historical Fuel Prices (Minstry of Business, Innovation and Employment, 2017)

Applying generation/conversion efficiencies using the 2017 (trend) cost basis, the approximate cost differential against the HFO base case was calculated as follows:

Table 5-1 Operating and Maintenance Costs

Generation / Conversion Method	Use ($\%_{MWh}$)	Eff. ($\%_{LHV}$)	Energy Cost ($/MWh$_e$)	Energy Delta ($/y)	Maint. ($/y)
Status Quo O/B HFO Generation (low speed engine)	100%	51%	$140	$0	$0
Shore Power Grid Supply (frequency converter)	33%	99%	$120	-$70,000	$25,000
Shore Power Diesel Generation (medium speed engine)	33%	47%	$252	$390,000	$90,000

Generation / Conversion Method	Use ($\%_{MWh}$)	Eff. ($\%_{LHV}$)	Energy Cost ($/MWh$_e$)	Energy Delta ($/y)	Maint. ($/y)
Shore Power LNG Generation (high speed engine)	33%	49%	$160*	$70,000	$105,000
Shore Power Natural Gas Generation (high speed engine)	33%	49%	$80	-$210,000	$100,000
Shore Power Methanol Generation (medium speed engine)	33%	47%	$175	$125,000	$110,000
Shore Power Grid + Solar Generation (frequency converter)	33%	99%	$120	-$140,000	$30,000
Shore/Barge Scrubber O/B HFO Generation (low speed engine)	75%	51%	$140	$0	$300,000
Fuel Switching O/B Diesel Generation (low speed engine)	100%	51%	$232	$985,000	$0

*Estimated bulk cost (LNG not currently available in New Zealand)

The final operating and maintenance costs represent the sum of the maintenance cost and the fuel cost differential. Costs were ranked high, medium or low. Ranking criteria was as follows:

- Low (3) – Costs less than $100kNZD / year.
- Medium (2) – Costs between $100kNZD / year and $400kNZD / year.
- High (1) – Costs greater than $400kNZD / year.

5.2.4 Emission Reductions (Pollutants)

The amount of pollutant reductions against the status quo were considered to capture growing public concern and associated health impacts. The baseline emissions were calculated assuming all vessels berthing at POAL were fuelled by HFO with 2.7% average sulphur content. Emissions for diesel and natural gas options were based on the National Pollutant Inventory report on Emission Estimation Technique Manual for Combustion Engines (Australian Government, 2008). Methanol emission figures were based on Table 4.2 of Methanol as Marine Fuel. (Lasselle & Abusdal, 2016)

An assumed annual generation of 10,710 MWh (119 Vessels with and average visit of 12hrs) of generated power was used to calculate the emission levels which are listed in Table 5-2 . Where Australian emission factors were not available, emission factors from US EPA AP-42 were used (US EPA 2000). The annual emissions were calculated using the generation and the average emission rates throughout the year were used as input to a dispersion model.

Table 5-2 Baseline Emission Levels

Hoteling Energy (MWh_e)	Emissions (tonnes)				
	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO_2-e
10710	157	118	16	16	7756

Each subsequent option was assessed against the base case to determine the emission reduction percentage. The results are illustrated in Figure 5-2 and Figure 5-3. It should be noted that emissions for shore power options assume vessels only equipped with the required equipment would use the technology. All other vessels unable to connect would generate using HFO resulting in residual pollutants.

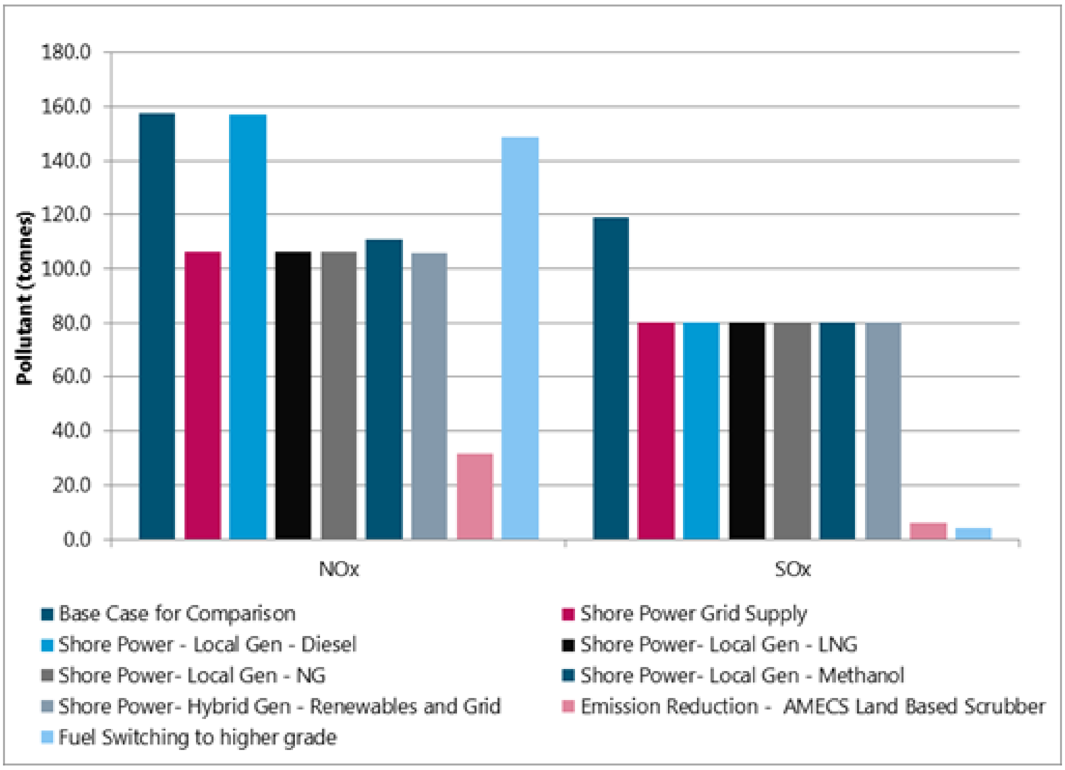

Figure 5-2 Annualised Pollutant NOx and SOx Emission Levels for Year 1 (33% Vessels using Shore Power)

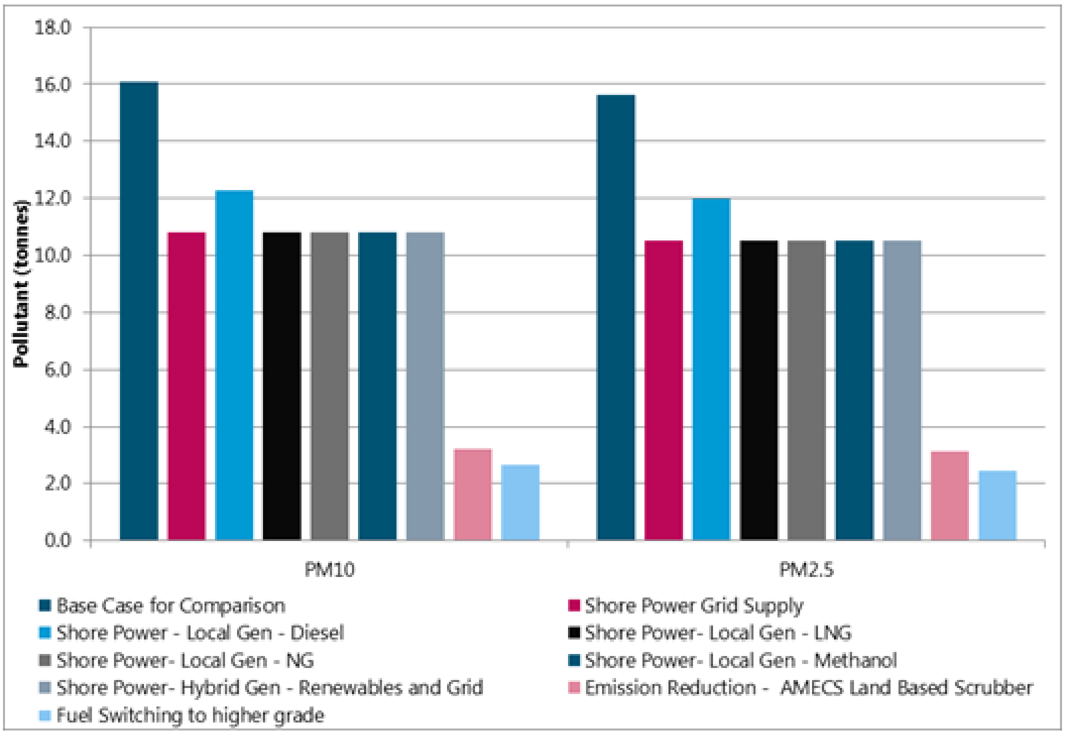

Figure 5-3 Annualised Pollutant PM_{10} and $PM_{2.5}$ Emission Levels for Year 1 (33% Vessels using Shore Power)

For the fuel switching option it was assumed all vessels have the necessary fuel system modifications required to operate on low sulphur fuel, given many travel through the ECAs along the Pacific coast line of North America.

Depending on the assumed acceptance and use of the technology, the general reduction in pollutants was between 30% and 85% of the HFO base case.

Finally, in order to assess the total emission reduction for each option, the tonnes produced per pollutant where compared with guidelines of the US EPA which trigger the requirement for Air Dispersion Modelling. The emission limits prescribed by the US EPA (2014) are:

- NO_x emissions: 40 t/yr
- SO_2 emissions: 40 t/yr
- $PM_{2.5}$ emissions: 10 tonnes per year (t/yr)

The calculated tonnes for NOx, SOx and PM were divided by the 40, 40 and 10 respectively and added together to provide a total emission assessment level (EMAL) value. This method placed a greater emphasis on the PM pollutants due to its associated additional health risks. The total emission number was compared to the HFO base case to determine a percentage for ranking. Rankings were as follows:

- Low (1) –. Less than 20% reduction against base case
- Medium (2) –. Between 20% and 50% reduction against base case
- High (3) – Greater than 50% reduction against base case

It should be noted that analysis of fuel switching to low sulphur diesel assumed a sulphur content of 0.1%, in line with MARPOL regulations within ECA zones. All diesel produced in New Zealand, however, has a nominal sulphur content of 0.0008%. If this was utilised, further reductions in SO_2 emissions could be expected.

5.2.5 Emission Reductions (Green House Gases)

Green House Gas (GHG) emissions are widely accepted to be responsible for global warming and reductions from operations are critical for POAL to meet its zero-emission target.

To determine the GHG emission rankings, the CO_2 equivalent (CO_2-e) of each option was calculated. The HFO base case was compared against the CO_2-e for each option to determine the percentage reduction in GHG emissions. Rankings were as follows:

- Low (1) - Less than 15% reduction against base case
- Medium (2) - Between 15% and 30% reduction against base case
- High (3) - Greater than 30% reduction against base case.

The results of GHG reduction scores are illustrated in Figure 5-4.

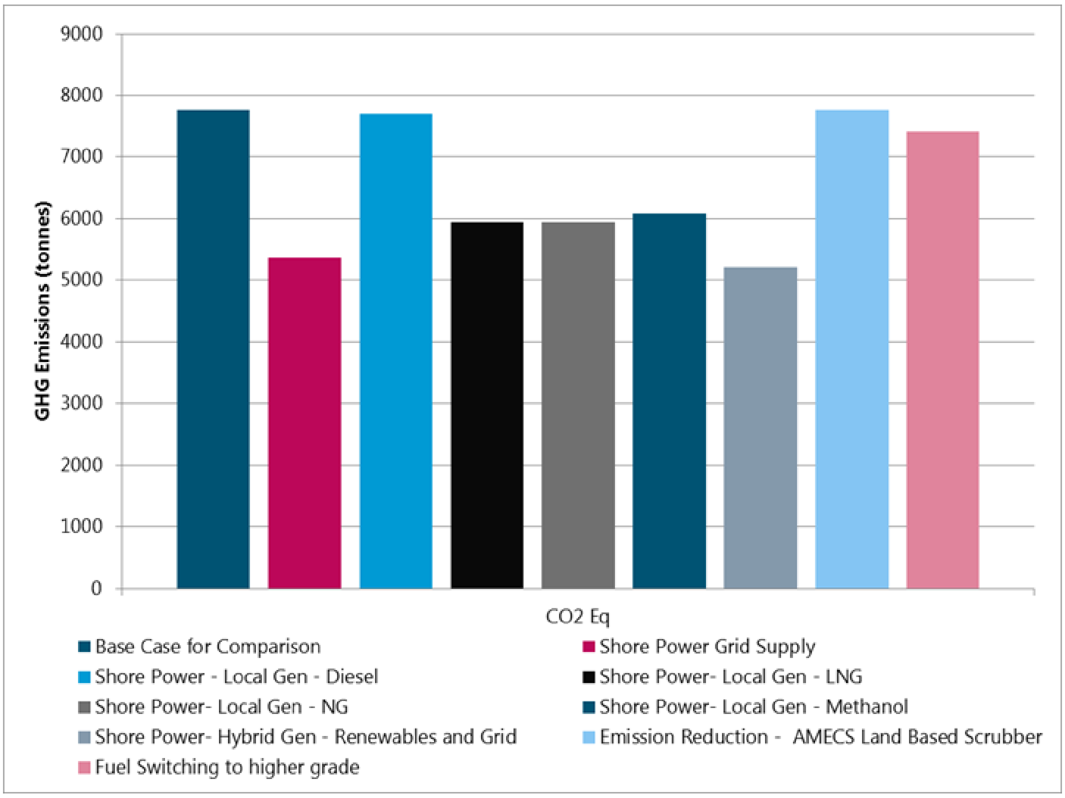

Figure 5-4 Annualised GHG Emission Levels in Year 1 (33% Vessels using Shore Power)

5.2.6 Emission Reduction Summary

Percentage reductions of emissions against baseline levels are summarised for each option in Table 5-3, below.

Table 5-3 Emission Reduction Summary

Option	Emissions Reduction (% against HFO baseline)				
	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO_2-e
Shore Power - Grid Supply	33%	33%	33%	33%	31%
Shore Power - Diesel Generation	0%	33%	23%	23%	1%

Option	Emissions Reduction (% against HFO baseline)				
	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO_2-e
Shore Power - LNG Generation	32%	33%	33%	33%	23%
Shore Power - Natural Gas Generation	32%	33%	33%	33%	23%
Shore Power - Methanol Generation	30%	33%	33%	33%	22%
Shore Power - Grid + Solar Generation	33%	33%	33%	33%	33%
Shore/Barge Scrubber - HFO Generation	80%	95%	80%	80%	0%
Fuel Switching - Diesel Generation	5%	96%	83%	84%	4%

5.2.7 Noise

Noise is an important criterion to consider. Low frequency noise associated with running reciprocating engines can have negative effects on a person's health, particularly for the apartments and hotels in the area surrounding the Queens Wharf. The study team assessed noise reduction for each of these options. Calculating the environment's noise for the base case and the different options is out of the scope of this study. Rankings were based on a qualitative assessment of whether each technology reduced, left unchanged, or increased the noise levels when compared with the base case.

In making the assessment, the following was assumed for noise generating equipment:

Table 5-4 Equipment Noise Levels

Equipment	Sound Pressure Level (dB(A) @ 10m)	Comment
Onboard Generator Set	75-85 dB(A)	Baseline. Assumed identical for HFO or Diesel fuel.
Transformers and Switchgear	<65 dB(A)	Required for all shore power solutions. Negligible noise generation
Frequency Converters	75-85 dB(A)	Additional equipment for grid supplied shore power. Cooling system primary source of sound. Additional attenuation possible
Diesel Generator Set	65-85 dB(A)	Acoustic enclosure assumed. Different attenuation options available.
Natural Gas Generator Set	65-85 dB(A)	Acoustic enclosure assumed. Different attenuation options available.
Shore/Barge Based Scrubber	75-85 dB(A)	Limited information available. Assumed some attenuation from baseline

Rankings were defined as follows:

- Low (1) – No/negligible noise reduction in relation than base case
- Medium (2) – Medium noise reduction in relation to base case.
- High (3) – High noise reduction in relation to base case.

5.2.8 Port Interruptions

Disruption of port operations was considered due to the perceived complexity of some of the proposed option installations. In particular, this relates to operational shutdowns or rescheduling of operations outside the wharf where the final equipment will be installed (i.e. Queens Wharf). Any work requiring shutdowns of other facilities within the port must be very carefully planned and executed, with special consideration of the associated risks which should be understood and agreed by the Stakeholders. Rankings were as follows:

- Low (1) – Interruptions greater than 4 weeks.

- Medium (2) – Interruptions between 2 and 4 weeks.
- High (3) – Interruptions less than 2 weeks.

5.3 Decision Matrix

Figure 5-5 shows the decision matrix and ratings developed for each option during the study workshop.

Item	Options	Options Description	*Criteria*								Total Score
				Commercially available in Magnitude Required / Feasible? Yes/No	Cost (Capital) Low: 1-5M$ Med. : 5-20M$ High: >20M$	Cost (O&M) Low: 100 k$/Y Med. : 100-400 k$/Y High: >400 k$/Y	Pollution Reduction Low: EMAL <20 Medium: 20<EMAL<50 High: >50	GHG Reduction Low: GHG% <15 Medium: 15<GHG%<30 Hi: GHG%>30	Noise Reduction Low - No Reduction Medium - Med Reduction Hi - High Reduction	Disruption to port operations Low: >4wk Medium: 2wk<..<4wk Hi: <2wk	
			Weighting	15	20	15	25	25	5	5	110
1	Shore Power- Connection to Grid	Conventional Shore power fed from Vector grid	Score	Yes	Medium	Low	Medium	High	High	Medium	93
			Weighted Score	15	13	15	17	25	5	3	
2	Shore Power- Local Gen - Diesel	Generation using Diesel with lower Sulphur content.	Score	Yes	Medium	High	Low	Low	Medium	High	58
			Weighted Score	15	13	5	8	8	3	5	
3	Shore Power- Local Gen - LNG	Land based generation using LNG	Score	No	Hi	Medium	Medium	Medium	Medium	High	58
			Weighted Score	0	7	10	17	17	3	5	
4	Shore Power- Local Gen - NG	Land based generation using NG	Score	Yes	Hi	low	Medium	Medium	Medium	Medium	77
			Weighted Score	15	7	15	17	17	3	3	
5	Shore Power- Local Gen - Methanol	Land based generation using Methanol	Score	Yes	Hi	Medium	Medium	Medium	Medium	High	73
			Weighted Score	15	7	10	17	17	3	5	
6	Shore Power- Hybrid Gen - Renewables and Grid	Combination of Grid power and renewables to compensate power fluctuations or shift to non-peak time frames.	Score	Yes	Medium	Low	Medium	High	High	Medium	93
			Weighted Score	15	13	15	17	25	5	3	
7	Fuel Switching to higher grade	Switch from high sulphur content to low sulphur content diesel when at port	Score	Yes	Low	High	High	Low	Medium	High	82
			Weighted Score	15	20	5	25	8	3	5	
9	Emission Reduction - Carbon Capture System	Land/Barge based treatment package with flexible exhaust intake head.	Score	Yes	Medium	Medium	High	Low	Medium	High	80
			Weighted Score	15	13	10	25	8	3	5	

Figure 5-5 Decision Matrix of Evaluated Options

5.4 Overall Evaluation

The evaluation matrix shortlisted the following three options:

1. Grid Supplied Shore Power
2. Shore Power with a Hybrid Renewable Supply
3. Fuel Switching to Low Sulphur Fuel

The weighted evaluation matrix demonstrated a preference for grid supply shore power solutions (with or without renewable supplement). These are the only options that can significantly reduce pollutants, noise and GHG emissions in parallel. A driving factor behind this selection is the fact that over 80% of New Zealand's electricity grid generation mix is delivered from renewable sources. It should also be acknowledged that the balance of the grid electricity emissions typically occur outside the Auckland airshed.

The major limitation of these options is the number of ships that can utilise these technologies. Currently this translates to roughly one third of visiting vessels. It will be a challenge for POAL to encourage more ship operators to upgrade their existing vessels with the required shore to ship connection equipment. The introduction of new, larger, shore power enabled vessels, however, represents a significant opportunity for increased system utilisation. Visit schedules proposed for new builds indicate that the proportion of electricity demand from shore power capable vessels will likely increase from approximately 33% to 48% by late 2019.

Fuel switching was ranked third by the evaluation matrix. For this option to be successful, POAL and ship operators would need to evaluate the cost implications associated with using a more expensive fuel. If all the ship operators switch to the lower sulphur fuel, the pollutant reductions and, hence, health benefits far exceed the reductions calculated for the other shortlisted options. The limitation of fuel switching is the minimal reduction in GHG emissions and limited contribution to the POAL 2040 zero emission target.

6 Preferred Solutions

This section further discusses the required infrastructure, associated costs and potential health impacts of each of the shortlisted options. These options include grid supplied shore power, shore power with renewable energies and fuel switching.

6.1.1 Grid Supplied Shore Power

Below is a description of the required landside electrical infrastructure for the proposed installation on Queens Wharf.

- New 22kV switchgear in the Quay Street Substation to feed the shore power substation (owned by grid operator).
- New supply cables and conduits between the Quay Street substation and the new shore power substation. It has been assumed the new cable will be routed via POAL property to limit public disruption (and costs) associated with trenching along Quay Street. At the transition point between land and the piled structure, this cable will transfer from an underground duct to suspended conduit or tray underneath the wharf deck.
- New shore power substation to be located within the 7m corridor that exists along the face of Queens Wharf East. The new shore power substation shall have an approximate footprint of 290m^2 and will consist of the following:
  - Frequency and voltage conversion system including:
    - Static Frequency Converter 20 MVA
    - 2 x 10MVA Step-down transformers
    - 3 x step-up transformers to supply either 6.6kV or 11kV (as required by the vessel)
    - Chiller unit - mounted on the roof of the substation.
  - 22kV Medium Voltage Switchgear.
  - Load Side (11kV and 6.6kV) Medium Voltage Switchgear.
  - Shore power master control system.
  - Miscellaneous Low Voltage equipment.

  It has been assumed the existing wharf has sufficient structural capacity to support the additional equipment and enclosures.
- 3 connection pits installed in the wharf deck to facilitate the ship to shore connection. These cable pits will be installed with a horizontal spacing of approximately 70m. Accurate spacing to be finalised during the detailed design phase.
- Cables installed from the shore power substation to the connection pits. These cables will drop below the deck of the wharf and run underneath in a cable tray suspended underneath.
- A mobile cable management system to facilitate connection between the ship and the pits.

6.1.2 Hybrid Shore Power

The conceptual design of the shore power system is identical to the grid supplied shore power system. In addition, the following equipment shall be installed.

- Photovoltaic solar panels with an annual output capacity of 600 MWh (400 kW peak) to be installed on port buildings. It has been assumed the structures will be capable of withstanding the additional load. To achieve the required energy approximately 4,000m^2 of solar panels is required. These panels would cover roughly 60% of the Shed 2's roof area.
- A battery bank capable of storing the power generated by the solar panels (if required). This bank will form part of the grid to facilitate peak shaving. Accordingly, it is expected this would be installed by the grid operator (subject to commercial conditions).

6.1.3 Fuel Switching

Fuel switching is the lowest capital cost option yet delivers significant reductions in pollutant emissions.

Based on the average power requirement of each cruise vessel berthing at POAL (approximately 90MWh), typical diesel consumption for each cruise stay is 16,000 L. Extending this to all vessels translates to annual consumption of approximately 2 million litres.

Discussions with the Marsden Point refinery confirm an additional 2 million litres of low sulphur diesel per year is within the refinery's current production capacity and therefore no upgrades would be required to supply the required fuel. Also, following consultations with POAL, WorleyParsons anticipate that sufficient bunkering capacity exists to supply low sulphur diesel to the hoteling cruise ships, particularly if vessels already carry the required fuel. A capital investment of $2.2 million has, however, been included to allow for any POAL local storage upgrades.

As discussed previously, a limit of 0.1% sulphur (or equivalent emissions treatment) is proposed because it follows the precedence set globally by other regions such as ECA regulations and other initiatives worldwide, both mandatory and voluntary. Diesel suppled in New Zealand, however, has a Sulphur content of approximately 0.0008% and, if utilised, would deliver further pollutant reductions.

To ensure success of this option POAL would need to lead an initiative to understand how the fuel cost premium could be met by stakeholders.

6.2 Cost Estimate

6.2.1 Capital Cost

A Type I cost estimate has been prepared for the installation for the grid supplied shore power and the hybrid shore power systems. These estimates are based on budgetary pricing from equipment vendors in combination with general factors and norms for the anticipated installation works.

The estimates are broken down as follows:

- Equipment (based on budgetary proposals and historical data).
- Bulks (norm based from anticipated quantities).
- Construction (norm based from anticipated quantities).
- Indirect costs including engineering, project management, construction management and overhead recovery costs (factored from direct procurement and construction costs).
- Contingency (nominated percentage for accuracy level).

At a Type I accuracy level (±30%), the total installed cost has been estimated at $18.3 million for the grid connected shore power ($14 million direct costs, $4.3 million indirect costs) and $19.9 million for the hybrid shore power ($15.3 million direct costs, $4.6 million indirect costs).

An estimate summary is provided in Appendix 3.

6.2.2 Operating and Maintenance Cost

Operating and Maintenance costs of each option have also been developed. These estimates are broken down as follows:

- Maintenance costs are based on the industry assumed percentage factors of the equipment budgetary pricing. Maintenance costs have only been included for equipment owned or operated by POAL (i.e. maintenance costs associated with shipping engines are excluded from these estimates).
- Operating costs for each of these options are based on the fuel/electricity cost in comparison to onboard generation with HFO.

The costs are summarised in Table 6-1. These costs include the capital costs associated with the electricity supply infrastructure (from the substation), local shore power system, maintenance of the system, and the energy utilisation costs. An annualised cost of investment was also nominated based a discount rate of 8% over a 10 year period.

Table 6-1 Cost Estimate Summary

Option	Capital Cost	O&M Costs	Annualised Cost
Grid Supplied Shore Power	$18,300,000	-$43,000	$2,660,000
Hybrid Shore Power	$19,900,000	-$111,000	$2,850,000
Fuel Switching	$2,200,000	$986,000	$1,310,000

6.3 Potential Health Outcomes

A comprehensive health assessment is beyond the scope of this study. A basic health assessment was completed for the evaluation. The lack of availability of New Zealand based literature which focused on the health effects associated with the specific pollutants (NO_x, SO_x, and PM) made it difficult to qualify any resulting health outcomes.

In general, it is assumed that the improvements in health outcomes are directly proportional to the reduction in pollutants. These reductions are summarised for the shortlisted option in the Table 6-2.

Table 6-2 Preferred Option Pollutant Reduction from Base Case

Option	NO_x	SO_x	PM
Grid Supplied Shore Power	33%	33%	33%
Hybrid Shore Power	33%	33%	33%
Fuel Switching*	5%	96%	84%

*Assumes application to 100% of visiting vessels

It is recommended a detailed screening assessment of the New Zealand population be completed before any further health assessments associated with the proposed emission reduction schemes are completed.

7 Conclusion and Recommendations

The following recommendations are provided for POAL consideration:

- Implement fuel switching as an interim solution. The solution requires minimum capital investment yet delivers significant reduction in pollutants. Exemptions should be granted for vessels achieving equivalent emissions (e.g. through onboard scrubbers) in line with MARPOL Annex VI regulations within ECA.
- Plan for the installation of a grid supply shore power system (with possible 400kW solar generation system) in the next 5 years. This will ensure higher GHG emission reductions, improve sustainability and contribute towards POAL's 2040 zero emission target.
- Following the completion of a grid supply shore power system, continue with fuel switching for vessels not capable of connection to shore power.

To successfully implement any of the proposed initiatives, POAL should first develop a business case involving the full range of stakeholders and determine an appropriate means of funding, instigating and managing the programme. This should involve both cruise lines and relevant government bodies. The benefits of the programme can then be measured fairly against the costs and resources required to implement it.

Particular care should be taken around adopting mandatory requirements where cruise lines will be forced to bear compliance costs. Fuel switching evidently lends itself to implementation in this manner. The restrictions may, however, have adverse effects on POAL's position as a cruise vessel destination and push operators to other New Zealand (or Australian) ports. Potential effects would need to be factored into the business case.

The following points and assumptions were considered in developing the final recommendations, above:

- The study assumes all vessels visiting POAL are capable of operating their auxiliary engines on low sulphur diesel with minimal modifications. If future contradicting data is received from the vessel operators, implementing this option as the interim solution may become impractical. Our analyses indicate at least a 40% acceptance of the fuel switching by the cruise ships is required to exceed the benefits of a 30% shore power acceptance.
- Fuel switching to lower Sulphur content will otherwise impose additional cost to vessel operators. With no current mandatory regulation, POAL should consider ways to work with stakeholders to implement this option.
- Shore power solutions have the best impact on emission reductions, particularly when noting that the New Zealand grid generation typically consists of over 80% low emission, renewable energy. However, as a limited number of vessels currently visiting POAL are equipped to receive shore power connection (circa 30%); the emission reduction impact of this option is substantially reduced. It should be mentioned that if the number of vessels with shore power capability increases in the future, this option becomes more favorable and the recommendations should

be reviewed. With new, larger vessels likely to call in future years, POAL should review berthing schedules periodically to determine the impact on system utilisation and take the opportunity to install the required shore power infrastructure

- Unlike the shore power solutions, fuel switching provides only a marginal reduction in GHG emissions. This study has not considered any potential carbon pricing that may be implemented in the future which may impact the overall feasibility of the fuel switching option.
- Currently, there are no regulations mandating that port authorities in New Zealand be equipped with the shore power connection capability. The study did not consider that such regulations will take effect in the near future. If such regulations are proposed, POAL should review the final selection.
- If further vendor information becomes available on shore or barge based scrubber systems, this option should be reviewed as a potential alternative to fuel switching. Low capital cost for the equipment and/or unforeseen difficulty implementing fuel switching may alter the initial assessment.
- Introduction of the global 0.5% fuel sulphur limit in 2020 (under MARPOL Annex VI) will likely increase the cost of the HFO vessels must use. This may impact the economic evaluation and should factored into any business case.

8 References

ABB. (2016, September 28). *Shore-to-ship power and smart port solutions*. Retrieved from ABB: https://search-ext.abb.com/library/Download.aspx?DocumentID=9AKK106930A1687&LanguageCode=en&DocumentPartId=&Action=Launch

Broome, R. A., Cope, M. E., Goldsworthy, B., Emmerson, K., Jegasothy, E., & Morgan, G. G. (n.d.). The mortality effect of ship-related fine particulate matter in the Sydney greater metropolitan region of NSW, Australia. *Environmental International, 87*, 85-93.

Carr, E., & Corbett, J. J. (2017). *Evaluation of Cruise Industry Global Environmental Practices and Performance*. Energy and Environmental Research Associates, LLC.

Chinese Emission Control Areas (ECAs) effective from 1 January 2016. (n.d.). Retrieved March 2017, from UK Chamber of Shipping: https://www.ukchamberofshipping.com/library/chinese-emission-control-areas-ecas-effective-1-january-2016/

City & Port Development, CMP and the City of Copenhagen. (2015). *Options for Establishing Shore Power fro Cruise Ships in Port of Copenahgen Nordhavn*. Copenhagen: City and Port Development, CMP and City of Copenhagen.

Corbett, J. J. (2007). Mortality from Ship Emissions: A Global Assessment. *Environmental Science and Technology 41, 24*, pp. 8512-8518.

Cruise New Zealand. (2013). *Ships*. Retrieved Feb 2017, from Cruise New Zealand: http://cruisenewzealand.org.nz/ships/

Cruise Shipping Legislation. (2017). Retrieved 2017, from NSW EPA: http://www.epa.nsw.gov.au/air/cruise-ship.htm

den Boer, E., & Hoen, M. (2015). *Scubbers - An econmic and ecological assessment*. CE Delft.

Environmental Leader. (2014, May 22). Retrieved from Carnival Expands Cruise Ship Scrubber Technology: https://www.environmentalleader.com/2014/05/carnival-expands-cruise-ship-scrubber-technology/

Environmental Protection Authority NSW. (2015, October). *Low Sulfur Fuel Requirements for Cruise Ships in Sydney Harbour*. Retrieved from http://www.epa.nsw.gov.au/resources/air/150695-low-sulfur-fuel-cruise-ships.pdf

Ericsson, P., & Fazlagic, I. (2008). *Shore Side Power Suply*. Chalmers University of Technology, Department of Energy and Enviroment. Goteborg Sweden: Chalmers University of Technology.

Ernst & Young. (June 2016). *Consultant's Report to the Port Future Study.* Auckland: Earnest & Young.

Helfre, J.-F., & Boot, P. A. (2013). *Emission Reduction in the Shipping Industry: Regulations, Exposure and Solutions.* Sustainalytics.

Lasselle, S., & Abusdal, H. (2016). *Methanol as marine fuel: Enviromental benefits, technology readiness, and economic feasibility.* DNV GL.

Linwood, N. (2017, August 23). Email. *RE: [EXTERNAL] POAL Cruise Vessel Emission Reduction Study*. RCL Cruises Ltd.

Ministry for the Environment. (2015, April). Summary of Emissions Factors for the Guidance for Voluntary Corporate Greenhouse Gas Reporting - 2015.

Ministry of Business, Innovation & Employment. (2017). *Electricity*. Retrieved from Ministry of Business, Innovation & Employment: http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/documents-image-library/electricity.xlsx

Minstry of Business, Innovation and Employment. (2017). *Prices*. Retrieved Feb 2017, from Minstry of Business, Innovation and Employment: http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/prices

Natural Resources Defense Council. (2014). *Prevention and Control of Shipping and Port Emissions in China.* NRDC.

Peeters, S. (2010). *Port-Related Air Emissions for the Auckland Region 2006 & 2010.* Auckland: M&P Consulting Limited.

Port of Montreal. (2017, August 11). *Shore Power Project Completed: Cruise Ships Can Now be Powered by Electricity at the Port of Montreal*. Retrieved from Port Montreal: http://www.port-montreal.com/en/shore-power-en.html

Press Release City of Los Angeles and Community and Environmental Groups Reach Record Settlement of Challenge to China Shipping Terminal Project at Port. (n.d.). Retrieved 2017, from Natrual Resources Defence Council: https://www.nrdc.org/media/2003/030305

Princess Cruises. (n.d.). *Princess Ships Clear the Air with Shore Power Connections*. Retrieved from Princess Cruises: https://www.princess.com/news/backgrounders_and_fact_sheets/factsheet/Princess-Ships-Clear-the-Air-with-Shore-Power-Connections.html

Rotterdam could get LNG Hybrid Barge. (2017). Retrieved Feb 2017, from Marine Log: http://www.marinelog.com/index.php?option=com_k2&view=item&id=9849:rotterdam-could-get-lng-hybrid-barge&Itemid=231

Wang, H., Mao, X., & Rutherford, D. (2015, December). *Costs and Benefits of Shore Power at the Port of Shenzen.* Retrieved from Wilson Centre: https://www.wilsoncenter.org/sites/default/files/costs_and_benefits_of_shore_power_at_the_port_of_shenzhen.pdf

Watts, M. (2017, September 9). Email. *POAL Cruise Vessel Emission Reduction Technologies*. Cochran Marine Systems.

World Health Organization. (2013). *Health Effects of Particulate Matter: Policy implications for countries in eastern Europe, Caucasus and central Asia.* Copenhagen: WHO Regional Office Europe.

World Maritime News. (2014, December 23). *Royal Caribbean to Retrofit 19 Ships with Scrubbers*. Retrieved from World Maritime News: http://worldmaritimenews.com/archives/148324/royal-caribbean-to-retrofit-19-ships-with-scrubbers/

World Ports Climate Initiative. (n.d.). *Ports Using OPS*. Retrieved 2017, from World Ports Climate Initiative - Onshore Power Supply: http://www.ops.wpci.nl/ops-installed/ports-using-ops/

Appendix 1: Cruise Schedule and Vessel Information

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Ship Inventory

Shore Power Selection: Capable <5y

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

Ship Name	Operator	Parent Compay	Length (m)	Estimated Power Draw (MW)	Actual Power Draw (MW)	Shore Power Capable Now	Shore Power Capable <5y	Shore Power Capable <10y	Nominated Power Draw (MW)	Comments
Albatros	V Ships Leisure SAM	-	205	7.5		No	No	No	0	
Amadea	Phoenix Reisen GmbH	-	193	4.1		No	No	No	0	
Amsterdam	Holland America Line NV	Carnival	237	7.5		Yes	Yes	Yes	7.5	
Arcadia	Carnival Plc	Carnival	290	7.5		No	No	No	0	
Artania	Phoenix Reisen GmbH	-	231	7.5		No	No	No	0	
Astor	Cruise & Maritime Voyages Ltd	-	176	4.1		No	No	No	0	
Asuka II	NYK Cruises Co Ltd	-	241	7.5		No	No	No	0	
Aurora	Carnival Plc	Carnival	270	7.5		No	No	No	0	
Azamara Journey	Celebrity Cruises Inc	RCCL	181	4.1		No	No	No	0	
Azamara Quest	Celebrity Cruises Inc	RCCL	181	4.1		No	No	No	0	
Black Watch	Fred Olsen Cruise Lines Ltd	-	178	4.1		No	No	No	0	
Bremen	Hapag-Lloyd Kreuzfahrten	-	112	4.1		No	No	No	0	
Caledonian Sky	Noble Caledonia Ltd	-	91	4.1		No	No	No	0	
Carnival Legend	Carnival Cruise Lines	Carnival	294	7.5		No	No	No	0	
Carnival Spirit	Carnival Cruise Lines	Carnival	294	7.5		No	No	No	0	
Celebrity Solstice	RCL Cruises Ltd	-	315	10		No	No	No	0	
Coral Discoverer	Coral Princess Cruises	-	63	4.1		No	No	No	0	
Costa Deliziosa	Costa Crociere SpA	Carnival	294	7.5		No	Yes	Yes	7.5	
Costa Luminosa	Costa Crociere SpA	Carnival	294	7.5		No	Yes	Yes	7.5	
Crystal Serenity	Crystal Cruises LLC	-	250	7.5		No	No	No	0	
Crystal Symphony	Crystal Cruises LLC	-	238	7.5		No	No	No	0	
Dawn Princess	Princess Cruise Lines Ltd	Carnival	266	7.5		Yes	Yes	Yes	7.5	
Deutschland	Scandlines Deutschland GmbH	-	175	4.1		No	No	No	0	
Diamond Princess	Princess Cruise Lines Ltd	Carnival	290	7.5		Yes	Yes	Yes	7.5	
Emerald Princess	Princess Cruise Lines Ltd	Carnival	290	7.5		Yes	Yes	Yes	7.5	
Europa	Columbia Cruise Services Ltd	-	199	4.1		No	No	No	0	
Europa 2	Columbia Cruise Services Ltd	-	226	7.5		No	No	No	0	
Explorer of the Seas	Royal Caribbean Cruises Ltd	RCCL	311	10		No	No	No	0	
Golden Princess	Princess Cruise Lines Ltd	Carnival	290	7.5		Yes	Yes	Yes	7.5	
Insignia	Oceania Cruises Inc	-	180	4.1		No	No	No	0	
L'Austral	PONANT	-	142	4.1		Yes*	Yes*	Yes*	0	Connection voltage 690V. Exclude from Analysis
Legend of the Seas	Royal Caribbean Cruises Ltd	RCCL	264	7.5		No	No	No	0	
Le'Soleal	PONANT	-	142	4.1		Yes*	Yes*	Yes*	0	Connection voltage 690V. Exclude from Analysis
Maasdam	Holland America Line NV	Carnival	219	7.5		No	No	No	0	
Magellan	Global Cruise Lines Ltd	-	222	7.5		No	No	No	0	
Marina	Oceania Cruises Inc	-	238	7.5		No	No	No	0	
Nippon Maru	Mitsui Passenger	-	153	4.1		No	No	No	0	
Noordam	Holland America Line NV	Carnival	289	7.5		No	No	No	0	
Norwegian Star	NCL Bahamas Ltd	-	294	7.5		Yes	Yes	Yes	7.5	Starboard side

Advisian WorleyParsons Group		Ship Inventory						Shore Power Selection	Capable <5y	PORTS OF AUCKLAND TĀMAKI HERENGA WAKA
Ship Name	**Operator**	**Parent Compay**	**Length (m)**	**Estimated Power Draw (MW)**	**Actual Power Draw (MW)**	**Shore Power Capable Now**	**Shore Power Capable <5y**	**Shore Power Capable <10y**	**Nominated Power Draw (MW)**	**Comments**
Ocean Princess	Oceania Cruises Inc	-	181	4.1		No	No	No	0	Repeat - Renamed Sirena
Oceanic Discoverer	Coral Princess Cruises	-	63	4.1		No	No	No	0	Repeat - Renamed Coral Discoverer
Oosterdam	Holland America Line NV	Carnival	290	7.5		Yes	Yes	Yes	7.5	
Ovation of the Seas	Royal Caribbean Cruises Ltd	RCCL	348	10		No	No	No	0	
Pacific Aria	Carnival Australia	Carnival	219	7.5		No	No	No	0	
Pacific Dawn	Carnival Australia	Carnival	245	7.5		No	No	No	0	
Pacific Jewel	Carnival Australia	Carnival	245	7.5		No	No	No	0	
Pacific Pearl	Carnival Australia	Carnival	247	7.5		No	No	No	0	
Pacific Princess	Princess Cruise Lines Ltd	Carnival	168	4.1		No	No	No	0	
Pacific Venus	Japan Cruise Line Inc	-	183	4.1		No	No	No	0	
Queen Elizabeth	Cunard Line Ltd	-	294	7.5		No	No	No	0	
Queen Mary II	Cunard Line Ltd	-	345	10		No	No	No	0	
Queen Victoria	Cunard Line Ltd	-	294	7.5		No	No	No	0	
Radiance of the Seas	Royal Caribbean Cruises Ltd	RCCL	293	7.5		No	No	No	0	
Sea Princess	Princess Cruise Lines Ltd	Carnival	261	7.5		Yes	Yes	Yes	7.5	
Seabourn Encore	Seabourn Cruise Line Ltd	Carnival	210	7.5		No	No	No	0	
Seabourn Odyssey	Seabourn Cruise Line Ltd	Carnival	198	4.1		No	No	No	0	
Seven Seas Mariner	Regent Seven Seas Cruises Inc	-	217	7.5		No	No	No	0	
Seven Seas Navigator	Regent Seven Seas Cruises Inc	-	171	4.1		No	No	No	0	
Seven Seas Voyager	Regent Seven Seas Cruises Inc	-	204	7.5		No	No	No	0	
Silver Discoverer	Silversea Cruises Ltd	-	103	4.1		No	No	No	0	
Silver Spirit	Silversea Cruises Ltd	-	199	4.1		No	No	No	0	
Silver Whisper	Silversea Cruises Ltd	-	186	4.1		No	No	No	0	
Sirena	Oceania Cruises Inc	-	181	4.1		No	No	No	0	
Sun Princess	Princess Cruise Lines Ltd	Carnival	261	7.5		Yes	Yes	Yes	7.5	
The World	Wilhelmsen Ship Mgmt Ltd-USA	-	196	4.1		No	No	No	0	
Voyager of the Seas	Royal Caribbean Cruises Ltd	RCCL	311	10		No	No	No	0	

Estimated Power Usage

Cruise Vessels

Vessel Type	Min Length	Max Length	Avg. Power	Peak Power	Peak Power - 95% of Vessels
Cruise Ship <200m		200	4.1	7.3	6.7
Cruise Ship >200m	200	300	7.5	11	9.5
Cruise Ship >300m	300		10	20	12.5

Other Vessels

Vessel Type	Min Length	Max Length	Avg. Power	Peak Power	Peak Power - 95% of Vessels
Container Vessels <140m		140	0.17	1	0.8
Container Vessels >140m	140		1.2	8	5
Container Vessels Overall			0.8	8	1
RoRo & Vehicle Vessels			1.5	2	1.8
Oil & Product Tankers			1.4	2.7	2.5

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Ports of Auckland Berth Analysis for Shore Power

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

	Berth 1						Berth 2						Berth 3						
Date	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Total Draw**
01/01/2015																			0
02/01/2015	Dawn Princess	02/01/2015 8:30	02/01/2015 20:00	11.5	7.5	86.25													7.5
03/01/2015	Sea Princess	03/01/2015 5:30	03/01/2015 18:00	12.5	7.5	93.75													7.5
04/01/2015	Celebrity Solstice	04/01/2015 4:30	04/01/2015 20:00	15.5	0	0													0
05/01/2015																			0
06/01/2015	Seven Seas Mariner	06/01/2015 5:30	06/01/2015 21:00	15.5	0	0	Seabourn Odyssey	06/01/2015 5:30	06/01/2015 16:00	10.5	0	0	Voyager of the Seas	06/01/2015 7:30	06/01/2015 17:00	9.5	0	0	0
07/01/2015	Sun Princess	07/01/2015 5:30	07/01/2015 18:00	12.5	7.5	93.75													7.5
08/01/2015																			0
09/01/2015	Oceanic Discoverer	09/01/2015 12:30	10/01/2015 0:00	11.5	0	0													0
10/01/2015	Oceanic Discoverer	10/01/2015 0:00	11/01/2015 0:00	24	0	0													0
11/01/2015	Oceanic Discoverer	11/01/2015 0:00	11/01/2015 17:00	17	0	0	Caledonian Sky	11/01/2015 6:30	11/01/2015 18:00	11.5	0	0							0
12/01/2015																			0
13/01/2015																			0
14/01/2015																			0
15/01/2015	Dawn Princess	15/01/2015 8:30	15/01/2015 20:00	11.5	7.5	86.25													7.5
16/01/2015																			0
17/01/2015	Sea Princess	17/01/2015 5:30	17/01/2015 18:00	12.5	7.5	93.75													7.5
18/01/2015																			0
19/01/2015																			0
20/01/2015	Sun Princess	20/01/2015 5:30	20/01/2015 18:00	12.5	7.5	93.75													7.5
21/01/2015																			0
22/01/2015	Diamond Princess	22/01/2015 4:30	22/01/2015 18:00	13.5	7.5	101.25	L'Austral	22/01/2015 5:30	22/01/2015 18:00	12.5	0	0							7.5
23/01/2015																			0
24/01/2015																			0
25/01/2015																			0
26/01/2015																			0
27/01/2015																			0
28/01/2015																			0
29/01/2015	Voyager of the Seas	29/01/2015 7:30	29/01/2015 17:00	9.5	0	0													0
30/01/2015																			0
31/01/2015	Sea Princess	31/01/2015 5:30	31/01/2015 18:00	12.5	7.5	93.75													7.5
01/02/2015																			0
02/02/2015	Dawn Princess	02/02/2015 8:30	02/02/2015 20:00	11.5	7.5	86.25													7.5
03/02/2015																			0
04/02/2015																			0
05/02/2015	Amsterdam	05/02/2015 6:30	06/02/2015 0:00	17.5	7.5	131.25													7.5
06/02/2015	Amsterdam	06/02/2015 0:00	06/02/2015 18:00	18	7.5	135													7.5
07/02/2015	Seabourn Odyssey	07/02/2015 5:30	07/02/2015 16:00	10.5	0	0													0
08/02/2015	Celebrity Solstice	08/02/2015 4:30	08/02/2015 20:00	15.5	0	0	Silver Discoverer	08/02/2015 5:00	08/02/2015 12:30	7.5	0	0							0
09/02/2015	Oosterdam	09/02/2015 5:30	09/02/2015 17:00	11.5	7.5	86.25	Albatros	09/02/2015 5:30	10/02/2015 0:00	18.5	0	0							7.5
10/02/2015	Pacific Princess	10/02/2015 5:30	10/02/2015 20:00	14.5	0	0	Albatros	10/02/2015 0:00	11/02/2015 0:00	24	0	0							0
11/02/2015	Sun Princess	11/02/2015 5:30	11/02/2015 18:00	12.5	7.5	93.75	Albatros	11/02/2015 0:00	11/02/2015 20:00	20	0	0							7.5
12/02/2015	Silver Spirit	12/02/2015 5:30	12/02/2015 18:00	12.5	0	0													0
13/02/2015	Voyager of the Seas	13/02/2015 7:30	13/02/2015 18:00	10.5	0	0													0
14/02/2015																			0
15/02/2015	Diamond Princess	15/02/2015 4:30	15/02/2015 18:00	13.5	7.5	101.25	Dawn Princess	15/02/2015 8:30	15/02/2015 20:00	11.5	7.5	86.25	L'Austral	15/02/2015 5:30	15/02/2015 18:00	12.5	0	0	15
16/02/2015	Deutschland	16/02/2015 5:00	17/02/2015 0:00	19	0	0	Radiance of the Seas	16/02/2015 5:30	16/02/2015 18:00	12.5	0	0							0
17/02/2015	Deutschland	17/02/2015 0:00	17/02/2015 19:30	19.5	0	0													0
18/02/2015																			0
19/02/2015	Crystal Serenity	19/02/2015 5:30	20/02/2015 0:00	18.5	0	0													0
20/02/2015	Crystal Serenity	20/02/2015 0:00	21/02/2015 0:00	24	0	0	Asuka II	20/02/2015 7:30	21/02/2015 0:00	16.5	0	0	Oceanic Discoverer	20/02/2015 6:30	20/02/2015 14:00	7.5	0	0	0
21/02/2015	Crystal Serenity	21/02/2015 0:00	21/02/2015 23:00	23	0	0	Asuka II	21/02/2015 0:00	21/02/2015 9:00	9	0	0							0
22/02/2015																			0
23/02/2015																			0

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Total Draw**
24/02/2015	Oosterdam	24/02/2015 5:30	24/02/2015 16:00	10.5	7.5	78.75													7.5
25/02/2015	Amadea	25/02/2015 6:30	26/02/2015 0:00	17.5	0	0													0
26/02/2015	Amadea	26/02/2015 0:00	27/02/2015 0:00	24	0	0	Aurora	26/02/2015 6:30	26/02/2015 20:30	14	0	0							0
27/02/2015	Amadea	27/02/2015 0:00	27/02/2015 18:00	18	0	0													0
28/02/2015	Dawn Princess	28/02/2015 8:30	28/02/2015 20:00	11.5	7.5	86.25	Marina	28/02/2015 4:30	28/02/2015 18:00	13.5	0	0							7.5
01/03/2015																			0
02/03/2015																			0
03/03/2015																			0
04/03/2015																			0
05/03/2015																			0
06/03/2015																			0
07/03/2015																			0
08/03/2015	Sea Princess	08/03/2015 5:30	08/03/2015 18:00	12.5	7.5	93.75													7.5
09/03/2015	Ocean Princess	09/03/2015 6:30	09/03/2015 19:00	12.5	0	0													0
10/03/2015	Costa Deliziosa	10/03/2015 7:30	11/03/2015 0:00	16.5	7.5	123.75													7.5
11/03/2015	Costa Deliziosa	11/03/2015 0:00	11/03/2015 13:00	13	7.5	97.5													7.5
12/03/2015																			0
13/03/2015	Dawn Princess	13/03/2015 8:30	13/03/2015 20:00	11.5	7.5	86.25													7.5
14/03/2015																			0
15/03/2015	Sun Princess	15/03/2015 5:30	15/03/2015 18:00	12.5	7.5	93.75													7.5
16/03/2015																			0
17/03/2015																			0
18/03/2015																			0
19/03/2015	Queen Victoria	19/03/2015 5:30	19/03/2015 20:00	14.5	0	0													0
20/03/2015	Queen Mary II	20/03/2015 5:30	21/03/2015 0:00	18.5	0	0													0
21/03/2015	Queen Mary II	21/03/2015 0:00	21/03/2015 20:00	20	0	0													0
22/03/2015	Sea Princess	22/03/2015 5:30	22/03/2015 18:00	12.5	7.5	93.75													7.5
23/03/2015																			0
24/03/2015																			0
25/03/2015																			0
26/03/2015																			0
27/03/2015																			0
28/03/2015	Sun Princess	28/03/2015 5:30	28/03/2015 18:00	12.5	7.5	93.75													7.5
29/03/2015																			0
30/03/2015																			0
31/03/2015																			0
01/04/2015																			0
02/04/2015																			0
03/04/2015																			0
04/04/2015																			0
05/04/2015	Sea Princess	05/04/2015 5:30	05/04/2015 18:00	12.5	7.5	93.75	Oosterdam	05/04/2015 5:30	05/04/2015 16:00	10.5	7.5	78.75							15
06/04/2015	Pacific Pearl	06/04/2015 5:30	06/04/2015 16:00	10.5	0	0													0
07/04/2015	Celebrity Solstice	07/04/2015 5:30	07/04/2015 16:00	10.5	0	0													0
08/04/2015																			0
09/04/2015																			0
10/04/2015	Sun Princess	10/04/2015 5:30	10/04/2015 18:00	12.5	7.5	93.75													7.5
11/04/2015																			0
12/04/2015																			0
13/04/2015																			0
14/04/2015																			0
15/04/2015																			0
16/04/2015	Pacific Pearl	16/04/2015 5:30	16/04/2015 16:00	10.5	0	0													0
17/04/2015																			0
18/04/2015																			0
19/04/2015	Pacific Pearl	19/04/2015 5:30	19/04/2015 16:00	10.5	0	0													0

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Ports of Auckland Berth Analysis for Shore Power

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
20/04/2015																			0
21/04/2015																			0
22/04/2015																			0
23/04/2015																			0
24/04/2015																			0
25/04/2015																			0
26/04/2015																			0
27/04/2015																			0
28/04/2015																			0
29/04/2015	Pacific Pearl	29/04/2015 5:30	29/04/2015 16:00	10.5	0	0													0
30/04/2015																			0
01/05/2015																			0
02/05/2015																			0
03/05/2015																			0
04/05/2015																			0
05/05/2015																			0
06/05/2015																			0
07/05/2015																			0
08/05/2015	Pacific Pearl	08/05/2015 5:30	08/05/2015 16:00	10.5	0	0													0
09/05/2015																			0
10/05/2015																			0
11/05/2015																			0
12/05/2015																			0
13/05/2015																			0
14/05/2015																			0
15/05/2015																			0
16/05/2015																			0
17/05/2015																			0
18/05/2015	Pacific Pearl	18/05/2015 5:30	18/05/2015 16:00	10.5	0	0													0
19/05/2015																			0
20/05/2015																			0
21/05/2015																			0
22/05/2015																			0
23/05/2015																			0
24/05/2015																			0
25/05/2015	Insignia	25/05/2015 6:30	25/05/2015 18:00	11.5	0	0													0
26/05/2015																			0
27/05/2015	Pacific Pearl	27/05/2015 5:30	27/05/2015 16:00	10.5	0	0													0
28/05/2015																			0
29/05/2015																			0
30/05/2015																			0
31/05/2015																			0
01/06/2015																			0
02/06/2015																			0
03/06/2015																			0
04/06/2015																			0
05/06/2015																			0
06/06/2015	Pacific Pearl	06/06/2015 5:30	06/06/2015 16:00	10.5	0	0													0
07/06/2015																			0
08/06/2015																			0
09/06/2015																			0
10/06/2015																			0
11/06/2015																			0
12/06/2015																			0
13/06/2015																			0

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
14/06/2015																			0
15/06/2015																			0
16/06/2015																			0
17/06/2015																			0
18/06/2015																			0
19/06/2015																			0
20/06/2015																			0
21/06/2015																			0
22/06/2015																			0
23/06/2015																			0
24/06/2015																			0
25/06/2015																			0
26/06/2015																			0
27/06/2015																			0
28/06/2015																			0
29/06/2015																			0
30/06/2015																			0
01/07/2015																			0
02/07/2015																			0
03/07/2015																			0
04/07/2015																			0
05/07/2015																			0
06/07/2015																			0
07/07/2015																			0
08/07/2015																			0
09/07/2015																			0
10/07/2015																			0
11/07/2015																			0
12/07/2015																			0
13/07/2015																			0
14/07/2015																			0
15/07/2015																			0
16/07/2015																			0
17/07/2015																			0
18/07/2015																			0
19/07/2015																			0
20/07/2015																			0
21/07/2015																			0
22/07/2015																			0
23/07/2015																			0
24/07/2015																			0
25/07/2015																			0
26/07/2015																			0
27/07/2015																			0
28/07/2015																			0
29/07/2015																			0
30/07/2015																			0
31/07/2015																			0
01/08/2015																			0
02/08/2015																			0
03/08/2015																			0
04/08/2015																			0
05/08/2015																			0
06/08/2015																			0
07/08/2015																			0

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TĀMAKI HERENGA WAKA

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
08/08/2015																			0
09/08/2015																			0
10/08/2015																			0
11/08/2015																			0
12/08/2015																			0
13/08/2015																			0
14/08/2015																			0
15/08/2015																			0
16/08/2015																			0
17/08/2015																			0
18/08/2015																			0
19/08/2015																			0
20/08/2015																			0
21/08/2015																			0
22/08/2015																			0
23/08/2015																			0
24/08/2015																			0
25/08/2015																			0
26/08/2015																			0
27/08/2015																			0
28/08/2015																			0
29/08/2015																			0
30/08/2015																			0
31/08/2015	Sea Princess	31/08/2015 5:30	31/08/2015 22:00	16.5	7.5	123.75													7.5
01/09/2015																			0
02/09/2015																			0
03/09/2015																			0
04/09/2015																			0
05/09/2015																			0
06/09/2015																			0
07/09/2015																			0
08/09/2015																			0
09/09/2015																			0
10/09/2015																			0
11/09/2015																			0
12/09/2015																			0
13/09/2015																			0
14/09/2015																			0
15/09/2015																			0
16/09/2015																			0
17/09/2015																			0
18/09/2015																			0
19/09/2015																			0
20/09/2015																			0
21/09/2015																			0
22/09/2015																			0
23/09/2015																			0
24/09/2015																			0
25/09/2015																			0
26/09/2015																			0
27/09/2015																			0
28/09/2015																			0
29/09/2015																			0
30/09/2015																			0
01/10/2015																			0

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
02/10/2015																			0
03/10/2015																			0
04/10/2015																			0
05/10/2015																			0
06/10/2015																			0
07/10/2015																			0
08/10/2015	Diamond Princess	08/10/2015 6:30	08/10/2015 19:00	12.5	7.5	93.75													7.5
09/10/2015																			0
10/10/2015	Golden Princess	10/10/2015 5:30	10/10/2015 18:00	12.5	7.5	93.75													7.5
11/10/2015																			0
12/10/2015																			0
13/10/2015																			0
14/10/2015																			0
15/10/2015	Sun Princess	15/10/2015 5:30	15/10/2015 18:00	12.5	7.5	93.75													7.5
16/10/2015																			0
17/10/2015	Celebrity Solstice	17/10/2015 8:30	17/10/2015 19:00	10.5	0	0													0
18/10/2015																			0
19/10/2015																			0
20/10/2015																			0
21/10/2015																			0
22/10/2015																			0
23/10/2015																			0
24/10/2015																			0
25/10/2015																			0
26/10/2015																			0
27/10/2015																			0
28/10/2015																			0
29/10/2015																			0
30/10/2015																			0
31/10/2015																			0
01/11/2015																			0
02/11/2015	Costa Luminosa	02/11/2015 6:30	02/11/2015 19:00	12.5	7.5	93.75													7.5
03/11/2015																			0
04/11/2015																			0
05/11/2015																			0
06/11/2015																			0
07/11/2015	Dawn Princess	07/11/2015 6:30	07/11/2015 19:00	12.5	7.5	93.75													7.5
08/11/2015	Noordam	08/11/2015 5:30	08/11/2015 20:00	14.5	0	0													0
09/11/2015	Voyager of the Seas	09/11/2015 5:30	09/11/2015 18:00	12.5	0	0													0
10/11/2015																			0
11/11/2015																			0
12/11/2015																			0
13/11/2015																			0
14/11/2015	Celebrity Solstice	14/11/2015 4:30	14/11/2015 20:00	15.5	0	0													0
15/11/2015																			0
16/11/2015	Golden Princess	16/11/2015 8:30	16/11/2015 20:00	11.5	7.5	86.25													7.5
17/11/2015																			0
18/11/2015																			0
19/11/2015																			0
20/11/2015	Dawn Princess	20/11/2015 5:30	20/11/2015 18:00	12.5	7.5	93.75													7.5
21/11/2015																			0
22/11/2015																			0
23/11/2015																			0
24/11/2015																			0
25/11/2015																			0

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
26/11/2015																			0
27/11/2015																			0
28/11/2015	Astor	28/11/2015 6:30	28/11/2015 22:00	15.5	0	0													0
29/11/2015	Golden Princess	29/11/2015 8:30	29/11/2015 20:00	11.5	7.5	86.25													7.5
30/11/2015																			0
01/12/2015	Noordam	01/12/2015 5:30	01/12/2015 17:00	11.5	0	0													0
02/12/2015																			0
03/12/2015	Dawn Princess	03/12/2015 5:30	03/12/2015 18:00	12.5	7.5	93.75													7.5
04/12/2015																			0
05/12/2015	Pacific Pearl	05/12/2015 6:30	05/12/2015 18:00	11.5	0	0													0
06/12/2015	Explorer of the Seas	06/12/2015 5:30	06/12/2015 18:00	12.5	0	0													0
07/12/2015																			0
08/12/2015	Sea Princess	08/12/2015 5:30	08/12/2015 18:00	12.5	7.5	93.75													7.5
09/12/2015																			0
10/12/2015																			0
11/12/2015																			0
12/12/2015	Golden Princess	12/12/2015 8:30	12/12/2015 20:00	11.5	7.5	86.25													7.5
13/12/2015																			0
14/12/2015																			0
15/12/2015	Voyager of the Seas	15/12/2015 5:30	15/12/2015 15:00	9.5	0	0													0
16/12/2015	Celebrity Solstice	16/12/2015 4:30	16/12/2015 20:00	15.5	0	0													0
17/12/2015	Diamond Princess	17/12/2015 5:30	17/12/2015 18:00	12.5	7.5	93.75													7.5
18/12/2015																			0
19/12/2015	Silver Discoverer	19/12/2015 6:00	20/12/2015 0:00	18	0	0													0
20/12/2015	Silver Discoverer	20/12/2015 0:00	20/12/2015 17:00	17	0	0													0
21/12/2015																			0
22/12/2015																			0
23/12/2015																			0
24/12/2015	Asuka II	24/12/2015 9:30	24/12/2015 21:00	11.5	0	0													0
25/12/2015	Golden Princess	25/12/2015 8:30	25/12/2015 20:00	11.5	7.5	86.25	Voyager of the Seas	25/12/2015 6:30	25/12/2015 18:00	11.5	0	0							7.5
26/12/2015	Coral Discoverer	26/12/2015 12:30	27/12/2015 0:00	11.5	0	0													0
27/12/2015	Coral Discoverer	27/12/2015 0:00	27/12/2015 17:00	17	0	0													0
28/12/2015	Noordam	28/12/2015 5:30	29/12/2015 0:00	18.5	0	0													0
29/12/2015	Noordam	29/12/2015 0:00	29/12/2015 17:00	17	0	0	Explorer of the Seas	29/12/2015 5:30	29/12/2015 18:00	12.5	0	0							0
30/12/2015	Diamond Princess	30/12/2015 5:30	30/12/2015 18:00	12.5	7.5	93.75													7.5
31/12/2015																			0
01/01/2016																			0
02/01/2016	Sea Princess	02/01/2016 5:30	02/01/2016 18:00	12.5	7.5	93.75													7.5
03/01/2016	Carnival Legend	03/01/2016 5:30	03/01/2016 18:00	12.5	0	0													0
04/01/2016																			0
05/01/2016																			0
06/01/2016																			0
07/01/2016																			0
08/01/2016	Caledonian Sky	08/01/2016 6:30	08/01/2016 18:00	11.5	0	0													0
09/01/2016																			0
10/01/2016																			0
11/01/2016																			0
12/01/2016	Dawn Princess	12/01/2016 5:30	12/01/2016 18:00	12.5	7.5	93.75	Voyager of the Seas	12/01/2016 5:30	12/01/2016 18:00	12.5	0	0							7.5
13/01/2016	Explorer of the Seas	13/01/2016 7:30	13/01/2016 19:00	11.5	0	0													0
14/01/2016	Diamond Princess	14/01/2016 10:30	14/01/2016 21:00	10.5	7.5	78.75													7.5
15/01/2016																			0
16/01/2016																			0
17/01/2016																			0
18/01/2016																			0
19/01/2016	Golden Princess	19/01/2016 5:30	19/01/2016 17:00	11.5	7.5	86.25	Celebrity Solstice	19/01/2016 4:30	19/01/2016 20:00	15.5	0	0							7.5

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
20/01/2016																			0
21/01/2016																			0
22/01/2016	Le'Soleal	22/01/2016 6:00	22/01/2016 18:00	12	0	0													0
23/01/2016																			0
24/01/2016	Explorer of the Seas	24/01/2016 5:30	24/01/2016 18:00	12.5	0	0													0
25/01/2016							Noordam	25/01/2016 5:30	26/01/2016 0:00	18.5	0	0							0
26/01/2016	Diamond Princess	26/01/2016 10:30	26/01/2016 21:00	10.5	7.5	78.75	Noordam	26/01/2016 0:00	26/01/2016 17:00	17	0	0							7.5
27/01/2016	Seabourn Odyssey	27/01/2016 6:00	27/01/2016 18:00	12	0	0	Silver Discoverer	27/01/2016 5:30	27/01/2016 17:30	12	0	0	Caledonian Sky	27/01/2016 6:30	27/01/2016 18:00	11.5	0	0	0
28/01/2016																			0
29/01/2016	Legend of the Seas	29/01/2016 5:30	29/01/2016 18:00	12.5	0	0													0
30/01/2016																			0
31/01/2016	Azamara Quest	31/01/2016 5:30	31/01/2016 20:00	14.5	0	0													0
01/02/2016	Golden Princess	01/02/2016 5:30	01/02/2016 17:00	11.5	7.5	86.25													7.5
02/02/2016	Amsterdam	02/02/2016 6:30	02/02/2016 18:00	11.5	7.5	86.25													7.5
03/02/2016																			0
04/02/2016	Pacific Pearl	04/02/2016 5:30	04/02/2016 16:00	10.5	0	0													0
05/02/2016	Coral Discoverer	05/02/2016 5:30	05/02/2016 14:00	8.5	0	0													0
06/02/2016																			0
07/02/2016	Diamond Princess	07/02/2016 10:30	07/02/2016 22:00	11.5	7.5	86.25	Explorer of the Seas	07/02/2016 5:30	07/02/2016 18:00	12.5	0	0							7.5
08/02/2016	Pacific Pearl	08/02/2016 6:00	08/02/2016 16:00	10	0	0	Silver Whisper	08/02/2016 5:30	08/02/2016 22:00	16.5	0	0	Pacific Princess	08/02/2016 5:30	08/02/2016 20:00	14.5	0	0	0
09/02/2016	Sea Princess	09/02/2016 5:30	09/02/2016 18:00	12.5	7.5	93.75	Le'Soleal	09/02/2016 5:30	09/02/2016 18:00	12.5	0	0							7.5
10/02/2016	Artania	10/02/2016 6:30	11/02/2016 0:00	17.5	0	0													0
11/02/2016	Artania	11/02/2016 0:00	12/02/2016 0:00	24	0	0	Aurora	11/02/2016 5:30	11/02/2016 23:00	17.5	0	0							0
12/02/2016	Artania	12/02/2016 0:00	12/02/2016 20:00	20	0	0													0
13/02/2016	Noordam	13/02/2016 5:30	13/02/2016 20:00	14.5	0	0	Pacific Venus	13/02/2016 12:30	14/02/2016 0:00	11.5	0	0							0
14/02/2016	Celebrity Solstice	14/02/2016 4:30	14/02/2016 20:00	15.5	0	0	Pacific Venus	14/02/2016 0:00	14/02/2016 18:00	18	0	0							0
15/02/2016	Golden Princess	15/02/2016 8:30	15/02/2016 20:00	11.5	7.5	86.25													7.5
16/02/2016																			0
17/02/2016																			0
18/02/2016	Pacific Pearl	18/02/2016 6:30	18/02/2016 16:00	9.5	0	0													0
19/02/2016	Carnival Spirit	19/02/2016 6:30	19/02/2016 17:00	10.5	0	0													0
20/02/2016																			0
21/02/2016	Europa	21/02/2016 4:30	21/02/2016 21:00	16.5	0	0													0
22/02/2016	Pacific Pearl	22/02/2016 5:30	22/02/2016 16:00	10.5	0	0													0
23/02/2016	Queen Victoria	23/02/2016 5:30	23/02/2016 22:00	16.5	0	0													0
24/02/2016																			0
25/02/2016																			0
26/02/2016	Arcadia	26/02/2016 5:30	26/02/2016 23:00	17.5	0	0													0
27/02/2016																			0
28/02/2016	Golden Princess	28/02/2016 8:30	28/02/2016 20:00	11.5	7.5	86.25													7.5
29/02/2016																			0
01/03/2016	Diamond Princess	01/03/2016 5:30	02/03/2016 0:00	18.5	7.5	138.75	Pacific Pearl	01/03/2016 7:30	01/03/2016 17:00	9.5	0	0							7.5
02/03/2016	Diamond Princess	02/03/2016 0:00	02/03/2016 18:00	18	7.5	135													7.5
03/03/2016																			0
04/03/2016	Albatros	04/03/2016 6:30	05/03/2016 0:00	17.5	0	0	Queen Mary II	04/03/2016 4:30	04/03/2016 23:59	19.4833	0	0							0
05/03/2016	Albatros	05/03/2016 0:00	06/03/2016 0:00	24	0	0													0
06/03/2016	Albatros	06/03/2016 0:00	06/03/2016 18:00	18	0	0													0
07/03/2016																			0
08/03/2016																			0
09/03/2016	Costa Luminosa	09/03/2016 7:30	10/03/2016 0:00	16.5	7.5	123.75	Marina	09/03/2016 4:30	09/03/2016 18:00	13.5	0	0							7.5
10/03/2016	Costa Luminosa	10/03/2016 0:00	10/03/2016 13:00	13	7.5	97.5													7.5
11/03/2016	Pacific Pearl	11/03/2016 6:30	11/03/2016 16:00	9.5	0	0													0
12/03/2016	Noordam	12/03/2016 4:30	12/03/2016 20:00	15.5	0	0													0
13/03/2016	Explorer of the Seas	13/03/2016 5:30	13/03/2016 18:00	12.5	0	0													0
14/03/2016	Pacific Pearl	14/03/2016 5:30	14/03/2016 16:00	10.5	0	0													0

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
15/03/2016																			0
16/03/2016																			0
17/03/2016																			0
18/03/2016																			0
19/03/2016																			0
20/03/2016																			0
21/03/2016																			0
22/03/2016																			0
23/03/2016																			0
24/03/2016	Pacific Pearl	24/03/2016 5:30	24/03/2016 16:00	10.5	0	0													0
25/03/2016																			0
26/03/2016	Golden Princess	26/03/2016 8:30	26/03/2016 20:00	11.5	7.5	86.25													7.5
27/03/2016																			0
28/03/2016	Pacific Pearl	28/03/2016 5:30	28/03/2016 16:00	10.5	0	0													0
29/03/2016																			0
30/03/2016																			0
31/03/2016																			0
01/04/2016																			0
02/04/2016																			0
03/04/2016																			0
04/04/2016	Noordam	04/04/2016 5:30	04/04/2016 17:00	11.5	0	0													0
05/04/2016	Pacific Pearl	05/04/2016 5:30	05/04/2016 16:00	10.5	0	0													0
06/04/2016																			0
07/04/2016	Explorer of the Seas	07/04/2016 5:30	07/04/2016 18:00	12.5	0	0													0
08/04/2016																			0
09/04/2016																			0
10/04/2016																			0
11/04/2016																			0
12/04/2016																			0
13/04/2016	Celebrity Solstice	13/04/2016 5:30	13/04/2016 16:00	10.5	0	0													0
14/04/2016																			0
15/04/2016	Pacific Pearl	15/04/2016 7:30	15/04/2016 18:00	10.5	0	0													0
16/04/2016	Dawn Princess	16/04/2016 5:30	16/04/2016 18:00	12.5	7.5	93.75													7.5
17/04/2016																			0
18/04/2016	Pacific Pearl	18/04/2016 5:30	18/04/2016 16:00	10.5	0	0													0
19/04/2016	Explorer of the Seas	19/04/2016 7:30	19/04/2016 19:00	11.5	0	0													0
20/04/2016																			0
21/04/2016																			0
22/04/2016																			0
23/04/2016																			0
24/04/2016																			0
25/04/2016																			0
26/04/2016																			0
27/04/2016	Pacific Pearl	27/04/2016 5:30	27/04/2016 16:00	10.5	0	0													0
28/04/2016																			0
29/04/2016																			0
30/04/2016																			0
01/05/2016																			0
02/05/2016																			0
03/05/2016																			0
04/05/2016																			0
05/05/2016																			0
06/05/2016																			0
07/05/2016	Pacific Pearl	07/05/2016 5:30	07/05/2016 16:00	10.5	0	0													0
08/05/2016																			0

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
09/05/2016																			0
10/05/2016																			0
11/05/2016	Sea Princess	11/05/2016 7:30	11/05/2016 18:00	10.5	7.5	78.75													7.5
12/05/2016																			0
13/05/2016																			0
14/05/2016																			0
15/05/2016																			0
16/05/2016	Pacific Pearl	16/05/2016 5:30	16/05/2016 16:00	10.5	0	0													0
17/05/2016																			0
18/05/2016																			0
19/05/2016	Insignia	19/05/2016 6:30	19/05/2016 18:00	11.5	0	0													0
20/05/2016																			0
21/05/2016																			0
22/05/2016																			0
23/05/2016																			0
24/05/2016																			0
25/05/2016																			0
26/05/2016	Pacific Pearl	26/05/2016 5:30	26/05/2016 16:00	10.5	0	0													0
27/05/2016																			0
28/05/2016																			0
29/05/2016																			0
30/05/2016																			0
31/05/2016																			0
01/06/2016																			0
02/06/2016																			0
03/06/2016																			0
04/06/2016																			0
05/06/2016																			0
06/06/2016																			0
07/06/2016																			0
08/06/2016																			0
09/06/2016																			0
10/06/2016	Pacific Pearl	10/06/2016 5:30	10/06/2016 18:00	12.5	0	0													0
11/06/2016																			0
12/06/2016																			0
13/06/2016	Pacific Pearl	13/06/2016 5:30	13/06/2016 16:00	10.5	0	0													0
14/06/2016																			0
15/06/2016																			0
16/06/2016																			0
17/06/2016																			0
18/06/2016																			0
19/06/2016																			0
20/06/2016																			0
21/06/2016																			0
22/06/2016																			0
23/06/2016	Pacific Pearl	23/06/2016 7:30	23/06/2016 16:00	8.5	0	0													0
24/06/2016																			0
25/06/2016																			0
26/06/2016																			0
27/06/2016																			0
28/06/2016																			0
29/06/2016																			0
30/06/2016																			0
01/07/2016																			0
02/07/2016																			0

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Total Draw**
03/07/2016																			0
04/07/2016																			0
05/07/2016																			0
06/07/2016																			0
07/07/2016																			0
08/07/2016																			0
09/07/2016																			0
10/07/2016																			0
11/07/2016																			0
12/07/2016																			0
13/07/2016																			0
14/07/2016																			0
15/07/2016																			0
16/07/2016																			0
17/07/2016																			0
18/07/2016																			0
19/07/2016																			0
20/07/2016																			0
21/07/2016																			0
22/07/2016																			0
23/07/2016																			0
24/07/2016																			0
25/07/2016																			0
26/07/2016																			0
27/07/2016																			0
28/07/2016																			0
29/07/2016																			0
30/07/2016																			0
31/07/2016																			0
01/08/2016																			0
02/08/2016																			0
03/08/2016																			0
04/08/2016																			0
05/08/2016																			0
06/08/2016																			0
07/08/2016																			0
08/08/2016																			0
09/08/2016																			0
10/08/2016																			0
11/08/2016																			0
12/08/2016																			0
13/08/2016																			0
14/08/2016																			0
15/08/2016																			0
16/08/2016																			0
17/08/2016																			0
18/08/2016																			0
19/08/2016																			0
20/08/2016																			0
21/08/2016																			0
22/08/2016																			0
23/08/2016																			0
24/08/2016	Sea Princess	24/08/2016 5:30	24/08/2016 18:00	12.5	7.5	93.75													7.5
25/08/2016																			0
26/08/2016																			0

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
27/08/2016																			0
28/08/2016																			0
29/08/2016																			0
30/08/2016																			0
31/08/2016	Sun Princess	31/08/2016 8:30	31/08/2016 22:00	13.5	7.5	101.25													7.5
01/09/2016																			0
02/09/2016																			0
03/09/2016																			0
04/09/2016																			0
05/09/2016																			0
06/09/2016																			0
07/09/2016																			0
08/09/2016																			0
09/09/2016																			0
10/09/2016																			0
11/09/2016																			0
12/09/2016																			0
13/09/2016																			0
14/09/2016																			0
15/09/2016																			0
16/09/2016																			0
17/09/2016																			0
18/09/2016																			0
19/09/2016																			0
20/09/2016																			0
21/09/2016																			0
22/09/2016																			0
23/09/2016																			0
24/09/2016																			0
25/09/2016																			0
26/09/2016																			0
27/09/2016																			0
28/09/2016																			0
29/09/2016																			0
30/09/2016																			0
01/10/2016																			0
02/10/2016																			0
03/10/2016																			0
04/10/2016	Celebrity Solstice	04/10/2016 8:30	04/10/2016 18:00	9.5	0	0													0
05/10/2016																			0
06/10/2016																			0
07/10/2016																			0
08/10/2016																			0
09/10/2016																			0
10/10/2016																			0
11/10/2016																			0
12/10/2016																			0
13/10/2016	Sun Princess	13/10/2016 5:30	13/10/2016 18:00	12.5	7.5	93.75													7.5
14/10/2016																			0
15/10/2016																			0
16/10/2016																			0
17/10/2016																			0
18/10/2016																			0
19/10/2016																			0
20/10/2016	Costa Luminosa	20/10/2016 6:30	20/10/2016 20:00	13.5	7.5	101.25													7.5

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
21/10/2016																			0
22/10/2016																			0
23/10/2016																			0
24/10/2016																			0
25/10/2016																			0
26/10/2016																			0
27/10/2016																			0
28/10/2016	Dawn Princess	28/10/2016 7:30	28/10/2016 18:00	10.5	7.5	78.75													7.5
29/10/2016																			0
30/10/2016																			0
31/10/2016																			0
01/11/2016																			0
02/11/2016																			0
03/11/2016																			0
04/11/2016																			0
05/11/2016																			0
06/11/2016																			0
07/11/2016																			0
08/11/2016	Noordam	08/11/2016 5:30	08/11/2016 17:00	11.5	0	0													0
09/11/2016																			0
10/11/2016																			0
11/11/2016																			0
12/11/2016																			0
13/11/2016																			0
14/11/2016																			0
15/11/2016																			0
16/11/2016																			0
17/11/2016																			0
18/11/2016	Pacific Aria	18/11/2016 6:30	18/11/2016 18:00	11.5	0	0													0
19/11/2016																			0
20/11/2016																			0
21/11/2016																			0
22/11/2016																			0
23/11/2016																			0
24/11/2016	Emerald Princess	24/11/2016 5:30	24/11/2016 18:00	12.5	7.5	93.75													7.5
25/11/2016																			0
26/11/2016																			0
27/11/2016	Astor	27/11/2016 6:30	27/11/2016 17:00	10.5	0	0													0
28/11/2016																			0
29/11/2016																			0
30/11/2016																			0
01/12/2016	Sea Princess	01/12/2016 5:30	01/12/2016 18:00	12.5	7.5	93.75													7.5
02/12/2016	Maasdam	02/12/2016 5:30	02/12/2016 23:00	17.5	0	0													0
03/12/2016																			0
04/12/2016																			0
05/12/2016	Dawn Princess	05/12/2016 5:30	05/12/2016 18:00	12.5	7.5	93.75													7.5
06/12/2016																			0
07/12/2016																			0
08/12/2016	Golden Princess	08/12/2016 8:30	08/12/2016 20:00	11.5	7.5	86.25													7.5
09/12/2016																			0
10/12/2016																			0
11/12/2016																			0
12/12/2016																			0
13/12/2016																			0
14/12/2016																			0

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
15/12/2016																			0
16/12/2016	Radiance of the Seas	16/12/2016 4:30	16/12/2016 20:00	15.5	0	0													0
17/12/2016	Noordam	17/12/2016 6:30	17/12/2016 18:00	11.5	0	0													0
18/12/2016	Dawn Princess	18/12/2016 5:30	18/12/2016 18:00	12.5	7.5	93.75													7.5
19/12/2016																			0
20/12/2016	Europa 2	20/12/2016 5:30	20/12/2016 19:00	13.5	0	0							Caledonian Sky	20/12/2016 21:04	21/12/2016 0:00	2.93333	0	0	0
21/12/2016	Golden Princess	21/12/2016 10:30	21/12/2016 22:00	11.5	7.5	86.25	Crystal Symphony	21/12/2016 4:30	21/12/2016 21:00	16.5	0	0	Caledonian Sky	21/12/2016 0:00	21/12/2016 18:00	18	0	0	7.5
22/12/2016																			0
23/12/2016	Emerald Princess	23/12/2016 5:30	23/12/2016 18:00	12.5	7.5	93.75													7.5
24/12/2016																			0
25/12/2016																			0
26/12/2016																			0
27/12/2016	Ovation of the Seas	27/12/2016 5:30	27/12/2016 16:00	10.5	0	0													0
28/12/2016																			0
29/12/2016																			0
30/12/2016	Radiance of the Seas	30/12/2016 6:30	30/12/2016 18:00	11.5	0	0													0
31/12/2016																			0
01/01/2017																			0
02/01/2017	Maasdam	02/01/2017 5:30	02/01/2017 23:00	17.5	0	0													0
03/01/2017	Golden Princess	03/01/2017 8:30	03/01/2017 20:00	11.5	7.5	86.25													7.5
04/01/2017																			0
05/01/2017																			0
06/01/2017																			0
07/01/2017																			0
08/01/2017																			0
09/01/2017	Caledonian Sky	09/01/2017 5:30	09/01/2017 18:00	12.5	0	0													0
10/01/2017																			0
11/01/2017																			0
12/01/2017	Dawn Princess	12/01/2017 8:30	12/01/2017 20:00	11.5	7.5	86.25													7.5
13/01/2017																			0
14/01/2017	Ovation of the Seas	14/01/2017 6:30	14/01/2017 18:00	11.5	0	0	Noordam	14/01/2017 6:15	14/01/2017 18:15	12	0	0							0
15/01/2017	Sea Princess	15/01/2017 5:30	15/01/2017 18:00	12.5	7.5	93.75													7.5
16/01/2017	Radiance of the Seas	16/01/2017 5:30	16/01/2017 18:00	12.5	0	0	Crystal Symphony	16/01/2017 6:30	16/01/2017 17:00	10.5	0	0							0
17/01/2017																			0
18/01/2017																			0
19/01/2017	Europa 2	19/01/2017 4:30	19/01/2017 19:00	14.5	0	0	Legend of the Seas	19/01/2017 5:30	19/01/2017 18:00	12.5	0	0							0
20/01/2017																			0
21/01/2017																			0
22/01/2017																			0
23/01/2017																			0
24/01/2017	Celebrety Solstice	24/01/2017 4:30	24/01/2017 20:00	15.5	0	0													0
25/01/2017	Dawn Princess	25/01/2017 8:30	25/01/2017 20:00	11.5	7.5	86.25													7.5
26/01/2017	Seven Seas Voyager	26/01/2017 5:30	26/01/2017 18:00	12.5	0	0													0
27/01/2017	Golden Princess	27/01/2017 5:00	27/01/2017 17:00	12	7.5	90	Silver Whisper	27/01/2017 5:30	27/01/2017 19:00	13.5	0	0							7.5
28/01/2017																			0
29/01/2017	Maasdam	29/01/2017 5:30	29/01/2017 16:00	10.5	0	0													0
30/01/2017																			0
31/01/2017	L'Austral	31/01/2017 5:30	31/01/2017 18:00	12.5	0	0													0
01/02/2017	Radiance of the Seas	01/02/2017 5:30	01/02/2017 18:00	12.5	0	0													0
02/02/2017																			0
03/02/2017	Pacific Pearl	03/02/2017 5:30	03/02/2017 16:00	10.5	0	0													0
04/02/2017	Emerald Princess	04/02/2017 10:30	04/02/2017 22:00	11.5	7.5	86.25													7.5
05/02/2017																			0
06/02/2017	Ovation of the Seas	06/02/2017 6:00	06/02/2017 16:00	10	0	0	Albatros	06/02/2017 6:30	06/02/2017 22:00	15.5	0	0							0
07/02/2017	Europa	07/02/2017 5:00	07/02/2017 19:00	14	0	0	Pacific Pearl	07/02/2017 5:30	07/02/2017 16:00	10.5	0	0							0

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	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
08/02/2017	Pacific Princess	08/02/2017 5:30	08/02/2017 22:00	16.5	0	0													0
09/02/2017	Dawn Princess	09/02/2017 5:00	09/02/2017 18:00	13	7.5	97.5	Golden Princess	09/02/2017 5:30	09/02/2017 17:00	11.5	7.5	86.25							15
10/02/2017																			0
11/02/2017	Caledonian Sky	11/02/2017 6:30	11/02/2017 18:30	12	0	0													0
12/02/2017	Sun Princess	12/02/2017 5:30	12/02/2017 18:00	12.5	7.5	93.75	Nippon Maru	12/02/2017 7:30	13/02/2017 0:00	16.5	0	0							7.5
13/02/2017	Arcadia	13/02/2017 7:30	14/02/2017 0:00	16.5	0	0	Nippon Maru	13/02/2017 0:00	14/02/2017 0:00	24	0	0							0
14/02/2017	Arcadia	14/02/2017 0:00	14/02/2017 22:00	22	0	0	Nippon Maru	14/02/2017 0:00	14/02/2017 18:00	18	0	0	Noordam	14/02/2017 5:30	14/02/2017 17:00	11.5	0	0	0
15/02/2017																			0
16/02/2017	Magellan	16/02/2017 4:30	16/02/2017 21:00	16.5	0	0	Pacific Pearl	16/02/2017 5:30	16/02/2017 16:00	10.5	0	0	Black Watch	16/02/2017 5:00	17/02/2017 0:00	19	0	0	0
17/02/2017	Celebrity Solstice	17/02/2017 4:30	17/02/2017 20:00	15.5	0	0	The World	17/02/2017 7:30	18/02/2017 0:00	16.5	0	0	Black Watch	17/02/2017 0:00	17/02/2017 18:00	18	0	0	0
18/02/2017	Norwegian Star	18/02/2017 4:30	18/02/2017 18:00	13.5	7.5	101.25	The World	18/02/2017 0:00	19/02/2017 0:00	24	0	0	Seabourn Encore	18/02/2017 5:30	18/02/2017 16:00	10.5	0	0	7.5
19/02/2017							The World	19/02/2017 0:00	20/02/2017 0:00	24	0	0							0
20/02/2017							The World	20/02/2017 0:00	20/02/2017 6:00	6	0	0							0
21/02/2017	Queen Elizabeth	21/02/2017 5:30	21/02/2017 23:00	17.5	0	0	Artania	21/02/2017 5:00	22/02/2017 0:00	19	0	0							0
22/02/2017	Dawn Princess	22/02/2017 6:00	22/02/2017 18:00	12	7.5	90	Artania	22/02/2017 0:00	23/02/2017 0:00	24	0	0	Insignia	22/02/2017 5:30	22/02/2017 19:00	13.5	0	0	7.5
23/02/2017							Artania	23/02/2017 0:00	23/02/2017 20:00	20	0	0							0
24/02/2017	Emerald Princess	24/02/2017 4:30	24/02/2017 18:00	13.5	7.5	101.25													7.5
25/02/2017																			0
26/02/2017																			0
27/02/2017																			0
28/02/2017	Pacific Pearl	28/02/2017 7:30	28/02/2017 17:00	9.5	0	0													0
01/03/2017																			0
02/03/2017																			0
03/03/2017																			0
04/03/2017																			0
05/03/2017																			0
06/03/2017	Queen Victoria	06/03/2017 5:30	06/03/2017 23:00	17.5	0	0	Azamara Journey	06/03/2017 5:30	06/03/2017 20:00	14.5	0	0							0
07/03/2017																			0
08/03/2017																			0
09/03/2017	Costa Luminosa	09/03/2017 6:30	09/03/2017 20:00	13.5	7.5	101.25	Golden Princess	09/03/2017 8:30	09/03/2017 20:00	11.5	7.5	86.25							15
10/03/2017	Noordam	10/03/2017 5:00	10/03/2017 18:00	13	0	0	Pacific Pearl	10/03/2017 6:30	10/03/2017 16:00	9.5	0	0							0
11/03/2017																			0
12/03/2017	Dawn Princess	12/03/2017 5:30	12/03/2017 18:00	12.5	7.5	93.75	Aurora	12/03/2017 6:30	12/03/2017 19:00	12.5	0	0							7.5
13/03/2017	Pacific Pearl	13/03/2017 5:30	13/03/2017 16:00	10.5	0	0													0
14/03/2017																			0
15/03/2017																			0
16/03/2017	Bremen	16/03/2017 0:30	16/03/2017 20:00	19.5	0	0													0
17/03/2017																			0
18/03/2017	Radiance of the Seas	18/03/2017 5:30	18/03/2017 18:00	12.5	0	0													0
19/03/2017																			0
20/03/2017																			0
21/03/2017																			0
22/03/2017	Golden Princess	22/03/2017 8:30	22/03/2017 20:00	11.5	7.5	86.25													7.5
23/03/2017	Pacific Pearl	23/03/2017 5:30	23/03/2017 16:00	10.5	0	0													0
24/03/2017																			0
25/03/2017																			0
26/03/2017	Noordam	26/03/2017 5:30	26/03/2017 17:00	11.5	0	0													0
27/03/2017	Emerald Princess	27/03/2017 5:30	27/03/2017 18:00	12.5	7.5	93.75	Pacific Pearl	27/03/2017 6:00	27/03/2017 16:00	10	0	0							7.5
28/03/2017																			0
29/03/2017																			0
30/03/2017																			0
31/03/2017																			0
01/04/2017	Sea Princess	01/04/2017 5:30	01/04/2017 18:30	13	7.5	97.5	Radiance of the Seas	01/04/2017 6:30	01/04/2017 18:00	11.5	0	0							7.5
02/04/2017																			0
03/04/2017	Emerald Princess	03/04/2017 10:30	03/04/2017 22:00	11.5	7.5	86.25													7.5

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
04/04/2017																			0
05/04/2017																			0
06/04/2017																			0
07/04/2017																			0
08/04/2017																			0
09/04/2017																			0
10/04/2017																			0
11/04/2017																			0
12/04/2017																			0
13/04/2017																			0
14/04/2017																			0
15/04/2017																			0
16/04/2017																			0
17/04/2017																			0
18/04/2017																			0
19/04/2017	Emerald Princess	19/04/2017 5:30	19/04/2017 18:00	12.5	7.5	93.75													7.5
20/04/2017																			0
21/04/2017																			0
22/04/2017																			0
23/04/2017	Sirena	23/04/2017 4:30	23/04/2017 18:00	13.5	0	0													0
24/04/2017	Celebrity Solstice	24/04/2017 5:30	24/04/2017 16:00	10.5	0	0													0
25/04/2017																			0
26/04/2017																			0
27/04/2017																			0
28/04/2017																			0
29/04/2017																			0
30/04/2017																			0
01/05/2017																			0
02/05/2017																			0
03/05/2017																			0
04/05/2017																			0
05/05/2017																			0
06/05/2017																			0
07/05/2017																			0
08/05/2017																			0
09/05/2017																			0
10/05/2017																			0
11/05/2017																			0
12/05/2017																			0
13/05/2017																			0
14/05/2017																			0
15/05/2017																			0
16/05/2017	Sea Princess	16/05/2017 7:30	16/05/2017 21:00	13.5	7.5	101.25													7.5
17/05/2017																			0
18/05/2017																			0
19/05/2017																			0
20/05/2017																			0
21/05/2017																			0
22/05/2017																			0
23/05/2017																			0
24/05/2017																			0
25/05/2017																			0
26/05/2017																			0
27/05/2017																			0
28/05/2017																			0

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
29/05/2017																			0
30/05/2017																			0
31/05/2017																			0
01/06/2017																			0
02/06/2017																			0
03/06/2017																			0
04/06/2017																			0
05/06/2017																			0
06/06/2017																			0
07/06/2017																			0
08/06/2017																			0
09/06/2017																			0
10/06/2017																			0
11/06/2017																			0
12/06/2017																			0
13/06/2017																			0
14/06/2017																			0
15/06/2017																			0
16/06/2017																			0
17/06/2017																			0
18/06/2017																			0
19/06/2017																			0
20/06/2017																			0
21/06/2017																			0
22/06/2017																			0
23/06/2017																			0
24/06/2017																			0
25/06/2017																			0
26/06/2017																			0
27/06/2017																			0
28/06/2017																			0
29/06/2017																			0
30/06/2017																			0
01/07/2017																			0
02/07/2017																			0
03/07/2017																			0
04/07/2017																			0
05/07/2017																			0
06/07/2017																			0
07/07/2017																			0
08/07/2017																			0
09/07/2017																			0
10/07/2017																			0
11/07/2017																			0
12/07/2017																			0
13/07/2017																			0
14/07/2017																			0
15/07/2017																			0
16/07/2017																			0
17/07/2017																			0
18/07/2017																			0
19/07/2017																			0
20/07/2017																			0
21/07/2017																			0
22/07/2017																			0

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Ports of Auckland Berth Analysis for Shore Power

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
23/07/2017																			0
24/07/2017																			0
25/07/2017																			0
26/07/2017																			0
27/07/2017																			0
28/07/2017																			0
29/07/2017	Golden Princess	29/07/2017 8:30	29/07/2017 22:00	13.5	7.5	101.25													7.5
30/07/2017																			0
31/07/2017																			0
01/08/2017																			0
02/08/2017																			0
03/08/2017																			0
04/08/2017																			0
05/08/2017																			0
06/08/2017																			0
07/08/2017																			0
08/08/2017																			0
09/08/2017																			0
10/08/2017																			0
11/08/2017																			0
12/08/2017																			0
13/08/2017																			0
14/08/2017																			0
15/08/2017																			0
16/08/2017																			0
17/08/2017																			0
18/08/2017																			0
19/08/2017																			0
20/08/2017																			0
21/08/2017																			0
22/08/2017																			0
23/08/2017																			0
24/08/2017																			0
25/08/2017																			0
26/08/2017																			0
27/08/2017																			0
28/08/2017																			0
29/08/2017	Sea Princess	29/08/2017 8:30	29/08/2017 23:00	14.5	7.5	108.75													7.5
30/08/2017																			0
31/08/2017																			0
01/09/2017	Pacific Jewel	01/09/2017 5:30	01/09/2017 16:00	10.5	0	0													0
02/09/2017	Golden Princess	02/09/2017 8:30	02/09/2017 22:00	13.5	7.5	101.25													7.5
03/09/2017																			0
04/09/2017	Pacific Jewel	04/09/2017 5:30	04/09/2017 16:00	10.5	0	0													0
05/09/2017																			0
06/09/2017																			0
07/09/2017																			0
08/09/2017																			0
09/09/2017																			0
10/09/2017																			0
11/09/2017																			0
12/09/2017																			0
13/09/2017																			0
14/09/2017																			0
15/09/2017																			0

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Ports of Auckland Berth Analysis for Shore Power

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
16/09/2017																			0
17/09/2017																			0
18/09/2017																			0
19/09/2017	Pacific Jewel	19/09/2017 5:30	19/09/2017 16:00	10.5	0	0													0
20/09/2017																			0
21/09/2017																			0
22/09/2017																			0
23/09/2017																			0
24/09/2017																			0
25/09/2017																			0
26/09/2017																			0
27/09/2017																			0
28/09/2017																			0
29/09/2017	Pacific Jewel	29/09/2017 7:30	29/09/2017 17:00	9.5	0	0													0
30/09/2017																			0
01/10/2017																			0
02/10/2017																			0
03/10/2017																			0
04/10/2017																			0
05/10/2017																			0
06/10/2017																			0
07/10/2017																			0
08/10/2017																			0
09/10/2017																			0
10/10/2017																			0
11/10/2017	Golden Princess	11/10/2017 5:30	11/10/2017 18:00	12.5	7.5	93.75													7.5
12/10/2017																			0
13/10/2017																			0
14/10/2017																			0
15/10/2017																			0
16/10/2017	Celebrity Solstice	16/10/2017 8:30	16/10/2017 20:00	11.5	0	0													0
17/10/2017																			0
18/10/2017																			0
19/10/2017																			0
20/10/2017																			0
21/10/2017																			0
22/10/2017	Dawn Princess	22/10/2017 8:30	22/10/2017 20:00	11.5	7.5	86.25													7.5
23/10/2017																			0
24/10/2017																			0
25/10/2017																			0
26/10/2017																			0
27/10/2017																			0
28/10/2017																			0
29/10/2017																			0
30/10/2017																			0
31/10/2017																			0
01/11/2017																			0
02/11/2017	Costa Luminosa	02/11/2017 6:30	02/11/2017 20:00	13.5	7.5	101.25													7.5
03/11/2017																			0
04/11/2017																			0
05/11/2017	Noordam	05/11/2017 6:30	06/11/2017 0:00	17.5	0	0													0
06/11/2017	Noordam	06/11/2017 0:00	06/11/2017 17:00	17	0	0													0
07/11/2017																			0
08/11/2017																			0
09/11/2017																			0

Ports of Auckland Berth Analysis for Shore Power

	Berth 1						Berth 2						Berth 3						
Date	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Vessel Name	Arrival	Departure	Duration (h)	Draw (MW)	Energy (MWh)	Total Draw
10/11/2017																			0
11/11/2017	Celebrity Solstice	11/11/2017 5:00	11/11/2017 20:00	15	0	0													0
12/11/2017																			0
13/11/2017																			0
14/11/2017																			0
15/11/2017																			0
16/11/2017																			0
17/11/2017																			0
18/11/2017																			0
19/11/2017																			0
20/11/2017																			0
21/11/2017																			0
22/11/2017																			0
23/11/2017	Golden Princess	23/11/2017 8:30	23/11/2017 19:00	10.5	7.5	78.75													7.5
24/11/2017	Diamond Princess	24/11/2017 5:30	24/11/2017 18:00	12.5	7.5	93.75													7.5
25/11/2017																			0
26/11/2017																			0
27/11/2017																			0
28/11/2017	Golden Princess	28/11/2017 5:30	28/11/2017 17:00	11.5	7.5	86.25													7.5
29/11/2017																			0
30/11/2017																			0
01/12/2017	Noordam	01/12/2017 5:30	02/12/2017 0:00	18.5	0	0													0
02/12/2017	Noordam	02/12/2017 0:00	02/12/2017 17:00	17	0	0													0
03/12/2017																			0
04/12/2017																			0
05/12/2017	Sun Princess	05/12/2017 5:30	05/12/2017 18:00	12.5	7.5	93.75													7.5
06/12/2017	Pacific Dawn	06/12/2017 6:30	06/12/2017 18:00	11.5	0	0													0
07/12/2017	Diamond Princess	07/12/2017 5:30	07/12/2017 18:00	12.5	7.5	93.75	Maasdam	07/12/2017 5:30	07/12/2017 17:30	12	0	0							7.5
08/12/2017																			0
09/12/2017	Celebrity Solstice	09/12/2017 5:00	09/12/2017 20:00	15	0	0													0
10/12/2017																			0
11/12/2017	Golden Princess	11/12/2017 5:30	11/12/2017 17:00	11.5	7.5	86.25													7.5
12/12/2017																			0
13/12/2017	Sea Princess	13/12/2017 5:30	13/12/2017 17:30	12	7.5	90													7.5
14/12/2017																			0
15/12/2017																			0
16/12/2017																			0
17/12/2017																			0
18/12/2017																			0
19/12/2017																			0
20/12/2017																			0
21/12/2017																			0
22/12/2017																			0
23/12/2017																			0
24/12/2017																			0
25/12/2017																			0
26/12/2017																			0
27/12/2017																			0
28/12/2017																			0
29/12/2017																			0
30/12/2017																			0
31/12/2017																			0
Total					**102**	**9618.75**					**4**	**337.5**					**0**	**0**	**9956.25**
									Shore Power Enabled Ships										
2017				**74**	**32**	**2981.25**					**2**	**172.5**					**0**	**0**	**3153.75**

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Ports of Auckland Berth Analysis for Shore Power

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

	Berth 1						Berth 2						Berth 3						
Date	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Vessel Name**	**Arrival**	**Departure**	**Duration (h)**	**Draw (MW)**	**Energy (MWh)**	**Total Draw**
2016				**86**	**30**	**2820**					**0**	**0**					**0**	**0**	**2820**
2015				**90**	**40**	**3817.5**					**2**	**165**					**0**	**0**	**3982.5**
All Ships																			
2017				**74**	**74**	**7178.3**					**25**	**2241.2**					**5**	**372.05**	**9791.55**
2016				**86**	**86**	**8115.2**					**15**	**1508.88**					**4**	**192.427**	**9816.51**
2015				**90**	**90**	**8502.8**					**16**	**1469.35**					**3**	**120.95**	**10093.1**

Appendix 2: Concept Layouts

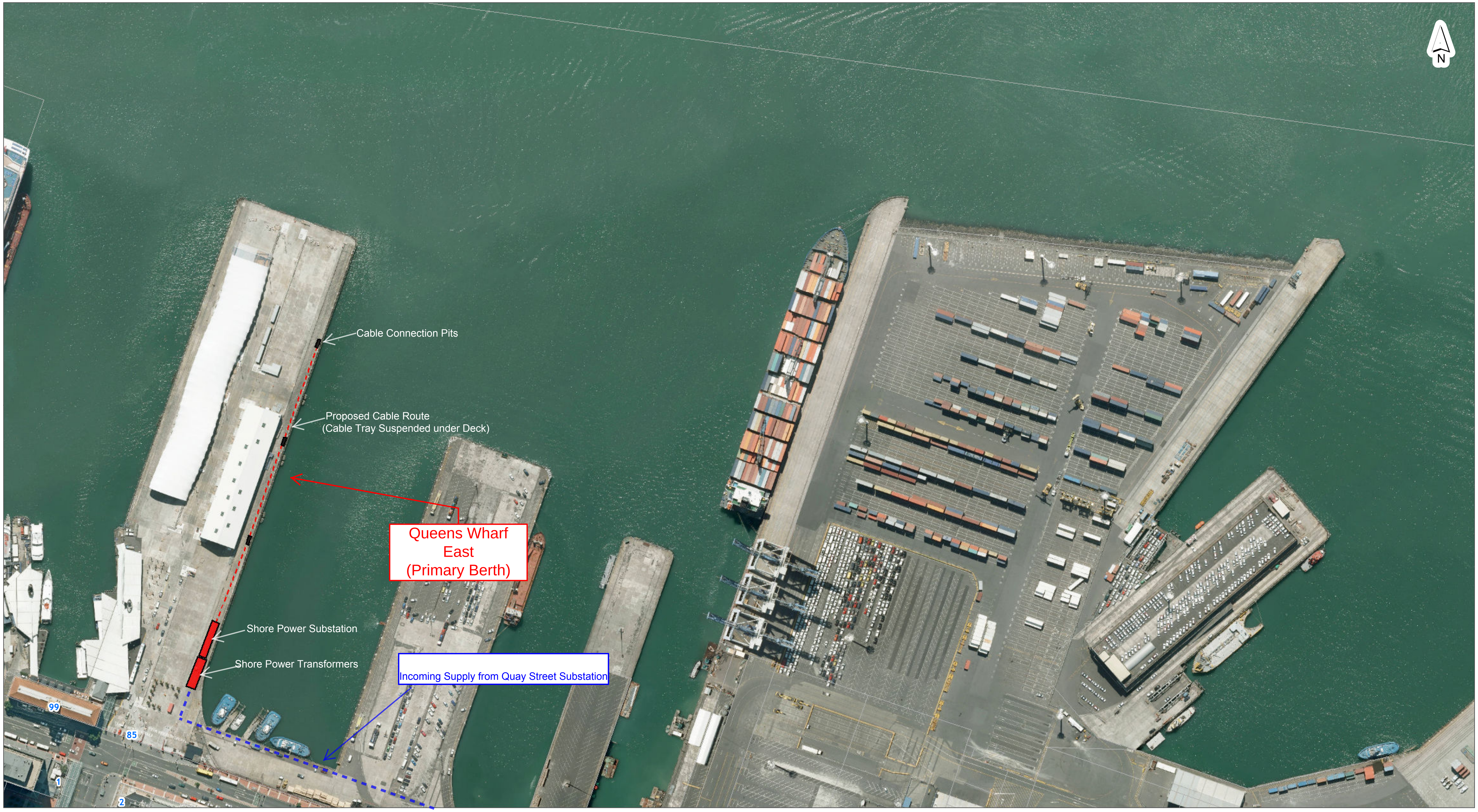
Ports of Auckland Proposed Electrical Supply

0 50 100 150
Meters

Scale @ A3
= 1:5,000

Date Printed:
23/02/2017

Auckland Council
Te Kaunihera o Tāmaki Makaurau



Ports of Auckland Grid Supplied Shore Power

0 25 50 75
Meters

Scale @ A3
= 1:2,500

Date Printed:
16/03/2017

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Map

DISCLAIMER:
This map/plan is illustrative only and all information should be independently verified on site before taking any action. Copyright Auckland Council. Land Parcel Boundary information from LINZ (Crown Copyright Reserved). Whilst due care has been taken, Auckland Council gives no warranty as to the accuracy and plan completeness of any information on this map/plan and accepts no liability for any error, omission or use of the information.
Height datum: Auckland 1946.

Ports of Auckland Local Generation Shore Power

0 25 50 75
Meters

Scale @ A3
= 1:2,500

Date Printed:
16/03/2017

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Ports of Auckland Shore Power Hybrid Supply

0 25 50 75
Meters

Scale @ A3
= 1:2,500

Date Printed:
16/03/2017

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Appendix 3: Capital and Maintenance Cost Estimates

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Capital Cost Estimates Preferred Options

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

Option 1 - Shore Power Grid Supply Cost Estimate ± 30%				
Investment Life			**10**	
Discount Rate			**8%**	
Item	**Item Description**		**Total Cost**	**Annualised Cost**
1	**Direct Costs**			
	- Utility Upgrades		$ 1,900,000	
	- Shore Power Substation and Cable Position System		$ 9,240,000	
	- Construction Costs		$ 882,550	
	- Contengency (20% of Constuction and SP Equipment)		$ 2,024,510	
		Subtotal	**$ 14,047,059**	**$ 2,093,426**
2	**Indirect Costs**			
	- EPCM Costs (20%)		$ 2,404,510	
	- Owners Cost (8%)		$ 1,154,165	
	- Contingency (20%)		$ 711,735	
		Subtotal	**$ 4,270,410**	**$ 636,417**
2	**POAL Annual Maintenance Costs**			**$ 26,000**
3	**Operating Costs**			**-$ 68,508**
		Total	**$ 18,317,469**	**$ 2,687,336**

Option 2 - Shore Power Hybrid Supply Cost Estimate ± 30%				
Investment Life			**10**	
Discount Rate			**8%**	
Item	**Item Description**		**Total Cost**	**Annualised Cost**
1	**Direct Costs**			
	- Utility Upgrades + Solar Panel Installation and Tie in		$ 2,895,000	
	- Shore Power Substation and Cable Position System		$ 9,240,000	
	- Construction Costs		$ 882,550	
	- Contengency (20% of Constuction and SP Equipment)		$ 2,223,510	
		Subtotal	**$ 15,241,059**	**$ 2,271,367**
	Indirect Costs			
	- EPCM Costs (20%)		$ 2,603,510	
	- Owners Cost (8%)		$ 1,249,685	
	- Contingency (20%)		$ 770,639	
		Subtotal	**$ 4,623,834**	**$ 689,088**
2	**POAL Annual Maintenance Costs**			**$ 29,560**
3	**Operating Costs**			**-$ 52,698**
		Total	**$ 19,864,893**	**$ 2,937,317**

Option 3 - Fuel Switching Cost Estimate ± 30%				
Investment Life			**10**	
Discount Rate			**8%**	
Item	**Item Description**		**Total Cost**	**Annualised Cost**
1	**Direct Costs**			
	- Storage Upgrade Allowance		$ 1,500,000.00	
	- Contengency (20%)		$ 300,000	
		Subtotal	**$ 1,800,000**	**$268,253.08**
2	**Indirect Costs**			
	- EPCM Costs (20%)		$ 300,000	
	- Owners Cost (8%)		$ 24,000	
	- Contingency (20%)		$ 64,800	
		Subtotal	**$ 388,800**	**$57,942.67**
2	**POAL Annual Maintenance Costs**			**$ -**
3	**Operating Costs**			**$ 985,529.16**
		Total	**$ 2,188,800.00**	**$1,311,724.90**