Final Report For :

Deltaport Third Berth Container Terminal Cold Ironing Feasibility Study

Westmar

Project No : 06095

May 2007

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Consulting Engineers

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VIA E-MAIL

May 30, 2007

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Project No.: 06095

Attention: Simon Daniels, P.Eng.
Project Manager

Reference: TSI Terminal Systems Inc.
Final Report for Deltaport Third Berth Container Terminal
Cold Ironing Feasibility Study

Dear Sirs:

Please find attached five hard copies of our final report of today's date, for the above referenced project, for your review and distribution to TSI Terminal Systems Inc.

If you have any questions or concerns, please do not hesitate to contact us.

Yours truly,

WESTMAR CONSULTANTS INC.

[Original signed by Robert Louie]

Robert Louie, P.Eng.
Manager
Electrical and Controls Division

RKL/clh
Encl.

TSI TERMINAL SYSTEMS INC.

Final Report for:

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Prepared by: ***[Original signed by Robert Louie]***
Robert Louie, P.Eng.

Westmar

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Executive Summary

The provision of power from shore to shipping vessels is known as cold ironing. This report is focussed on the feasibility of cold ironing container ships as part of the Deltaport Third Berth Project and more specifically the possible implementation of cold ironing infrastructure for Berth No. 3.

Work began in early October 2006 with a trip to the Los Angeles area to see first hand how both the Port of Los Angeles (POLA) and the Port of Long Beach (POLB) implemented cold ironing. POLA has trade marked the term Alternative Maritime Power™ or AMP™ which is synonymous to cold ironing.

Current international efforts are focussed on the reduction of Criteria Air Contaminant (CAC) emissions. However, concerns are growing over global warming and the need to reduce Green House Gas (GHG) emissions. If 100% of Deltaport's container ships were cold ironed the reduction in emissions would be 390 tonnes of CAC and 3,067 tonnes of CO_2. This is equivalent to 13.6% of CAC and 3.5% of CO_2 when compared with GVRD's year 2000 container ship emission inventory.

Capital expenditure necessary for cold ironing is significant. As well there is the ongoing cost of operation and maintenance. Currently, it is more expensive in terms of energy cost to use shore power than operating the ship's auxiliary engines with HFO.

The 2004 Environ report estimates a cost effectiveness of USD$11,000 to USD$15,000 per tonne of emissions reduced. This is expensive compared to other technologies that have cost effectiveness numbers of around $2,500 per tonne. Although some of these other technologies provide a significant reduction in containments emitted, cold ironing is required to achieve further reduction.

There is currently no legislated requirement for cold ironing both in Canada and internationally. The European Union (EU) are asking their members for voluntary compliance. California has formed a workgroup to develop cold ironing regulations. International port authorities, operators and shipping lines are considering initiates to voluntarily build partial or full cold ironing infrastructure with new ship or new terminal construction projects. Ports in Los Angeles and Long Beach who have long term contracts with shipping lines are making cold ironing compliance a condition of their lease renewals. Of the 896 container ships planned to be delivered from 2005 to 2008, 6% will be fitted for cold ironing.

There are challenges with the implementation of cold ironing both on the land side and on the ship. A common set of standards do not exist yet. Ports who have implemented cold ironing are making their best guesses at the size of the transformers as well as location and quantity of receptacles. The International Organization of Standards (ISO) has started on a path to developing standards. A Publicly Available Specification (PAS) is expected to be released prior to the ratification of the official standard.

Ships currently fitted for cold ironing are likely destined for ports where there are cold ironing provisions. On the west coast the ports would be POLA and POLB. With the current shipping routes ships that call on Deltaport do not call on POLA or POLB so it is unlikely that Deltaport can take advantage of cold ironing fitted ships at this time. However, since shipping routes change from time to time, there may be opportunities in the future.

For Deltaport, an order-of-magnitude cost for the on-shore portion of the cold ironing infrastructure is anywhere from $4 million to $7 million per berth. In terms of power supply, options explored consist of installing the transformer either in the existing substation or a new substation. The final draft of the power system study is recommending the expansion of the existing substation. At the berth face, options explored consist of installing the receptacle pits above the deck, into the cope wall or beside the cope wall. Installing beside the cope wall is deemed to be the best option.

The environmental benefits cannot be realized unless ships calling on Deltaport have cold ironing provisions. Without recognized standards in place, or expected ships with cold ironing provisions calling on Deltaport it is not prudent to fully implement the on-shore cold ironing facility at this time. Keeping in mind that a two-year lead time is required for full implementation the recommended course of action is to consider a staged approach as follows:

- As part of the Third Berth Project install capped underground conduits for cold ironing from the substation area to the third berth at a location beyond the waterside rail.
- On a conceptual basis allocate space for the cold ironing transformer and switchgear at the substation and a space for the cold ironing pits.
- As a future project, reassess the cold ironing feasibility study report when any of the following occurs:
  - ISO standards for cold ironing are published; or,
  - Canadian legislation is imminent; or,
  - There are requests from the shipping lines for cold ironing their ships.

1 Introduction

1.1 General

Omni Engineering Inc. (Omni) and Westmar Consultants Inc. (Westmar) were retained by TSI Terminal Systems Inc. (TSI) to provide a feasibility study report on shore power for container vessels calling on the third berth at Deltaport.

The provision of power from shore to shipping vessels is known as cold ironing. This is a well understood term in the shipping industry and as such will be the term that this report will use.

This report is focussed on the feasibility of cold ironing container ships as part of the Deltaport Third Berth Project and more specifically the possible implementation of cold ironing infrastructure for Berth No. 3.

Work began in early October 2006 with a trip to the Los Angeles area to see first hand how both the Port of Los Angeles (POLA) and the Port of Long Beach (POLB) implemented cold ironing (see notes in *Appendix C*).

This introduction section will provide the purpose and scope of the study, an explanation of the various terms used for cold ironing, a discussion on why it is being done or should be done and the path forward.

The practices and standards section will follow. This section explores the cold ironing design and installation practices as it is today and finishes with a discussion on the prevailing standards, or lack thereof.

Following that will be the Deltaport third berth section that will look at the potential specific implementation of cold ironing, a discussion of the shipping vessels calling on Deltaport, costs, schedule and a summary of the issues.

Finally the report will wrap-up with the conclusions and recommendations section.

1.2 Purpose and Scope

TSI has committed to the incorporation of the required infrastructure for the provision of shore power for ships in the design and construction of the Deltaport Third Berth project.

The study shall include:

- An inventory of all container vessels currently calling on Deltaport capable of connecting to shore power, their power and connection requirements.

- An assessment of the worldwide container vessel fleet trend for shore power capability and estimated timeline for the worldwide fleet conversion to shore based power.

- An assessment of the power requirements needed dockside and any infrastructure improvements to support shore based power.

- The results of the above investigation shall be provided in a report providing a summary timeline and targets for providing shore based power in line with the existing container fleet calling at Deltaport B3 and based on the assessed trend for the worldwide container fleet conversion to shore based power.

1.3 Explanation

The provision of power from shore to shipping vessels is known by the term cold ironing. POLA has trade marked the term Alternative Maritime Power™ or AMP™ which is synonymous to cold-ironing. Many of those who contributed to the first cold ironing project at POLA on Berth No. 100 have adopted the term to describe their products.

Another term that is commonly used in European Community is shore-side electricity. Again this means the same thing as cold ironing.

What is cold ironing? Normally when a ship is docked it operates its on-board generators to provide electrical power to the ship's load. For a container ship this means power for loads such as lighting, air conditioning, communications equipment, and refrigerated containers or reefers.

However, with increasing concerns expressed by the public regarding pollutants emitted from the ships' auxiliary engines when docked, ongoing efforts are being made:

- to reduce emissions, or;
- to eliminate auxiliary engine emissions altogether by finding alternative power supplies for the ship's loads.

The effort required to provide ships with power from shore is not trivial. The following are some of the challenges:

- Power required by the ships is significant and in some cases as great as the power required by the terminal itself.

- The local utility that supplies power to the terminal must have adequate local reserves to provide the power required by the ship otherwise it will need to upgrade its infrastructure.

- Historically, ships use voltages which are different than those normally used at terminals and thus require transformers and switchgear. The power needs to be delivered to the berth face using underground conduits and cables.

- Special receptacles, safety devices and control circuitry are needed at the berth face to allow the ship to plug in. As well the location and quantities of these receptacles need to be determined to provide berthing flexibility for the ships without having receptacles that are rarely used or, worse yet, will never be used.

- Ships do not have the facility to accept shore power. An existing ship will need to be retrofitted and a new ship will need to have it incorporated.

- A cable management system that can effectively pay or of take up cable as the ship move up or down relative to the terminal's deck is required.

The cruise ship industry in North America has taken the lead on this. Specifically Princess Cruise Lines, who have outfitted their cruise ships with receptacles for taking on shore power in Juneau, Alaska and in Seattle. The container handling industry started cold ironing at the POLA in 2004 with China Shipping ships.

1.4 Why Do It?

1.4.1 The Environment

Ships have auxiliary engines that drive generators to provide electrical power to the ship's load while docked. These engines produce air pollutants as a by-product. Reduction or elimination of pollutants from auxiliary engines contributes to better human health, visibility, vegetation and the overall environment.

Cold ironing uses shore power to operate the ship's electrical loads thereby allowing the ship to shutdown their auxiliary engines. Since BC's electrical utility primarily produces hydro-electric power, secondary emissions due to the use of shore power is minimal compared with power taken from fossil fuel based power plants. This makes cold ironing an excellent alternative to operating the ship's auxiliary engines in BC.

A group of pollutants known as Common[1] or Criteria[2] Air Contaminants (CAC) contribute to air quality issues such as smog and acid rain[3]. They consist of the following:

- Carbon Monoxide (CO)
- Volatile Organic Compounds (VOC)
- Nitrogen Oxides (NOx) - consists mainly of NO
- Sulphur Oxides (SOx) - consists mainly of SO_2
- Particulate Matter (PM)
- Ammonia (NH_3)[4]

There are two conventions used in reporting NOx and SOx values. GVRD uses a traditional method of reporting by converting the weights of all NOx compounds to an NO_2 equivalent and all SOx compounds to an SO_2 equivalent. Because NOx consists mainly of NO and the molecular weight of NO_2 is 150% of NO, the GVRD reported values are higher by the same proportion. There is less of a difference with SOx since it mainly consists of SO_2. Unless noted otherwise, this report will use the other convention which does not convert the weights but rather uses the actual weights of the respective compounds.

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[1] (GVRD and FVRD) 2003, List of Acronyms, Page ix.
[2] (EC, 2006) Website, Pollutants.
[3] (EC, 2006) Website, Pollutants.
[4] Ammonia is not always included in CAC Group.

A group of pollutants known as Green House Gases (GHG) contribute to global warming. They consist of the following:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)

GHG emissions are generally reported as Carbon Dioxide Equivalent (CO_2E). This value of tonnage is obtained by summing the product of each gas and their respective 100-year Global Warming Potential (GWP)[5, 6].

A number of air emissions studies have been done for the Lower Fraser Valley Region. Of particular interest is the air emissions data for Ocean Going Vessels (OGV) and specifically container ships.

Levelton Consultants Ltd. (Levelton) prepared an April 2002 study for the Greater Vancouver Regional District (GVRD) and Environment Canada (EC) entitled "Marine Vessel Air Emissions in the Lower Fraser Valley for the Year 2000" (Levelton, 2002). The results of this study was included in the "2000 Emission Inventory for the Canadian Portion of the Lower Fraser Valley Airshed" report (GVRD and FVRD, 2003) prepared by the GVRD and the Fraser Valley Regional District (FVRD) that covered all emission sources. The data presented was only categorized by emission source and did not have further breakdowns by location. Therefore, emissions by container ships calling on Deltaport only, could not be extracted. A summary of CAC emissions showing the impact of all container ships verses other emission sources within the Canadian side of the Lower Fraser Valley (LFV) is tabulated in the following *Table 1.4.1a*.

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[5] (GVRD and FVRD, 2003) Page 4.
[6] (RWDI, 2005) Appendix A, Page 44.

TABLE 1.4.1a: GVRD - Environment Canada Year 2000 CAC Annual Emissions (tonnes/year) for the Canadian Side of the LFV

Description	CO	VOC	NOx	SOx	PM	NH_3	CO_2E
Ocean Going Vessels (OGV) in LFV							
Container Ships in LFV							
Dockside[7]	73.8	31.4	839.0	586.0	99.0	0.1	57,602[8]
Manoeuvring[9]	30.4	1.6	153.0	17.3	11.5	2.9	6,358[10]
Underway[11]	49.1	15.3	552.6	316.2	46.0	10.7	23,475[12]
Total Container Ships in LFV	**153**	**48**	**1,545**	**920**	**157**	**14**	**87,435**
Remaining OGV	513	187	5,505	3,999	588	30	336,329
Total OGV in LFV[13]	**666**	**235**	**7,050**	**4,919**	**745**	**44**	**423,764[14]**
Other Marine Vessels[15]	4,141	1,416	5,071	254	161	3	317,028
Other Emission Sources	362,472	69,260	44,179	3,621	15,757	14,467	19,391,186
Total LFV Emission[16]	**367,279**	**70,911**	**56,300**	**8,794**	**16,663**	**14,514**	**19,708,214**

As part of the Environmental Assess Application (EAA) for the Third Berth Project, air emissions were evaluated. Technical Volume 8, entitled “Roberts Bank Container Expansion Project Air Quality and Human Health Assessment”, *Appendix A* provides CAC emissions data for the year 2003. However, the estimated GHG emissions were only provided as 2011 projected values. A summary of the emissions data is tabulated in the following *Table 1.4.1b*.

7 (Levelton, 2002), Table A-0-5, Page A6.
8 (Levelton, 2002), Table A-0-6, Page A7.
9 (Levelton, 2002), Table A-0-3, Page A4.
10 (Levelton, 2002), Table A-0-4, Page A5.
11 (Levelton, 2002), Table A-0-1, Page A2.
12 (Levelton, 2002), Table A-0-2, Page A3.
13 (Levelton, 2002), Table 3-1, Page 29.
14 (Levelton, 2002), Table 3-2, Page 30.
15 (GVRD and FVRD, 2003) Table 1, Page 9.
16 (GVRD and FVRD, 2003) Table 1, Page 9.

TABLE 1.4.1b: EAA - Year 2003 CAC Annual Emissions (tonnes/year) from *Appendix A*

Description	CO	VOC	NOx	SOx	PM	NH_3[17]	CO_2E 2011 Projection[18]
Container Ships at Deltaport[19]							
Dockside	22.50	9.60	256.0	214.0	30.20	N/A	16,581
Manoeuvring	11.80	0.64	59.1	38.5	4.45	N/A	2,297
Underway	5.25	1.64	59.1	39.7	4.92	N/A	2,348
Total Container Ships at Deltaport	**40**	**12**	**374**	**292**	**40**	**N/A**	**21,226**
Total from All Sources at Deltaport	**110**	**28**	**689**	**328**	**54**	**N/A**	**48,296**

A study conducted by the Chamber of Shipping (CoS) resulted in the report “2005 - 2006 BC Ocean-Going Vessel Emissions Inventory” issued January 25, 2007 as a Final Draft (CoS, 2007). This study was a result of recommendations made by SENES Consultants Ltd.’s (SENES) 2004 work for Environment Canada to review methods used in calculating marine vessel emission inventories[20]. CoS applied a new methodology that relies on high-resolution Coast Guard tracking data. Together with results of a detailed vessel engine survey the report provides the most recent inventory of ocean-going vessels in BC.

A review of the CoS report and quality assurance checks were conducted by SENES (SENES, 2006). The Vancouver Port Authority (VPA) subsequently asked SENES to review the potential benefits of shore-side power at their terminals based on the latest CoS report data. SENES subsequently provided a letter memo to Christine Rigby of the VPA (SENES, 2007). The memo included Deltaport container ship data, based on year 2003 visits, tabulated in the following *Table 1.4.1c*.

[17] Values of NH_3 not provided.
[18] (RWDI, 2005) Appendix A, Table A-49, Page 47.
[19] (RWDI, 2005) Appendix A, Table A-1, Page 5; does not include GHG emissions.
[20] (CoS, 2007) page 11.

TABLE 1.4.1c: Dockside Emissions (tonnes/year)

Description	CO	VOC (HC)	NOx	SOx	PM	NH_3 [21]	CO_2E
Boilers	9	1	25	110	3	N/A	2,037
Auxiliary Engines	15	6	205	158	15	N/A	3,170
Total[22]	**25**	**6**	**230**	**268**	**18**	**N/A**	**5,206**
Potential Reduction[23]	**15**	**5**	**199**	**153**	**15**	**N/A**	**3,067**

The noted potential reduction in dockside emissions is primarily due to the shutdown of the auxiliary engines while cold ironed. Boilers onboard the ship will continue to operate to generate heat and hot water.

If 100% of Deltaport's container ships were cold ironed the reduction in emissions would be 390 tonnes of CAC and 3,067 tonnes of CO_2. This is equivalent to 13.6% of CAC and 3.5% of CO_2 when compared with GVRD's year 2000 container ship emission inventory as tabulated in *Table 1.4.1a*.

1.4.2 Costs

Costs to support cold ironing are significant. Not only is there a large initial capital cost for both the shore and ship but there is the ongoing cost of buying power.

The capital expenditure required for cold ironing would include:

- Shore-Side Costs: These include a suitably sized transformer to transform the voltage to a value the ship can use, multiple switchgear, underground ducts, cabling, multiple receptacles, control circuits, plus all of the supporting civil works. Existing installations indicate a wide variation in cost from USD$1 million to USD$14 million.

[21] Values of NH_3 not provided.
[22] (SENES, 2007) Table 1, Page 2.
[23] (SENES, 2007) Table 2, Page 4.

- Ship-Side Costs: These include a cable management system, flexible cabling with plugs, switchgear, synchronizing controls for a bumpless transfer and a transformer to step down voltage for older and smaller ships. Existing installations indicate a cost of USD$0.8 million to USD$2 million per ship.

The on-going operating and maintenance costs would include:

- Electricity Costs: Electricity cost in BC is amongst the lowest of any utilities in North America. The nominal cost of energy plus demand is about CAD$0.08 per kWh[24]. The demand cost component can result in a much higher cost per kWh. Power usage on a container ship is dependent on the number of reefers plugged in and the ambient temperature. An average power usage would be 2,700 kW to 5,000 kW. Larger ships are being built with more reefer slots. This can increase the power usage to over 7,000 kW.

- Personnel Costs: Cost of having personnel connect and disconnect the cables. This would likely require three electricians for one hour to connect and another hour to disconnect.

- Maintenance Costs: Equipment will need to be maintained to ensure personnel safety and minimize downtime.

The credits and benefits would include:

- Diesel Usage and Cost When Docked: 2006 cost of fuel is about USD$333 per tonne for HFO and USD$624 to USD$631 per tonne for MDO/MGO[25].

- Fuel used annually by all container ships while docked at Deltaport is 5,206 tonnes with a total CAC emissions reduction of 547 tonnes[26]. This works out to 105 kg of CAC emissions per tonne of fuel used.

[24] (Genesis, 2003) Based on BCH Schedule 1211.
[25] (CoS, 2007A) Singapore, from Bunkerworld, June 1, 2006.
[26] (SENES, 2007) Table 1, Page 2.

A comparison of energy cost based on average container ship characteristics at Deltaport[27] is as follows:

- Electrical demand of 1,234 kW: CAD$98.72 per hour.
- Fuel consumption of 0.18 tonne/hour: USD$59.94 per hour for HFO.
  USD$113.58 per hour for MGO.

The cost effectiveness of cold ironing is calculated by taking the ratio of Net Present Value (NPV) of the costs and the reduction in CAC emissions in tonnes. For container ships the cost effectiveness values were determined by the Environ study as follows:

- USD$15,000 per ton for a 5,302 TEU vessel with 500 reefer plugs, calling the port 10 times a year with an average berth time of 63 hours per call[28].

- USD$11,000 per ton for a 5,344 TEU vessel with 300 reefer plugs, calling the port eight times a year with an average berth time of 121 hours per call[29].

Recent values from ports in California indicate higher values. In comparison to other technologies, values of cost effectiveness for CAC emissions reduction with cold ironing are high. For example, a combination of Selective Catalytic Reduction (SCR) and use of Marine Diesel Oil (MDO) will reduce emissions while docked by 90% for a cost effectiveness of $2,700 per tonne[30]. Cold ironing would be the likely choice to reduce the remaining CAC emissions.

In Europe, a council directive (1999/32/EC) requires 0.1% sulphur diesel fuel be used unless engines are switched off and cold ironing used when docked. A document entitled Shore-Side Electricity Summary Advice, issued by the Commission of the European Communities as an annex to a May 8, 2006 Commission Recommendation, indicates that it is economically and environmentally preferable to utilize cold ironing instead of converting to 0.1% diesel fuel.

[27] (SENES, 2007) Page 9.
[28] (Environ, 2004) Table 6-12, Page 89.
[29] (Environ, 2004) Table 6-12, Page 89.
[30] (Genesis, 2003) Page 104.

1.4.3 Legislation

Legislation requiring cold ironing does not yet exist. However it is currently being considered in places like California. Regulations of emissions, especially sulphur dioxide, is becoming more stringent. Once technologies with low effective costs are implemented, higher effective cost solutions will need to be considered.

Regulatory agencies in European Union (EU) are asking countries within the EU to voluntarily promote cold ironing and to submit a plan to reduce ship emissions. It will be a matter of time before this becomes mandatory in the EU.

POLA's Pier 100 Cold Ironing Project with China Shipping was a result of a 2003 settlement agreement in a lawsuit launched by the Natural Resources Defence Council (NRDC). Since then both POLA and POLB have taken a proactive approach, during renegotiations of their existing leases and negotiations of new leases, to include environmentally friendly initiatives in their new lease agreements. Shipping lines, who are the ports' primary tenants, are supportive of these environmental initiatives.

The Goods Movement Emission Reduction Plan was approved by California's Air Resource Board (CARB). This plan has set the following goals:

- Shore power for 20% of visits by 2010.
- Shore power for 60% of visits by 2015.
- Shore power for 80% of visits by 2020.

In order to meet these goals a workgroup has been formed to develop and present the regulation to CARB for consideration in November 2007.

There is no indication of legislation being imminent in Canada. Unlike POLA and POLB VPA terminals such as Deltaport services many shipping lines. Therefore opportunities to tie long term lease agreements with environmental initiatives do not exist.

1.5 <u>Path Forward</u>

1.5.1 POLA and POLB

POLA and POLB are further ahead than others in terms of implementing cold ironing within container terminals. In a joint effort to improve air quality they released the San Pedro Bay Ports Clean Air Action Plan in June 2006. In terms of cold ironing the aggressive plan requires full compliance within five years. Below is a summary of the cold ironing projects for their container terminals.

POLA

- B100 and B102, China Shipping, B100 completed 2005, B102 still remaining.
- B212 - B218, Yusen Terminals, one receptacle completed - expected to plug in November 2006, but postponed to May 2007 due to resolution of labour issues, NYK granted $810,000 USD as incentive.
- B224 - B236, Evergreen, one berth, 2008.
- B136 - B147, TraPac, two berths, 2009.
- Pier 300, APL, one berth, 2011.
- Pier 400, APM, two berths, 2011.
- B206 - B209, P&O NL, one berth, 70% ships AMP'd by third year of lease, 2011.
- B175 - B181, Pasha, one berth, 2011.
- B121 - B131, WBCT, two berths, 2011.

POLB

- Pier T, Berth No. T121, BP, one berth (tanker), total USD$15 million cold ironing infrastructure ready for fourth quarter of 2007.
- Pier G, three berths, 234, 236, ITS, K-Line, ready 2011, total cost USD$12-14 million.
- Pier C, two berths, SSAT (JV between SSA & Matson), ready for 2011.
- Pier S, three berths, ready 2011.

1.5.2 The European Union

The EU recognizes the need to move forward with cold ironing. This is indicated in a May 8, 2006 Commission Recommendation issued by the Commission of the European Communities recommends that member states:

- Consider cold ironing installations.
- Look into cost its effectiveness.
- Promote development of harmonized international standards.
- Consider offering economic incentives to operators.
- Promote awareness of cold ironing among port authorities.
- Encourage port authorities to exchange best practices.
- Report to the Commission on the action they intend to take to reduce ship emissions.

1.5.3 Conclusion

Without any legislation, international port authorities, operators and shipping lines are considering initiatives to voluntarily build partial or full cold ironing infrastructure with new construction projects. This means the incorporation of on-shore infrastructure when new terminals are being built or rebuilt and on-ship infrastructure when new ships are being built or rebuilt.

2 Practices and Standards

2.1 General

Currently there are no official standards with which to base the implementation of cold ironing. However, the International Organization of Standards (ISO) is currently working on developing an international standard. Until those standards have been developed any cold ironing implementation may result in subsequent rework of the installation once the standards have been established. For those who wish to implement cold ironing before formal standards are in place, the best approach would be to base the design on the existing projects. This section discusses the current practices.

The cold ironing system has the following components listed in order of power flow from the utility to the ship's electrical room:

- Power connection to the utility.
- Transformation from the utility voltage to a distribution voltage.
- Switchgear at the transformer to protect the outgoing cable.
- Cables and conduits to carry the power to the switchgear units and receptacles pits.
- Multiple switchgear units near the berth face to distribute and switch power to the receptacles.
- Multiple receptacle pits along the deck at berth face.
- Flexible cable with plugs and cable management system.
- On ship distribution, transformation and synchronization.

2.2 Power Supply

2.2.1 Power Connection to the Utility

Power for cold ironing is usually connected at the utility level. This provides a degree of isolation from the main terminal distribution. The reasons for this are:

- to minimize impact to the terminal should the cold ironing system fail; and,
- provide a separately metered service if required.

Incoming voltage from the utility may be at a distribution level (10 kV to 40 kV) or at a transmission level (60 kV and greater).

In BC, customers connected to the utility at a transmission voltage level are charged a lower electricity cost. The electricity cost is made up of two components, energy and demand.

Energy is measured in kWh. Cost for energy is typically given as cents per kWh. Therefore, the more you use over a given period of time, the more you will pay.

Demand is the energy usage per unit time and is measured in kW or kVA. The demand is typically calculated over a 15 or 30 minute time interval. The highest demand value for the month is called the peak demand. The demand charge is kind of a penalty cost and as such is based on a number of demand values. For BC transmission customers the demand is the greater of:

- the peak demand for the month; or,

- 75% of the peak demand in the preceding period of November to February inclusive; or,

- 50% of the Contract Demand Value.

Therefore, if the addition of cold ironing:

- exceeds the current Contract Demand then the Contract Demand will need to be renegotiated; and,

- is a significant percentage of the new Contract Demand then the demand charge will be significant.

2.3 Land Side

2.3.1 Transformer

Container ships typically operate with 3-phase, 60 Hz and either a distribution voltage of 440 V or 6.6 kV. This requires a transformer to step down the voltage. The voltage of choice would be 6.6 kV to reduce the size and quantity of copper cables to be installed.

The transformer capacity needs to consider the current and future requirements of the ships. With container ships, reefers make up a significant portion of the load. Recent ships are trending towards larger reefer capacities.

The latest 14,000 TEU Maersk ships being built have 1,300 reefer plugs and the 10,150 TEU ships have 900 plugs. With an estimated average load of 5 kW for each plug a fully occupied 900 plug reefer area could easily draw 4.5 MW.

The consensus at POLA and POLB is to use a 7.5 MVA transformer for cold ironing, which is a reasonable size considering the increases in reefer capacities.

2.3.2 Switchgear at the Transformer to Protect the Outgoing Cable

A switchgear cell is required between the transformer output and the cables going to the dock face. Protective relaying is required at the switchgear cell to protect the transformer and the feeder cables.

2.3.3 Cables and Conduits

Cables and conduits will be similar to those for the rest of the terminal. To keep cables to a manageable size, one cable is typically sized to provide 4 MVA of power. Two cables can therefore provide 8 MVA.

The preferred medium for the controls circuitry is fibre optic rather than copper. The degree of complexity for the controls needs further investigation. The cold ironing system at Yusen Terminals utilized a Programmable Logic Control (PLC) for its control logic. This is an area where the need for standardization is very important since the controls on the shore side must line-up exactly with the controls on the ship’s side.

Conduits are sized to meet code fill requirements. One conduit is typically used for each power cable with a separate conduit for communications and controls.

2.3.4 Multiple Switchgear Units Near the Berth Face

Each receptacle needs to be capable of being switched off when not being used. To facilitate this, switchgear units are required near the berth face.

2.3.5 Multiple Receptacle Pits

Cavotec connection boxes and receptacles are used at POLA and POLB. *Figure 3.3a* shows a pit with a connection box that accepts two cables.

FIGURE 3.3a: Receptacle Pit

The receptacles are key-interlocked with the nearby switchgear using Kirk Keys. This procedure is typically as follows:

- Once the plug from the ship is inserted into the receptacle the key can be removed. This locks the plug to the receptacle preventing it from being removed. The same is done for the second plug.

- The keys are then brought to the nearby switchgear which is usually powered continuously from the transformer switchgear. Both keys are inserted into the locks at the breaker and turned. The breaker can then be closed. Closing the breaker hold the keys captive.

- The ship's onboard power is then synchronized to the shore power. Once synchronized the breaker on the ship is closed to receive power. The generators can then be shut down at anytime.

Current designs have placed receptacle pits every 200 ft. to provide flexibility not knowing where the ship will berth along the dock and not knowing where the ship's cables are located. This can result in five or six pits per berth.

The latest concept is to consider the berthing position of the ship. Connections are generally near the ship's stern therefore placing two receptacles near the bow and two near the stern of each ship's berthing position will accommodate a port or starboard berthed ship. This means four receptacles per ship providing four possible locations to hook up.

2.4 Vessels

2.4.1 On Ship Distribution, Transformation and Synchronization

Most of the existing ships have 440 V distribution systems. Newer larger ships have 6.6 kV as a distribution voltage. It is fortunate that virtually all ships operate with either of these two voltages at a frequency of 60 Hz.

A distribution voltage of 440 V, unfortunately, is not ideal for providing shore power because of the large amperage required. To mitigate issues such as voltage drop, the supply to the berth face would need to be at a higher voltage, such as 6.6 kV, and a step-down transformer located on the berth face or on the ship in order to provide the 440 V.

In its implementation of cold ironing with China Shipping, POLA decided to use a barge system to mount the step-down transformer and the cable management system. Because of operational issues such as having to store the barge off site and the man-handling of the nine power cables, they have since decide against doing this again.

The general consensus now is that the step-down transformer and the cable management system should reside on the ship. Ships that are currently being fitted for cold ironing follow this concept.

To make the switchover from ship's power to shore power one of two methods is used. The ship's power can be turned off and then connected to shore power or the ship can remain energized and synchronized to the shore power for a bumpless transfer of power. With cruise ships the need for bumpless transfer is critical because of the impact to the on-board systems when power is lost. It is less critical with container ships where a significant portion of the load is reefers which can tolerate a brief interruption in power. However, power interruptions are detrimental to equipment reliability. Therefore, even container ships are moving towards the incorporation of synchronizing equipment with their cold ironing implementation.

2.4.2 Flexible Cable with Plugs and Cable Management System

The most practical place for the cable and cable management system is on board the ship. In previous installations considerable effort was required to bring the cables up to the ship's electrical room. Even with a crane man-handling the large cables is awkward at best. Cavotec is a company that manufactures a one or two cable solution depending on the capacity required.

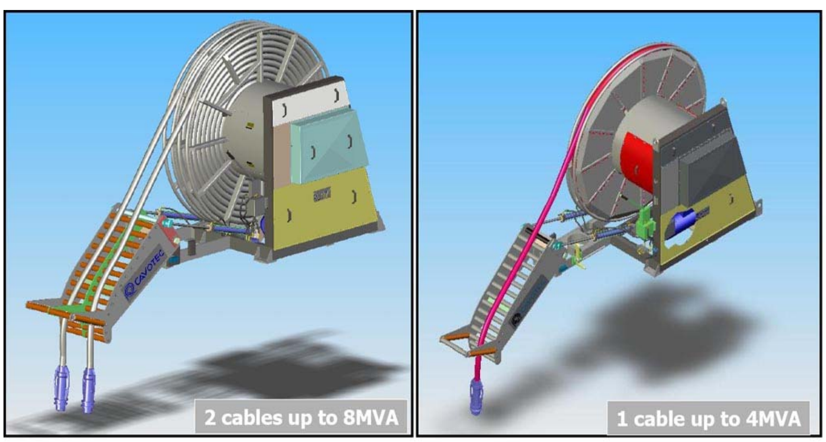

FIGURE 3.3b: Cavotec Cable Reel

A German company, Sam Electronics, has also provided cable management systems.

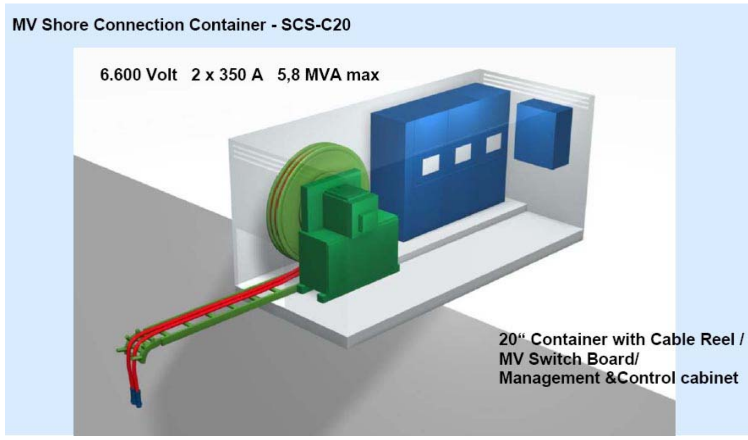

FIGURE 3.3c: SAM Electronics Containerized Cable Management

A Japanese company, JRCS, has manufactured a containerized cable management system for five K-Line container ships.

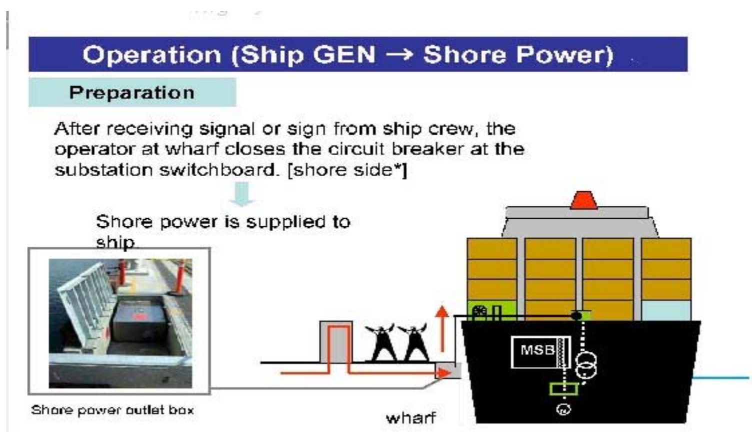

FIGURE 3.3d: JRCS Containerized Cable Management

2.4.3 Container Ships Committed to Cold Ironing

According to a number of published sources, there are 896 container ships that are due to be delivered from 2005 to 2008. Of those ships, 52, or 6%, will be fitted with the ability to plug into shore power. Out of the 896 ships, 360 are 5,000 TEU or greater. Of those ships, 40, or 11%, will be fitted for cold ironing.

2.5 Standards

A common set of standards do not exist yet. However the process has begun with ISO initiating a workgroup under its Technical Committee 8 and Sub-Committee 3 (TC8/SC3) to develop a shore-power standard. It will ensure that an international standard is developed by bringing together expertise from the ports and representatives from its voting members ANSI (USA), BSI (U.K.), DIN (Germany), DS (Denmark), DSSU (Ukraine), GOST R (Russian Federation), IPQ (Portugal), JISC (Japan), KATS (Republic of Korea), NEN (Netherlands), SAC (China), SNV (Switzerland) and UNI (Italy).

An initial meeting was conducted in September 2006 primarily to develop a scope and action plan. The POLA, POLB, and the Port of Rotterdam agreed to take a leading role in standardization effort. Recognizing the need to get information out quickly their initial objective is to establish a Publicly Available Specification (PAS) prior to the ratification of the official standard.

3 Deltaport Third Berth Project

3.1 General

This section looks at cold ironing as it relates to Deltaport and its Third Berth Project. Areas discussed are as follows:

- Power supply availability and operating costs.
- Land side infrastructure including transformer, switchgear, conduits and receptacle pits with options on pit locations.
- Vessels calling on Deltaport and their shipping routes.
- Capital cost estimate of the cold ironing facility required for Berth No. 3.
- Schedule of implementation.

As part of the Deltaport Third Berth Project, underground conduits are intended to be installed to facilitate cold ironing.

3.2 Power Supply

3.2.1 64 kV Transmission Supply

Deltaport receives power from BCH at 64 kV. The 64 kV transmission line at Roberts Bank is shared with the neighbouring coal handling facilities Westshore Terminals Limited Partnership. Cold ironing is expected to have a maximum demand of 7.5 MVA. Although BCH has not formally confirmed the availability of power for cold ironing, indications are that power availability is not an issue at the present time.

3.2.2 Electricity Rates

What may be at issue are the electricity rates to be paid for cold ironing power. There are two components of BCH's power billing including demand and energy. These were briefly discussed in *Section 3*.

3.2.2.1 Demand Charge

The demand charge is based on the greater result of three formulae. These are:

- Formula A: The peak demand for the month.
- Formula B: 75% the peak demand in the preceding period of November to February inclusive; and,
- Formula C: 50% of the Contract Demand Value.

Based on the BCH data to date the peak demand during the period of November 2005 to February 2006 is 3.649 MVA. The value for Formula B would be:

- 75% x 3.649 = 2.74 MVA

The current Contract Demand Value is 3.2 MVA. BCH allows an ad hoc increase in demand of 0.5 MVA without being notified. Demand beyond this value requires notification. The value for Formula C would be:

- 50% x 3.2 = 1.6 MVA

With the present operation, Formula A would normally be the greatest value. Using the average demand of 3 MVA the annual demand cost would be:

- 3 MVA x $4,411/MVA/month x 12 months = $158,796

With cold ironing, however, there could be a dramatic increase to the demand charge. For example if only one ship was equipped to plug in at Deltaport it can establish a peak in which Formula B would apply for the entire year.

If the ship took on 4 MVA of power for a minimum of 30 minutes while docked, the magnitude of the potential cost payable for the entire year would be:

- 75% x (4 + 3) MVA x $4,411/MVA/month x 12 months = $277,893

This is $119,097 higher than the average demand cost.

The Contract Demand Value in the Electrical Supply Agreement with BCH may need to be changed to reflect the additional demand. If the value is increased by the value of the added 7.5 MVA transformer then the new value would be 3.2 + 7.5 = 10.7 MVA. Note that we would not usually go to this extreme. But if this were the case, Formula C would apply and the resulting value would be:

- 50% x 10.7 MVA x $4,411/MVA/month x 12 months = $283,186

This is $124,390 higher than the average demand cost.

If only one or two ships are being plugged in to begin with, the prudent thing to do may be to leave Contract Demand as is and notify BCH just prior to plugging in each ship. Or agree to a lower value of Contract Demand that is reasonable. With ad hoc power the risk is that BCH may not have adequate power at the given moment.

3.2.2.2 Energy Charge

The energy charge component is based on the metered kWh usage. BCH instigated a stepped rate program in April 2006. The method in place is to first determine a Customer Baseline Load (CBL) from the previous year's energy usage. BCH will then charge a Tier 1 rate of approximately $0.024/kWh for 90% of the CBL and a Tier 2 rate of $0.054/kWh for the remaining 10%. As long as annual energy usage does not vary from year to year there should not be any significant impacts.

3.2.2.3 Interruptible Rates

BCH has indicated that they are pursuing a new set of rates based on providing interruptible power. Utilities such as Seattle City Light already provide interruptible power at a reduced rate.

For a given distribution grid there are many customers that use power at different times. The amount if power demanded at any given time is much less than the sum of the maximum power demanded by each customer. As well demand also depends on conditions such as time of day and weather. Utilities normally work with a reserve that is used for handling unusual demand which for the majority of the time is not utilized. By selling it as interruptible power, BCH can capitalize on this rarely used reserve on the basis that they can interrupt it at any given time. In areas where there is limited power available or where a large capital investment is required to provide additional power, interruptible power is attractive in cases where a power interruption is tolerable.

For ports located in Vancouver city where power is limited this may be the only option for cold ironing. For Deltaport, where there is available power, it may or may not be offered by BCH. In any case the question that needs to be addressed is whether or not an interruption in shore power is acceptable to container ships.

3.2.3 Deltaport Substation

At Deltaport's substation two 5 MVA transformers step the voltage down to 4,160 V to supply the electrical loads on terminal. With the present loads one transformer supplies power while the second is on standby.

In line with current practices at other terminals, cold ironing power will be supplied from a separate 7.5 MVA transformer connected at 64 kV. Location of the transformer will depend on whether or not a new substation is built for the third berth project.

3.3 Land Side

The land side infrastructure for Cold ironing at Deltaport will require the design and construction of various civil components to provide shore power to the ships at berth. These include the following:

- Transformer and Substation Switchgear: Power for cold ironing will be sourced by a new transformer located at the existing substation or at the new substation located in the new Berth No. 3 Terminal Facilities.
- Conduits: Power will be distributed from the transformer to the berth through underground PVC conduits to be installed as a part of the Berth No. 3 Terminal Facilities by TSI and conduits installed as part of the Berth No. 3 construction by VPA.
- Multiple Switchgear Units Near the Berth Face: A local control facility with switchgear and control equipment near the berth to enable personnel to coordinate the flow of power to the ship.
- Receptacle Pits: The physical connection point for the ships to cold iron.

Below is a description of the landside infrastructure concept including discussions on substation location options and receptacle pit location options.

3.3.1 Transformer and Substation Switchgear

There are two options proposed for the location of the transformer and switchgear. The options are dependent on the course of action for supplying power to the Berth No. 3 loads excluding cold ironing. A separate power system study is looking at this. If the power system study deems it necessary to build a new substation for the Berth No. 3 loads then the cold ironing transformer and switchgear will be located in the new substation. Otherwise it will be located in the old substation.

3.3.1.1 Option A - Existing Substation

Power will be provided by a new transformer and switchgear installed in the existing substation located in POD 4. The transformer will be installed within the existing transformer yard with connections to 64 kV. A 6.6 kV switchgear cell will be located either in the electrical room or in a weatherproof enclosure in the transformer yard.

A conduit run will be required to distribute 6.6kV power from the substation to the berth.

3.3.1.2 Option B - New Substation

Power is provided by a new transformer and switchgear installed in the new substation located in the terminal facilities of the Berth No. 3 extension (see *Drawing No. 1788-C-SK1050* in *Appendix A*). It is expected that the new substation will have space allocation for cold ironing. The transformer will be installed within the transformer yard with connections to 64 kV. A 6.6 kV switchgear cell will be located in an allocated space in the electrical room.

As with Option A, a conduit run for the distribution of 6.6 kV power from the proposed substation location to the berth will be required.

3.3.2 Cables and Conduits

Underground PVC conduits are intended to be installed as part of the Terminal Facilities portion of the Deltaport Berth No. 3 Expansion Project to distribute power for cold ironing to the berth. The distribution conduits will extend from the transformer location to the berth apron area where they will connect with the distribution conduits installed during Berth No. 3 Construction by VPA.

At the berth area, VPA have designed for two power ducts plus one communication duct that will terminate at the 1,200 mm diameter service tunnel that runs the length of the berth within the cope wall. No other electrical or communication connections are currently proposed for Berth No. 3.

3.3.2.1 Conduit Routing and Termination

Routing cable through the service tunnel to the receptacle pit locations will provide flexibility with respect to receptacle pit location when cold ironing is installed, either as new construction or as a retrofit.

From the service tunnel, conduit blanks through the cope wall to the proposed location of receptacle pits will be installed during the construction of the cope wall. Coring connections will impact reinforcement of the cope wall.

3.3.2.2 Bend Radius of the Cables

Typical bend radius for these cables is 10 to 12 times the diameter. Routing through the service tunnel via cable tray or conduit to the pits should account for this bend.

3.3.2.3 Working in the Service Tunnel

The service tunnel is a confined space that will pose access and workability problems for personnel. Ideally, the location of the receptacle pits should be in close proximity to the access manholes.

3.3.3 Switchgear at Berth Area

Switchgear at the berth area will allow personnel to activate cold ironing at the berth. The local switchgear and control will require a 20 ft. by 20 ft. concrete pad with electrical cabinets and protection. The location is shown conceptually on *Drawing No. 1788-C-SK1050* in *Appendix A*.

3.3.4 Multiple Receptacle Pits

The physical connection from the ship to shore is through a 6.6 kV, 350 A power connector which attaches to an outlet box (900 ft. x 900 ft. x 1,200 ft.) located on the berth. *Drawing No. 1788-C-SK1051* (see *Appendix A*) notes the conceptual size and location options for the receptacle pits.

3.3.4.1 Underground versus Aboveground Pit

To eliminate congestion on the berth, the outlet should be located in a below ground vault capable of withstanding the heavy wheel loads on the berth face. An aboveground connection will interfere with berthing and ship service activities, and is not recommended.

3.3.4.2 Horizontal Spacing of Pits

The cable management systems on the ships will limit the horizontal spacing of the receptacle pits. POLA and POLB are working with 200 ft. spacing for the pits. A sufficient number of pits should be provided to accommodate ships tie-up to the berth at slightly varying locations and the varying locations of the on-board cable reel.

3.3.4.3 Portside versus Starboard Side Berthing

Ships calling at Deltaport currently berth starboard side on. As the size of ships calling at Deltaport increases, the direction ships berth may be reversed to Port side on. As well the side on which the cable reels are located differ with different ships. Most ships currently do not have the flexibility to spool out cable on either side. Additional receptacle pits will have to be installed should the berthing arrangement be reversed.

3.3.4.4 New Construction versus Retrofit

The installation of receptacle pits at *Deltaport Drawing No. 1788-C-SK1051* (see *Appendix A*) poses two Options for location of the receptacle pits with respect to the cope wall. Deltaport does not have the same spatial concerns as other terminals. The water side crane rail is approximately 20 ft. from the face of the berth, as opposed to 10 ft. at many older terminals.

For new construction, where the receptacle pits are installed during construction of the berth, the pits will be located within the cope wall structure. This allows the pit to be close to the berth face, reducing the amount of cable deployed by the ship for connection.

For retrofit, where the receptacle pits are installed following construction of the berth, the receptacle pit could be installed between the cope wall and the Waterside crane beam, with the drainage trench rerouted around the receptacle pit. A cable trench with hatch covers would connect the pit to the berth face.

3.4 Vessels

3.4.1 General

Unlike the ports in the US, Deltaport does not have long term contracts with shipping lines. They provide facilities that a number of shipping lines use. This is a disadvantage when it comes to providing cold ironing infrastructure in absence of a standard. Whereas the US ports can work with the shipping lines to build a custom infrastructure Deltaport cannot.

Below is a summary of the shipping lines and ships that call on Deltaport.

3.4.2 Shipping Lines

Deltaport currently handles six shipping routes. Each shipping route is used by one or more shipping line. The routes contain ports of call to Seattle, Tacoma and Oakland but not to POLA or POLB. Unless the routes change, one can assume that ships being retrofitted for cold ironing at POLA and POLB are not likely show up at Deltaport. Since shipping routes do change from time to time, there may be opportunities in the future.

The routes are as follows:

- PNX - Pacific North Express:
  - Grand Alliance route used by NYK, OOCL, CPS, PIL, Hapag Lloyd.
  - Comes from Asia to Vancouver, Seattle and back to Asia.
- WAE - US West Coast - Asia - Europe Pendulum:
  - Evergreen route that is also used by Italia Marittima SPA, Hatsu Marine.
  - Comes from Asia to Tacoma, Vancouver and back to Asia and Europe.
- ANW1 - West America Line IV:
  - CSCL route that is also used by CMA-CGM, ZIM.
  - Comes from Asia to Vancouver, Seattle, Oakland and back to Asia.
- AMP - Asia-Med Pacific:
  - ZIM route that is also used by CSAV-Norasia, CSCL.
  - Comes from Asia to Vancouver, Seattle and back to Asia.

- CPN - China - Korea - North US West Coast Svc:
    - Evergreen route that is also used by Italia Marittima SPA, Hatsu Marine.
    - Comes from Asia to Tacoma, Vancouver and back to Asia.
- TP2 - Transpacific 2:
    - Maersk - Sealand route.
    - Comes from Asia to Tacoma, Vancouver and back to Asia.

3.4.3 Vessels Calling On Deltaport

Table 3.4.3 outlines a list of vessels scheduled for Deltaport from October 31, 2006 to December 21, 2006. The vessel details were obtained from an online database of container ships.

TABLE 3.4.3: Vessels calling on Deltaport Between October 31, 2006 and December 21, 2006

Vessel	Line	Route	TEU Maximum	Reefer	Year	Length (m)	Beam (m)
CSCL Qingdao	CSCL	AMP	4,051	400	2001	259.8	32.2
Lircay	NCLL	AMP	4,043	879	2006	268.8	32.2
ZIM Atlantic	ZIM	AMP	3,480	165	1996	253.7	32.2
ZIM China	ZIM	AMP	3,480	175	1997	253.7	32.2
ZIM Israel*	ZIM	AMP	3,029	121	1992	236.0	32.3
ZIM Korea	ZIM	AMP	3,029	121	1991	236.0	32.2
ZIM Qingdao	ZIM	AMP	4,250	400	2006	263.0	32.2
ZIM USA	ZIM	AMP	3,480	175	1997	253.7	32.2
CMA CGM Jamaica*	CMA	ANW	4,334	600	2006	264.0	32.2
CSCL Hamburg	CSCL	ANW	4,051	400	2001	259.8	32.2
CSCL Rotterdam	CSCL	ANW	4,051	400	2002	259.8	32.2
Xin Fu Zhou	CSCL	ANW	5,668	610	2004	279.9	40.3
Xin Shan Tou	CSCL	ANW	4,250	400	2005	263.0	32.2
Xin Ying Kou*	CSCL	ANW	4,250	400	2006	263.0	32.2

Vessel	Line	Route	TEU Maximum	Reefer	Year	Length (m)	Beam (m)
Aphrodite*	EVER	CPN	2,728	156	1984	230.8	32.2
EVER Garden*	EVER	CPN	2,728	156	1984	230.8	32.2
EVER Gentle	EVER	CPN	2,728	156	1984	230.8	32.2
LT Going	EVER	CPN	2,728	156	1983	230.8	32.2
LT Greet*	EVER	CPN	2,728	156	1984	230.8	32.3
Antwerpen Express	HALO	PNX	4,864	370	2000	294.0	32.2
NYK Castor*	NYK	PNX	6,118	500	1998	299.0	40.0
OOCL China	OOCL	PNX	5,344	300	1996	262.0	40.0
OOCL France	OOCL	PNX	5,762	656	2001	277.4	40.0
OOCL Hong Kong*	OOCL	PNX	5,344	300	1995	276.0	40.0
OOCL San Francisco	OOCL	PNX	5,714	---	2000	277.4	40.0
Maersk Portland*	MRSK	TP2	2,959	260	1995	195.7	32.2
SL Defender	MRSK	TP2	2,472	209	1980	257.5	30.7
SL Developer	MRSK	TP2	2,472	209	1980	257.5	30.7
SL Explorer*	MRSK	TP2	2816	209	1980	257.5	30.7
SL Patriot	MRSK	TP2	2,816	209	1980	257.5	30.7
EVER Ulysses	EVER	WAE	5,364	562	2000	294.1	40.0
EVER Unific	EVER	WAE	5,364	562	1999	294.1	40.0
EVER Unique	EVER	WAE	5,364	562	1997	294.1	40.0
EVER Unity	EVER	WAE	5,652	570	1999	294.1	40.0
EVER Uranus	EVER	WAE	5,364	562	1999	294.1	40.0
EVER Urban	EVER	WAE	5,652	570	2000	294.1	40.0
LT Usodimare	EVER	WAE	5,652	562	2000	294.1	40.0

Note: *Indicates a return call during period.

3.4.4 Future Vessels

In the case of POLA and POLB where there are signed agreements between the ports and the shipping lines, efforts are being made by the shipping line to fit their ships with provisions for cold ironing (see *Section 2.5.1*). It can be concluded that shipping lines are receptive to cold ironing as long as there is available power and power infrastructure to plug into.

Because of the costs involved, future vessels are unlikely to be fitted with cold ironing provisions unless there is already a plug-in power infrastructure at the terminal.

Without established standards, ships fitted for cold ironing are installing plugs where it suits the ship and their berthing configuration at the ports with cold ironing. This is why connection points are not consistent amongst the ships. Some have a connection point on the starboard side, some on port side and some at the stern. The newer vessels have connection points near the ship's house.

To provide shore power to the variety of ships calling on Deltaport, any cold ironing system to be installed at Deltaport will need to be flexible enough to accommodate the variation of connections.

3.5 Cost

An order-of-magnitude cost was developed for the two substation options and the two pit configuration options at Berth No. 3 for purposes of comparison only. Costs were based on in-house costing data. It is not meant to be a definitive cost estimate. Additional engineering effort will be required for a definitive cost estimate.

Options A and B are for the installation of the transformer and switchgear in the existing substation and new substation respectively. Both options assume that a minimum infrastructure is in place for adding this equipment. The existing substation has space. The new substation option is only viable if the third berth project decides to build a new substation in which case it would provide the minimum infrastructure for cold ironing. The minimum infrastructure includes:

- Switchyard: Adequate space for the transformer and ability to tie into the 64 kV system.
- Substation Electrical Room: Adequate floor space for the 6.6 kV switchgear and the incoming and outgoing cables.

Both options assume that the underground ducts are done with the construction of the new third berth project.

Options 1 and 2 are for locating the cold ironing receptacle pit into the cope wall or next to the cope wall respectively. Both options assume that the civil portions of the pits and ducts are done with the construction of the third berth project. Addition costs will be required if the pits are added after the construction of the berth is complete. It will be near impossible to put the pit into the cope wall afterwards.

The cost estimate combines Options A and B with Options 1 and 2. More pits provide connection flexibility albeit at an increase in cost. The incremental cost per pit provides an idea of what the increase or decrease in cost is. A summary of the total costs is presented in *Table 3.5*.

TABLE 3.5: Summary of Total Costs for Options A1, A2, B1 and B2

Option	Description	Cost for Four Pits	Incremental Cost for One Pit
A1	Existing Substation with Pits in Cope Wall	$7,258,900	$1,018,500
B1	New Substation with Pits in Cope Wall	$7,246,800	$1,018,500
A2	Existing Substation with Pits Beside Cope Wall	$6,824,900	$910,000
B2	New Substation with Pits Beside Cope Wall	$6,812,800	$910,000

The following are comments relating to the summary of total costs:

- The main difference between Options A and B, existing substation and new substation, is the length of cable run with the new substation option being shorter. However, the cost difference only $12,100 which is not significant.
- The cost difference between Options 1 and 2, in cope wall and beside cope wall, is $434,000 with the pit in cope wall option being the more expensive one.
- The incremental cost per pit is approximately $1 million. Therefore the minimum installed cost is for one pit which will cost about $3 million less. Having four pits per berth, however, provide the most flexibility.

A detailed breakdown of the cost estimate can be found in *Appendix D*.

3.6 Schedule

Development of cold ironing standards by ISO has only just begun. Since this process will take time, a Publicly Available Specification (PAS) is expected to be available ahead of the formal standards.

Both POLA and POLB are setting an aggressive schedule to have cold ironing in place in 5 years, i.e., 2011. Shipping lines that are on-board with this include China Shipping, NYK, Evergreen, K-Line, Matson and APL.

The shipping routes of ships that call on Deltaport currently do not call on POLA or POLB. If they did, then there is a possibility of being able to take advantage of cold ironing equipped ships. With the current shipping routes, it is unlikely that the ships, fitted for cold ironing and destined for POLA or POLB, will call on Deltaport. Since shipping routes change from time to time, there may be opportunities in the future.

The prudent thing to do at this time is to incorporate minimum infrastructure within the third berth project. Then wait for the development of the standards and how the industry reacts to them.

Lead time required for engineering, procurement and construction is approximately two years. If cold ironing requires to be in place by 2011, then engineering will need to begin in 2009.

4 Conclusion and Recommendations

Cold ironing allows the ships to shut off their auxiliary engines while docked thereby reducing pollutants. This benefits human health, visibility, vegetation and the overall environment.

Cost effectiveness for cold ironing has been reported in 2004 to be in the neighbourhood of USD$11,000 to USD$15,000 per tonne of CAC reduced. Costs in 2007 will be greater. Even so the 2004 value is high compared with other technologies which are in the range of $2,500 per tonne of CAC reduced. Despite cost effectiveness cold ironing would be required for maximum emissions reduction.

If 100% of Deltaport's container ships could be cold ironed the reduction in emissions would be 390 tonnes of CAC and 3,067 tonnes of CO_2. This is equivalent to 13.6% of CAC and 3.5% of CO_2 when compared with GVRD's year 2000 container ship emission inventory.

Legislation, internationally and in Canada, requiring cold ironing does not currently exist. Ports in LA (POLA) and Long Beach (POLB) who lease facilities to shipping lines and enter into long term contracts are able to impose cold ironing requirements. Deltaport does not have long term contracts and vessels that call from a particular shipping line also changes from time to time. The probability of achieving 100% cold ironing or even a large percentage on a voluntary basis is low.

Of the new ships being built for delivery between 2005 and 2008 only 6% are fitted with cold ironing provisions. Most of these ships will likely be calling on the ports of LA and Long Beach. With the current shipping routes, the ships that call on POLA and POLB do not call on Deltaport. Therefore the expectation that Deltaport can take advantage of these ships is low. Since shipping routes change from time to time, there may be opportunities in the future.

Recognized standards for power connections do not currently exist. Shipping lines are currently providing power connections to match their specific berthing arrangements. These connections may change from the resulting standards being developed by ISO. Therefore full installation of cold ironing provisions at this time without recognized standards and without any prearranged ships with cold ironing provisions may require additional expenditure for rework at a later date.

The environmental benefits cannot be realized unless ships calling on Deltaport have cold ironing provisions. Without recognized standards in place or expected ships with cold ironing provisions calling on Deltaport it is not prudent to fully implement the on-shore cold ironing facility at this time. Keeping in mind that a two-year lead time is required for full implementation, the recommended course of action is to consider a staged approach as follows:

- As part of the Third Berth Project install capped underground conduits for cold ironing from the substation area to the third berth at a location beyond the waterside rail.
- On a conceptual basis, allocate space for the cold ironing transformer and switchgear at the substation and a space for the cold ironing pits.
- As a future project, reassess the cold ironing feasibility study report when any of the following occurs:
    - ISO standards for cold ironing are published
    - Canadian legislation is imminent
    - There are requests from the shipping lines for cold ironing their ships

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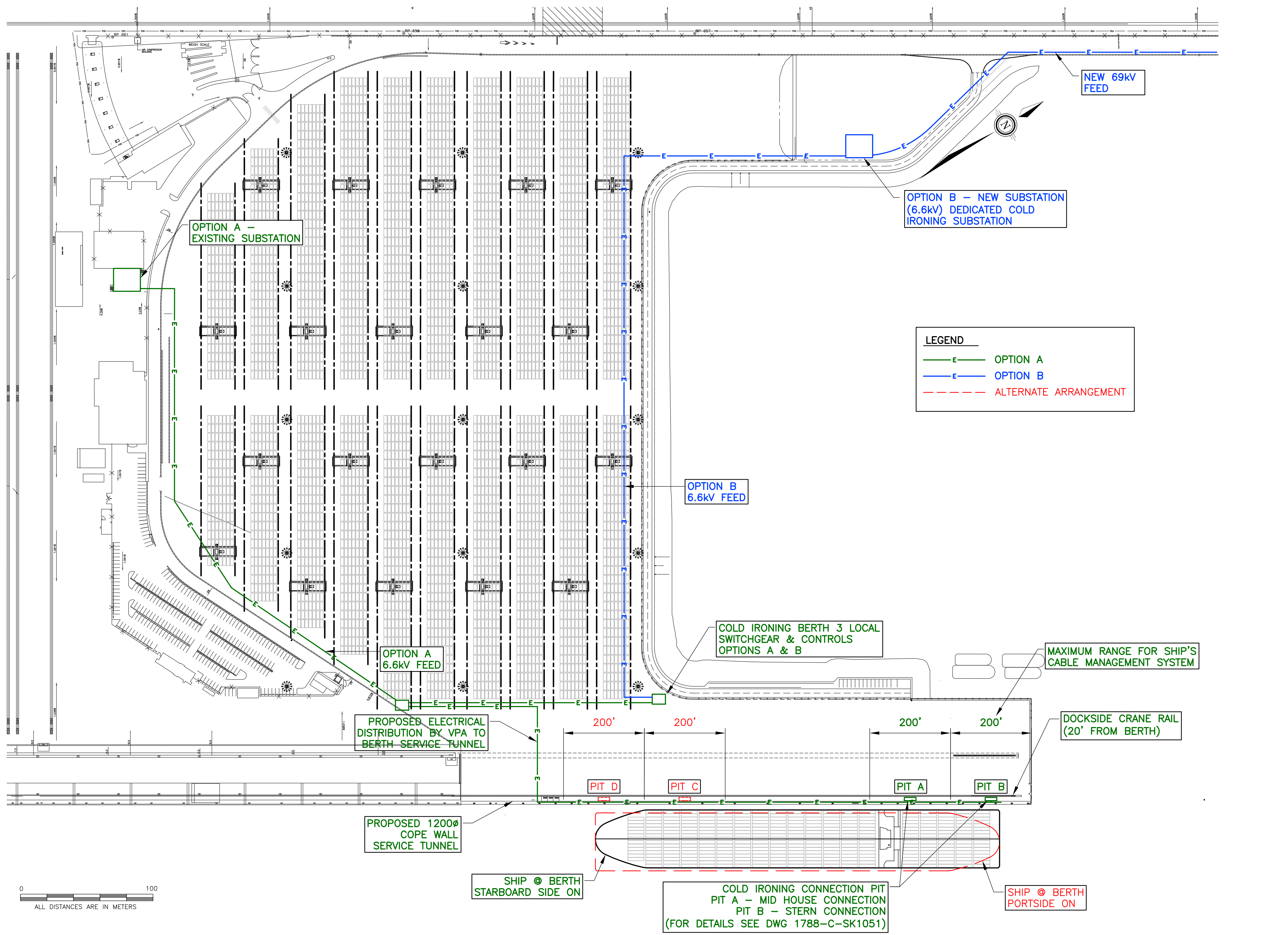
APPENDIX A

Drawings



SITE PLAN
SCALE 1:1500

CONCEPT DRAWING ONLY

REFERENCE DRAWINGS		
NO.	TITLE	REV.

NO.	BY	DATE	DESCRIPTION
P1	CV	NOV27/06	ISSUED FOR REVIEW

REVISION

SEAL:

DATE:

CONSULTANT:

LEVELTON Engineering Solutions

Westmar Consulting Engineers

OMNI ENGINEERING INC.

101 – 1861 Welch St.
North Vancouver B.C.
V7P 1B7 985–0508

CLIENT:

TSI

PROJECT:
DELTAPORT BERTH 3
TERMINAL FINISHING WORKS

DRAWING TITLE:
CONCEPT COLD IRONING
SITE PLAN

ENGINEER: SWD		DATE: NOV25/06	
DESIGN BY: SWD		SCALE: AS SHOWN	
DRAWN BY: CV		ACAD FILE NO: 1788	
DRAWING NUMBER: 34–1788–C–SK1050		REVISION NUMBER: P1	

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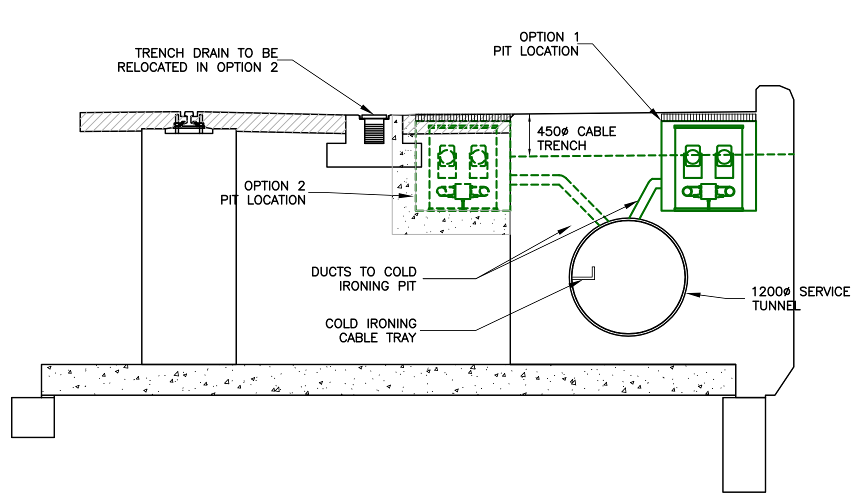
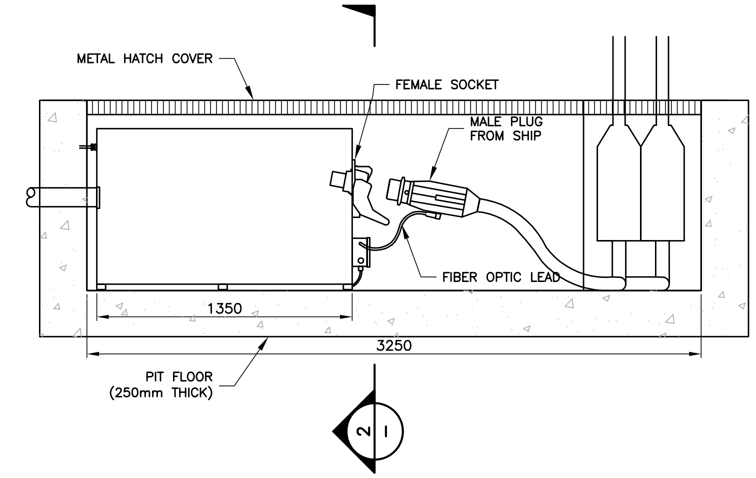
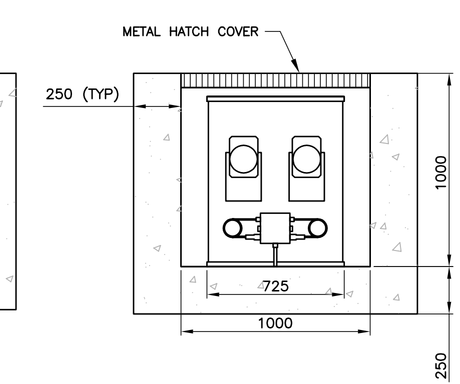
Last Saved: Nov. 27/06 12:23pm Plotted: Nov. 27/06



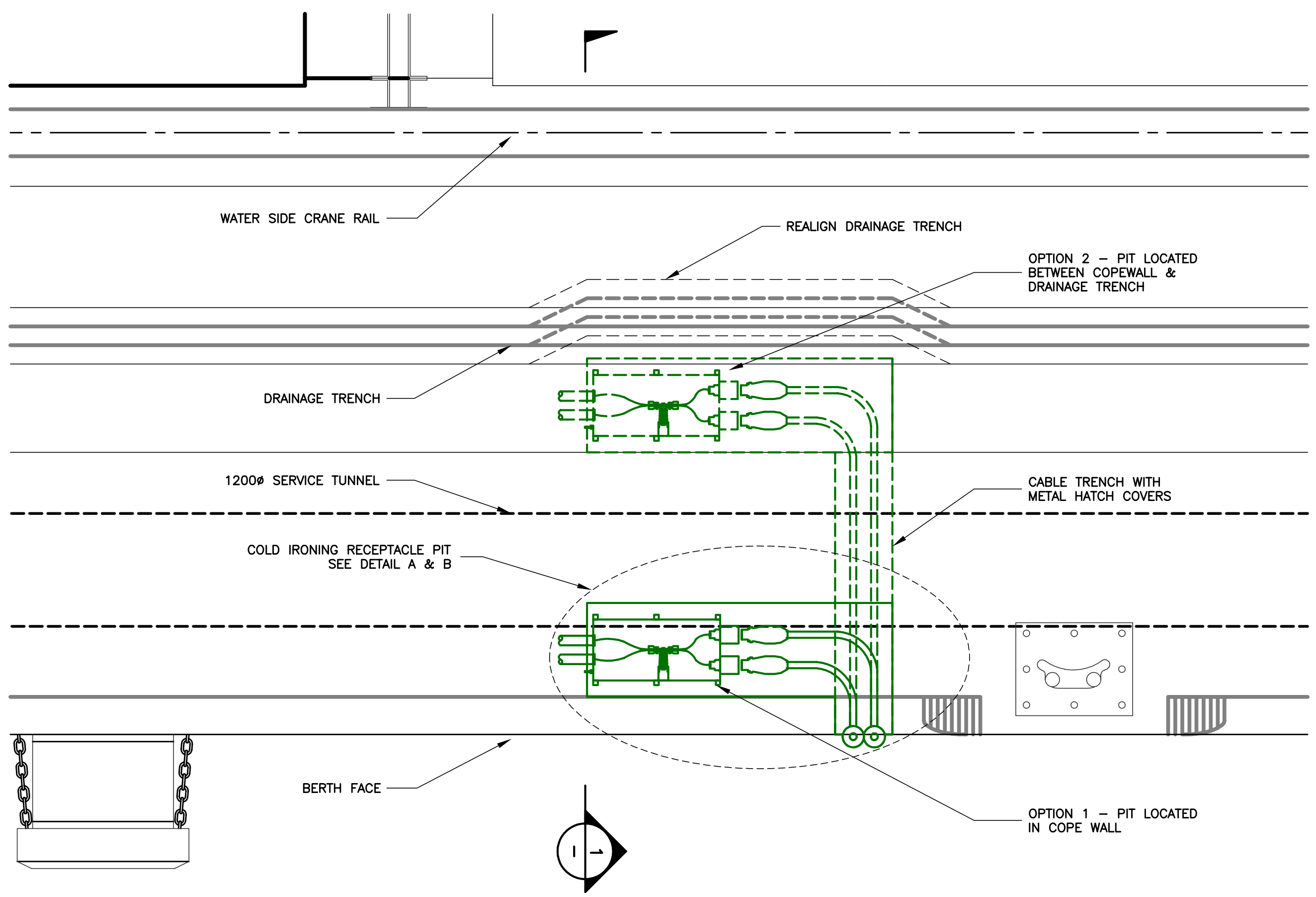
SECTION (1) COLD IRONING PIT
SCALE 1:40



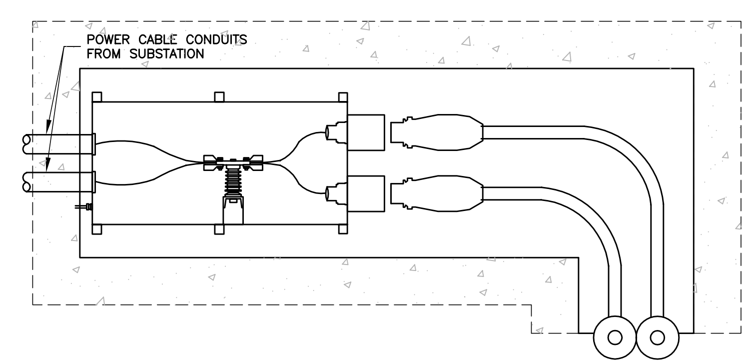
DETAIL (B) COLD IRONING PIT ELEVATION
SCALE 1:20



SECTION (2)
SCALE 1:20



BERTH PLAN FOR COLD IRONING RECEPTACLE PIT
SCALE 1:40



DETAIL (A) COLD IRONING PIT PLAN VIEW
SCALE 1:20

CONCEPT DRAWING ONLY

REFERENCE DRAWINGS

NO.	TITLE	REV.

REVISION

NO.	BY	DATE	DESCRIPTION
P1	TS	NOV27/06	CONCEPT DRAWING ISSUED

SEAL:

DATE:

CONSULTANT:

LEVELTON Engineering Solutions

Westmar Consulting Engineers

OMNI ENGINEERING INC.

101 – 1861 Welch St.
North Vancouver B.C.
V7P 1B7 985–0508

CLIENT:

TSI

PROJECT:
DELTAPORT BERTH 3
TERMINAL FINISHING WORKS

DRAWING TITLE:
CONCEPT COLD IRONING
CONNECTION PIT
DETAILS

ENGINEER:	SWD	DATE:	NOV22/06
DESIGN BY:	SWD	SCALE:	AS SHOWN
DRAWN BY:	TS	ACAD FILE NO:	1788
DRAWING NUMBER:	34–1788–C–SK1051	REVISION NUMBER:	P1

APPENDIX B

Abbreviations and Symbols

ABBREVIATIONS AND SYMBOLS

TABLE A-1: Abbreviations and Symbols

Description	Abbreviation/Symbol
American Wire Gauge	AWG
Ampere	A
British Thermal Unit	Btu
Centimetre	cm
Cubic Feet per Minute	cfm
Cubic Feet per Second	ft^3/s or cfs
Cubic Foot	ft^3 or cu. ft
Cubic Inch	in^3 or in. ft
Cubic Metre	m^3 or cu. m
Cubic Yard	yd^3 or cu. yd
Day	d
Days per Week	d/wk
Days per Year (Annum)	d/a or d/y
Dead Weight Tonnes	dwt
Degree	°
Degrees Celsius	deg. C
Degrees Fahrenheit	deg. F
Diameter	dia
Foot or Feet	ft.
Gallon	gal.
Gallons per Minute (US)	gpm
Gram	g
Hectare	ha
Hertz	Hz
Horsepower	hp
Hour	h
Hours per Day	h/d
Hours per Week	h/wk

Description	Abbreviation/Symbol
Inch	in.
Kiloampere	kA
Kilocalorie	kcal
Kilo (Thousand) Circular Mils	kcmil
Kilogram	kg
Kilograms per Cubic Metre	kg/m^3
Kilograms per Hour	kg/h
Kilojoule	kJ
Kilometre	km
Kilometres per Hour	km/h
Kilopascal	kPa
Kilovolt	kV
Kilovolt-Ampere	kVA
Kilovolt-Ampere Reactive	kvar
Kilowatt Hour	kWh
Kilowatt Hours per Year (Annum)	kWh/a
Kilowatt	kW
Kilowatts Adjusted for Motor Efficiency	kWe
Litre	L
Megapascal	MPa
Megavolt-ampere	MVA
Megavolt-Ampere Reactive	Mvar
Megawatt	MW
Metre	m
Metres per Minute	m/min
Metres per Second	m/s
Metric Ton (Tonne)	t
Micrometre (Micron)	µm
Miles per Hour	mph
Millimetre	mm
Million Circular Mils	MCM

Description	Abbreviation/Symbol
Minute	min.
Ounce	oz.
Parts per Billion	ppb
Parts per Million	ppm
Percent	%
Phase (Electrical)	Ph
Pound	lb
Pounds per Square Inch	psi
Power Factor	pF
Revolutions per Minute	rpm
Second	s
Short Ton (US 2,000 lb.)	st
Short Tons per Day	stpd
Short Tons per Hour	stph
Short Tons per Year	stpy
Specific Gravity	SG
Square Foot	ft^2 or sq. ft
Square Inch	in^2 or sq. in
Square Kilometre	km^2 or sq. km
Square Metre	m^2 or sq. m
Tonne (Metric, 1,000 kg)	t
Tonnes per Day	t/d or tpd
Tonnes per Hour	t/h or tph
Tonnes per Year (annum)	t/a or tpy
Volt	V
Volt-Ampere Reactive	var
Watt	W
Week	wk
Wet Metric Ton	wmt
Yard	yd
Year (Annum)	a

Description	Abbreviation/Symbol
Terminology - General	
Alternating Current	AC
Aluminum Conductor Steel Reinforced	ACSR
Automatic Transfer Switch	ATS
Automatic Voltage Regulator	AVR
Canadian Electrical Code	CEC
Cathode Ray Tube	CRT
Circuit Breaker	CB
Closed Circuit Television	CCTV
Current Transformer	CT
Direct Current	DC
Distributed Control System	DCS
Engineering, Procurement and Construction Management	EPCM
Engineering, Procurement and Construction	EPC
Fibreglass Reinforced Plastic	FRP
Front-End Loader	FEL
Generator Set (Diesel Engine and Electric Generator)	Genset
Goods and Services Tax	GST
Global Positioning System	GPS
Graphic User Interface	GUI
Heating, Ventilating and Air Conditioning	HVAC
High Density Polyethylene	HDPE
Human Machine Interface	HMI
Input/Output	I/O
Life Cycle Cost	LCC
Life Cycle Cost Analysis	LCCA
Liquid Crystal Display	LCD
Living-Out Allowance	LOA
Local Area Network	LAN
Man Machine Interface	MMI
Management Information System	MIS

Description	Abbreviation/Symbol
Manual Transfer Switch	MTS
Motor Control Centre	MCC
Net Present Value	NPV
Personal Computer	PC
Plant Control System	PCS
Polyvinyl Chloride	PVC
Potential Transformer (No Longer Used - Use VT Instead)	PT
Power Distribution Centre	PDC
Process Functional Specification	PFS
Programmable Logic Controller	PLC
Provincial Social Service Tax	PST
Rigid Galvanized Steel	RGS
Transmission Control Protocol/Internet Protocol	TCP/IP
Uninterruptible Power Supply	UPS
Variable Frequency Drive	VFD
Voltage Transformer	VT
Wide area Network	WAN
Terminology - Industry Specific	
Ammonia	NH_3
British Columbia Hydro	BCH
California Air Resources Board	CARB
Carbon Monoxide	CO
Criteria Air Contaminants	CAC
Customer Baseline Load	CBL
Environment Canada	EC
Environmental Assessment Application	EAA
European Commission	EC
European Union	EU
Greater Vancouver Regional District	GVRD
International Organization of Standards	ISO
Natural Resources Defence Council	NRDC

Description	Abbreviation/Symbol
Nitrogen Oxides	NOx
Particulate Matter	PM
Port of Los Angeles	POLA
Port of Long Beach	POLB
Publicly Available Specification	PAS
Sulphur Oxides	SOx
Terminal Systems Inc.	TSI
Vancouver Port Authority	VPA
Volatile Organic Compounds	VOC

APPENDIX C

Correspondence

From: Robert Louie
Sent: Tuesday, October 03, 2006 8:47 PM
To: 'Simon Daniels P.Eng.'
Cc: Jim Erickson; 'tim.glasheen@portvancouver.com'; 'rkristen@tsi.bc.ca'
Subject: 06095 Meeting with POLB regarding Cold Ironing

Simon,

My notes below. Hopefully I've interpreted what I heard correctly. If not please feel free to correct it.

1. Attendees: Kevin ? - Long Beach Container Terminal, Tyler Sparks - Moffat & Nichol, Ben Chavdarian - POLB, Tim Glasheen - VPA, Roy Kristensen - TSI, Simon Daniels - Omni, Robert Louie - Westmar.

2. M&N are providing engineering for a container terminal at the POLB. Design incorporates cold ironing. Other terms that mean the same thing include: AMP - Alternative Maritime Power which has been trademarked by the POLA, Shore-to-Ship power.

3. POLB are sharing information in the hopes that a standard will be developed. They are hoping that the Coast Guard will adopt some of the ideas into a standard and advise the ISO organization of what the Americans are doing.

4. POLB feel that handling 440 V is awkward because of the number of cables and have decided to only provide 6.6 kV. Any transformation from 6.6 kV will need to take place on the ship.

5. As well they feel that the barge mounted cable management system used by the POLA (for Pier 100) is not practical. The cable management system should also be located on the ship.

6. Ben is happy with the cable management system developed by Cavotec and have indicated that Cavotec has 75 orders for ship-mounted cable management systems. Typically the cables come off of the ship and plug into junction box mounted receptacles near the edge of the wharf. The junction box is located in a shallow cavity on the deck that has an opening at the face of the wharf to allow routing of the ship's cables. A steel hinged lid provides access to the cavity and junction box to allow insertion of the plugs into the receptacles. A place within the cavity is also available for anchoring the cables' cable grip system.

7. Most container ships require around 3 MVA. However POLB feels that in the future this is likely to grow and therefore they have pegged a value of 7.5 MVA as the design size for each ship connection. With the Cavotec system two parallel cables are required.

8. In terms of grounding the POLB will provide a ground cable to the ship and will leave it up to the ship to determine what to do with it. This may include connecting it solidly to their ground bus, through a resistance, or not use it at all.

9. Ben spoke about the project at BP Berth T121:
- cold ironing for oil tankers
- require 10 MVA therefore 3 sets of cables
- receptacle at one location - located on a dedicated dolpin
- separate copper cable for controls/status/communication
- BP designed a system to provide many status signals and interlocks between ship and shore - more than Ben feel is necessary. For example each cable has signals on both ends to indicate whether or not they are plugged in and that ties into the power switching system.

10. Instead of a separate copper cable for communications Ben feels that fibreoptics should be used. This can be incorporated within the flexible power cable.

11. The physical connection is made jointly between ship and shore personnel. Note that this may not be the case universally.

12. A kirk key system is used to insure correct plugs are plugged into the sockets and before switches are energized. Ben indicated that the shore side is energized first allowing the ship to monitor the supply power before deciding whether of not they wish to take on the shore power.

13. There was a discussion on the location of the receptacles. Initial concept was to place a receptacle every 200 or 220 ft. on the wharf face to provide maximum flexibility. This translates to 5 or 6 receptacles per ship position.

14. Current thinking is to consider the berthing position of the ship. Connections are generally near the ship's stern therefore placing two receptacles near the bow and two near the stern of each ship's berthing position will accomodate a port or starboard berthed ship. This means 4 receptacles per ship. For full flexibility the ship will need to have the ability to connect shore power from either the port of starboard side. One way this can be accomplished is with a relocatable cable reel system.

15. A switch feeds each receptacle. via 2 x 5" conduits. Only the receptacle being used is switched on - ie. if there are 4 receptacles per ship, one is energized and 3 are not.

16. Ben shared with us his thoughts about power demand from the electrical utility. For each ship position a 7.5 MVA transformer and metering would be required. The transformer is typically located behind the crane. For a 3 ship berth there would be three identical configurations. Utility would normally require a contract demand of 3 x 7.5 MVA. Ben feels that this is not necessary because of diverse power usage. Contract demand may not need to exceed 7.5 MVA. If it turns out that, on the rear occasion, the three berthed ships require more than the contract demand and the additional amount is not available from the utility one of the three ships will need to stay on generator power. Although this may not be acceptable to the air quality regulators.

17. Currently cold ironing is not mandatory (except for the legal settlement at Pier 100). This may change in time. The POLB and POLA are putting in cold ironing provisions voluntarily with their new terminal projects.

18. Cold ironing provisions are not cheap. Ben cited an example where costs can escalate dramatically. He felt that people considering cold ironing should expect it to cost at least $5 million. If that money is not available then don't consider it.

19. We discussed synchronized transfer of power whereby the ship's power is synchronized with the shore power before transferring over. This is currently being done by cruise ships since they cannot tolerate even a brief loss of power. Ben thinks the bulk handling and container ships are also doing this or are thinking of doing this.

20. We briefly discussed energy cost. Ben recalls a value of 7-8 cents/kwh for operating the ship's generators versus 15 cents/kwh for purchased electricity.

Regards,

Robert Louie, P.Eng., P.E.
Manager, Electrical & Controls Division

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From: Robert Louie
Sent: Thursday, October 05, 2006 1:38 AM
To: 'Simon Daniels P.Eng.'
Cc: Jim Erickson; 'tim.glasheen@portvancouver.com'; 'rkristen@tsi.bc.ca'
Subject: RE: 06095 Meeting with Yusen Terminals & POLA regarding Cold Ironing

Simons,

My notes below:

1. Attendees: Gary Reynolds (briefly) - Yusen Terminals (YTI), Joe Di Massa - Yusen Terminals (YTI), Shawki Aboul-Hosn - Port of Los Angeles, Tim Glasheen - VPA, Roy Kristensen - TSI, Simon Daniels - Omni, Robert Louie - Westmar.

2. YTI/POLA showed us their cold ironing installation consisting of one set of receptacles for the NYK Atlas. Inaugural visit slated for beginning of Nov/06.

3. YTI indicated that the Atlas is a 6200 TEU ship with 500 refer plugs and cold ironing plugs in from of the house on the starboard side. YTI feels that this is not as flexible as having them on the bow which would allow plugs to be swung over the port side or starboard side of the ship. With the current arrangement NYK would have to berth on the starboard side and position the ship accurately to the receptacles. When asked why YTI did not provide more receptacles they explained that the wharf would be eventually reconfigured and more will be added then. In future POLA is considering 2 sets of receptacles per ship position to allow the ship to berth on either side. However the ships will need to have plugs accessible from either side.

4. NYK decided to install a connection for cold ironing part way through their building of the ship. They use Cavotec's cable management system with two set of power cables and embedded fibreoptic cables. The ship's distribution voltage is 6.6 kV (instead of 440 V) therefore they do not need a step down transformer for the shore power. Their transfer over system includes equipment for synchronizing to provide a bumpless transfer. POLA/YTI indicated that they were adamant about not going black during the transfer because of the detrimental effects on their ships equipment. It was noted that China Shipping vessels at Pier 100 go black during the transfer because they do not have synchronizing equipment for shore power.

5. POLA provided shore power via a dedicated 34.5 - 6.6 kV, 7.5 MVA transformer. There are two sets of switchgear: one at the transformer which provides basic protection and a second unit more or less in line with the receptacles and a ways back from the crane rails. The second switchgear carries the bulk of the protection including the reverse power relay, ground check relay and a PLC for ship-shore interlocks.

6. Conduits run from the second switchgear underneath the wharf deck to a cavity at the wharf face. The cavity had to be built out beyond the berth face because of the limited deck space on the water side of the water side rail. A Cavotec receptacle box is installed inside the cavity with a number of checker plate lids on top. The receptacles are kirk key interlocked with breaker. Also inside the cavity is fibre optic termination panel and an E-Stop pushbutton which, when pressed, trips the second switchgear breaker. The opening for the cable on the face of the wharf is surrounded buy rubber coated rollers to prevent damage to the flexible cables.

7. Each flexible cable has 2 ground check conductors. Because two cables were used a decision was made to use one ground check conductor from each cable for the shore mounted gorund check relay and the second set of conductors for a ship mounted ground check relay.

8. The fibreoptic signals are used to prevent the breaker from closing if the ship's conditions are not met. An example would be the cable reel tension which must be working properly before the breaker can be closed.

9. POLA basically bought a package from SquareD consisting of the breakers, PLC and programming.

10. POLA said that they will provide us with copies of any drawings and/or reports that we may need. Roy to send e-mail stating requirement.

Regards,

Robert Louie, P.Eng., P.E.
Manager, Electrical & Controls Division
Westmar Consultants Inc.
T : 604.985.6488 F : 604.985.2581
e-mail : rlouie@westmar.com
Web : www.westmar.com

From: Simon Daniels P.Eng. [sdaniels@omniengineering.bc.ca]
Sent: Tuesday, October 10, 2006 9:24 AM
To: Tim Glasheen; Robert Louie; Roy Kristensen
Cc: David Stewart P.Eng.
Subject: Emailing: Notes from LA shore power trip 10-06-2006

Attachments: Notes from LA shore power trip 10-06-2006.doc

Notes from our brainstorming session in Long Beach.

Simon

Simon Daniels P.Eng.
Omni Engineering Inc.
604 813 5411
sdaniels@omniengineering.bc.ca

The message is ready to be sent with the following file or link attachments:
Notes from LA shore power trip 10-06-2006

Note: To protect against computer viruses, e-mail programs may prevent sending or receiving certain types of file attachments. Check your e-mail security settings to determine how attachments are handled.

SWD Notes from LA/LB Shore Power Trip **October 6, 2006**

Notebook 1 – Miscellaneous Discussions

- Only ducts to Utility Corridor in Berth (1m diameter)
  - Believe 2 x 125mm elec and 2 x comm.
  - Located @ caisson 18

- Bending of cable (max 10 x diameter of cable)

- Should think about designing for shore power now
  - Rather than retrofit a cope wall
  - 2 x 5" dia. Seems light

- Port side berth for largest ships (8500 teu)
  - Recommendation from Pilot's report
  - These ships more likely to have shore power
  - May not cold iron older ships (440V)
  - Need more data from:
    - Pilots (variations for berthing)
    - Shipping lines (who will have plug option)

- Are all wires "hot"
  - No, according to Ben (LBPA)
  - Need individual switchgear (local (dockface) and at power sub)

- Could have a 6.6 kV transformer at the substation (existing) with load break switch locally
  - Switch could be remotely activated

- TG has Princess start-up procedure for cold iron connection
  - Quite complex

- Electrical load
  - Need to get forecasts for reefer loads to accurately determine loads
    - Check with Morley (TSI)
    - Shipping lines

- Deltaport Substation Issues
  - Room for a future 5 kV transformer
    - Shown on the record drawings
    - Substation will not handle additional 7.5mVa load (known)

- Costs for Transformer
  - 2 x 10 mVa transformers (69 – 12)
    - $250,000 each (to be confirmed)

- 12 kV issues
    - New cranes are bigger
        - Reel size issues (3 ott – 95sq. mm cable)

<u>Notebook 2 – Cold Ironing Issues (in no particular order)</u>

- Protect Port Infrastructure
    - Coordination, isolation, synchronization issues
        - Software control is a significant expense

- Soft versus hard break on connection
    - Comm. And software issues

- Grounding
    - Ship or shore responsibility

- Cable management
    - General agreement that it should be managed on the ship
    - Need to harmonize with emerging standards

- Desirable Voltage
    - Provide 6.6 to dock
    - On ship transform to 440V or other
    - No barge

- What ships will be ready to cold iron?
    - Need to talk to shipping lines
        - Old ships may not be retrofitted
        - How much power is required (7.5 mVa seems high)

- How much power to supply per berth
    - 7.5 mVa is emerging standard
    - Tested ships at Deltaport maybe need 1 – 2 mVa
    - What is impact on existing substation?

- Plug locations on berth, local disconnect/connect procedures
- Which way does ship berth/which side is plug on?
    - Need to get enough ducts in the ground now (during berth construction)
        - Send to terminal area for connection to substation
    - Running through berth utility corridor not desirable
    - Provide duct raceways through waterside crane rail foundation now
    - Should berth design be altered for vault locations now (difficult and expensive job to retrofit (ie Vanterm retrofit difficulties)
        - Need to know locations (yet to be determined)

        - Have time between tender close and project start-up/material orders

- Impact on Electricity Rates

- Ship to shore communication
    - Fibre versus wireless

- Commercial issues
    - $ (who pays, how?)
    - Fibre may not be the best way
    - Wireless also has issues
    - Robert suggested an Ethernet protocol

- Labour
    - Who will connect

- Safety

- Liability

- Timing
    - Ship conversion
        - Try to match pace of ship retrofits
    - Shore conversion
    - Regulatory requirements
        - Be proactive rather than being regulated

- Flexibility
    - Keep our options open
    - Pressure to cold iron could send ships elsewhere
        - Vancouver has 30 day contracts, US has 1 year contracts
            - Fraser/Surrey example

- What are the shipping lines doing
    - Costs
    - Plan
    - How many ships
    - How does it work economically
        - Commercial side (who pays the bills)
    - Cavotec report notes mid size ships (5000 – 6500 teu) are getting AMP systems
        - Can come in both sides
    - Good info in CARB report
        - Ship surveys

Cold Ironing Discussion – Various Details

- AMP (Alternate Maritime (marine?) Power)

- Size of Cold Ironing Connection (we will see at Yusen Terminal)
    - Size (from Power Point Presentation)
        - Looks about 4' x 10' x 3' deep (confirmed in field)
        - Cable emerges from face of berth
        - 2 plugs (4mVa each)
        - Kellum's Grip attachment (cable relief)
        - Difficult to retrofit in a cope wall berth

- Barge Idea is not well liked
    - Labour issues (costs)
        - Awkward (so many cables)
    - Safety
    - Obviously first cut at the problem

- Cable Reel (Cavotec)
    - Looks good
    - Shown dropping cable straight down
    - What about horizontal run or pull
        - Testing with LBPA showed it handled horizontal pull
        - Will it catch on fenders, mooring lines?
    - Positioning
        - LB/LA have small tides (6') versus 16' in Vancouver
        - Need to talk to Cavotec
        - Spacing of pits versus tides
        - What is loading (force) criteria
            - How far can it reach (practically)
            - How heavy (labour issues – Yusen needs two people to handle cable)
            - How much cable

Tasks to complete

- Get shipping line contacts
    - Through TSI from Roy or Morley
    - Chamber of Shipping is a good contact
        - Rick Bryant

- Provide a survey to ships calling at Deltaport
    - Roy and Simon to follow up

- Report Point Outline from VPA (Trevor Peach) may be dictated from Draft Enviro Conditions for DB3

- Simon to forward points to Robert

Notebook 3 - Substation Issues

- 15 kV versus 5 kV
  - Future Equipment size
    - 80 tonne cranes
      - Flicker/short circuit issues
  - Roy working with ABB on requirements
  - Robert working with others on similar

- Space @ Substation
  - Transformer yard
  - Substation Building
    - 12 kV may cause space concerns

- Future sub relocation/expansion
  - Expensive and difficult
  - Split new berth to new sub

- 69 kV feed
  - Big enough?

- Substation lifespan
  - Age of equipment
  - Location
  - Redundancy options
    - Do we have enough spares and options
    - Terminal shut-down is bad

- Cold Ironing Impacts

- Future RMGs on B3 Terminal Facilities

- High Mast Lighting

- Equipment loads
  - Confirm these loads
    - RK's data (site and hydro data)

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38155

March 1, 2007

Vancouver Port Authority
100 The Pointe
999 Canada Place
Vancouver, B.C. V6C 3T4

Attention: Christine Rigby, Environmental Specialist
Air Emissions

Re: Potential Benefits of Shoreside Power at LFV Terminals

This memo presents a discussion of the potential benefits of establishing shoreside power (electrification) as an alternative to use of auxiliary diesel engines for berthing power demands for cruise ships, container ships and bulk carriers. To a lesser degree, the discussion also involves diesel-fired boilers that are also used by these ship classes while dockside. While the air contaminant emission reduction potential can be established to a reasonable degree of accuracy, determination of related health benefits requires much more analysis and therefore is not addressed here, but potentially could be discussed in a qualitative way in the future without a great deal of effort.

Although this memo is not an exhaustive review, a description of past feasibility studies on shore power is included in Attachment 1. Several studies prepared for U.S. ports have very useful information and detail that was considered for this work. However, use of recently captured shipping characteristics for the Lower Fraser Valley (LFV) allow for the estimation of dockside berthing emissions specific to Canada Place (cruise ships) and Roberts Bank (container ships and bulk carriers). These emission estimates facilitate a higher accuracy determination of the emission reduction potential with establishment of shoreside (electrical) power at LFV terminals.

Table 1 provides an estimate of auxiliary and boiler fuel consumption and emissions during dockside activity at Canada Place (cruise ships) and Roberts Bank (container ships and bulk carriers) in 2005. Ship engine and berthing characteristics used to complete the estimates are provided in Attachment 1. Annual totals relate to actual ship visits in 2005 for cruise ships and bulk carriers, and 2003 visits for container ships (as stated in the Deltaport Third Berth Expansion air assessment report prepared in 2005).

Table 1
Dockside Emissions for Cruise, Container and Bulk Carrier Ships at Canada Place and Roberts Bank

	Ship Activity		Emissions and Fuel Use (tonnes)							
			NO_x	SO_x	HC	PM_{10}	PM_{25}	CO	CO_2	Fuel Use
Canada Place	Cruise Ships	Boiler	12	38	0	1	1	1	2,984	938
		Auxilliary	244	139	7	18	17	17	11,979	3,766
		Total	*255*	*177*	*7*	*20*	*18*	*18*	*14,964*	*4,705*
Roberts Bank	Container Ships	Boiler	25	110	1	3	2	9	6,477	2,037
		Auxilliary	205	158	6	15	14	15	10,081	3,170
		Total	*230*	*268*	*6*	*18*	*16*	*25*	*16,558*	*5,206*
	Bulk Carriers	Boiler	13	53	0	1	1	5	3,344	1,052
		Auxilliary	101	72	3	8	7	8	4,964	1,561
		Total	*114*	*125*	*3*	*9*	*8*	*12*	*8,308*	*2,612*

The Table highlights the fact that boiler emissions represent a small portion of total dockside emissions for cruise ships, but represent a significant portion of dockside emissions for container and bulk carrier ships. As shown in Attachment 1, California has clearly focussed on dockside auxiliary engine emissions only – both for cruise ship shoreside power and for two container ship terminal electrification projects (Long Beach) that SENES knows of. SENES has previously noted that California marine vessel emission inventories have significantly under-estimated the significance of boiler emissions while dockside, and this may be part of the reason for the focus on auxiliary engines only.

Experiences from the shoreside electrification of the cruise ship terminal at Juneau, Alaska show that provision of both electricity and steam (to prevent use of diesel-fired boilers) is possible. However, a future assumption that cruise ships will use lower sulphur fuel while dockside would reduce the significance of boiler emissions such that the additional effort to supply steam as well as electricity to cruise ships would be unwarranted.

A significant issue associated with the potential for use of shoreside power at Roberts Bank is the frequency of vessel visits to the same terminal over a year. Although there are no clear economic criteria to apply to this issue, anecdotal comments from the Port of Long Beach (re: container ship terminal) suggest that a minimum of three visits per year by a particular vessel would be required before installment of the necessary infrastructure (on ship) to allow connection to shoreside power would be considered.

The B.C. Chamber of Shipping (CoS) 2005 commercial marine emissions inventory shows that 1/3 of the container ships that visit B.C. terminals do so five or more times a year (at least in 2005/2006). This is likely a reasonable fraction to apply specifically to Deltaport as well (although this issue should be investigated further with a detailed analysis of the CoS database). This situation is much 'worse' for bulk carriers, which tend to be infrequent visitors on an individual ship basis over the year.

Table 2 shows the theoretical maximum emission reduction potential that could be achieved with the establishment of shoreside power for auxiliary engines at either Canada Place or Roberts Bank. This theoretical maximum assumes all ships make use of shoreside electrification, which may be reasonable for cruise ships in the future, but is likely an unreasonable assumption for container ships and certainly unreasonable for bulk carriers. SENES believes that currently used particulate matter emission rates for marine boilers may be too low by up to a factor of three (assuming current average sulphur levels in heavy fuel oil used at berth). Therefore, the reduction potential percentage of total dockside emissions may be over-estimated for PM.

Table 2
Annual Maximum Theoretical Emission Reduction Potential for Terminal Electrification (Dockside Emissions)

	Ship Activity		Emissions and Fuel Use (tonnes)							
			NO_x	SO_x	HC	PM_{10}	PM_{25}	CO	CO_2	Fuel Use
Canada Place	Cruise Ships	Total Dockside Emissions	255	177	7	20	18	18	14,964	4,705
		Reduction Potential	220	125	6	17	15	15	10,781	3,390
		Reduction as % of Total	***85.9%***	***70.9%***	***85.4%***	***84.4%***	***83.8%***	***85.0%***	***72.1%***	***72.0%***
Roberts Bank	Container Ships	Total Dockside Emissions	230	268	6	18	16	25	16,558	5,206
		Reduction Potential	199	153	5	15	13	15	9,756	3,067
		Reduction as % of Total	***86.2%***	***57.1%***	***85.0%***	***82.6%***	***84.0%***	***60.1%***	***58.9%***	***58.9%***
	Bulk Carriers	Total Dockside Emissions	114	125	3	9	8	12	8,308	2,612
		Reduction Potential	99	71	3	7	7	7	4,872	1,532
		Reduction as % of Total	***87.0%***	***56.8%***	***85.7%***	***83.2%***	***84.6%***	***59.9%***	***58.6%***	***58.6%***

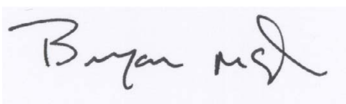
The maximum potential values shown in Table 2 account for the times required to connect and disconnect electrical cabling to ship. These times are not significant to container and bulk vessels, since their total dockside times per visit are relatively high compared to cruise ships. For cruise ships, up to $1/10^{th}$ of the total dockside period may be required for this process. To give a relative sense of the magnitude of these emission reduction potentials, *the NO_x value for cruise ships at Canada Place (220 tonnes) represents approximately 11% of the total NO_x emissions from all commercial marine vessel berthing emissions in the LFV.*

The analysis provided in this memo describes the general issues and expected benefits related to establishment of shoreside power at either Canada Place or Roberts Bank. However, a more detailed investigation is suggested, to both account for specific berthing details at the two LFV terminals and recent experiences from terminal operators who have commenced or fully established terminal electrification for ships. Approximate costs of establishing shoreside power systems and cost differentials for using shoreside power instead of diesel fuel can also be determined. Finally, related health effects (improvements) could also be addressed to a certain degree.

Please contact Dan or myself if you have questions related to this assessment.

Yours very truly,

SENES Consultants Limited



Bryan McEwen, M.Sc.
Senior Meteorologist

ATTACHMENT 1: Supporting Information and Calculations

Cruise Ships

A brief account of experiences at Juneau, Alaska and San Francisco are presented before a discussion of cruise ship visits to Canada Place.

Juneau, Alaska

On July 24, 2001, the first cruise ship (Dawn Princess) to use the newly established shoreside power system at Juneau arrived, although the shore steam system was not yet operational. The Juneau shoreside power system may be quite unique in that it allows provision of both electrical power (as an alternate to diesel auxiliary engine use) and pressurized steam (as an alternate to diesel-fired boiler use). The characteristics of the Juneau operation are shown below:

Primary Supply: 13 MW maximum electrical supply at either 6.6 kV or 11 kV to replace auxiliary engine(s) use by direct cable connection to ship.

Secondary Supply: 7 MW, 12.5 kV supply to a dockside electric boiler to replace use of on-board boilers for steam, by use of direct steam conduit to ship.

It was reported that Princess spent approximately $5.5 million for construction of the shoreside facilities and $500k each for two ship retrofits. A used electrode steam generator was purchased and commissioned as part of this work, which can generate 10,000 kg per hour of steam at a pressure of 9 bar.

The project was considered positive on a local as well as regional basis, as the electricity is sourced from a hydro-electric plant that had additional capacity during the summer. An accounting of the environmental benefit (i.e., emission reduction) is not readily available, since the primary purpose of the shoreside system was to achieve visibility goals through prevention of stack plume smoking or opacity (which were realized).

San Francisco, California

In 2005, Environ prepared a feasibility study for the Port of San Francisco for the provision of shoreside power for cruise ships. Addressing boiler emissions was not included as part of the project scope. Environ focussed on 4 cruise ships that frequented San Francisco moreso than other cruise ships. The 4 cruise ships provide a reasonable representation of cruise vessels that visit Canada Place (in terms of gross tonnage). Table A1 provides a listing of the cruise ship auxiliary engine characteristics. Table A2 provides an estimate of the emissions and fuel use per dockside visit. To produce the estimates, SENES assumed a 10 hour average vessel call and engine emission rates consistent with the 2005 B.C. Commercial Marine Inventory.

Table A1:
Cruise Ship Engine Characteristics (San Francisco Study)

Cruise Ship	Gross Tonnage	# Engines Used Dockside	Rated Power (kW)	Fuel Used	Average Electric Load (kW)
Celebrity Mercury	***77,713***	3	4,320	IFO 380	***9,500***
Crystal Harmony	***49,400***	1	8,640	MDO, IFO	***6,000***
Dawn Princess	***77,499***	1	11,650	IFO 380	***6,800***
Regal Princess	***69,845***	1	9,410	IFO 380/180	***6,700***

Table A2
Cruise Ship Emissions per Visit (San Francisco Study)

Cruise Ship	**Emissions estimate per visit (assumed to be 10 hours) in kg**							Fuel Use (tonnes)
	NO_x	SO_x	HC	PM_{10}	PM_{25}	CO	CO_2	
Celebrity Mercury	1,397	998	38	105	95	95	68,590	22
Crystal Harmony	882	630	24	66	60	60	43,320	14
Dawn Princess	1,000	714	27	75	68	68	49,096	15
Regal Princess	985	704	27	74	67	67	48,374	15

The estimate of ship emissions in Table A2 assumes use of bunker fuel with sulphur content of 2.5% (consistent with assumptions in the Environ report). One source of uncertainty is the average *mechanical* (i.e., from diesel engine) load. The average electrical load indicated in Table A1 was used to determine the emission rates, although a somewhat higher load (kW) may actually be appropriate. Discussion of this issue was not provided in the report.

The Environ report noted that, on average, 20 minutes is required to fully connect and 20 minutes to disconnect, the electrical cabling and that up to 1 hour could be expected (based on experiences at Juneau). Therefore, indications from this study are that:

> *A reasonable estimate of the emissions reduction potential at berth due to installment of shoreside power for cruise ships in San Francisco is 80% of the emissions indicated in Table 2 (per vessel visit).*

It should be noted that a full 80% reduction in dockside emissions for cruise ships would not actually be achieved with the instalment of shoreside power at cruise terminal(s) in San Francisco, since boiler emissions would still occur. Boiler emissions are addressed in the next section.

Canada Place, Lower Fraser Valley

The B.C. Inventory report shows that cruise ships that visited B.C. in 2005 used fuel with an average sulphur content of 1.8% (2% was assumed for this work). Further, a dockside visit of 10 hours and gross tonnage of 76,000 is representative for an average visit. These characteristics are a close match to those found for San Francisco. Finally, the B.C. report indicates that the average power demand for auxiliary engines for cruise ships while berthed was 6,100 kW during 2005[1], with an average boiler fuel consumption of 0.35 tonnes/hour. These characteristics represent B.C. as a whole; however, most of the cruise visits in 2005 occurred at Canada Place, according to VPA records (272).

Table A3 provides an estimate of the fuel use and air emissions for both auxiliary engines and boilers at Canada Place, both on a per-visit basis and by totals for the year.

Table A3
Estimated Cruise Ship Fuel Use and Emissions (while berthed) at Canada Place, 2005*

Cruise Ship Activity		Emissions and Fuel Use (tonnes)							
		NO_x	SO_x	HC	PM_{10}	PM_{25}	CO	CO_2	Fuel Use
Per Ship Visit	Boiler	0.042	0.138	0.001	0.004	0.004	0.004	11	3
	Auxilliary	0.897	0.512	0.024	0.068	0.061	0.061	44	14
Annual Total	Boiler	***12***	***38***	***0***	***1***	***1***	***1***	***2,984***	***938***
	Auxilliary	***244***	***139***	***7***	***18***	***17***	***17***	***11,979***	***3,766***

*Boiler PM emissions may be under-estimated by up to a factor of 3, due to current uncertainties in boiler emission rates in past and current inventories.

The per visit emission rates would not be representative of a relatively large cruise ship visit. Table A3 shows that emissions from boiler use are significant to total ship SO_2 and CO_2 emissions (and potentially to PM emissions as well). However, auxiliary engine emissions clearly dominate the total cruise ship emissions while at berth.

[1] This is mechanical power from the engines. Anecdotal information suggests that the electric power from the generator is slightly lower (perhaps up to 10% lower).

Ports in California and Washington have developed shoreside power systems that address auxiliary engine use only. The B.C. Inventory has provided more clarity on the significance of boiler emissions at berth, which is likely higher than previously assumed. However, with use of a lower sulphur fuel for cruise ship boilers at berth (i.e., distillate fuel), air contaminant emissions would be relatively low compared to auxiliary engine emissions, with the exception of carbon dioxide.

Anecdotal comments from port officials in California suggest that a reasonably conservative average time for fully connecting and disconnecting shoreside electrical power is 1 hour per visit. Assuming use of shoreside power at Canada Place for auxiliary engine use only, 90% of the auxiliary engine emissions shown in Table A3 could be prevented by use of shoreside power. *This represents almost 11% of the total berthing emissions of* NO_x *from all commercial marine vessels over the year* (the percentages for other air contaminants are similar or lower).

Container Ships

The following characteristics describe container ship visits to LFV terminals. Since many of the ship visits occur at Roberts Bank (Deltaport), it was assumed the characteristics represent Roberts Bank reasonably well. The information derives from the 2005 B.C. Inventory, with the exception of ship visits – which were sourced from the recent emissions assessment for the DP3 expansion project.

Average Container Ship Characteristics at Roberts Bank:

Berthing time:	31 hours
Auxilliary demand:	1,234 kW
Boiler Fuel consumption:	0.18 tonne/hour
Ship visits per year (2003):	365

Table A4 provides an estimate of container ship auxiliary and boiler emissions per average visit and as a total for the year.

Table A4
Estimated Fuel Consumption and Emissions during Berthing for Container Ships at Roberts Bank*

Ship Activity		Emissions and Fuel Use (tonnes)							
		NO_x	SO_x	HC	PM_{10}	PM_{25}	CO	CO_2	Fuel Use
Per Visit	Boiler	0.07	0.30	0.00	0.01	0.01	0.03	17.74	5.6
	Auxilliary	0.56	0.43	0.02	0.04	0.04	0.04	27.62	8.7
Annual Total	Boiler	***25***	***110***	***1***	***3***	***2***	***9***	***6,477***	***2,037***
	Auxilliary	***205***	***158***	***6***	***15***	***14***	***15***	***10,081***	***3,170***

*Assumes use of bunker with sulphur content of 2.7% (as indicated by the 2005 Inventory)
*PM emissions from boilers may be under-estimated by up to a factor of 3.

Table A4 highlights that boiler fuel use and related air emissions are more significant for this class of vessel than with cruise ships. Although auxiliary power demand at berth is much lower than that required for cruise ships (on average), annual total emissions at berth are close to those associated with cruise ship visits to Canada Place. This is primarily due to a much longer residence time at dock.

The Port of Long Beach (POLB) commissioned a study of shoreside power that included assessment of container ships. This work indicates that the per visit emissions shown in Table A4 are representative of some container ships that visit POLB, but would greatly under-estimate the emissions (and power demand) of container ships that handle refrigerated containers. In fact, such container ships would rival the power demand of cruise ships.

Over a full year, and not considering the future additional container ship traffic that may be associated with DP3 or even T2, the use of shoreside power for container ships at Roberts Bank to replace use of auxiliary engines would reduce the total berthing NO_x emissions of all commercial marine vessels in the LFV by approximately 10% (and by lesser amounts for other air contaminants). Also noteworthy, without change to the current fuels used in container ship boilers, container ships at Roberts Bank would still emit significant quantities of SO_x, CO_2 and potentially PM from boiler use. In that sense, the consideration of shoreside steam availability is more reasonable to consider for container ships at Roberts Bank than for cruise ships at Canada Place. However, it has to be recognized that a high number of repeated visits by the same ship (as is the case for cruise ships at Canada Place) may not be reasonable to assume at Roberts Bank. The 2005 B.C. Inventory shows that just 1/3 of container ships visiting B.C. terminals visit 5 or more times a year.

Bulk Carriers

SENES conducted a facility emissions inventory for Westshore Terminals at Roberts Bank in 2006. This assessment did not account for boiler emissions. The following characteristics for bulk carriers at Westshore were determined in consideration of both the Westshore Inventory and the 2005 B.C. Inventory:

Average bulk carrier characteristics for Roberts Bank during berthing:

Auxilliary Power Demand:	523 kW
Boiler Fuel Consumption:	0.08 tonnes/hr
Average time at berth:	55 hours

These average characteristics show that bulk vessels that berth at Roberts Bank tend to be slightly larger than the average for B.C., with a shorter berthing time. Table A5 provides an estimate of per visit and annual total fuel use and emissions from auxiliary and boiler use on bulk carriers at Westshore/Roberts Bank.

Table A5
Bulk Carrier Berthing Emissions and Fuel Use at Roberts Bank (Westshore) in 2005

Ship Activity		Emissions and Fuel Use (tonnes)							
		NO_x	SO_x	HC	PM_{10}	PM_{25}	CO	CO_2	Fuel Use
Per Visit	Boiler	0.05	0.22	0.00	0.01	0.00	0.02	14	4.4
	Auxilliary	0.42	0.30	0.01	0.03	0.03	0.03	21	6.5
Annual Total	Boiler	***13***	***53***	***0***	***1***	***1***	***5***	***3,344***	***1,052***
	Auxilliary	***101***	***72***	***3***	***8***	***7***	***8***	***4,964***	***1,561***

As with container ship visits, it can be seen that boiler emissions are more significant to total dockside ship emissions than is the case for cruise ships. Table A5 shows that total annual emissions from bulk carriers at Roberts Bank are approximately ½ of those due to container ships. The B.C. Inventory report shows that the bulk carrier ships arriving at B.C. terminals are sourced from a rather large fleet of vessels worldwide and therefore do not have a high degree of repeat visits over a year. This is likely the case for Roberts Bank/Westshore Terminals as well.

APPENDIX D

Capital Cost Estimate

Item	Description	Unit	Expected Quantity	Install Now	COMMENTS	Unit Price	Extension	One pit
DIRECT COSTS								
	OPTION A - At EXISTING SUBSTATION							
A.1	Substation Upgrade - civil	LS	1		Allowance - Civil only	$100,000	$100,000	$100,000
A.2	7.5 MVA, 64-6.6 kV Transformer	Each	1			$500,000	$500,000	$500,000
A.3	64 kV Switchyard Connections	LS	1			$150,000	$150,000	$150,000
A.4	6.6 kV Switchgear	Each	1			$200,000	$200,000	$200,000
A.5	Electrical Cables - 2 Runs	m	1139			$600	$683,400	$683,400
A.6	Electrical Ducts	m	1127	Y	From substation to local switchgear & service tunnel	$500	$563,500	$563,500
A.7	Cable Pull Pits	Each	2	Y		$25,000	$50,000	$50,000
A.8	Local Switchgear & Controls - Civil	LS	1			$50,000	$50,000	$50,000
A.9	Local Switchgear & Controls - Electrical	Each	4			$80,000	$320,000	$80,000
A.10	Cold Ironing Receptacle Pits	Each	4		Option 1 pit priced	$275,000	$1,100,000	$275,000
					PROJECT TOTAL - OPTION B		**$3,716,900**	**$2,651,900**
							(GST OUT)	**(GST OUT)**
	OPTION B - AT NEW SUBSTATION							
B.1	Substation Upgrade - civil	LS	1		Allowance - Civil only	$100,000	$100,000	$100,000
B.2	7.5 MVA, 64-6.6 kV Transformer	Each	1			$500,000	$500,000	$500,000
B.3	64 kV Switchyard Connections	LS	1			$150,000	$150,000	$150,000
B.4	6.6 kV Switchgear	Each	1			$200,000	$200,000	$200,000
B.5	Electrical Cables - 2 Runs	m	1128			$600	$676,800	$676,800
B.6	Electrical Ducts	m	1116		From substation to local switchgear & service tunnel	$500	$558,000	$558,000
B.7	Cable Pull Pits	Each	2			$25,000	$50,000	$50,000
B.8	Local Switchgear & Controls - Civil Only	LS	1			$50,000	$50,000	$50,000
B.9	Local Switchgear & Controls - Electrical	Each	4			$80,000	$320,000	$80,000
B.10	Cold Ironing Receptacle Pits - Civil Only	Each	4		Option 1 pit priced	$275,000	$1,100,000	$275,000
					PROJECT TOTAL - OPTION B		**$3,704,800**	**$2,639,800**
							(GST OUT)	**(GST OUT)**
	OPTION 1 PIT - COLD IRONING RECEPTACLE PIT IN COPE WALL							
1.1	Concrete Vault	LS	4		Walls: 250mm thick. Approx. pit dimensions: 3250mm L x 1000mm W x 1000mm H	$190,000	$760,000	$190,000
1.2	Electrical Ducts	m	400		From pits to service tunnel	$500	$200,000	$50,000
1.3	Cables	m	960		120m + 120m + 320m + 400m	$600	$576,000	$240,000
1.4	Metal Hatch Cover	LS	4			$6,500	$26,000	$6,500

Item	Description	Unit	Expected Quantity	Install Now	COMMENTS	Unit Price	Extension	One pit
1.5	Cold Ironing System	LS	4		Includes box, sockets, fibre optic junction box, fibre optic flying leads, insulators	$75,000	$300,000	$75,000
					Subtotal - Cold Ironing Pit in Cope Wall		**$1,862,000**	**$561,500**
							(GST OUT)	**(GST OUT)**
	OPTION 2 PIT - COLD IRONING RECEPTACLE PIT BESIDE COPE WALL							
2.1	Concrete Vault	LS	4		Walls: 250mm thick. Approx. pit dimensions: 3250mm L x 1000mm W x 1000mm H	$81,500	$326,000	$81,500
2.2	Electrical Ducts	m	400		From pits to service tunnel	$500	$200,000	$50,000
2.3	Cables	m	960		120m + 120m + 320m + 400m	$600	$576,000	$240,000
2.4	Metal Hatch Cover	LS	4			$6,500	$26,000	$6,500
2.5	Cold Ironing System	LS	4		Includes box, sockets, fibre optic junction box, fibre optic flying leads, insulators	$75,000	$300,000	$75,000
					Subtotal - Cold Ironing Pit Beside Cope Wall		**$1,428,000**	**$453,000**
							(GST OUT)	**(GST OUT)**
INDIRECT COSTS (All Options)								
I.1	Contingency				10% of higher direct cost option		$560,000	$330,000
I.2	Engineering, Procurement, Construction Management				estimated at 12% of higher direct cost		$672,000	$396,000
I.3	Owner's cost				estimated at 8% of higher direct cost		$448,000	$264,000
						Total Indirects	**$1,680,000**	**$990,000**
							(GST OUT)	**(GST OUT)**
SUMMARY OF TOTAL COSTS (Includes Direct and Indirect costs)								
							4 pits	**1 pit**
A1	Existing Substation and Pit in Cope Wall						$7,258,900	$4,203,400
B1	New Substation and Pit in Cope Wall						$7,246,800	$4,191,300
A2	Existing Substation and Pit Beside Cope Wall						$6,824,900	$4,094,900
B2	New Substation and Pit Beside Cope Wall						$6,812,800	$4,082,800