Summary

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Study and Update on Dock Electrification Technologies in Quebec

A study of

MeRLIN

TECHNOPOLE MARITIME DU QUÉBEC

Produced by

INNOVATION MARITIME

INSTITUT MARITIME DU QUÉBEC

Context

The shipping industry is looking to reduce its greenhouse gas emissions and decarbonize its operations. It is seeking to reduce its carbon footprint in port areas by exploring the option of shore power to reduce ship emissions during port calls. While Quebec benefits from clean and affordable electricity through the many hydroelectric dam present on its territory, few initiatives have emerged in Quebec maritime transport to develop this type of connection.

It is in this context that this study was commissioned from Innovation maritime for the MeRLIN network of Technopole maritime du Québec. Its objective is to carry out an inventory of the situation in Quebec and to identify technical and economic means to promote the installation of shore power technology in Quebec. In particular, the project highlights the conditions under which dockside electrification could become a valid option for the various parties concerned.

About MeRLIN

MeRLIN

Spearheaded and managed by Technopole maritime du Québec (TMQ), MeRLIN is an industrial network dedicated to innovation in the shipping and port sectors. The network aims to provide greater access to R&D expertise as it seeks to facilitate the implementation of innovative projects that address the challenges of the maritime industry.

MeRLIN supports the industry in defining its research needs, stimulating collaborative work on shared objectives, encouraging reflection and the quest for concrete solutions, promoting the implementation of long-term planning tools and fostering ties between stakeholders within the maritime community.

MeRLIN is the result of the contribution of its industrial members and its financial partners, Canada Economic Development (CED) and the Créneau Ressources Sciences et Technologies Marines.

MeRLIN members

Port Québec · Port Montréal · Canada Steamship Lines · Corporation de Gestion de la Voie Maritime du Saint-Laurent · Fednav · Groupe Desgagnés inc. · Port Trois-Rivières · Urgence Marine · Ocean

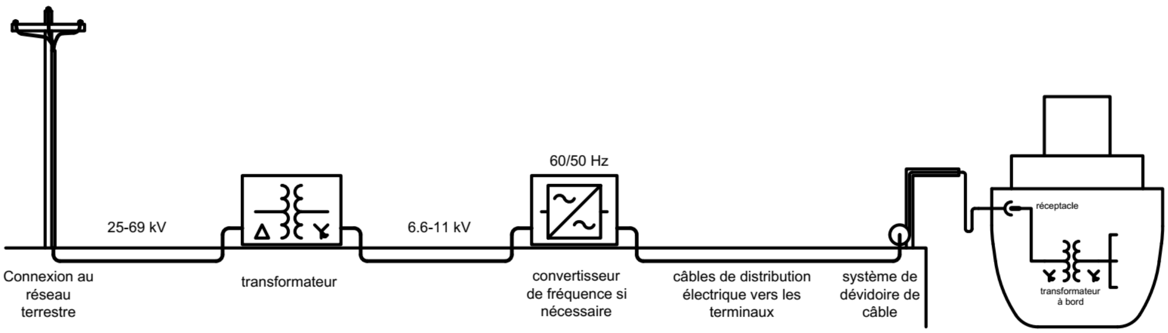
Financial Partners

Développement économique Canada pour les régions du Québec / Canada Economic Development for Quebec Regions · ACCORD · Une initiative de Québec

Introduction

In recent years, the shipping industry has made significant efforts to reduce its greenhouse gas (GHG) emissions. These are driven by a strong desire to reduce the environmental footprint generated by the industry's operations. One of the solutions under consideration is the use of shorepower systems to supply electricity to ships when docked (Figure 1). The energy sources used by land-based distribution networks offer clear environmental benefits compared to the on-board generators typically used. Financially speaking, shorepower systems can also reduce power supply costs by 40–70 % depending on the configurations and systems in place, as well as the pricing practices adopted by the ports.

Figure 1: Typical North American shore power configuration



Source : Innovation maritime.

Power in Quebec is mainly hydroelectric, which is renewable, clean and affordable. Despite these advantages, few initiatives have been developed to promote the use of hydroelectric power in Quebec's maritime sector. Yet, on-shore power for merchant ships appears to be a promising way to reduce GHG emissions in the sector.

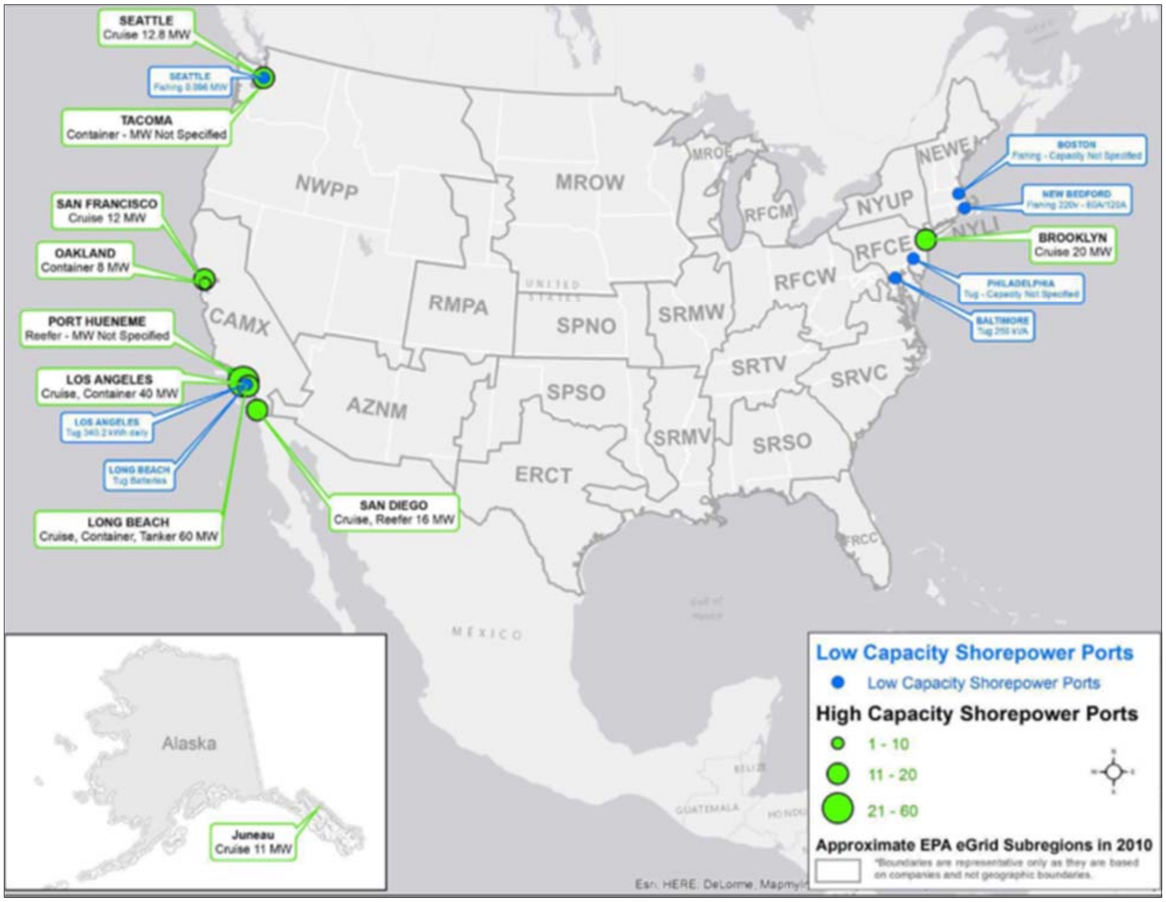
This study aims to overview of the current situation of dockside electrification in Quebec. It also identifies technologies that would facilitate the implementation of such services in Quebec ports. This document is a summary of the complete study, which is available from Technopole maritime du Québec.

01 | Current situation

1.1 Port electrification in North America

In North America, the trend toward dock electrification is most prevalent on the West Coast. In the US, around 10 ports on the Pacific Ocean were offering this service in 2017.

Figure 2: Map of US ports offering shore power in 2017



Source: United States Environmental Protection Agency.

In Canada, the ports of Halifax, Montréal and Vancouver offer shore power for cruise ships at voltages of 6.6 kV and 11 kV at 60 Hz.

In recent years, the ports of Prince Rupert and Vancouver also implemented container terminal electrification projects (6.6 kV/60 Hz).

In addition, the Société des transports du Québec (STQ) installed a low-voltage electrification system in Matane to power the *F.-A. Gauthier*, a ferry connecting Matane to Baie-Comeau and to Godbout, for use at the end of the workday. This 600-volt system provides a maximum power capacity of 1.66 megavoltamperes (MVA) for on-board living spaces

1.2 Main shipowners in Quebec

A survey was conducted of several major Canadian shipowners operating on the St. Lawrence River, with a view to identifying their vessels' dockside power needs. In total, a sample of 23 vessels was characterized to identify their main electrical consumption profiles.

The results show that most of the vessels (70 %) are powered by a 60 Hz electrical network. The ships are all powered by low voltage. The supply voltages range from 380 V to 600 V. In addition, 53 % of these vessels require a dockside power supply greater than 850 kW. A high-voltage supply would be preferable for this type of power.

02 | Main shorepower technologies available

Various shore power connection configurations can be deployed to power ships. The choice of connection configuration depends on the vessels' needs and the electrification services the port wishes to offer. Table 1 shows the main advantages and disadvantages of the most frequently used circuit topologies

Table 1: Comparison of the STS power system's described topologies

Topology	Advantages	Disadvantages
HV/one frequency	› The simplest and cheapest topology. › This configuration is very attractive in North America because the available frequency is 60 Hz.	› Only one frequency is available, i.e. the network frequency. However, mobile conversion units can be provided or installed dockside. › Another option is to install the required frequency converter on board a vessel.
HV/two frequencies with a converter	› The converter takes up relatively little room and is located far from the harsh dock environment. › The installation cost is slightly lower than for other topologies with multiple converters.	› The most failure-prone system (converter failure disables all 50 Hz terminals). › Limited availability of highly specialized services for high-power converters. › Low power quality (high harmonic distortion rate/HDR). Harmonic filters are needed.

HV/two frequencies with multiple converters	› The failure of one of the converters disables only one terminal; the other terminals keep on working without any problem. › Reliability can be enhanced by using multilevel redundancy. › The modules can operate in parallel to supply vessels with high power demands. › Easy access to the service. › High-quality voltage generated by inverters based on IGBT transistors. › Autonomous systems can be installed if the converters are located in containers, thus increasing the likelihood of extending the CENAQ system.	› The installation cost is slightly higher than for the single converter topology. › The required installation space is larger than it is with just one converter.
High-voltage direct current (HVDC)	› The area of the main station is the smallest of all the variants. › High performance due to lower losses in the DC cable distribution lines. › If the inverter is mobile, the dockside configuration is more flexible. › Modularity for easy expansion.	› The installation of fixed inverters (DC to AC converters) dockside interferes with the port infrastructure. › Inverters are more exposed to the harsh dock environment. › Failure of the AC/DC converter (if not redundant) in the main station prevents operation of the terminals. › Inverters increase costs even if the on-board frequency is the same as that of the land-based grid.

Sources: Tranapowicz & German-Galkin, Innovation maritime.

Please note that this table shows only high-voltage solutions. The same low-voltage topologies can be installed to match the vessels' voltage levels without the need for an on-board transformer. However, the number of standard voltage levels is significant: 230 V, 380 V, 400 V, 440 V, 450 V, 575 V, 600 V, and 690 V. In the event that the same dock is used by several vessels, it becomes more difficult to supply a voltage level compatible with the electrical needs of each ship.

For power consumption levels greater than 1000 kVA, a high-voltage connection (6.6 kV or 11 kV) is recommended to limit the number of connectors and the current delivered. For power consumption levels lower than 1000 kVA, the connection can be made at high voltage as well as low voltage.

Please note that not all possible topologies are listed, as it was decided to present the most common topologies. Regardless, a constraint of dock electrification is the capacity of the electrical grid currently available at the port.

Main ship-to-shore connection modes

To connect ships to a shore power system, various configurations are described in the IEC/IEEE 80005-1 standard. Variations in the number of cables, connector polarity, positioning of protective relays, etc. all depend on the types of vessels connected.

03 | Main shorepower connection issues

While shore power electrification offers significant environmental advantages, several important factors must be considered during its implementation. This section aims to highlight the main considerations. Also included are the British Ports Association's recommendations stemming from a study of the main barriers to dock electrification in the UK.

3.1 Factors to consider for successful dock electrification projects

3.1.1 Initial analysis

Several countries have adopted regulations or put forward initiatives to decarbonize the economy while moving towards ambitious environmental targets. Since dock electrification can make a significant contribution to reaching these goals, it is appropriate to examine the financial levers (i.e. government assistance programs) that can be used to support such efforts.

3.1.2 Terminal selection

Not all ports are optimal candidates for dockside power installation. The specific local situation, therefore, must be carefully considered to weigh economic costs and environmental benefits. Among other things, an analysis of the terminals' maritime traffic should be conducted to identify trends in the types of vessels (and their operating power) that would benefit from dockside power. It is also necessary to review the dock configuration and the manoeuvring options (berthing/unberthing) for vessels wishing to tap into shore power.

3.1.3 Terminal use and power consumption

Another selection criterion is the terminal's use. The higher the traffic to the port, the higher the energy consumption and the greater the potential environmental advantages of electrification. Vessels making frequent port calls with long stays and high energy consumption patterns are the best candidates for a reduction in GHG emissions and higher returns on investment.

The assumption, however, is that the availability of electrical energy is sufficient.

3.1.4 Distance from local communities

Since the implementation of dock electrification projects often involves large-scale investments, air quality modeling should also be conducted to prioritize investment projects based on their impact on neighbouring communities. The greatest benefits of electrification are gained when terminals are located close to population centres.

3.1.5 Involvement of shipowners

The success of shore power installation projects also depends on the willingness of shipowners to embrace the technology. A number of international shipowners have already invested in on-board electrification technology. They include NYK Line, Evergreen, Princess Cruises, Disney Cruise Line, Cunard Cruise, Norwegian Cruise Line, Holland America Line, China Shipping, MOL, Stena Line, Wagenborg, TransAtlantic, SOL, TransLumni, I CL and Cobelfret.

Further, the main shipowners consulted in Quebec expressed interest in bringing this technology on board. Connecting ships to dockside power would bring both environmental and economic gains.

3.1.6 Containers terminals need multiple connection points

Dockside connection is easier for some vessels, including oil tankers, cruise ships and ro-ro (roll-on / rolloff) ships that generally use the same dock. More connection points are needed in the case of container terminals, where ships do not always dock at the same location.

3.1.7 Cost of modifications

As shown in Table 2, the cost of retrofitting a vessel for dockside connection depends on its type, as well as on its tonnage. This investment also depends on the initial design of the ship's electrical systems and the capacity to vary the voltage and frequency range. When making a dockside connection in North America, for example, the vessel must be equipped with a frequency converter if its systems operate at 50 Hz.

Table 2: Estimated cost of retrofitting the on-board power supply by vessel type and gross tonnage

Investment cost for the vessel (thousands of US $)	1000 – 4999 GT	5000 – 9999 GT	10000 – 24999 GT	25000 – 49999 GT	50000 – 99999 GT	≥ 100000 GT
Oil tankers	50 – 350	100 – 400	100 – 400	100 – 400	300 – 750	300 – 750
Chemical / liquid tankers	50 – 350	100 – 400	300 – 750	300 – 750		
Gas tankers	50 – 350	300 – 750	300 – 750	300 – 750	300 – 750	300 – 750
Bulk carriers	50 – 350	50 – 350	500 – 1000	500 – 1000	100 – 400	
General cargo	50 – 350	50 – 350	500 – 1000	100 – 400		
Container ships	50 – 350	50 – 350	100 – 400	300 – 750	300 – 750	300 – 750
Ro-ro ships	50 – 350	50 – 350	100 – 400	100 – 400	300 – 750	

Source: GLOMEEP.

Retrofitting a vessel to allow a high voltage shore power connection requires a case-by-case evaluation. Adding shore power technology to an existing vessel will require a higher capital investment than if the required components are integrated during the vessel's construction. According to Schneider Electric, a vessel can be equipped with shore power technology for between €200,000 and €500,000 when it is in dry dock for maintenance. This cost may vary considerably depending on the vessel's size and power requirements.

Highlights

From a technical point of view, dockside power technologies are widely available and have a proven track record, dating back several years. The reliability and robustness of the systems deployed depend rather on the components and circuit configuration selected for implementation costs.

The only further technical constraint is whether the existing electrical grid can provide sufficient power for new electrification projects. Since virtually all the electrical energy produced in Quebec is renewable, upgrading the existing infrastructure is indeed a choice environmental solution. However, in the case of some provinces or countries where the electrical distribution network is powered by non-renewable energies, or where upgrading the electrical network would be too costly, the addition of generators directly in port facilities could be considered and the environmental footprint of these generators then reduced by using energy generated by alternative fuels.

In terms of stakeholder involvement, governments must facilitate the deployment of port electrification infrastructure by providing investment support and encouraging shore power to boost the potential number of connections. The goal here should be to help make electrification projects economically attractive to both port authorities and shipowners.

The unique thing about Quebec is that a Crown corporation is the main electricity supplier. This could facilitate discussions with government and result in better financial support for electrification projects. In addition to having a significant positive impact on the environment, these projects will increase electricity sales for Hydro-Québec, which could result in scaled-back investment efforts.

3.2 BPA report

The British Ports Association (BPA) published a report in 2020, including recommendations for successful dock electrification projects. Among other things, the BPA report mentions that the involvement of all stakeholders, especially governments, is necessary to ensure the success of such projects. The report notes that:

- There are significant barriers to implementing dockside power in the UK, with uncertainties and risk associated with ports and international events influencing cargo handling.
- The main obstacle is the cost of capital: no dockside power projects anywhere in the world have been undertaken without government support. A green maritime fund to support shore power in the UK is clearly needed to help deal with prohibitive costs, particularly around grids and power generation.
- There is a lack of consistent demand for shore power by ships calling at UK ports. The government must address this issue. The BPA is proposing a zero-emission dock standard for discussion with industry and government. This would increase demand for GHG emissions reduction technology while providing investors with greater certainty. The need to fairly apportion the costs of decarbonization and GHG emission reductions is mentioned. In addition, the idea was put forward to remove taxes on coastal electricity to promote competitiveness with marine fuels.

04 | Costs and benefits of dock electrification

Estimating the costs associated with dock/ship electrification is no easy matter. Indeed, several factors can have a significant impact on costs. Only in-depth case-by-case analysis can provide accurate estimates. The study of related cases can, however, shed light on the investments required of ports as well as of shipowners wishing to put electrification technologies in place. With those considerations in mind, this section presents the findings of electrification projects carried out on board ships or in ports.

The second part of the chapter presents the results of an analysis estimating the overall environmental gains (GHG emissions) assuming the electrification of docks and ships operating at the ports of Montréal, Québec City and Trois-Rivières.

4.1 Case studies

Various case studies were analyzed to shed light on important aspects of notable dock electrification projects. The main points are as follows:

- For some vessels, time at dock can represent a significant portion of their overall operating time. Dockside electrification supported by renewable energy sources can thus significantly reduce total GHG emissions.
- Although installing a dockside power connection system may require significant outlay, if available electricity costs are favourable, such a system can pay for itself in just a few years. However, profitability is dependent on the pricing practices adopted by the ports, particularly for connection/disconnection services.
- Electrified cruise/container ship terminals at the port of Vancouver are saving significant amounts of fuel. These terminals are supplied with high voltage (6.6 kV) at 60 Hz. Thanks to competitive electricity rates based solely on the amount consumed (not on grid overloads), this technology has good penetration.
- To optimize its electricity production, the port of Ancona in Italy evaluated a scenario involving thermal cogeneration plants. The study results show that, in addition to providing 1.5 MW of electricity, the plants would meet over 60 % of the facility's heating needs. This means a nearly 59 % reduction in current energy costs (electricity and heating) for the port's 14 buildings. The plants in the study are powered by LNG, although alternative fuels could be used to reduce environmental impacts.
- Australia's White Bay Cruise Terminal is electrifying two high-voltage docks, for a total power capacity of 15 MVA. The project cost is estimated at nearly CDN$25 million. It should be noted that this figure includes a 50–60 Hz frequency converter at a cost of approximately CDN$12 million, which would not be required for an electrification project in North America, as well as 21 connection points on the two docks, spaced 25 m apart, which is a very large number of connection points.

- Studies comparing low-voltage and high-voltage efficiency show that for ship power consumption levels greater than 1000 kVA, high-voltage connections make it possible to minimize cable-related losses by reducing the current flowing through them, making this option preferable.
- A supply voltage of 6.6 kV seems to be the consensus for power capacities ranging from 1 MVA to 10 MVA. This container ship range would also apply to cargo ships and self-unloading bulk carriers.
- For capacities below 1000 kVA, low-voltage installation costs would likely be lower than for highvoltage systems. It should be noted, however, that low-voltage systems generate more energy losses during dockside power supply and are limited in terms of the variety of vessels that can be connected to them. These last two factors reduce the long-term profitability of these facilities and should be considered when designing low-voltage solutions.
- The cost of upgrading vessels is virtually the same for a high-voltage or a low-voltage network.

4.2 Estimated potential environmental gains for three Quebec ports

The following exercise is based on a theoretical approach. The aim is to estimate potential environmental gains (GHG reductions) that may result from the implementation of dockside power at ports and its adoption by shipowners in Montréal, Québec City and Trois-Rivières. The results are theoretical, although they provide an estimate of the potential environmental impact at each port.

For the purposes of this exercise, 2019 was used as the reference period. Using the ships' AIS[1] data for each port and each type of ship, the number of port calls and the average duration of each were extracted. Calls of less than 90 minutes (i.e. the hypothetical maximum vessel connection/disconnection time) were excluded. This first step made it possible to estimate the total berth time for vessels that could theoretically have connected to dockside power. For that same period, a total of 90 minutes was deducted for each port call, i.e. the theoretical time required for each vessel to connect and disconnect. The end result is the total number of connection hours.

The estimates are based on the following assumptions:

1. Domestic and foreign fleets had similar energy requirement profiles to vessels navigating around the world.
2. The estimated GHG emissions level is based on the following types of ships: general cargo/bulk carriers, cruise ships (less than 200 m and between 200 and 300 m), tankers, container ships (less than 140 m and greater than 140 m).
3. All vessels ran on marine diesel oil (MDO).[2]

[1] *AIS: The ships' Automatic Identification System.*

[2] *This hypothesis is known to be not entirely accurate. Some vessels use alternative fuels (LNG, biofuels, etc.) that are less harmful to the environment.*

4. It is assumed that the ships' energy consumption is the same when switching from on-board fuel to dockside power.

5. The average relation between fuel consumption and GHG emissions is consistent across the fleets and is estimated at 0.7 kg of GHG per kWh of electrical energy generated dockside.[3]

6. The cost of purchasing one kWh from Hydro-Québec for shipowners is set at $0.10.[4] This is similar to BC Hydro's cost for Shore Power pricing.

7. The cost of one kWh produced from fossil fuel is estimated at $0.15[5] at the time of this study.

Table 3 presents scenarios under which 25 %, 50 % and 75 % of the vessel types would use dockside power.

Tableau 3: Summary of potential annual environmental gains for the ports of Montréal, Trois-Rivières and Québec City

Ports	Potential gain, in tons of GES[1,2] (total)	Potential gain (in tons of GHG)			Total cost Energy before dockside power	Savings on electricity production	Potential revenue for Hydro-Québec
		25 % of port calls	50 % of port calls	75 % of port calls			
Montréal	95 469	23 867	47 735	71 602	$ 20,457,692	$ 6,819,231	$ 13,638,462
Trois-Rivières	6 935	1 734	3 468	5 202	$ 1,486,156	$ 495,385	$ 9,90,771
Québec	41 864	10 466	20 932	31 398	$ 8,970,777	$ 2,990,259	$ 5,980,518

[1] Based on 0.7 kg of GHG generated per kWh of electrical energy produced on shore by auxiliary generators

[2] Assuming all vessels use dockside power service

[3] This hypothesis is taken from OLMER N., COMER B., ROY B., MAO X., and RUTHERFORD D. Greenhouse gas emissions from global shipping, 2013-2015, Detailed methodology, icct The International Council On Clean Transportation, Washington DC, 2017, 59 p.

[4] It should be noted that service charges for using the power supply may also be included in the cost of electricity. Practices differ from port to port.

[5] This estimate is linked to the cost of fuel on world markets and may vary significantly depending on economic and political issues.

05 | Findings and main recommendations

Dockside power is recognized by various international organizations as the most effective method of reducing GHG emissions when ships are at berth. In addition to this environmental gain, reduced fuel and maintenance costs for generators is an attractive benefit for shipowners when this method is used regularly.

To date, there have been several dockside electrification initiatives at international ports. The main electrified terminals are for the cruise ship sector and the largest container ships (> 140 m), i.e. those with the highest energy demand when docked.

Much work remains in regards to dry bulk, liquid bulk and general cargo transport and smaller container vessels. Very few projects have been rolled out, especially given the major potential benefits for the environment.

In terms of technology, the first shore power systems were implemented over 40 years ago. Therefore, the technologies used are reliable and can be found in various configurations adapted to the needs and realities of each terminal. It should be noted that in Quebec and for the majority of countries in America, the frequency of the distribution network is set at 60 Hz, like on board most large ships. This may significantly reduce the cost of infrastructure required in electrification projects since there is no need to add a 50 Hz to 60 Hz frequency converter.

The main issues facing widespread distribution of this technology may be summarized as follows:

The capacity of the electrical network

The capacity of the local electrical grid to support the large-scale electrification of several terminals is not always guaranteed. Indeed, additional demands of several MVA can cause significant voltage drops if the grid is not large enough. In the event that a distribution substation near the port needs to be upgraded to support terminal electrification, these costs are included in the overall implementation budgets.

To address this issue, some ports deployed alternative power generation systems near terminals. For example, LNG generators, thermal cogeneration power plants and the implementation of renewable energies (wind and solar panels) are among the solutions advanced to address this issue.

Recommendation

Quebec, which boasts a province-wide 60 Hz grid powered by 99% hydroelectricity, enjoys some of the world's lowest electricity rates. It is therefore important to weigh all options for upgrading substations near ports before considering auxiliary power generation equipment.

Profitability of infrastructure

The return on investment for shore power connections continues to be a major stumbling block for largescale roll-out of these technologies. The costs of dockside implementation depend on several factors, including the distances to be covered and the choice of technology. The available electricity must also be able to compete with the production costs of on-board systems already in place.

As regards ships, costs vary depending on the adaptability of the existing network to the land-based grid, as well as on power requirements. Even though the studies mentioned in this report show that a return on investment can be achieved within just a few years, budgetary concerns remain a major issue for shipowners. Profitability for shipowners may depend for many on the cost of fuel but also on the pricing practices of ports to encourage shore power connections.

The stakeholders quoted in this study are unanimous: government involvement is needed to mitigate ROI issues, both for ports and shipowners. Various steps may be taken:

› Subsidizing electricity costs to increase competitiveness over fossil fuels.

› Setting fixed and predictable rates independent of grid overloads.

› Investing public funds in port electrification projects.

It should be noted that for some ports, environmental issues and the impact of activities on local communities are much greater than financial concerns.

Recommendation

For dock electrification projects, Quebec has the unique advantage of a Crown corporation being the main electricity supplier. The bulk of the revenues generated by the sale of electricity from ships at berth would therefore be collected by the provincial government. This situation should favour project financing for the roll-out of this technology across Quebec.

Furthermore, Advantage St. Lawrence, Quebec's new maritime strategy, prioritizes sustainable and competitive development of the St. Lawrence River. The implementation of a large-scale terminal electrification strategy ties in perfectly with its goals.

It should be noted that all shipowners consulted for this study expressed an interest in dockside electrification technologies. This is a major and essential aspect of supporting a province-wide dock electrification strategy.

Lack of standards

While ports hosting cruise ships and container ships are electrifying docks using high-voltage power to meet their high energy consumption and to ensure connectivity compatibility in many international ports, the reality in the rest of the shipping industry (i.e. vessels with lower and more varied energy demands) opens the door to various options. For example, energy demand can vary from about 200 kVA to several MVA for various ships on the St. Lawrence. While this study suggests that a high-voltage system would be more profitable than a low-voltage system for capacities greater than 1 MVA, various options remain available for lower capacities.

The lack of a standard hinders larger-scale deployment, since electrical compatibility is not guaranteed from terminal to terminal.

In this context, and given the fact that the profitability of this type of project is a major factor for its feasibility, the current tendency is to select recurring electricity transits with a minimum threshold of annual connections and to make available electrical installations tailored to this recharging scenario. While this method is appropriate in some cases, it limits the broader integration of other vessels and thus hinders larger-scale deployment at shared terminals.

Recommendations

ÀIn light of the above, a more flexible type of connection adaptable to the vast majority of merchant vessels should clearly be considered for dock electrification, both in Quebec and in the ports of the St. Lawrence/Great Lakes axis, where a homogeneity of systems should be sought (Quebec, the Maritimes, Ontario). Consultation with the other Provinces is necessary to implement a standardization of the type of connection for a greater number of users. For the time being, a high-voltage 6.6 kV connection solution can meet most of those needs.

With such a configuration, future vessels could be included in this type of network, thus benefiting from a potential increase in connections and boosting project profitability.

Further, research shows that a ship's cost of connecting to a high-voltage network that is different from the voltage of the on-board supply network entails little additional cost for upgrading.

Needless to say, low-voltage connections may remain relevant when defining projects more specific to a limited number of vessels able to ensure a sufficient number of connections and sufficient energy demand to make the investment projects profitable.

Conclusion

The purpose of this report was to review the current situation in Quebec with respect to dockside electrification, to identify available technologies and to highlight related issues. It showed that Quebec has significant assets, which enable it to further commit to dockside electrification for the maritime transport sector. The potential benefits are numerous and affect all parties. For shipowners, dockside GHG reductions could improve their annual emissions performance while reducing operating costs. For ports, environmental balance sheets would be improved while also providing an additional service to shipowners. For local communities, air quality around port facilities stands to be greatly improved.

However, several factors must be considered before moving forward with such projects. In all cases, required investments are significant. Case-by-case analyses would be required to properly evaluate the real economic, environmental and social gains that may result from such initiatives. The various technological options available on the market are mature. However, in addition to some specific cases, it appears that a high-voltage electrification goal for terminals with maximum potential benefits could be considered as part of a province-wide strategy. Its modern infrastructure would position Quebec strategically, in line with a green, sustainable and promising development for the coming years. Such a strategy would require the involvement of all stakeholders to make it a success.

