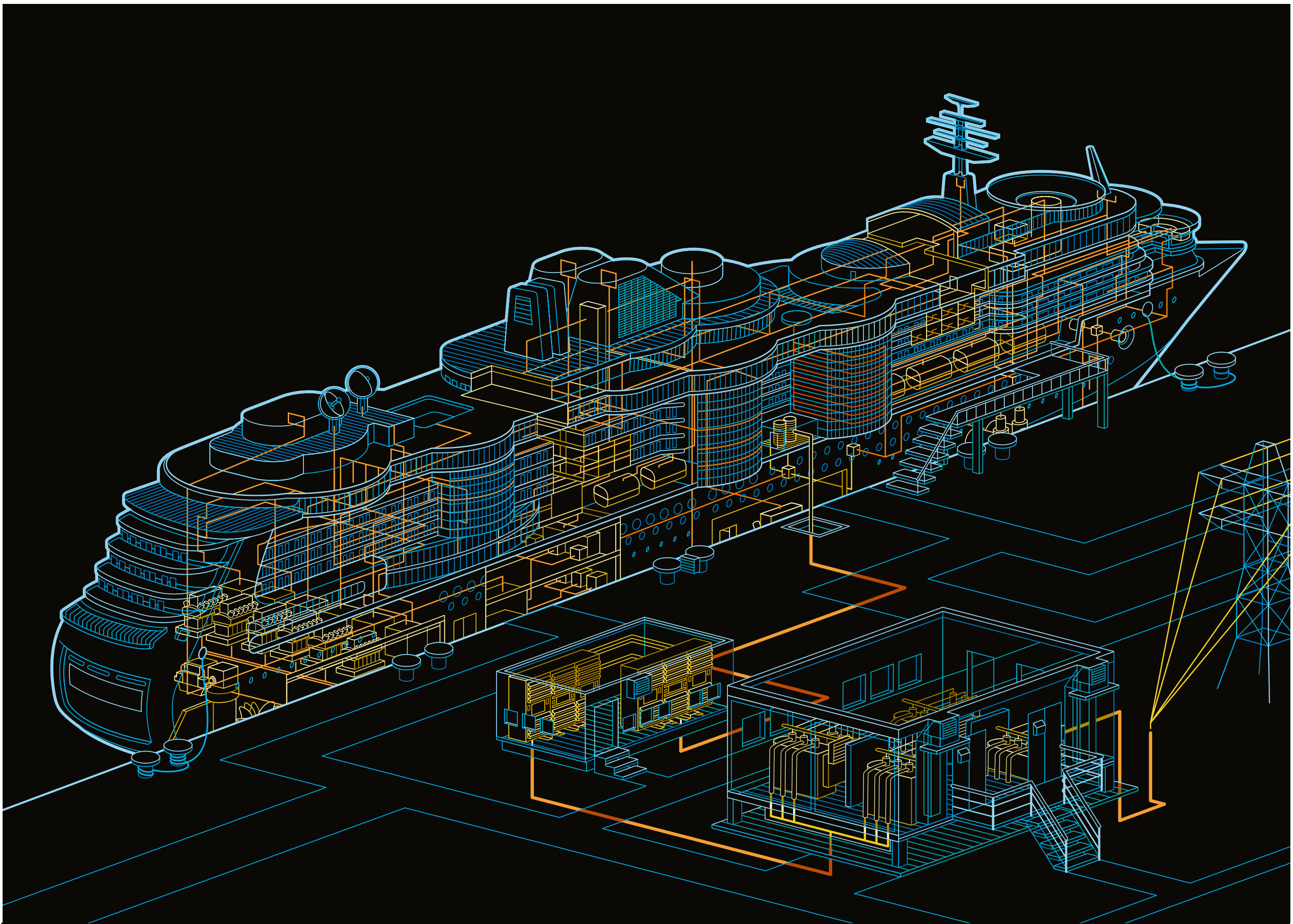

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Substations and electrification
Analyzing the cost efficiency of emissions reduction with shore-to-ship power

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Analyzing the cost efficiency of emissions reduction with shore-to-ship power

PETR GURYEV – Maritime shipping accounts for approximately 4 to 5 percent of the world's total emissions, with emissions from ships at ports comprising about 7 percent of a ship's total emissions. In recent years, attention has turned to reducing port-side emissions. Of the technologies available for port-side emissions reduction, including LNG (liquefied natural gas), scrubbers and purified fuels, shore-to-ship power is the most effective solution available. Only shore-to-ship power allows complete emissions reduction at ports by connecting to electricity from the grid, which is often cheaper and much cleaner to produce. ABB has been supplying shore-to-ship solutions since 2000, when it delivered the first-ever high-voltage shore-to-ship connection to the port of Gothenburg, Sweden.

1 Typical segment requirements at port

Shipping segment	Average nominal power (kW)	Number of visits at the same port (p.a.)	Time at port per visit (h)	Investments*	
				Ship (thousand $)	Port (thousand $)
Cruise (250+m and regional voyages)	10,000	16	15	1,170	6,500
Cruise (250+m and global voyages)	10,000	2	15	1,170	6,500
Ro-ro/ro-pax/ferry	1,500	156	6	975	1,430
Container (2,500+ TEU feeder service)	1,200	52	9	1,040	1,430
Container (5,000+ TEU global service)	2,500	8	24	1,040	1,430
Tanker	1,200	20	24	780	1,430
Bulk	800	5	168	520	650
AHT/WSV (anchor handling tugs/well stimulation vessels)	80	80	24	78	195

*For the electrical infrastructure to connect one ship at a time

2 Cost efficiency of investments in shore-to-ship power projects in ECAs among different segments to reduce port SO_2 emissions

Since that first shore-to-ship connection, many more successful connections have followed. To spur further development of shore-to-ship power projects, some governments provide subsidies or regulative and fiscal incentives. Almost every project implemented worldwide has received a certain level of subsidy from either public authorities or supporting funds. In North America the development of shore-to-ship power projects fell to the cruise and container segments, enforced legislatively by the state of California in the United States and later financially supported by the US and Canadian governments. The direct trade route for container ships between East Asia and the west coast of the United States, where shore-to-ship power requirements are already in place, is driving new shore-to-ship power projects in Asia in the same segment. In Europe the majority of the projects is in the ro-ro/ro-pax/ferry[1] segment, which is driven more by business reasons than legislation.

Different types of ships have different needs at port, spend varying lengths of time there, and have different power requirements – ie, each ship type has a unique annual emissions profile. Furthermore the investment costs for the different segments vary for both ship and port infrastructures. Thus shore-to-ship power projects in the different shipping segments will have varying emissions reduction cost-efficiency. Because of this, an accurate method of measuring and analyzing the cost efficiency of emissions reduction is needed.

Typical parameters of the major maritime shipping segments are shown in → 1. Cruise and container segments are separated into two subsegments with different port visit profiles and, in the case of container ships, different power requirements.

The annual energy consumption by a ship in port can be calculated with the following formula:

Energy [kWh] = Power at port [kW] · number of port visits [times] · time at port [h]

Assuming that all ships have new generators and use similar fuel – MDO/MGO (marine diesel oil/marine gas oil) – the emissions reduction at port per annum can be calculated with the following formula:

Emissions [g] = Energy [kWh] · Fuel emissions [g/kWh]

Title picture
In 2012 ABB supplied Sweden's fifth largest port, the port of Ystad, with its turnkey shore-to-ship power solution for ro-ro/ro-pax/ferry vessels.

Footnote
1 Ro-ro (roll-on/roll-off) is the type of ship used to transport wheeled cargo, usually cars and large trucks. Ro-pax is a ro-ro ship with passenger-carrying capacity.

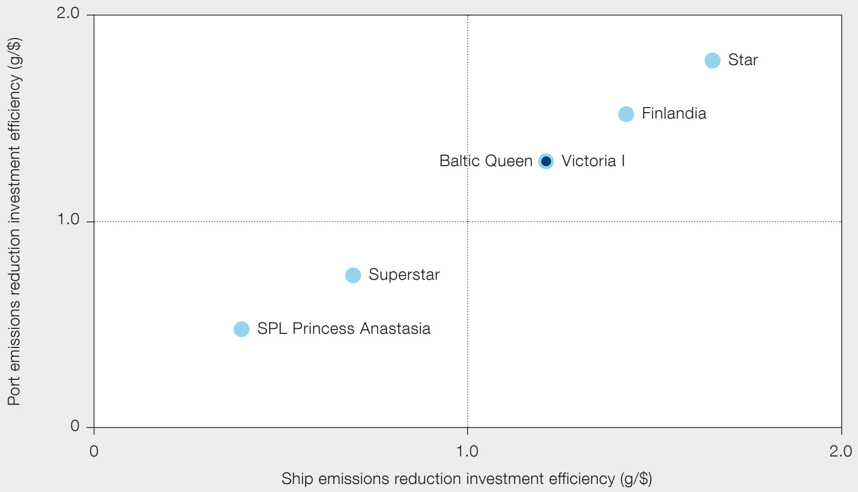
The emissions reduction cost-efficiency ratio shows how much port emissions can be reduced annually for each dollar spent on capital investment for shore-to-ship power installations on ships and at ports.

3 Ro-pax ships visiting the port of Tallinn in Estonia on a regular basis

Shipping line	Vessel	Estimated port visits (p.a.)	Average (weighted) time at port (h)	Investments	
				Ship side (thousand $)	Shoreside* (thousand $)
St. Peter Line**	SPL Princess Anastasia	50	7.5	780	650
Tallink Silja	Victoria I	180	8	975	910
Tallink Silja	Baltic Queen	180	8	975	910
Eckerö	Finlandia	600	3.75	975	910
Viking Line	Viking XPRS	734	5.6	975	910
Tallink Silja	Star	1,095	3	975	910
Tallink Silja	Superstar	1,095	1	975	910

* Investments are lower because ships do not need frequency conversion.
** Investment costs are considered for the LV shore connection.

4 Efficiency of investments in shore-to-ship power projects for regular ro-pax/ferry ships in Tallinn to reduce port SO_2 emissions*



* The Baltic Queen and Victoria I have the same level of investment efficiency to reduce emissions at port.

As SO_2 is considered one of the most harmful exhaust gases, it has been used by ABB for shore-to-ship power benchmarking. The maximum sulfur content of 0.1 percent has been set by legislation in Emission Control Areas (ECAs). The maximum emissions of SO_2 in ECAs is 0.41 g/kWh.[2] The efficiency of investments in shore-to-ship power projects among different segments to reduce SO_2 emissions at port are shown in → 2.

Cost efficiency of shore-to-ship power is identified as the ratio of annual emissions at port to capital investments in electrical infrastructure onboard or at port. Assuming that ships' generators are the same age among segments and consume the same type of fuel at port (MDO/MGO), their fuel emissions also can be assumed to be the same. The emissions reduction cost-efficiency ratio shows how much port emissions can be reduced annually for each dollar spent on capital investment for shore-to-ship power installations on ships and at ports.

The cost efficiency to reduce emissions with shore-to-ship power for the ro-ro/ro-pax/ferry segment is one of the highest for ship and port investments. The emissions reduction directly depends on energy consumption. If for each kWh of shore power, the port or ship would be able to earn or save a fixed amount of money, the efficiency of investment ratio can be used as a benchmark for payback period among different segments. The shortest payback period for a shore-to-ship power project for port and ship infrastructure would be for the ro-ro/ro-pax/ferry segment. It should be noted that this framework is based on a typical profile of shipping segments, but there might be projects in which ships would have better or worse emissions reduction cost efficiency.

On March 26, 2014 the European Commission adopted the "implementing decision" to establish a Multi-Annual Work Programme for financial assistance in the field of the Connecting Europe Facility (CEF) transport sector for 2014–2020, supporting the development of the Trans-European Transport Network (TEN-T). There are 64 core ports identified by TEN-T guidelines;[3] these ports are eligi-

Footnotes

2 For purified fuel with a sulfur content of 0.1 percent, as identified by the ABB business case tool. For areas outside Emission Control Areas, the maximum content of sulfur in the fuel is 3.5 percent; the maximum emissions of SO_2 is 14.35 g/kWh.

3 As identified by: European Commission. (2013, September). The Core Network Corridors. [Online]. Available: http://www.tentdays2013.eu/Doc/b1_2013_brochure_lowres.pdf

5 The Port of Ystad in Sweden utilizes shore-to-ship power to keep emissions down.

Shore-to-ship power is a well-established solution for complete emissions reduction from ships at port.

ble for financial support for shoreside electricity projects set in line with Motorways of the Sea[4] priorities. Such shore-to-ship power projects could receive up to 20 percent[5] of the funding, according to the CEF regulation, provided adequate cost-benefit analysis is implemented. Based on the framework identified above an example of a cost-benefit analysis was done for regular ro-pax ships at the Estonian port of Tallinn → 3.

The Port of Tallinn authority is considering installing shore-to-ship power and, assuming a limited budget, the investment should be allocated to the segment with the highest emissions reduction cost efficiency. The ferry routes between the Baltic states, Finland and Sweden are highly competitive; shipping lines often rotate vessels from one shipping route to another based on market demand and company performance. It is therefore hard to predict long-term schedules for particular ships and how long they will stay at a port on a regular basis. Analysis of the emissions reduction cost efficiency is based on intermittent schedule results, which were acquired in June 2014. The Tallink Europa is excluded from the analysis due to rear use of the ship; the Viking XPRS is also excluded because it is LNG-driven and the emissions footprint at port is already reduced. The investment costs are calculated for the turnkey electrical installation. The parameters of the ro-pax ships visiting the port of Tallinn on a regular basis are shown in → 3.

Of the ships visiting the port of Tallinn only the Princess Anastasia has the power outlet capable of accepting shore power, and only in low voltage with a maximum capacity of 2,700 kW / 0.4 kV. The shore connection panel was installed onboard this ship for connection in Stockholm where electricity is much cheaper due to reduced excise duties (see “Clean air in the docks” in ABB Review 3/2014). The average nominal power requirements for the Princess Anastasia are assumed to be 2,000 kW. According to a survey performed by ABB the average nominal shore-power requirement for the Victoria I and the Baltic Queen also can be around 2,000 kW with a peak of 2,500 kW. Estimating that all other ships will require on average nominally 1,500 kW, the Tallink Star will demand 1,200 kW due to night stays at the port when the power requirements are much lower. The port of Tallinn is located in an ECA where SO_2 emissions from fuel are capped at 0.41 g/kWh. Assuming the ships using MDO/MGO emit this same amount, the efficiency of investment to reduce port emissions with shore-to-ship power can be determined → 4.

The best environmental benefits

Financial support is a well proven means of stimulating development of environment-oriented and capital-intense projects. With the financial support available to develop TEN-T infrastructure for ports, it is important to allocate funds to the most cost-effective projects. Shore-to-ship power is a well-established solution for complete emissions reduction from ships at port → 5. Although the efficiency of investments in shore-to-ship power infrastructure can significantly vary among ship types, as a general rule ro-ro/ro-pax/ferry ships have the highest cost efficiency and thus are recommended for prioritized implementation in TEN-T port infrastructure.

Petr Guryev
Formerly with ABB Smart Grids
petr.guryev@gmail.com

For more information about ABB’s shore-to-ship power offering, visit www.abb.com/ports or write to shore-to-ship@ch.abb.com

Footnotes

4 Motorways of the Sea is a TEN-T project that “aims to promote green, viable, attractive and efficient sea-based transport links.” See www.mos-helpdesk.eu

5 According to the Commission Implementing Decision C (2014) 1921

Further reading
P. Guryev, “Clean air in the docks: Taxation incentives can improve air quality in ports,” ABB Review 3/2014, pp. 76–79.

Contact us

ABB Switzerland Ltd
Power Systems
Bruggerstrasse 72
CH-5400 Baden, Switzerland
Phone: +41 58 585 77 44
Fax: +41 58 585 55 77
E-Mail: substations@ch.abb.com

ABB S.p.A.
Power Systems
Via Luciano Lama 33
20099 Sesto San Giovanni (MI), Italy
Phone: +39 02 2415 0000
Fax: +39 02 2414 8008
E-Mail: contact.center@it.abb.com

www.abb.com/substations

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