LOWERING PORT EMISSIONS THROUGH SHORE-TO-SHIP ELECTRIC POWER SUPPLY

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Abstract: *While moored at port, ships require power to maintain their lights, heating, cooling, and other essential vessel functions. Usually, this power is provided by running the ship's auxiliary engines (generators) on diesel fuel. Normally ship uses more than one generator during cargo operations.*

Shore power, also known as "Cold-ironing" or Alternative Marine Power (AMP), is the process of providing electrical power from the shore to a ship while it is alongside the pier, thereby allowing a ship's auxiliary engines to be turned off and preventing burning of diesel fuel. Therefore, shore power is an effective way of reducing air emissions and improving port area air quality. Additionally, by providing ship operators with an alternative to running diesel auxiliary engines, shore power technology also reduces ship owners' fuel costs.

Keywords: *Ship power supply, "Cold-ironing", Alternative Marine Power (AMP), environmental protection, port operations*

НАМАЛЯВАНЕ НА ПРИСТАНИЩНИТЕ ЕМИСИИ ЧРЕЗ БРЕГОВО ЕЛЕКТРОЗАХРАНВАНЕ НА КОРАБИТЕ

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Резюме: *Докато са швартовани в пристанище, корабите се нуждаят от захранване, за да поддържат своите светлини, отопление, охлаждане и други основни функции на кораба. Обикновено тази мощност се осигурява от спомагателните двигатели на кораба, работещи с дизелово гориво. Обикновено корабът използва повече от един генератор по време на товарни операции.*

Бреговото захранване, известно още като „Cold-ironing" или алтернативно морско захранване (Alternative Marine Power – AMP), е процес на осигуряване на електрическа енергия от брега до кораб, докато той е на кея, като по този начин позволява изключване на спомагателните двигатели на кораба и предотвратява изгарянето на дизелово гориво. Следователно захранването от брега е ефективен начин за намаляване на емисиите във въздуха и подобряване на качеството на въздуха в пристанищния район. Освен това, като предоставя на корабните оператори алтернатива на работата на дизелови спомагателни двигатели, технологията за захранване от брега също намалява разходите за гориво на собствениците на кораби.

Ключови думи: *Корабно захранване, „Cold-ironing", алтернативна морска енергия (AMP), опазване на околната среда, пристанищни операции*

1. Introduction

Like all the economic sectors, shipping generates greenhouse gas (GHG) emissions and it is struggling to reduce them. International shipping carries over 80% of the world goods trade volume and it is claimed to produce nearly 3% of all global GHG emissions. Every year, the conventional shipping industry pours out some 600 to 700 million tonnes of carbon dioxide into the atmosphere [8].
Although shipping contributes relatively small shares of GHG emissions per unit of transport work, without further action, emissions from the sector would continue to increase. Commercial shipping is governed by rules and regulations negotiated and agreed at the International Maritime Organization (IMO). In the resent years many steps have been taken in order to prevent air pollution, starting in 1997 with adoption of MARPOL 73/78 Annex VI. The Annex entered into force on 19 May 2005 and set limits on sulphur oxide (SOx) and nitrogen oxide (NOx) emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances, designated emission control areas set more stringent standards for SOx, NOx and particulate matter. With this Annex were introduced Emission Control Areas (ECAs) for SOX emission control, Energy efficiency design index (EEDI), Ship Energy Efficiency Management Plan (SEEMP) and 2 new ships certificates – International Air Pollution Prevention (IAPP) Certificate and International Energy Efficiency (IEE) Certificate [4]. With Resolution MEPC.304(72) the IMO has initiated a GreenVoyage2050 Project, which sets out a clear vision and levels of ambition, one of which is to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 [6].

On European level, EU Recommendation 2006/339/EU promotes the implementation of shore-side electrical facilities, while EU Recommendation 2003/96/EC proposes the subsidisation of shore-side power supply for ships through the cancellation of electricity taxes. At same time European Union is working for reducing GHG as well [2]. Issuing the FuelEU Maritime Regulation and the Alternative Fuels Infrastructure Regulation will reduce the carbon footprint of the maritime sector in the EU. The EU has also introduced the **Fit for 55** package, a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are into line with the climate goal of reducing EU emissions by at least 55% by 2030 [9].

Additionally, from 1 January 2024, the EU Emissions Trading System (EU ETS) is extended to cover CO2 emissions from ships of 5,000 GT and above calling EU ports, regardless of flag. Ships engaged in voyages between two EU ports, and voyages between the EU and a third country, will be covered by the EU ETS. In compliance, shipping companies will be mandated to submit verified Company Emissions Reports to the competent authority, using data derived from MRV (Measurement, Reporting, and Verification).

2. Shore Power Supply Technology

Increases in maritime shipping and environmental pollution concerns have created a demand for ship-to-shore power solutions that comply with environmental restrictions in ports [3]. Even berthed alongside, ships' need of uninterrupted electric power is essential for various operations. Normally this electric power is generated by diesel auxiliary engines, but their operation leads to air and noise pollution. The burning of fossil fuels produces CO2 emissions and contributes to global climate change. The Shore Power Technology ("Cold-ironing") is an effective and environmentally friendly practice and is one of main ways to limit air pollution and greenhouse gas emissions and to improve air quality in ports and neighboring areas. The process of ships shutting down on-board generation and then plugging into shore-side power while alongside, can reduce air pollution significantly.

In both European Regulations, mentioned above, is pointed an obligation for passenger ships and containers to use on-shore power supply for all electricity needs while moored at the quayside in major EU ports. The IMO has also developed guidelines on safe operation of onshore power supply (OPS) service in port for ships engaged on international voyages, aiming at safe operation of the system [5].

The onshore power supply system is equipment, which can supply onshore electric power to ships, moored in port, both High and Low Voltage. Except shore installations, it requires also ship-side installations in order to accept shore power. On both sides the installations consist of different parts: switchgear and protections, transformers, frequency convertors (if necessary), plugs, power cables, automation, cable monitoring system etc. Shore power can be supplied to all types of vessel and has been used for years for smaller vessels, but also some for larger passenger vessels. Smaller vessels are capable of making use of normal grid voltage and frequency, and replace the energy from the generators with the shore power with only marginal investments. For the larger vessels with higher power requirements is more complicated. To serve these vessels with shore power, dedicated and relatively costly installations are required, both on land and on board the vessels. This normally is done through a shore power dispenser, or HVSC (high voltage shore power connection). (Fig. 1)

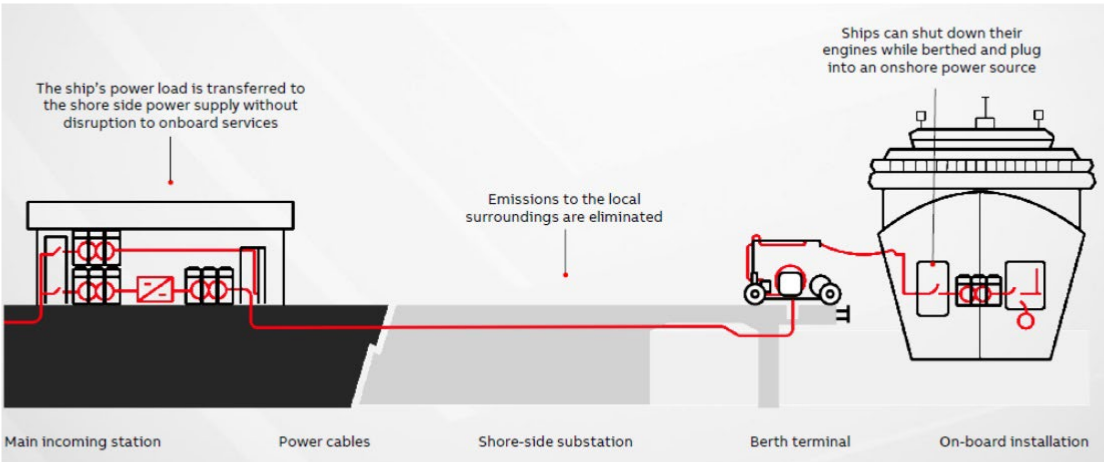

Fig.1. Schematic diagram of shore power supply. Source: https://new.abb.com

There are several basic types of OPS systems (Fig. 2):

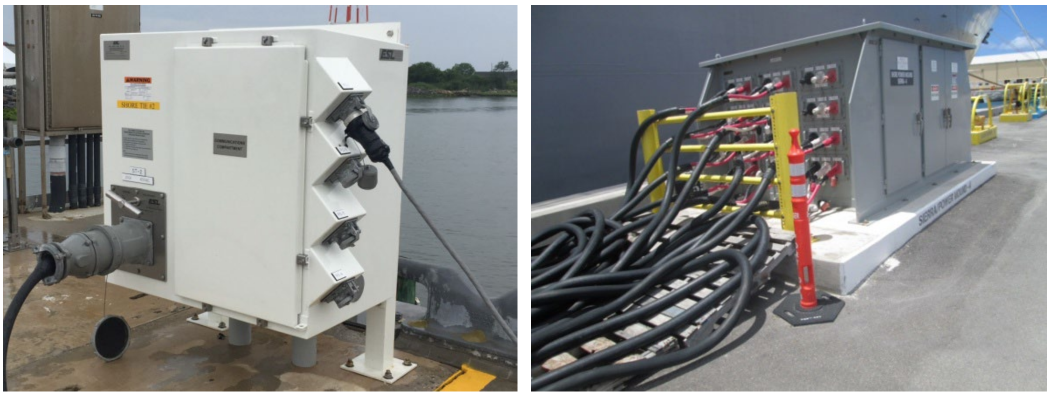

Fig.2a. Fixed OPS systems.

Fig.2b. Mobile OPS systems.

Fig.2c. Telescopic OPS systems.

Fig.2d. Container-based OPS systems (normally in high-cube containers).

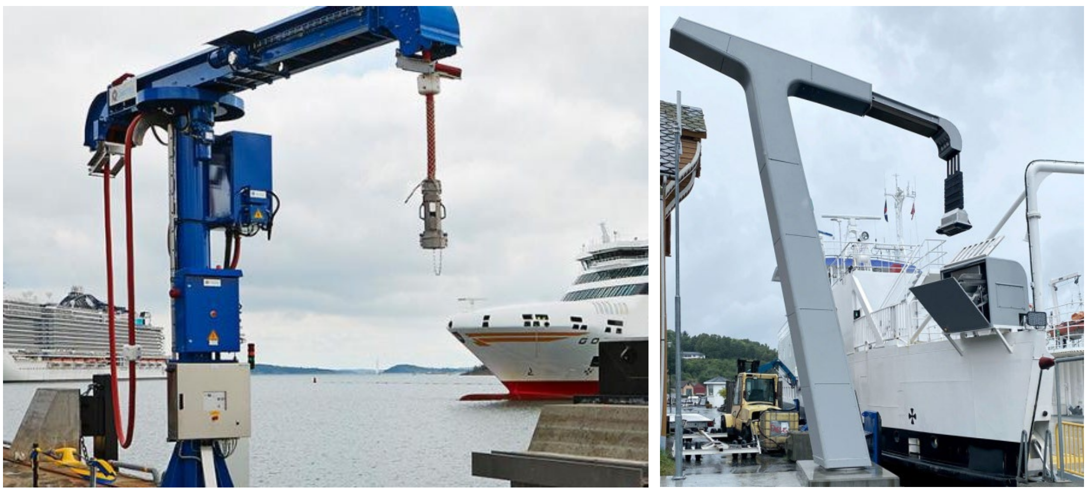

Fig.2e. Battery-charging OPS systems.

Shore power supply continues to develop, recently a new type of wireless charging systems came in operation. They replaced traditional cable connection method, facilitating transfer of electric power to ships. Shore charging is covering from low rated manually connectable charge lines to huge automatic, robotic power connections, both AC- and DC-charging. These systems are particularly suitable for fully electric vessels using batteries, such as ferries. The main advantage for them is that charging starts as soon as the vessel is moored, without waiting for connecting charging cables, which shortens their time in the port.

For calculating the estimated reduction in emissions that can be achieved by drawing from the shore-side utility grid instead of generating electric power using onboard generators ships, CO2 calculators are developed, as these of ABB, SPEC and DNV GL.

Two common standards are regulating the OPS. The IEC 80005-1 describes a high voltage solution for container, RoRo and cruise vessels and LNG carriers and tankers, and this standard can also be applied to PCTC (Pure Car-Truck Carriers), RoPax vessels such as ferries and super yachts. The IEC 80005-3 standard regulates a low voltage solution for all vessels that need up to 1 MW shore power, for example bulkers or offshore vessels. Regardless of the solution in question, it must be approved by a classification society.

The shipping industry plays a crucial role in global trade, but it also contributes to air and water pollution through the burning of fossil fuels. Traditional shipboard power generation systems, relying on diesel engines, emit substantial amounts of greenhouse gases, sulfur oxides, and nitrogen oxides, negatively impacting both the environment and public health. Shore-to-ship electric power supply is emerging as a sustainable alternative to address these challenges, it represents a vital step towards greening the maritime industry [7]. As the world focuses on sustainable practices and combating climate change, the implementation of such solutions becomes imperative. By embracing shore-to-ship power supply, the shipping industry can not only reduce its environmental impact but also contribute to creating cleaner and more liveable port communities. As technology advances and collaboration between stakeholders strengthens, shore-to-ship power supply is poised to become a standard practice, shaping the future of sustainable maritime operations.

There are still a number of unresolved issues in regard of OPS:

- Many ports still do not have the appropriate infrastructure to connect to vessels, as shore power components and upgraded connections to the electrical grid are often required. Implementing shore power infrastructure requires coordination between port authorities, energy providers, and shipping companies. Compatibility issues between different ships and shore power systems can also pose challenges.
- Ports need to invest in the necessary infrastructure, including onshore power supply systems and the installation of electrical connections at berths. The cost and logistics of retrofitting existing ports can be a significant consideration. While there are initial costs associated with installing the necessary infrastructure for shore power, the long-term benefits can include cost savings for shipping companies. Shore power can be more cost-effective than running onboard generators, especially in regions where electricity prices are competitive.
- Ships must be retrofitted with vessel-side infrastructure to connect to shore power systems, which can be costly and require thoughtful planning about component placement.
- While shore power can reduce or eliminate auxiliary engine emissions at berth, it does not address emissions from boilers or other vessel sources that must be operational while the vessel is at berth. Vessels also continue to emit while in the process of connecting to and disconnecting from shore power.

3. Shore Power Supply process

The whole process of OPS is governed by international regulations – IMO's MSC.1/Circ.1675 from 27 June 2023 [5], High Voltage Shore Connection (HVSC) Regulations by IEC, ISO and IEEE, EMSA Quick-Reference Guide and requirements of different classification societies – Lloyds, DNV GL, RINA, ABS, etc. The main concern during the entire operation shall be the safety of the ship and shore system. Both shore- and ship-sides should specify responsibilities and assignments, including the persons in charge (PIC) of the operation, who have to complete a pre-connection checklist. Before starting the operation for electric power supply, all necessary inspections and tests shall done, as well as an equipotential bonding between the ship hull and shore grounding electrode should be established. All the personnel engaged in power supply operation shall be well familiarized and wear appropriate safety equipment. Establishing a proper and secure communication between shore and ship's crew is of utmost importance for the safety.

Generally, the sequence for connecting and disconnecting a vessel to shore power includes the following steps:

• Vessel arrives in port.

• Power cables and control cables are connected.

• The last running engine is synchronized with the shore power grid.

• After the shore connection circuit breaker is closed, the generator is off-loaded and the engine is stopped.

• Before the vessel departs from the port, the first engine is started and synchronized with the shore power grid.

• After the load is transferred to the generator, the shore connection opens.

• Power cables and control cables are disconnected and the vessel is ready for departure.

Conclusions

In recent years, the maritime industry has been undergoing a significant transformation towards sustainability and environmental responsibility. Energy consumption in shipping is almost exclusively fossil fuel based, with heavy fuel oil (HFO) and marine diesel oil/marine gas oil (MDO/MGO) responsible for the largest shares of GHG emissions. Shore power is an effective way of reducing air and noise pollution, improving air quality in sensitive, densely populated port areas. One promising development in this journey is the implementation of shore-to-ship electric power supply systems. Many ports and regions around the world are implementing or considering regulations to encourage or require the use of shore power. This is often part of broader efforts to reduce emissions from the maritime sector and improve overall environmental sustainability.

The global shore power market in terms of revenue was estimated to be worth 1.6 billion USD in 2022 and is expected to reach 2.8 billion USD by 2027. The increasing demand for reducing carbon emissions and noise pollution is expected to fuel the demand for shore power during this forecast period [1]. But here comes the question – will the certain port be able to access sufficient energy and power to meet the needs of visiting vessels and in-port facilities at times of high demand?

While shore power has been adopted in some ports globally, it is not yet universally implemented. The industry's move toward greater sustainability and regulatory developments will likely drive increased adoption in the future. Currently 51 ports in 15 EU member states are equipped with 340 shore power connectors, and Sweden, the Netherlands and Germany lead the pack. The current shore power network supplies around 309 MW, mostly for container, passenger and cruise ships. The forthcoming revision of both EU regulations should include a requirement for all ships greater than or equal to 400 GT to connect to shore power in EU ports. To achieve this, the EU will require nearly 1,929 MW of additional shore power installation to meet average at-berth annual energy demands, and 3,342MW for peak energy demand [10]. On the other hand, the installation of new or retrofit shore power solutions requires electrical infrastructure development, which is a capital-intensive risk – the shore-side installation cost ranges from 5 to 20 million USD [1]. Significant investment will be also retrofitting (modifying) of existing ships for receiving shore electric power supply, as the cost of adapting a vessel for shore connection depends on the plant design and the possibility of varying the voltage and frequency range when needed.

In addition to traditional shore power, alternative technologies, such as mobile battery systems and hydrogen fuel cells, are being explored as potential solutions to provide clean power to ships in port.

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