

WÄRTSILÄ EGCS

- The Latest Technology and Achievements

1. INTRODUCTION

Since the introduction of the very first sulphur related marine regulations, exhaust gas cleaning (EGC), also known as SO_x scrubbing, has been an integral part of the solution to reduce the SO_x emissions to compliant levels. EGC systems (EGCS) have a long track record of land-based installations and have since been successfully adopted in marine applications. As a result, marine EGCS has cemented its role as an attractive and efficient means of complying with the International Maritime Organisation's (IMO) sulphur regulations, both in Emission Control Areas (ECA) and open seas.

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The 0.5% global sulphur cap that came into force in the beginning of 2020 was the catalyst to truly accelerate widespread scrubber adoption. Consequently, a great number of vessels were contracted with scrubber on board as January 1, 2020 approached. The trend was the same for both newbuilds and retrofits.

Wärtsilä's longstanding experience in the marine scrubber field has its roots in the development of inert gas scrubbers. This experience kickstarted SO_x scrubber development and enabled Wärtsilä to establish itself as the leading marine EGCS supplier.

However, new (forthcoming) requirements on emissions control from shipping's regulators, as well as various customer needs, demand constant R&D and product development efforts. This paper gives some insights to the current state of the art scrubber technology.



2. SCRUBBER TECHNOLOGY

2.1 Proven technology for various needs

Wärtsilä currently has three different standard portfolio products, listed below by order of their release to market:

- V-SO_x
- I-SO_x
- Q-SO_x

All these wet scrubbers are available with three different operating principles:

- Open Loop (OL)
- Closed Loop (CL)
- Hybrid

V-SO_x uses a venturi for the gas inlet into the scrubber body, as shown in the picture below. Efficient cooling of the exhaust gas flow and very good particulate matter (PM) reduction are intrinsic to the venturi model. Depending on the chosen configuration there can be a single venturi, or several venturis attached to the scrubber body.

I-SO_x is an inline system where exhaust gas enters the scrubber body directly from below. Hence, it does not require an additional exhaust gas bend piping originating from a bypass setup.

Q-SO_x is another side inlet type scrubber but instead of a venturi it has a single quench instead. By design, it is somewhat more cost efficient than the V-SO_x.



I-SO_x scrubber body.



V-SO_x scrubber body with a venturi.



Q-SO_x scrubber body with a quench.





2.2 Materials matter

There are various stainless steel grades on the market to choose from. However, given the corrosive environment, as well as the lifetime installation requirement for the scrubber, only certain steel qualities can properly withstand the conditions found in the scrubber body and the venturi / quench. In case of an inline type scrubber there is the added complexity of a dry running-related temperature requirement that needs to be taken into consideration.

There are different types of corrosion, e.g. pitting, galling, galvanic, and crevice corrosion. When it comes to conditions in scrubbers however, it is pitting and crevice corrosion that are the most relevant ones.

Pitting corrosion creates small, localized attacks, or pits, to the protective layer, which then spread to the metal itself. Pitting corrosion resistance can be estimated with a calculated value called 'Pitting Resistance Equivalent Number' (PREN): PREN = %Cr + 3.3 x (%Mo + 0.5%W) + 16 x %N where the percentages refer to weight-% of the corresponding elements in the composition.

It should be noted that PREN is only truly meaningful within the same stainless steel family (e.g. austenitic, ferritic, etc.). The higher the PREN, the better the pitting resistance.

Crevice corrosion occurs when a crevice between the stainless steel and another material allows chlorides to concentrate or prevents proper oxygen levels to regenerate the steel's oxide layer.

The difference between 'insufficient quality' – even if it would be considered good quality in some other applications – and 'required quality' can clearly be seen after some years in use. In the worst case scenario, this difference can be observed after only just a few weeks.

Using proper steel quality has been in the core of Wärtsilä's scrubber philosophy since the beginning and continues to be so going forward. This philosophy is based on the smart combination of different materials and plate thicknesses in the different parts of the scrubber, to keep cost, durability, and weight in an optimum balance.

2.3 Control and automation

A robust control and automation system with a user-friendly human machine interface (HMI) enables extensive safety features and convenient operation of the system by the ship crew. It is a prerequisite to prevent a range of issues, notably accidental flooding of the scrubber. This could cause water entering the turbochargers/engine and a subsequent engine blackout. In addition, being able to effortlessly provide the necessary reports to a range of bodies, including port authorities and for internal use, is of paramount importance.

Wärtsilä has performed an extensive failure mode, effect, and criticality analysis (FMECA) for its EGC control system. The FMECA is generally a tool for qualitative or semi-quantitative analysis of risk through identification of failure modes and corresponding effects to personnel, equipment, environment, and operation. It has been done to identify critical parts of the EGC standard control system, with a focus on availability and safety.

The FMECA ensures that critical equipment is reviewed systematically, and potential failure modes and the consequence of each failure mode is described. All identified failure modes have been ranked based on the criticality of the failure effect.

2.4 Connectivity

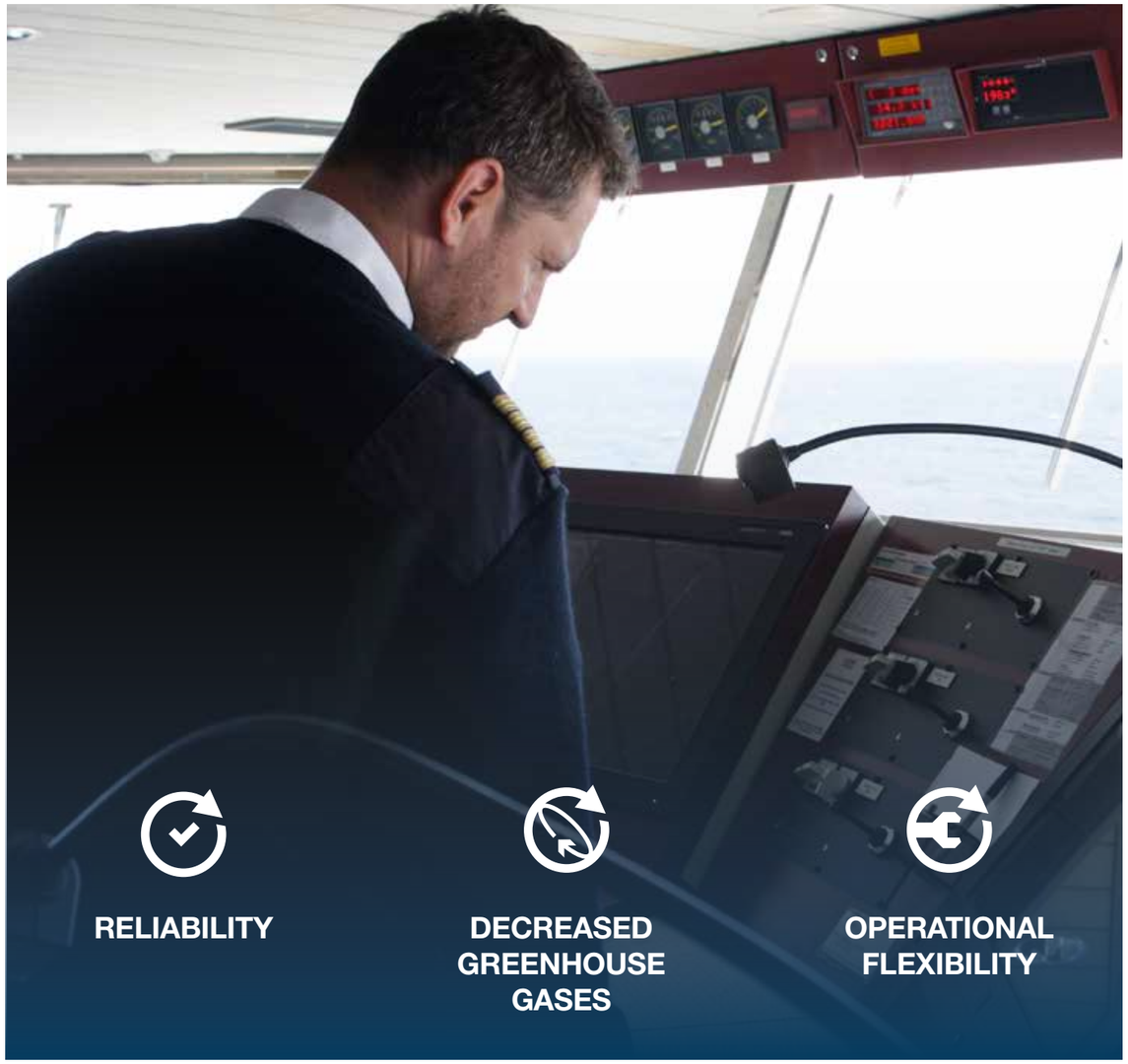
Connectivity is becoming an increasingly important aspect of scrubber systems. Consequently, it is possible to have a secure remote connection with the Wärtsilä scrubber system via a Wärtsilä Data Collection Unit (WDCU). This enables new reporting and advanced troubleshooting features, without sacrificing cyber security.



3. BENEFITS OF SCRUBBING

3.1 Operational flexibility

One of the great advantages of using a scrubber system is the operational flexibility it provides. Namely, one can continue operating the vessel with traditional (high sulphur) heavy fuel oil (HFO) while still complying with the IMO's sulphur regulations. In addition to lower operating costs compared to using low sulphur fuel oil (LSFO), scrubbers have been observed to provide an added benefit in terms of reliability of operations. This is due to different kinds of engine and fuel oil handling-related issues arising from variations in the properties of very low sulphur fuel oil (VLSFO) including viscosity, density and the chemistry of the fuel.



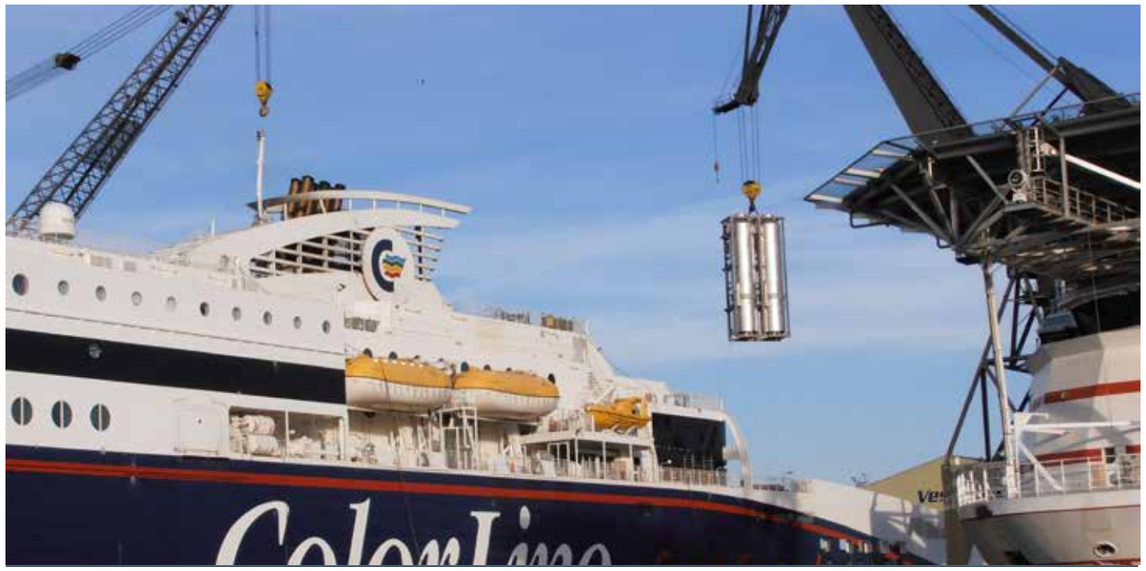
Fuel handling issues observed include separation failure, blocked filters, solids separation and cold flow / low viscosity at low temperature.

Engine problems have originated from piston ring breakage, injector failures, liner wear and scavenge fire. [1]

Another aspect is the higher risk of receiving an off-spec fuel oil batch related to the sulphur content when dealing with LSFO or VLSFO. This is because the standard commercial terms referring to ISO 8217 specification allow for a 95% confidence limit on the sulphur content, namely max 0.53% sulphur in case of LSFO, whereas IMO Marpol Annex VI regulation's 0.50% is a firm limit. [2]

The same firm limit naturally applies to HFO's 3.5%. However, it can be very difficult to find such fuel oil quality, with the global average having been at around 2.5 - 2.7 % sulphur.

Fortunately, IMO will adopt new rules that harmonise test methods. The rules are set to enter into force on April 1st, 2022. [3]





3.2 Decreased greenhouse gases

Compared to earlier HFO operations, both HFO with EGCS and VLSFO operations result in somewhat increased well-to-wake CO_2 emissions. This is because both EGCS operation and the fuel desulphurisation process require additional energy.

However, according to studies, the total well-to-wake CO_2 footprint of using a scrubber is lower than that of fuel oil desulphurisation. [4, 5]

It is also worth noting that EGCS-related CO_2 emissions are predominantly created during operation, while manufacturing-related emissions play only a very minor role.

4. OPERATIONAL EXPERIENCE

4.1 Wärtsilä scrubber reference base

Wärtsilä has been at the forefront of the marine scrubber business since its early stages. At the time of writing there are in total ca. 4 400 vessels with scrubbers in operation or on order according to DNV data. Of these, ca. 580 are sold by Wärtsilä.

13 %

OF SCRUBBERS WORLDWIDE HAVE BEEN SOLD BY WÄRTSILÄ

The sheer number of Wärtsilä units means the organisation accumulated a great amount of both manufacturing and operational experience with scrubbers. Key findings of those are presented in the following.

4.2 Corrosion

As discussed earlier in chapter 2, the chosen scrubber material(s) obviously plays a fundamental part in the corrosion resistance. But that is not all there is to it, as welding and related activities are other extremely important factors. It is therefore extremely important to pay attention to both welding quality and subsequent surface treatments, namely pickling and passivation.

Pickling is a metal treatment process that removes superficial impurities from metal. It also removes the oxide layer but doesn't harm the underlaying steel. Passivation restores the oxide layer. Both pickling and passivation are chemical treatments applied to the surface of stainless steel to remove contaminants and assist the formation of a continuous chromium-oxide passive film.



Using high alloy steels doesn't pay off if the welding and the surface treatments are not done properly. This was a lesson learned with a new welding supplier. Structural rust was observed in the welding seams after having taken the equipment in use. Rust removal followed by pickling and passivation needed to be done onboard the vessel to rectify the situation.

The root cause was traced to the welding, picking and passivation process at that specific welding supplier. Hence, corrective actions were taken to prevent this in the future.

It is also not uncommon to find the internal surfaces of the scrubber unit to be covered with a thin loose layer of rust – even if the scrubber material and the welding seams are in perfect condition. This externally induced corrosion originates from grinding splatter or inferior piping materials in the upstream of the scrubber body. In that case, closer examination will show that the steel material itself is intact under the loose rust layer, i.e., there are no signs of pitting in the steel material.

According to DNV the discharge diffusers have been observed to be prone to corrosion. Accordingly, any stainless steel in the diffuser seems to be vulnerable to abrasion and pitting. It is worth noting that Wärtsilä standard design does not have any diffusers in the overboard discharge.

The spool piece - the piece of piping between the SO_x scrubber overboard valve and the ship's hull - is another place where DNV have observed corrosion. According to their recommendation, the spool piece should be designed with a bolted or otherwise non-welded stainless sleeve. This has a high corrosion and abrasion resistance and enables more convenient annual class surveys. However, it does require high manufacturing and installation accuracy. [6]





4.3 Installation

There are various things that can go wrong during installation, especially if the scrubber installation time is very limited, as it usually is in the case of retrofit installations. This can unfortunately lead to cutting some corners to complete the jobs quickly.

For instance, it has been observed in some cases that connecting the cables has not been done according to industry standards, or/and the yard has used wrong type of connectors e.g. with the ethernet cables. As a result, the scrubber system has started generating communication failure errors due to cables detaching or creating shortcuts after the vessel has been operating for a while.

One way of preventing installation related issues is opting for dedicated scrubber installation supervision / site advisory. This will enable proactive monitoring of any issues during the installation phase, rather than afterwards during operation at the sea. This will result in reduced overall costs and smoother operations.

4.4 Operational issues

According to Wärtsilä's experience, a major part of scrubber-related operational issues originates from the lack of proper maintenance of the scrubber system. More specifically, it seems that this effect is more pronounced with the more delicate equipment of the system, namely the continuous emissions monitoring and water monitoring systems.

As a result, there can be filter clogging or calibration-related issues that can render the complete system as being non-compliant – even if it was cleaning as intended the whole time.

The best remedy for these issues is to host a dedicated scrubber system training programme for the ship crew and make sure that the learnings are transferred to new crews and / or crew members.

It is important to realise that even if the system is functioning for the most part automatically, it still requires maintenance as any other machinery on board the vessel.



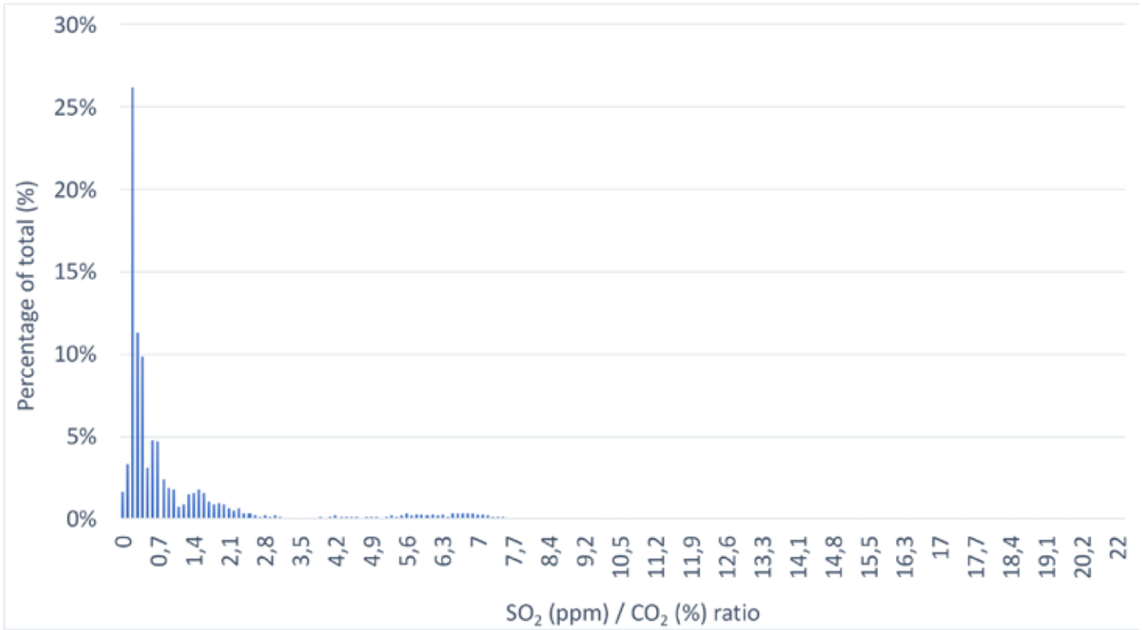
4.5 Actual SO_x emissions

It can be easily overlooked that scrubbers normally actually clean the SO_x emissions to much lower level than what is required by the regulations and consequently, to much lower level that what would be emitted when using compliant low sulphur fuel.

A good example of this can be observed by looking at months' worth of data from a sailing vessel operating with a Wärtsilä scrubber in open loop mode outside SO_x emission control area (SECA). That would mean 0.5% sulphur fuel if operating with compliant fuel, which corresponds to a SO_x (ppm) / CO_2 (%) ratio of 21.7. However, when looking at the scrubber data it can be observed that for the vast majority of the time the SO_x (ppm) / CO_2 (%) ratio with the scrubber has been between 0.1 to 0.4.

That means the SO_x emissions with the scrubber were ca. 92% lower than what they would have been by using compliant fuel.

This means that scrubber is not only more efficient from the greenhouse gas emissions point of view, as discussed earlier in Chapter 3, but also from an actual SO_x emissions point of view.



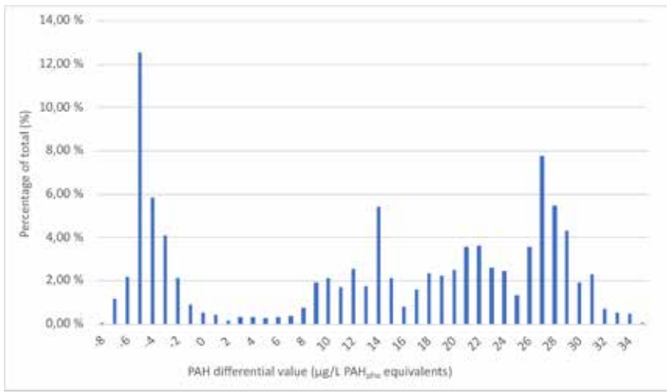
Cumulative distribution of SO_2 (ppm) / CO_2 (%) values in open loop mode.

4.6 Actual emissions to water

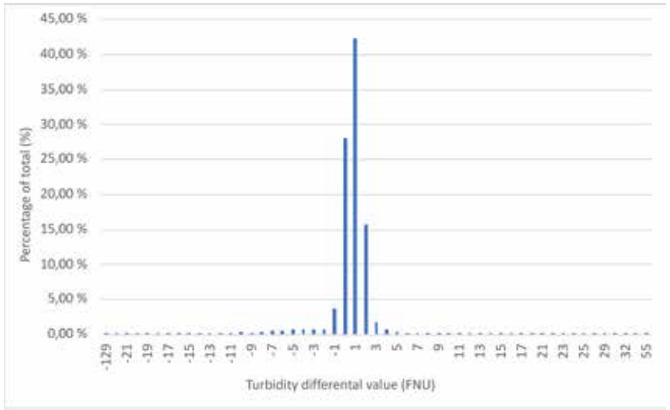
In addition to emissions to air, there are also strict regulations on the emissions to water from the scrubber.

> Using the same data as earlier it can be concluded that PAH (Polycyclic Aromatic Hydrocarbon) and turbidity values were well within the limits, at 50 µg/L PAHphe and 25 FNU / NTU (formazin nephlometric units / nephlometric turbidity units), respectively.

It should be noted that the negative values originate from the differential nature of the measurement, i.e., the value shown is the difference between the outlet and inlet measurements.



Cumulative distribution of PAH values in open loop mode.



Cumulative distribution of turbidity values in open loop mode.

5. PREPARED FOR THE FUTURE

5.1 Combination with an EGR

Combining a scrubber system with an exhaust gas recirculation (EGR) system opens a possibility to comply with both SO_x and NO_x emissions regulations without an additional selective catalytic reduction (SCR) system.

This configuration is highly cost effective and enables low exhaust emissions while virtually eliminating reagent costs.

5.2 Expert Insight

Wärtsilä's digital predictive maintenance product, Expert Insight, is now also available for scrubbers as a minimum viable product (MVP). Data evaluation and recommendations by Wärtsilä product experts, as well as predictive maintenance features, will be released in the near future.

The Expert Insight for scrubbers MVP is available for all Wärtsilä scrubber configurations, i.e., I-SO_x, V-SO_x, and Q-SO_x in open loop, closed loop and hybrid configuration. It currently provides valuable compliance information, including automated non-compliance incident reporting, scrubber usage statistics, and a live compliance map. Authorised users can access the data regardless of their location using an online 'Collaboration App' tool, where dashboards and performance indicators give easily understandable insights into scrubber operation. Local access is naturally also available.





REFERENCES

[1] https://www.rivieramm.com/news-content-hub/handling-issues-and-engine-damage-ndash-are-vlsfos-to-blame-62133

[2] https://shipandbunker.com/news/world/466439-feature-the-growing-problem-of-imo-2020-vlsfo-bunkers-with-marginally-off-spec-sulfur

[3] IMO MEPC 75

[4] “Well-to-wake energy and greenhouse gas analysis of SOX abatement options for the marine industry”, Hongrui Ma, Koen Steernberg, Xavier Riera-Palou, Nigel Tait, Transportation Research Part D 17, pp. 301–308, (2012)

[5] “Comparison of CO2 emissions of MARPOL Annex VI compliance options in 2020”, Jasper Faber, Anne Kleijn, Diederik Jaspers, CE Delft, (August 2020)

[6] “DNV GL Technical and Regulatory News No. 20/2019, revised Feb 2020”

green shipping”, Tor Øyvind Ask, The Motorship Propulsion & Future Fuels Conference 2019



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22.03.2021

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Wärtsilä's extensive reference list is evidence of our know-how and expertise in this field, and our expert team is ready to assist you every step of the way; from planning and selecting the right solution to post-installation service agreements.

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