

X-DF by WinGD

The proven platform for
fuel-flexibility

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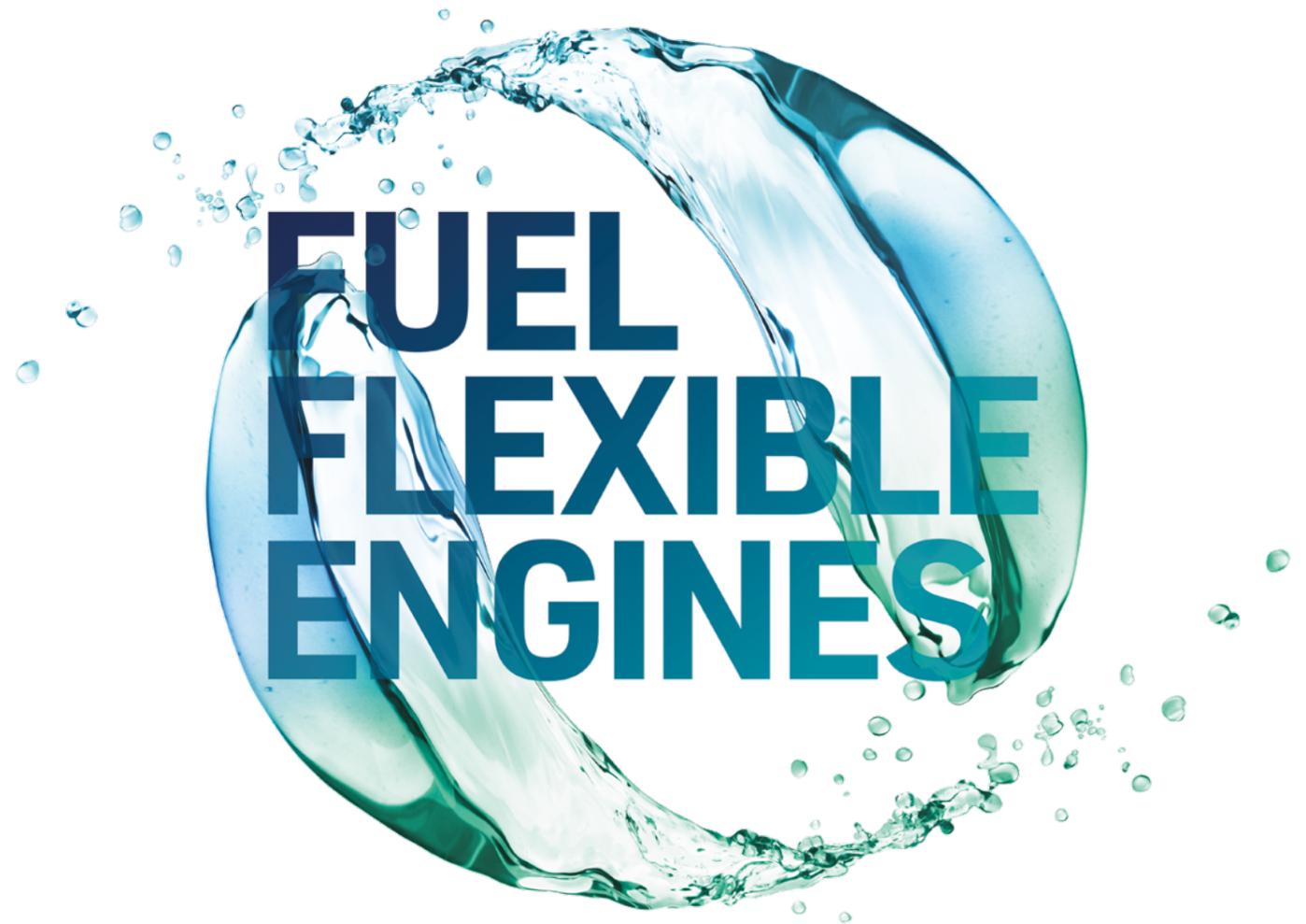
Fuel flexibility for your journey to zero emissions

WinGD's X-DF engines give operators ultimate choice over the fuels they want to use to cut climate impact.

The well-established X-DF engines series offers a pathway from fossil to carbon-neutral methane, with no adaptation needed to blend your way to net-zero fuel emissions. Already matured into its second generation, X-DF2.0 offers a viable and proven step today towards meeting the long-term climate ambitions of ship owners, regulators and society.

As shipping looks to new carbon-neutral and zero-carbon fuels, WinGD has expanded its X-DF portfolio to include ammonia and methanol engines, **X-DF-A** and **X-DF-M**, blending proven dual-fuel expertise with the Diesel cycle performance and reliability of WinGD's X-Engines.

The full X-DF portfolio sets the benchmark for fuel flexibility in maritime, engineered for efficiency to improve fuel consumption, emissions and cost over the vessel lifecycle, whichever fuel you choose.



The industry standard for dual-fuel performance and reliability

With dual-fuel engines in operation since 2016, X-DF is the pioneer in modern fuel flexible technology for two-stroke marine engines, offering a range of benefits over other dual-fuel engine concepts. X-DF technology for LNG combines both the traditional Diesel cycle and Otto cycle into one platform offering ship owners fuel flexibility without compromising on power, efficiency and reliability.

With X-DF2.0, WinGD builds on its proven, reliable platform with even greater efficiency and emissions performance. The intelligent control by exhaust recycling (iCER) technology targets superior combustion control, using inert gas to adjust the gas/air mix, improving both fuel consumption and emissions.

The benefits are impressive reductions of fuel consumption in both gas and diesel mode and up to a 50% reduction in methane slip and Tier III NO_x compliance in both modes without SCR.

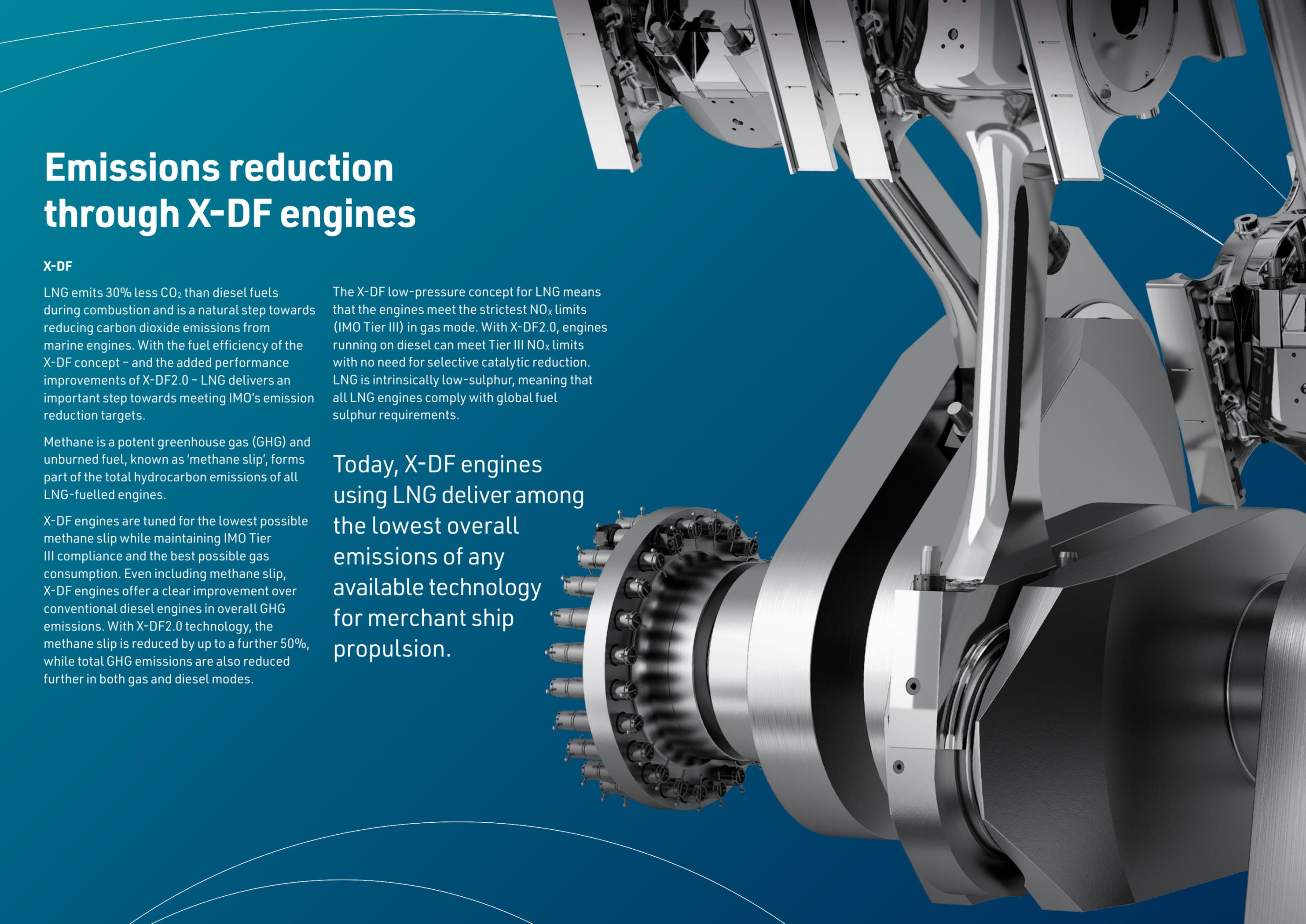
The fuel flexibility of X-DF engines will be extended further, with both methanol and ammonia fuelled engines available for vessels to be delivered from 2025. These engines will rely on two elements of WinGD's unique engine expertise. They will integrate with the fuel supply systems in the most effective and safe way possible, drawing on the dual-fuel know-how of the team that designed the X-DF engine. And they will deliver leading Diesel cycle performance already established in WinGD's X-Engine portfolio.

All WinGD engines have fuel flexibility built into their base design today, making them ready for future conversion to methanol, ammonia and other emerging low-carbon, zero carbon or carbon-neutral fuels without needing to replace major elements of the engine structure or powertrain. All engines currently in service and on order will be able to be retrofitted to use methanol and ammonia once the technology packages are available.



With X-DF2.0, WinGD builds on its proven, reliable low-pressure platform with even greater efficiency and emissions performance.

Emissions reduction through X-DF engines



X-DF

LNG emits 30% less CO₂ than diesel fuels during combustion and is a natural step towards reducing carbon dioxide emissions from marine engines. With the fuel efficiency of the X-DF concept – and the added performance improvements of X-DF2.0 – LNG delivers an important step towards meeting IMO's emission reduction targets.

Methane is a potent greenhouse gas (GHG) and unburned fuel, known as 'methane slip', forms part of the total hydrocarbon emissions of all LNG-fuelled engines.

X-DF engines are tuned for the lowest possible methane slip while maintaining IMO Tier III compliance and the best possible gas consumption. Even including methane slip, X-DF engines offer a clear improvement over conventional diesel engines in overall GHG emissions. With X-DF2.0 technology, the methane slip is reduced by up to a further 50%, while total GHG emissions are also reduced further in both gas and diesel modes.

The X-DF low-pressure concept for LNG means that the engines meet the strictest NO_x limits (IMO Tier III) in gas mode. With X-DF2.0, engines running on diesel can meet Tier III NO_x limits with no need for selective catalytic reduction. LNG is intrinsically low-sulphur, meaning that all LNG engines comply with global fuel sulphur requirements.

Today, X-DF engines using LNG deliver among the lowest overall emissions of any available technology for merchant ship propulsion.

Building new fuel capability with well-proven design

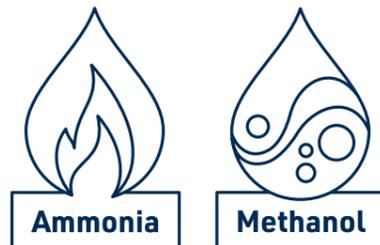
X-DF-A and X-DF-M

Methanol is a carbon-neutral fuel when produced with renewable electricity and captured carbon. It also offers significant reduction in vessel CO₂ emissions. Ammonia contains no carbon and can be produced with minimal supply chain emissions when made from renewable electricity.

While the fuels themselves reduce greenhouse gas emissions dramatically, efficiency will remain vital for engines, both in reducing emissions even further and in lowering costs associated with

expensive synthetic fuels. X-DF-A and X-DF-M derive their Diesel cycle efficiency from WinGD's X-Engines - including WinGD's popular X92-B, the leading choice for the ultra large container vessel segment, which are well known for their high efficiency and reliability.

Methanol and ammonia meet global sulphur limits. X-DF-A and X-DF-M will be delivered with the appropriate abatement systems to meet compliance standards for all emissions.



X-DF^A
by WinGD

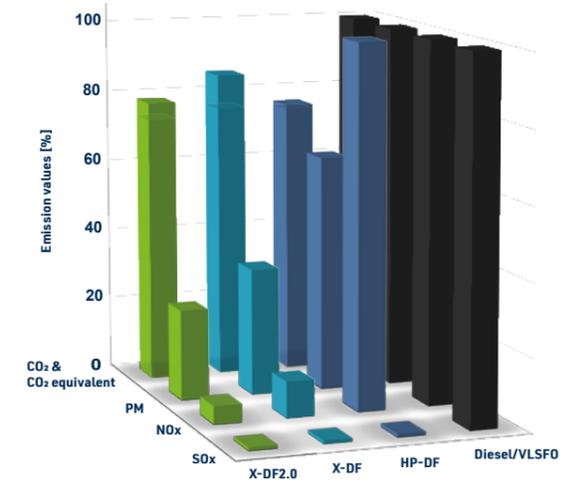
X-DF^M
by WinGD

X-DF technology concept for LNG

In gas mode, X-DF technology is based on the lean-burn principle (Otto cycle), in which fuel and air are premixed and burned at a relatively high air-to-fuel ratio. This concept provides the following benefits:

- Low-pressure gas supply means maximum simplicity, low investment costs and low power consumption
- Extremely small pilot fuel quantity, below 1% of the total energy consumption
- X-DF engines can be operated on gas down to very low loads
- Low NO_x emissions, close to zero SO_x emissions and IMO Tier III compliant without exhaust-gas after-treatment
- Particulate matter emissions significantly reduced.

While the fuels themselves reduce greenhouse gas emissions dramatically, efficiency will remain vital for engines.



Building on proven performance with X-DF2.0

Any LNG-fuelled X-DF engine can be ordered with X-DF2.0 technology. The iCER system is designed to cool and recirculate part of the exhaust gas to improve combustion. It is made up of a low-pressure exhaust recycling path with an efficient exhaust gas cooler.

When the recirculated exhaust gas is mixed with scavenge air, carbon dioxide partly replaces the oxygen in the fresh air, reducing the mixture's reactivity during combustion. This increases the ignition delay and stabilises the combustion speed. By raising resistance to auto-ignition and reducing combustion speed, iCER enables combustion control phasing so that the geometric compression ratio can be increased and the thermal efficiency improved.

The iCER solution for X-DF2.0 engines is available in either off- or on-engine configurations. On-engine iCER is an attractive

solution that offers identical performance in a more compact arrangement that simplifies installation and commissioning.

Reducing system complexity

X-DF technology for LNG requires a simple gas supply system, reducing system complexity and auxiliary power consumption. Since LNG is mixed with the scavenge air before compression, the required gas pressure is maximum 13 bar or lower when operating at lower loads. As a result, the fuel supply system is simple, safe, reliable and well-proven.

Better operational flexibility

The pre-chamber technology and design for the gas admission valve in X-DF engines using LNG offers the highest level of combustion stability and reduced emissions, well below IMO Tier III requirements.

This stability in dual-fuel operation allows for greater load flexibility while improving port-to-port operations and manoeuvrability at low speeds, ensuring operational control at all times.

With X-DF2.0, exhaust recycling rates of up to 50% allow the engine to reach higher compression ratios that further reduce fuel consumption and emissions. Exhaust gas recycling can be used across the full engine load profile in both gas and diesel mode. In gas mode, the pilot fuel required is the same across the full engine load range.

Improved cost efficiencies

WinGD developed smarter, efficient engine designs with X-DF dual-fuel technology for lower initial investment and operating costs. The combustion concept and engine design use the most economic supply system and the fewest components, reducing both space required and fuel costs.



Lower fuel consumption



Proven design for reliability and safety



Reduced Methane slip and CO₂ emissions

Committed to the decarbonisation of marine transportation through sustainable energy systems

WinGD designs marine power ecosystems utilising the most advanced technology in emissions reduction, fuel efficiency, digitalisation, service and support. With their two-stroke low-speed engines at the heart of the power equation, WinGD sets the industry standard for reliability, safety, efficiency and environmental design. Headquartered in Winterthur, Switzerland, since its inception as the Sulzer Diesel Engine business in 1893, it is powering the transformation to a sustainable future. WinGD is a CSSC Group company

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