



Four-  
stroke  
marine  
systems

# LNG shipping

**MAN Energy Solutions**  
Future in the making

**Cost-cutting  
dual fuel solutions**



# Moving big things to zero

MAN Energy Solutions is the world's leading provider of large-bore engines, turbomachinery, and integrated power systems. 250 years of experience in advanced engineering has prepared us well for our biggest challenge yet: to provide the technical solutions that will drive the global economy into a new carbon-neutral era.

The industries we serve are crucial for the world economy. Most of them are also hard to decarbonize. By providing sustainable solutions for marine transport, power generation, and industrial engineering we boost business and help to bring the world to net zero.

In the competitive field of LNG shipping, with its fluctuating fuel prices, we offer newbuild dual fuel engines and retrofits that enable alternative fuels. Our cost-effective propulsion systems comply with all emission legislation and meet strict safety requirements.

**MAN Energy Solutions: Future in the making.**



# Versatile engines for complex tasks

## Getting a good return on your investment

Although the market for LNG keeps on growing, building a vessel for the LNG supply industry is a major investment in complex technology that has to be amortized with a maximum of yearly operating hours. To future-proof your investment you need engines that can adapt to new environmental regulations and unpredictable fuel costs.

## Success factors

Maritime transport of LNG has proven to be safe thanks to very high safety standards. However, LNG is highly valuable freight and delivery delays are costly; this means that cargo tank management is essential. The engines have to be capable of coping with different boil-off gas (BOG) qualities and quantities, in line with charter requirements.

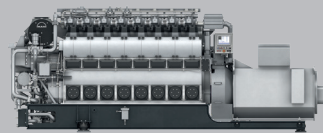
## Flexible propulsion solutions

Different LNG shipping applications have comparable requirements with a different technical emphasis: Reliability, flexibility, capital expenditures (CAPEX) and operating expenses (OPEX), emission regulations, and the energy efficiency design index (EEDI). Our newbuild dual fuel propulsion solutions can be tailored to meet every need. Our expertise in retrofits extends the lifecycle of your vessels and avoids stranded assets.



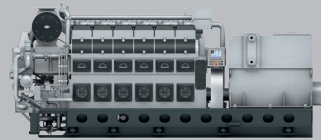


# Four-stroke engines for LNG vessels



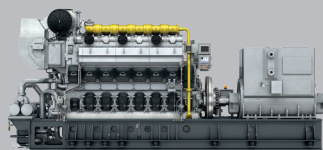
**MAN 23/30DF**  
GenSet

625 – 1,200 kW



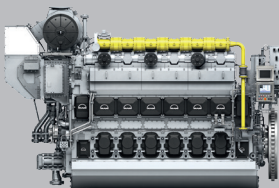
**MAN 28/32DF**  
GenSet

1,000 – 1,800 kW



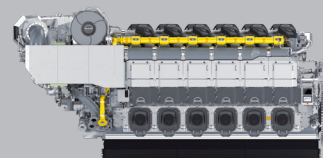
**MAN 35/44DF**  
GenSet

3,060 – 5,300 kW



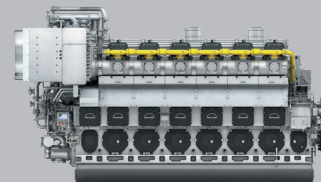
**MAN 35/44DF**  
Propulsion

3,060 – 5,300 kW



**MAN 49/60DF**  
Propulsion

7,800 – 13,000 kW  
15,600 – 18,200 kW



**MAN 51/60DF**  
Propulsion

High efficiency  
6,300 – 9,450 kW  
12,600 – 16,800 kW  
High power  
6,900 – 10,350 kW  
13,800 – 16,100 kW

## LNG carriers

08 – 11

MAN L35/44DF GenSet		3,060 – 5,300 kW
MAN L35/44DF		3,060 – 5,300 kW
MAN L51/60DF High efficiency		6,300 – 9,450 kW
MAN L51/60DF High power		6,900 – 10,350 kW
MAN L49/60DF		7,800 – 13,000 kW
MAN V51/60DF High power		13,800 – 16,100 kW
MAN V51/60DF High efficiency		12,600 – 16,800 kW
MAN V49/60DF		15,600 – 18,200 kW

## FSRU

12 – 15

MAN L35/44DF		3,060 – 5,300 kW
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## LNG feeder and bunker vessels 16 – 19

MAN L23/30DF GenSet		625 – 1,200 kW
MAN L28/32DF GenSet		1,000 – 1,800 kW
MAN L35/44DF		3,060 – 5,300 kW
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# Future-proof flexibility

## LNG carriers



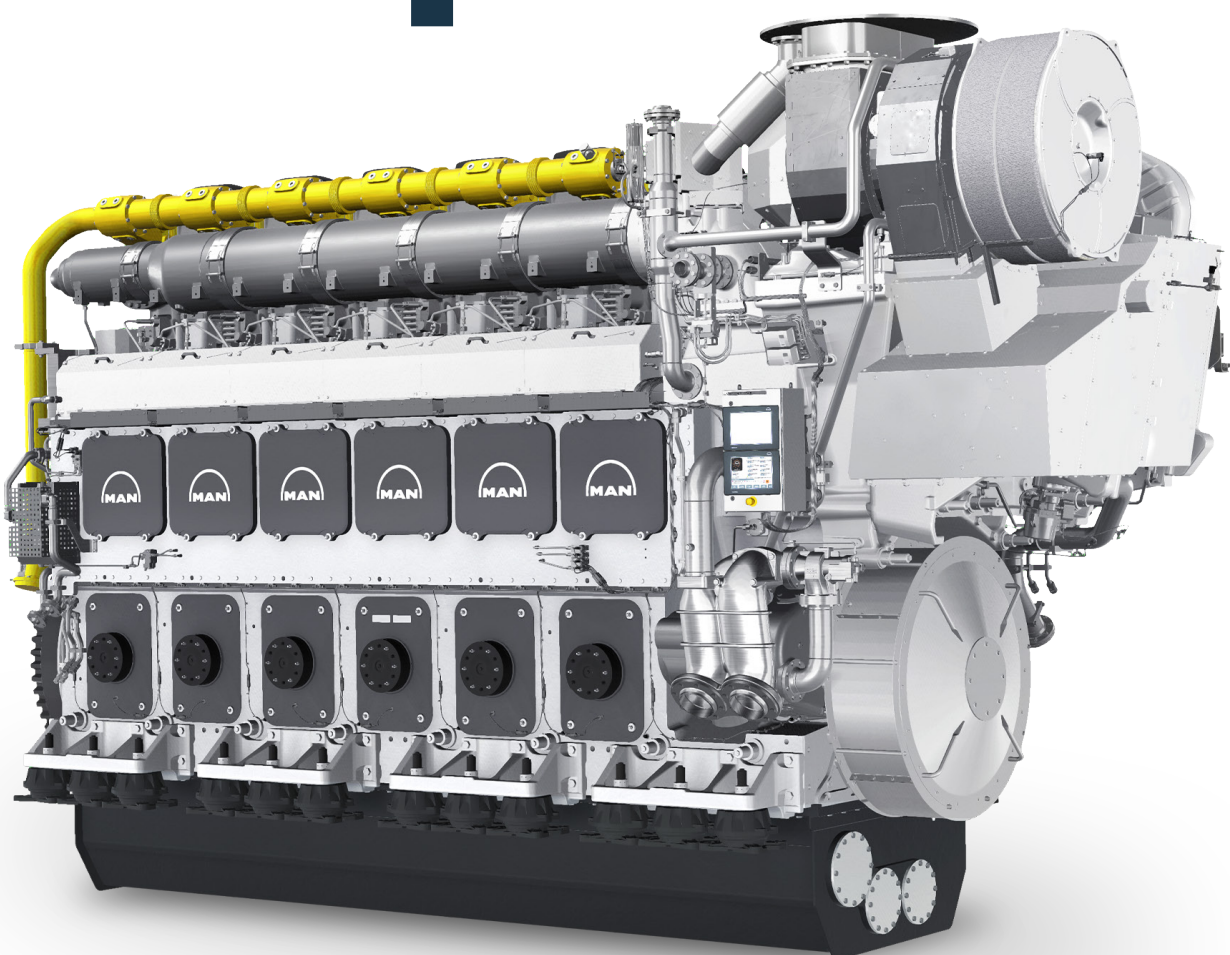
**LNG carriers have to deliver highly valuable freight on time, which means they require operational flexibility. Sailing through environmentally sensitive waters across the globe demands low emissions, and the operational safety of the propulsion system is paramount.**

**Navigating operational, contractual, and environmental challenges**

Modern LNG tankers need highly reliable propulsion systems and service support that can ensure constant engine availability. Operational challenges include the fulfillment of all safety norms (IGF, IGC Codes) and high load flexibility. Careful management is necessary to maintain correct pressure in the cargo tanks and to handle the boil-off gas. Furthermore, the engines have to cope with varying power demands.

The new IMO regulations impose tough limits on nitrogen oxide (NO<sub>x</sub>) and sulfur oxide (SO<sub>x</sub>) emissions. In the future, even stricter standards will apply in Emission Control Areas (ECAs). In order to deliver their very valuable freight on time and cost-efficiently, the owners and operators of LNG carriers also have to factor in the fluctuating costs of HFO and LNG as fuels. Our multi-fuel engines and propulsion systems with fuel flexibility meet all these challenges.

# Designed to **MAN** 49/60DF adapt



**With its high power density, the MAN 49/60DF has already set new benchmarks for efficiency in both gas and liquid fuel consumption. What makes it even more attractive is its in-built ability to adapt to future conditions, including future fuels – the MAN 49/60DF is already methanol-ready. Future compliance with environmental regulations is assured by its fuel flexibility and adaptable technologies. The new Dual-Fuel Electric+ (DFE+) concept adds operational flexibility that reduces carbon footprints as well as fuel bills.**

#### **Benefits**

##### **New benchmarks in efficiency**

171.0 g/kWh liquid fuel  
consumption at 85 % MCR\*  
6,990 kJ/kWh gas  
consumption at 85 % MCR\*  
\*Higher values apply for 8L and 10L

##### **Long-term CO<sub>2</sub> emissions compliance**

Thanks to benchmark efficiency, low methane emissions and fuel flexibility

##### **Ready for further digitalization**

With next-generation engine automation

##### **Compact design**

For increased power density

##### **Alternative paths for emission compliance**

Low methane slip and benchmark efficiency ensure vessels are emissions-compliant until approximately 2035. Solutions in response to more stringent regulations are easy to implement and include retrofittable exhaust gas after-treatment systems, replacing natural gas with bio gas or synthetic natural gas (SNG), and future fuels such as green methanol.

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##### **MAN SaCoS 5000 and ACC 2.0**

The MAN 49/60DF features the new MAN SaCoS 5000 engine automation system and the new Advanced Combustion Control ACC 2.0. Both features future proof your vessel for the digital age. While ACC 2.0 is essential for improved efficiency and robust in-field performance, the new MAN SaCoS offers enhanced remote support features and options to attain the highest levels of cybersecurity.

##### **Dual-Fuel Electric+ (DFE+)**

The DFE+ concept uses ABB's Dynamic AC (DAC) technology and delivers the operational flexibility shipowners need to reduce carbon footprints as well as fuel bills for liquefied natural gas (LNG) carriers.

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##### **Further power solutions**

**MAN 35/44DF GenSet**  
**MAN 35/44DF**  
**MAN 51/60DF**

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# The floating link

**FSRU**



© MOL

The floating storage and regasification unit (FSRU) turns the LNG fuel into gas, which can be pumped straight into the gas grid. It is a clever alternative to building a regasification system on land and thus a key element in the LNG supply chain. An FSRU is a promising business opportunity for owners and operators, but it does involve many technical, contractual, and environmental issues.

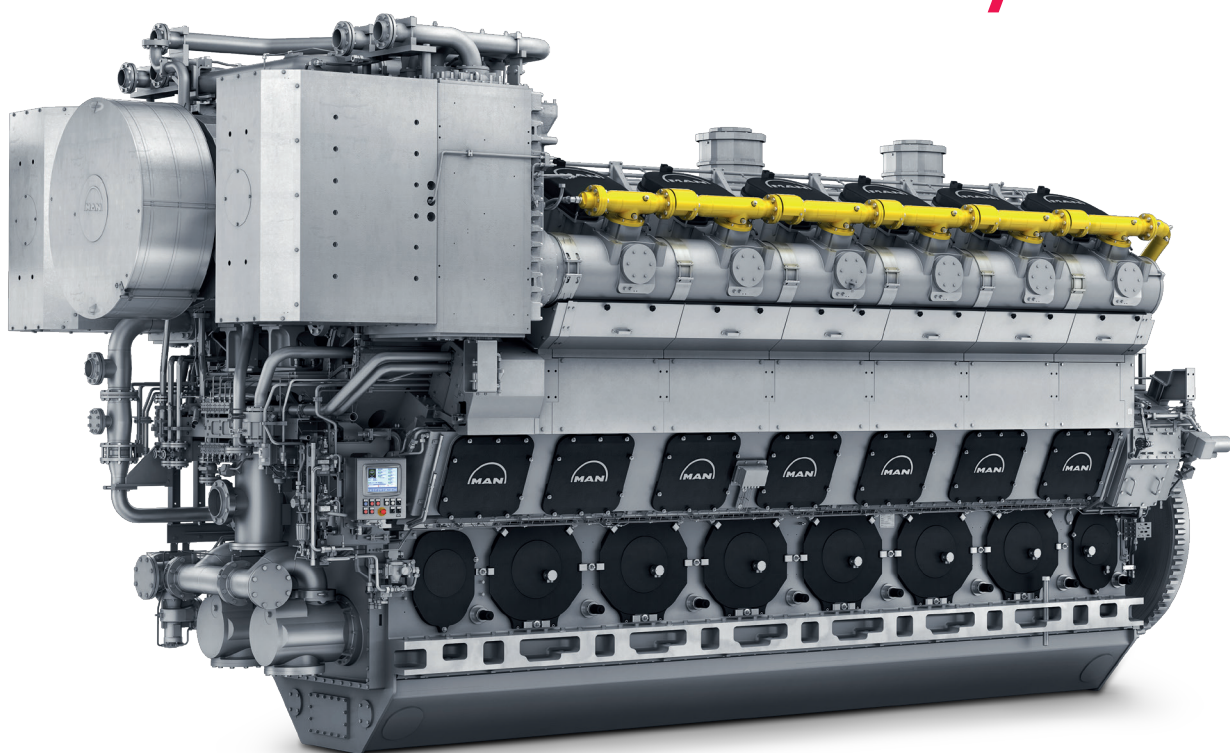
#### **Working with clean power**

The FSRU has to comply with coastal environmental regulations as well as the emission requirements of the ship's flag state. In terms of engine operation, safety comes first. Service support is important for high operational availability.

In terms of engine output, the operation of the regasification equipment usually requires less power than the propulsion. Careful cargo tank management is important to maintain pressure in the cargo tanks and handle the boil-off gas. Our dual fuel solutions make it easy.

# Clean, clever, and versatile

**MAN**  
**51/60DF**



In a multiple dual fuel engine plant, the MAN 51/60DF ensures high reliability and vessel speed flexibility. The engines within a multiple-engine concept can be switched on and off according to actual power demand, allowing the highest efficiency with the lowest possible fuel consumption and load dynamics. Intelligent engine utilization also makes it possible to minimize yearly maintenance costs.

The MAN 51/60DF complies with IMO Tier III regulations in gas mode. In liquid mode, it complies with the help of the MAN SCR (selective catalytic reduction) exhaust gas cleaning system.

#### Benefits

##### Full environmental compliance

IMO Tier III in gas mode and liquid mode (with optional MAN SCR)

##### High power output

Up to 1,150 kW per cylinder

##### Safe engine operation

In accordance with latest standards and regulations

##### Operating stability and flexibility

Gas start capability, seamless switch from HFO to gas mode and vice versa, gas operation even above 100 % MCR

#### Easy to operate

The low-pressure gas supply system is proven and easy to handle. The fuel quality manager optimizes the engine's combustion according to the quality of the boil-off gas. Our PrimeServ training academy offers a tailored training program for FSRU crew.

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##### Dual fuel technology

Pioneering hardware and software for engine control, monitoring, and diagnostics. Enables full fuel flexibility (HFO, MDO, MGO, and natural gas). Seamless switch from HFO to gas mode and vice versa, gas operation even above 100 % MCR.

##### Ease of maintenance

Segmented gas and charge air manifold for individual and simple removal of cylinder head.

##### MAN SaCoS<sub>one</sub> (safety and control system on engine)

Combines all functions of modern engine management into one complete system. It controls the additional pilot injection system as well as the gas admission system assembly.

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Further power solutions  
**MAN 35/44DF**

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# Enabling the switch to gas

**LNG feeder and  
bunker vessels**



© Ghenova ingeniera

Low gas prices are increasing the popularity of LNG as a maritime fuel. This, in turn, is driving the demand for feeder and bunker vessels that can efficiently deliver LNG to the ships that use it as fuel.

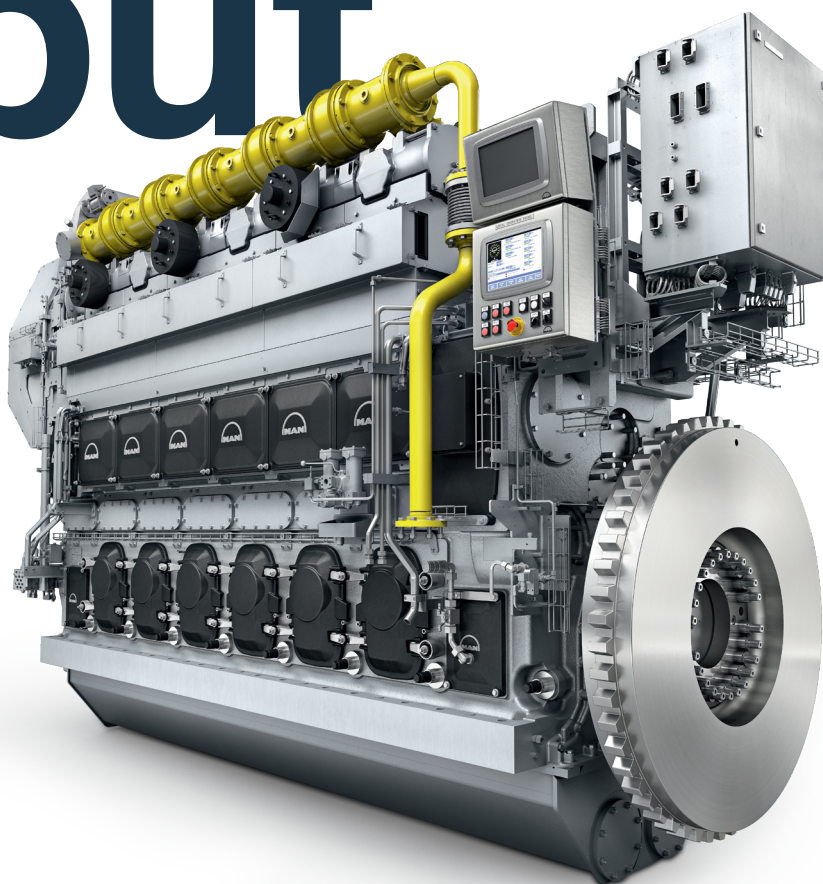
**High performance  
with low consumption**

Delivering LNG to marine clients is a challenging operation. Feeders and bunker vessels need high maneuverability to perform safely. They have to be available 365 days a year and must have low overall energy consumption – the less cargo they burn, the better. They should also be suitable for operating in noise-sensitive areas and comply with emissions regulations.

With their outstanding fuel economy, our dual fuel engines offer excellent solutions for operators who are looking for low CAPEX and OPEX and world-wide logistic support.

# Lowest emissions, highest output

**MAN**  
**35/44DF**



**The MAN 35/44DF allows you to harness all the benefits of dual fuel flexibility. It is ideal for mechanical and electric propulsion, and auxiliary genset applications. In gas mode, it complies fully with IMO Tier III standards. In liquid fuel mode, it fulfills IMO Tier II regulations.**

**The engine is equipped with a common rail injection system with injection pressures of up to 1,600 bar. With 530 kW/cyl., the engine yields the highest power output in its segment. The robust design is based on the MAN 32/44CR. Its reliable technology reduces daily maintenance and maximizes TBOs while ensuring safe operation in all fuel modes. Its success is demonstrated by the increased vessel resale value.**

#### **Benefits**

##### **Compliance with IMO Tier II and IMO Tier III standards**

No after-treatment needed in gas mode; MAN SCR option for liquid mode

##### **Based on established technology**

Design based on proven MAN 32/44CR engine

##### **Full fuel flexibility**

HFO, MDO, MGO, and natural gas

##### **More intelligent ways to save costs**

The MAN HyProp ECO is a hybrid solution that results in higher propeller efficiency and lower fuel consumption. The MAN 35/44DF is also available with MAN Cryo fuel gas supply and bunkering equipment as part of the system supply.

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##### **Conversion from MAN 32/44CR**

This is an economical retrofit solution that adds lean-burn technology from the MAN 51/60DF. Thanks to the high level of component compatibility, the engine can be easily remachined onboard.

##### **MAN SaCoS<sub>one</sub> (safety and control system on engine)**

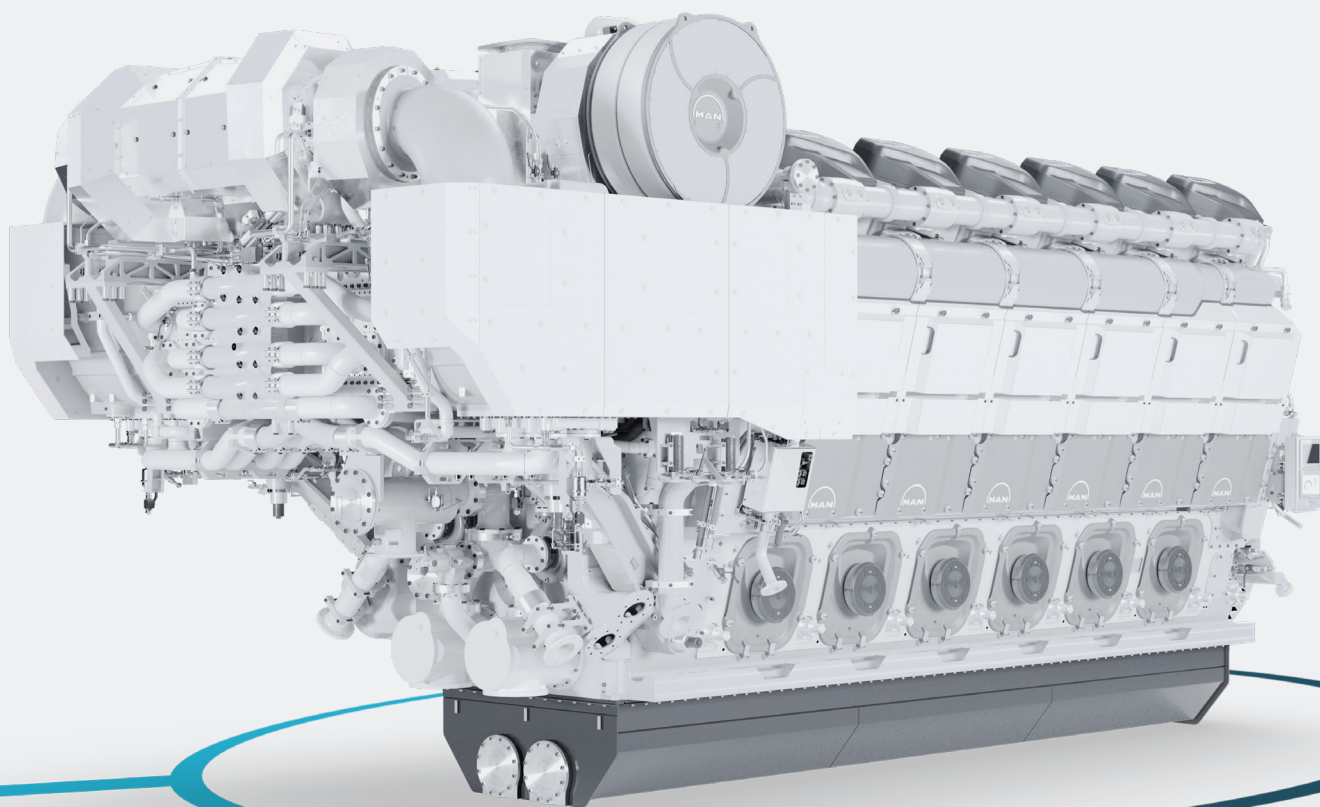
Combines all functions of modern engine management into one complete system. It controls the additional pilot injection system as well as the gas admission system assembly.

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##### **Further power solutions**

**MAN 23/30DF GenSet**  
**MAN 28/32DF GenSet**  
**MAN 51/60DF**

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# Dual-Fuel Electric+ concept

## **Revolutionary flexibility ensures path to regulation compliance until 2050**

Customers want to be able to make the best use of their assets to react quickly to changing market conditions. The new Dual-Fuel Electric+ (DFE+) concept is driven by the demand for efficient and flexible propulsion. It will deliver the technology necessary to reduce the CO<sub>2</sub> footprint and the fuel costs for LNG carriers while providing the certainty of long-term compliance with emission regulations.

The DFE+ propulsion concept for LNG carriers is based on new the MAN 49/60DF engine and ABB's Dynamic AC (DAC) power distribution and control system. Compared to conventional dual-fuel diesel electric (DFDE) propulsion, which is characterized by engines operating at constant speed over the entire engine load, DFE+ propulsion can operate at variable speed, delivering better efficiency with significant reduction of methane slip over the whole engine map.

Variable-speed applications are well established for liquid-fuel systems up to 10 MW. However, torque requirements and the low efficiency of first-generation dual fuel engines – including limitations in the e-systems design for diesel-electric propulsion systems over 10 MW – prevented the use of variable speed for propulsion systems over 10 MW. ABB's DAC technology enables the operation of propulsion systems above 10 MW at variable speed with all the accompanying benefits. In combination with the second-generation, high-efficiency MAN 49/60DF engine, with Air Lubrication System interface (ALSi) as an add-on, this DFE+ concept provides customers with next-level efficiency and flexibility.

# MAN PrimeServ

# Service with passion

MAN PrimeServ is the dedicated MAN Energy Solutions service brand. Via a network of over 100 service centers worldwide, MAN PrimeServ provides 24/7 service across the globe. Our range of services includes technical support, consulting, and OEM spares, as well as maintenance, repair, and comprehensive individualized service plans.



# 365

days a year

# 24

hours a day



#### MAN PrimeServ provides:

- Prompt delivery of high-demand OEM spare parts within 24 hours
- Fast, reliable, and competent customer support
- Individually tailored O&M contracts
- Ongoing training and qualification of operators and maintenance staff
- Global service, 24 hours a day, 365 days a year
- Diagnosis and troubleshooting with our high-performance online service

#### MAN Energy Solutions and legacy brands

MAN PrimeServ is our brand name for high-quality aftersales support for the entire MAN Energy Solutions product portfolio. Through refinements to our products and repair techniques, we ensure and reinforce our technological leadership and technical expertise as an original equipment manufacturer (OEM) for the brands united under MAN Energy Solutions.



BABCOCK BORSIG

**SULZER**  
TURBO

B+V Industrietechnik



**MAN Energy Solutions**



*Ruston*

*Paxman*

Mirrlees  
Blackstone

**HALFORD**  
GENERATING SETS

**B&W**  
MOTORS

# Worldwide service

**We offer retrofitting and upgrade services to bring engines and turbochargers already in service up to the very latest standards of performance and efficiency.**

Using the latest digital technology, we enable you to maximize the performance and availability of your MAN equipment by accessing real-time data analysis, remote support, and rapid solutions. We also offer an extensive range of training courses at MAN PrimeServ Academies around the world.

Our service does not vary according to location. We know that a vessel may be built in Asia, operated in Europe for ten years and then move to Africa for the next ten years. That does not alter our focus on dedicated training, fast delivery of strategic spare parts, a comprehensive approach, or our tailored maintenance contracts.

**For more information, please visit**  
**[www.man-es.com/services](http://www.man-es.com/services)**



# 100

service centers  
worldwide



MAN PrimeServ

# Get your engines started ...



## **An interactive experience**

Download our MAN Brochure Store app from the App Store or Google Play Store. Use its exciting interactive features to explore our complete range of products and services. Suitable for iPhone, iPad, and Android.



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