



100 years of striving for efficiency

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Ever since the first endeavours a century ago, the development of commercial vehicles at MAN has been driven by the pursuit of excellent transport performance at low cost.

When acquiring a new commercial vehicle today, customers consider operating costs a crucial factor. Yet as long ago as 1915, when MAN started building its first trucks and buses, low-consumption engines and technical innovations for economical operation were powerful arguments for investing in the new technology. Due to numerous innovations, the efficiency of MAN's machines has been continuously improved. Today, a tractor-trailer unit merely requires about one litre of diesel fuel to carry a ton of payload for a distance of 100 kilometres.

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Diesel and oxygen: the evolution of explosions inside cylinders

In the early 20th century, the construction of engines represented one of the major fields of innovation. The injection of diesel fuel into the cylinder and the process of diesel-air mix combustion are key factors for the efficiency of a diesel engine. MAN's engineers were pioneers in this field and the company therefore presented the first MAN truck driven by a diesel engine with direct fuel injection as early as 1924. The engine was a technical masterpiece compared with the petrol carburettor engines that had previously been standard, as it used significantly less fuel. As a result, the new engine saved up to 80% of operating costs compared with traditional petrol engines. Direct injection actually rendered the diesel engine small and light enough for utilisation in vehicles for the first time.

Efficient combustion: G-engines and M-engines

An important technical advancement in MAN's engine development followed in 1937, namely the G-engine. It drew its name from the round or "global" shape of its combustion chamber. Due to this special combustion chamber and a piston design, diesel fuel could burn with exceptional

The MAN Group is one of Europe's leading industrial players in transport-related engineering, with revenue of approximately €14.3 billion in 2014. As a supplier of trucks, buses, diesel engines, turbomachinery, and special gear units, MAN employs approximately 55,900 people worldwide. Its business areas hold leading positions in their respective markets.



efficiency in the G-engine. By 1939, all MAN trucks, buses and traction units were equipped with the new engine.

A further step in the evolution of diesel engines was the Meurer engine (or M-engine), from the early 1950s, which had been developed by Professor Siegfried Meurer at MAN's Augsburg diesel engine plant in 1952. The M-engine no longer consumed the fuel abruptly but rather in several phases – which eliminated the typical knocking effect – and delivered significantly reduced fuel consumption. For the next two decades, the M-engine provided the basis for MAN's further development of efficient engines.

In 1954, MAN integrated its engine development competence at a new engine research institute in Nuremberg. This competence centre remains the innovative centrepiece of engine development at MAN to the present day.

Turbocharging: the key to the modern high-performance engine

Another key technology paved the way to highly efficient diesel engines in the 1950s: turbocharging. A turbo diesel engine compresses more air – and therefore more oxygen – into the piston chamber, allowing for considerably more of the fuel-gas mixture to be converted into engine output with every explosion in the cylinder. MAN was the first German manufacturer of commercial vehicles to present a diesel engine with turbocharger in 1950: the D 1546 GT. Due to turbocharging, the MAN experts were able to draw a striking 175 hp-performance from the 8.72-litre displacement engine rather than the standard 130 hp – a remarkable 35% increase in engine performance. As of 1976, turbocharger diesel engines were available for all MAN's production series.

In 1979, MAN introduced engines with combined turbocharging and charge air cooling. Charge air cooling further enhances the efficiency of turbocharging, as cooled air contains more oxygen than hot air. At the same time, the engine components are subjected to less thermal stress. Today, most of MAN's engines operate on a principle of two-phase charging with intermediate cooling. Two serially arranged turbochargers of different sizes form the basis for the optimised supply of combustion air to the engine, thus providing an ideal torque curve over a broad rpm range. Due to the development of turbocharging, current commercial vehicle engines deliver a performance significantly above 500 hp, while retaining compact mass and weight ranges as well as featuring low fuel consumption. Today, the new engine generation of the MAN TGX D38 – a



serial six-cylinder engine with a cubic capacity of 15.2 litres and an output of up to 640 hp – is MAN's most powerful vehicle engine to date.

Common rail injection – high tech for maximum efficiency

Fuel injection is both a key factor for fuel consumption and low exhaust emissions of an engine. MAN was one of the first manufacturers to consistently employ modern common rail (CR) injection technology. Since 2002, common rail injection has been a standard of serial production, with the Euro 5, EEV-compliant and Euro 6 engines already utilising a third-generation CR system. Common rail injection works with a central high-pressure pump, which supplies the fuel at an injection pressure of up to 2,500 bar. Each cylinder features electronically controlled injectors, which inject fuel to the cylinder as directed by the engine management system. The extremely high injection pressure results in ultra-fine fuel nebulisation for clean, economical and residue-free combustion. The exact time, duration and quantity of the injection are freely determinable, along with the option of using several injections for one ignition process and thus controlling the combustion process in the cylinder. This fully variable fuel injection control allows for managing the balancing act in physical terms, adhering to the strict Euro 6 standards and limiting nitric oxides, particle emissions and consumption at every operating point.

Efficiency through networking: perfect interaction of systems

While the engine is certainly the heart of the drive train and provides the basis for an economical and powerful vehicle, the interaction of all systems is crucial to further optimise the efficiency of modern commercial vehicles beyond engine technology. This includes electronic driving assistance systems, as well as aerodynamics and intelligent gear shifting systems. With the introduction of the Trucknology Generation A (TGA for short) in 2000, MAN established new benchmarks for trucks in long-distance transport – including efficiency. For the first time, the new production series incorporated electronic networking of all vehicle systems via the CAN (Controller Area Network) data bus, which transferred all data to the vehicle management computer. This processor coordinates all driving systems such as engine, gears, retarder or braking systems in an optimised and real-time course of action. The CAN bus forms the basis for the integration of modern driving assistance, braking and gear-shifting systems, which act in an anticipatory and intelligent fashion. With the TGA series, MAN



introduced the first automated gear shifting system: the MAN TipMatic. It disencumbers the driver from selecting the optimised gear and saves both fuel and weight as compared with a manual transmission system. With its speed-shifting functionality, the current generation of the MAN TipMatic alternates even faster between gears 10, 11 and 12, thus saving fuel on gradients. The “Efficient Roll” function automatically switches to neutral on gently descending slopes, causing the truck to coast and therefore to save fuel.

Considerable fuel savings can be achieved by projecting the route in advance. Speed can be automatically reduced shortly before reaching a crest or momentum built before an upward slope. With its stored 3D maps and GPS-guided positioning of the truck, the GPS Tempomat EfficientCruise system recognises the topography of the route ahead.

Services for more efficiency: focus on overall costs

When considering the total cost of ownership (or TCO) to evaluate vehicle efficiency, technical solutions are not the only decisive factor responsible for efficient vehicle operation, but rather provided services as well: “While our customers primarily look at the total cost of ownership (TCO), which essentially means fuel consumption and depreciation, they also consider the uptime principle, meaning preferably minimum service and maintenance time,” explains Joachim Dürr, Head of Product Management & Strategy at MAN Truck & Bus.

The interdependent services offered by MAN Solutions are all aimed at reducing the TCO aspect, with the basic technical tool employed being the MAN TeleMatics System. It transmits the vehicle’s technical data and position in real time. With the new MAN ServiceCare service package, for example, the MAN service centre receives the maintenance data of the customer vehicle and controls maintenance management in such a way as to configure workshop periods as speedily and efficiently as possible for the customer.

Efficiency through training: MAN ProfiDrive

As economic operation in long-distance transport substantially depends on driving style, MAN includes the driver in the overall strategy for more efficiency. MAN ProfiDrive training courses not only offer truck and bus operators further education in theory, but also provide practical training for



an especially economical style of driving as well as an optimised use of the driving assistance systems and the TipMatic automated gears. The training objective is to make daily driving routines even safer and more efficient. When purchasing vehicles of the MAN EfficientLine, the ProfiDrive training is already included as part of the package – an attractive feature for customers. For more than 30 years, MAN ProfiDrive trainers have been imparting theoretical and practical knowledge to improve road traffic efficiency in 25 countries around the world. Gained experience proves that MAN ProfiDrive training courses can render as much as 10% in fuel savings.

MAN TGX EfficientLine: packaged technology and service

In 2010, the MAN TGX EfficientLine launched a new era by uncompromisingly combining fuel-saving measures and technologies in an independent model. No vehicle manufacturer had previously realised the known physical attributes as consistently in a vehicle as MAN by offering it today with its TGX EfficientLine 2.

All new electronic systems for fuel reduction are incorporated in the TGX EfficientLine 2 as a series standard. With its optimised use of momentum on ascents and descents, the anticipatory Tempomat EfficientCruise system saves up to 6% in fuel.

Incorporating D26 Top Torque engines, the drive train of the TGX is designed for exceptionally low-revolution and fuel-efficient driving. With 200 Nm of torque enhancement, the engines harmonise ideally with exceptionally long axle ratios. Particularly on upward gradients, this enhanced torque provides better control with fewer downshifts and sustainably cuts fuel consumption.

The DNA of the TGX EfficientLine 2 also includes the consistent reduction of air resistance and rolling resistance, as well as accessory engine output. Sun visors and pressurised air horns are therefore omitted and the aerodynamic side panelling of the chassis further contributes to fuel savings. While setting the speed limiter to 85 km/h instead of 89 km/h reduces driving resistance by 10%, low-resistance tyres are also utilised. The EfficientLine models include an air pressure management system, whereby pressurised air is supplied upon demand: The compressor is engaged only when pressurised air is actually consumed. Compared to a permanently activated compressor, this reduces operating times in long-distance transport by about 90%.



The MAN TeleMatics Onboard Module is also standard in the TGX EfficientLine 2. With TeleMatics, the truck transmits consumption and service data to its fleet manager, who can monitor the fuel consumption of vehicle and driver's fuel consumption and even check tyre pressures and brake conditions of an entire fleet through a data portal – thus ensuring that fuel is not needlessly consumed.

Beside its truck, MAN introduced the Lion's Coach EfficientLine in 2012, a travel coach consistently designed for maximised efficiency. Due to its drive train configuration with a D2676 engine, TipMatic coach gears and an eco-hypoid drive axle, it is exceptionally well constructed to save fuel. The purposeful further development of drive technology and a wide array of features consistently aimed at fuel economy demonstrate that today's long-distance coach transport bears the potential for considerable fuel savings.

Striving for efficiency will remain the central driving force for MAN in future. Optimising the drive train, further aerodynamic improvements, enhanced reliability throughout the product lifecycle and the minimisation and optimisation of service operations still offers considerable potential for reduced CO₂ emissions and lower fuel consumption. New developments in vehicle communications, as well as between vehicles and traffic control systems, result in improved utilisation of available road capacity, and can achieve greater transport efficiency through better traffic flow.