

# CITY BUS IN **PERFECTION**

The new MAN Lion's City.



Ready for Euro 6d





bus & coach engines  
Euro 6d  
(model year 2018-2020)

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Introduction

## What is exhaust emission regulation Euro 6d all about ?

### Control of exhaust gas emission

- For Euro 6d the same stringent On-Board-Diagnostics (OBD) and emission control demands apply as for Euro 6c.
- Permissible deviation of urea content in AdBlue significantly reduced
  - Lowering of OBD threshold for nitrogen oxides (NO<sub>x</sub>)
  - Additional control of OBD function (IUPR = In Use Performance Ratio).
- Euro 6d shows different frame conditions for PEMS (Portable Emissions Measurement Systems) which was introduced for Euro6 commercial vehicles
- Mandatory from **01.09.2018** for new vehicle types (new EG-type approval)
- Mandatory from **01.09.2019** for all new registered vehicles



# What is exhaust emission regulation Euro 6d all about ?

## Demands for On-Bord-Diagnostics (OBD) and control of exhaust gas emissions limits up to Euro 6d

Demand	Euro 6a–b	Euro 6c	Euro 6d
Control of particulates OBD- limit (warning cascade)	25 mg/kWh	25 mg/kWh	25 mg/kWh
OBD- limit NO <sub>x</sub>	1 500 mg/kWh	1 200 mg/kWh	1 200 mg/kWh
Quality deviation of AdBlue	900 mg/kWh	460 mg/kWh	460 mg/kWh
Permissible deviation of AdBlue consumption - validation	50 %	50 %	50 %
OBD- control of injector wear	no	yes	yes
IUPR – monitoring of OBD- diagnosis frequency	Monitoring-Phase	IUPR > 0,1 (per OBD-family and vehicle segment)	IUPR > 0,1 (per OBD-family and vehicle segment)
PEMS-measuring	at payload	50 %	<b>10 – 100 %</b>
	Valued engine power	> 20 %	<b>&gt; 10 %</b>
	Operating conditions	Hot engine	<b>Monitoring during warming up</b>

## What is exhaust emission regulation Euro 6d all about ?

### Mobile emissions measuring PEMS aggravated

- PEMS (Portable Emissions Measurement Systems), AKA **In-Use-Conformity** is to ensure that all components of the exhaust gas treatment systems work effectively throughout their lifetime and are not being negatively influenced through aging processes.
- Legal requirements demand a six year period, alternatively 300 000 km.
- PEMS-measurements within **Euro 6c** were carried out with a vehicle at normal operational temperatures, loaded from 50% to 60% of max. payload, as well as a well defined route, i.e. 20% city traffic, 25% intercity and 55% highway
- PEMS-measurements within **Euro 6d** are carried out with a vehicle from cold start up to normal operational temperatures. Additional load ranges from 10% to 100% of max. payload, as well as different route profiles



Mobile exhaust gas measuring device PEMS

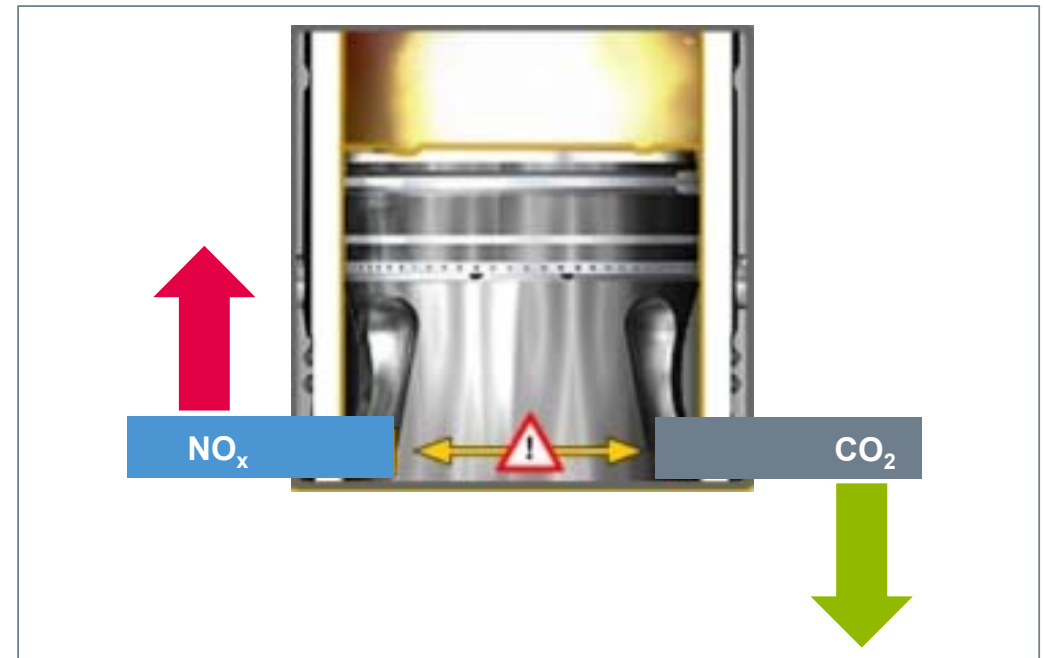
### Advantages

- As commercial vehicles are being tested on the road– different to passenger cars – irregularities of exhaust gas values are impossible
- Environmental protection is ensured under real-life conditions

## What are the technical changes in order to fulfill Euro 6d?

### Conflict of fuel consumption and noxious emissions

- Combustion at lowest possible fuel consumption and highest efficiency shows reduced particulate mass and CO<sub>2</sub> figures but higher NO<sub>x</sub> values.
- Starting with model year 2019 MAN modified its engines in order to solve this conflict as well as to fulfill legal demands, targeting minimum fuel consumption
  - In order to **internally** stabilize exhaust gas temperatures (also in low duty operation) MAN D26 engines (SCR with EGR) feature an enhanced thermo management, an improved Common-Rail injection system and a new EGR-module. D08 engine will be available as a SCR-only engine without EGR. D15 engine was developed from scratch and shows many new features.
  - **External** exhaust gas treatment reduces NO<sub>x</sub>-emissions by means of a SCR-catalyst (Selective Catalytic Reduction), particulates are being removed by means of the MAN CRT (Continuously Regenerating Trap) filter system



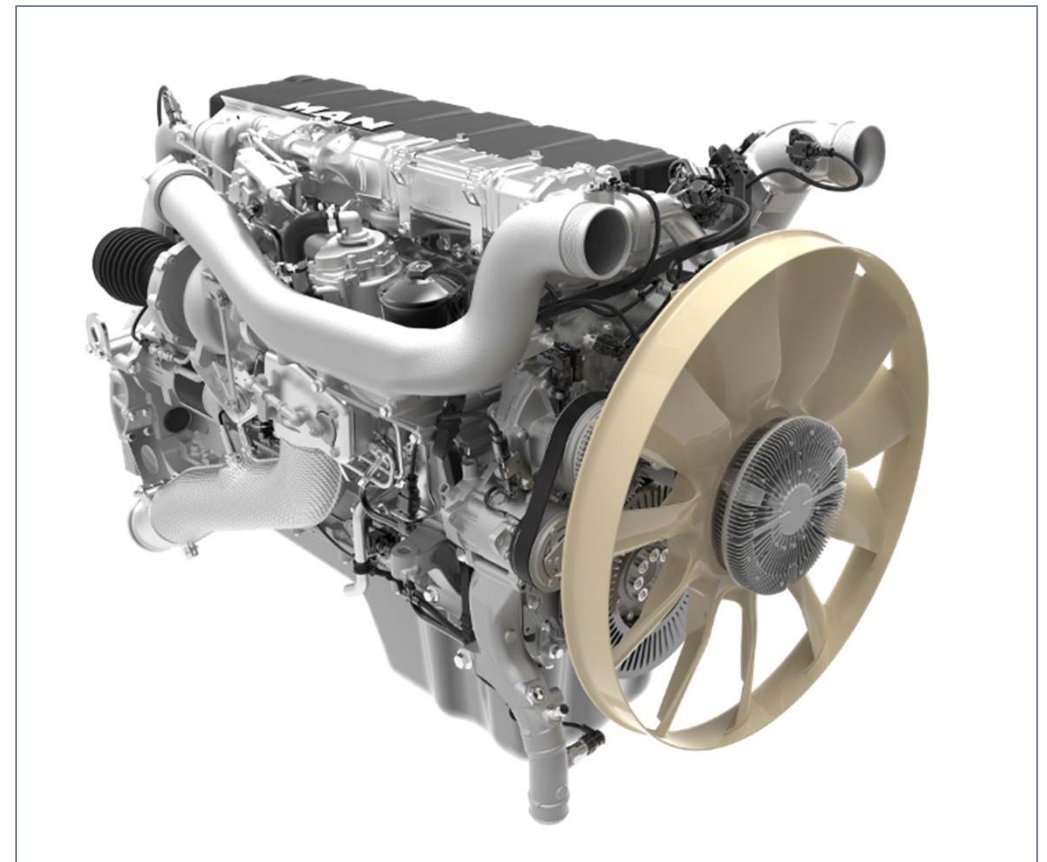
In-engine conflict of NO<sub>x</sub> and PM mass in exhaust gas

MAN engine types designed for actual vehicle range (model year '18 – '20) are fulfilling Euro6d demands by means of a highly efficient exhaust gas aftertreatment.

## What are the technical changes in order to fulfill Euro 6d?

### MAN Euro 6d introduction strategy

- While integrating new Euro 6d engines in their vehicles, MAN introduces several measures to lower fuel consumption and improves R & M management. This includes:
  - Development of new fuel filters for D08, D15 und D26 Euro 6d engines
  - Combustion system optimizations (i. e. no-leakage injection system, increase of cylinder end pressure; not D08)
  - Driveline-embracing control of engine cooling including new controllable coolant pump (D15 and D26)
  - Improved air compressor for all Euro 6d engines
  - Development of airless SCR-dispensing systems for all engines (introduced already for D08 Euro 6c SCR without EGR)
  - Reduction of exhaust gas treatment variants by means of a kit including only 2 basic variants (small, mid-size) of silencers, covering all Euro6d applications for trucks **and** buses



enhanced engine MAN D2676 Euro 6d

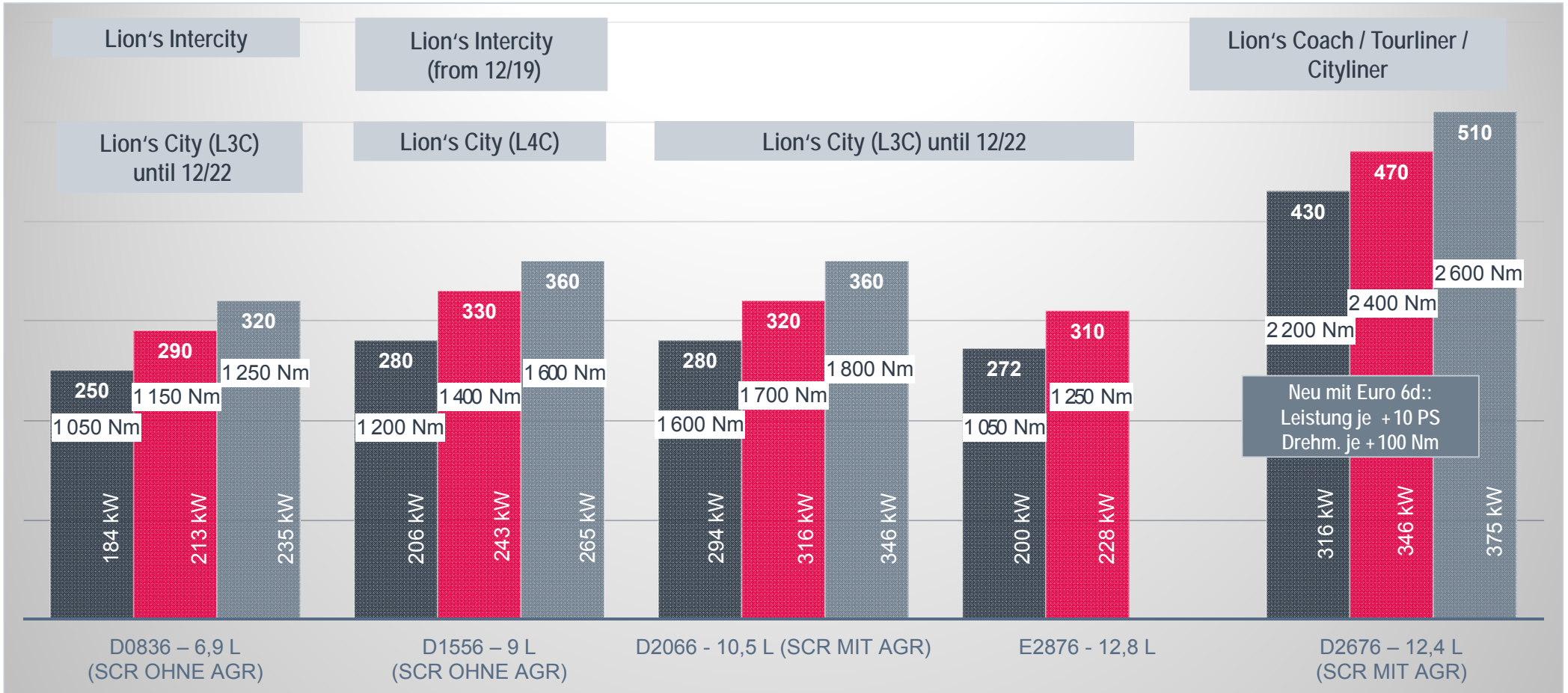


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Engine – portfolio

# MAN Bus engines Euro 6d

Skyliner



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engine- highlights Euro 6d

## Highlights of MAN Euro 6d engines (Bus)

### Optimized driveline concept

- **New:** higher engine power for D26 (SCR with EGR)
  - Power increase: + 10 bhp
  - Torque increase: + 100 Nm
- **New:** D15 Euro 6d (SCR without EGR) replaces D20 Euro 6c (SCR with EGR), all variants

### Improved performance

- **New:** Optimized thermo management to fulfill Euro 6d legal demands
- **New:** Cold start ability up to  $-32\text{ }^{\circ}\text{C}$  without flame start unit for D15 engine

### Simplified exhaust gas treatment

- **New:** reduction of variants
- **New:** airless SCR- dispensing system



### Adapted service interval calculator

- **New:** increased max. change intervals for engine oil and particulate filter (DPF), depending on operation

### Refined engines

- **New:** LIN-generator for all Euro 6d engines
- **New:** fuel saving air compressor for all Euro 6d engines
- **New:** 1-step turbo charger for D26 and D15
- **New:** Common-Rail-(CR)-components
- **New:** combustion chamber layout for D26
- **New:** EGR-module for D26

### fuels

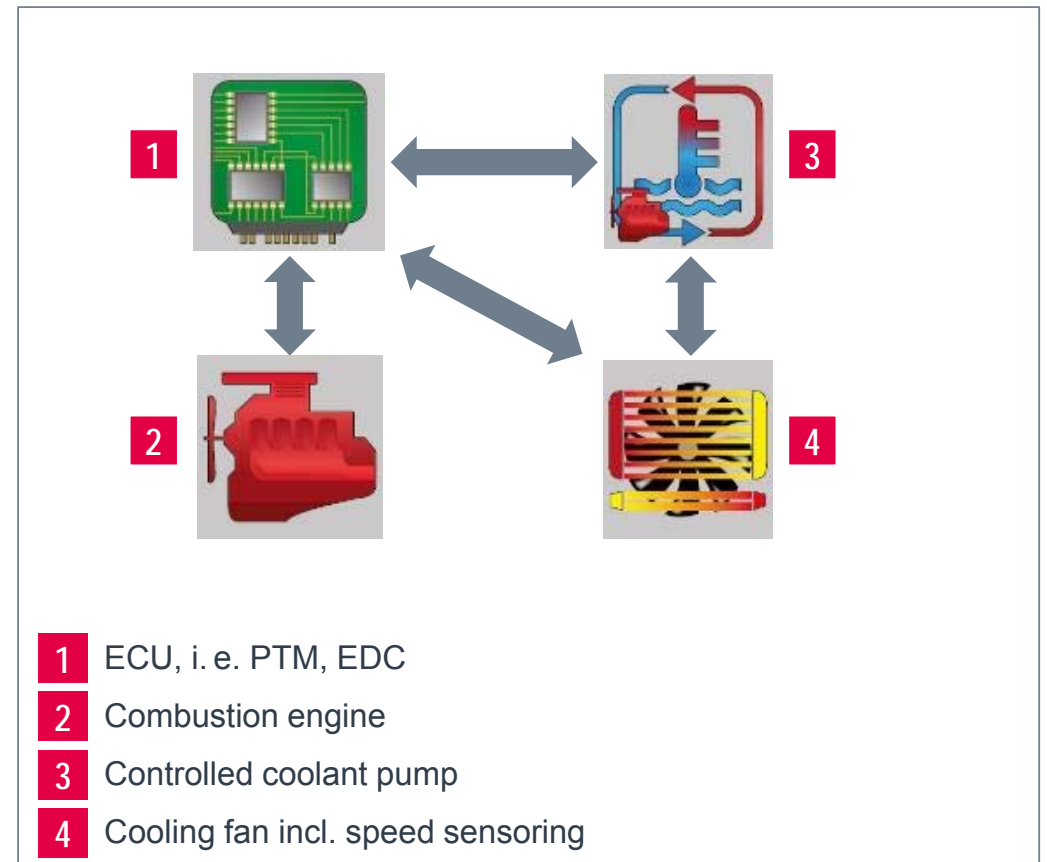
- **New:** 2-step fuel filter system
- **New:** Approval for paraffinic fuels (i. e. HVO) for Euro 6d

remarks: shown features not inevitably available for all engines. D15 newly designed for Euro 6d.

## Optimized thermal management

### Requirements

- Ensuring high exhaust gas temperatures is a new requirement in order to fulfill the stringent legal Euro 6d demands. This is inevitable, as PEMS- measurements are being carried out from cold start as well as additional pay loads from 10% up to 100%.
- MAN ensures compliance by means of an optimized thermal management, mainly including the following measures:
  - Controlled exhaust butterfly valve for all Euro 6d engines
  - Controlled coolant pump for D26 and D15 engines (a rigid coolant pump is available optionally )
  - Fan speed sensing and optimized oil cooler including thermostat



General overview: components for engine thermal management

## Approved fuels for MAN Diesel engines Euro 6d (Bus)

### Diesel fuel

- MAN Diesel engines can be operated with the following fuels:
  - European Norm EN 590
  - DIN EN 590 (Germany)
  - British Standards BS 2869 Class A1 (GB)
  - ÖNORM EN 590 (Austria)
  - ASTM D 975 No. 1 D (USA)
- Euro 6d requires a maximum sulphur content of 10 ppm, a water content of max. 200 ppm and a total fuel contamination of max. 24 mg/kg.

### Biodiesel fuel FAME

- As an alternative to fuel based on fossil oil Biodiesel is important, which is known as FAME. It is approved for D08, D20 and D15 engines.
- FAME (Fatty Acid Methyl Ester) fuels are categorized as „Biodiesel“ they are industrial produced fuels from regenerative raw materials, fulfilling European Standard EN 14214. Technical releases from MAN for engine operation with Biodiesel FAME relate to EN 14214.
- FAME shows different evaporation characteristics and hence causes irreversible oil dilution. Therefore engine oil change intervals must be reduced when operating with biodiesel. **MAN does ask for a Service Warranty Module to be purchased.**
- Mixing FAME with standard Diesel (B7) is uncritical: EN 590 standard does allow for a 7 vol-% content of FAME.
- Use of B100 (100 % Biodiesel) is possible for numerous vehicle/engine configurations

## Approved fuels for MAN Diesel engines Euro 6d (Bus)

### Paraffinic Diesel fuel HVO

- Another alternative to fuel based on fossil oil is HVO (engl.: Hydrotreated Vegetable Oil) according to European Standard EN 15940 . **HVO is approved for all MAN Euro 6d engines.**
- HVO is a second generation synthetic fuel, which is produced from hydrating vegetable oils as well as animal fatt or used cooking oil.
- HVO raw material origins from certified cultivation and therefore does not compete with food production.
- As hydration is already part of fossil fuel production HVO production can easily be integrated in an existing refinery.

### Advantages

- No expensive engine modifications (fuel lines, injectors, seals) necessary
- Service intervals stay unchanged (engine oil, particulate filter)
- No negative impacts concerning driveability (unchanged power)
- No negative impact concerning warranty conditions

## Approved fuels for MAN Diesel engines Euro 6d (Bus)

### Fuel comparison

features	Diesel fuel	Bio diesel fuel FAME	Paraffinic diesel fuel HVO
<b>Applicable standard</b>	<b>EN 590</b>	<b>EN 14214</b>	<b>EN 15940</b>
<b>Homologation available (necessary from Euro 6)</b>	Yes	On request	Yes
<b>MAN engine approval</b>	Yes	With Service Warranty Module	Yes
<b>Advantage</b>	<ul style="list-style-type: none"> <li>▪ Good availability</li> <li>▪ Good fuel station network</li> <li>▪ General approval</li> </ul>	<ul style="list-style-type: none"> <li>▪ Environmentally friendly</li> <li>▪ Quick biological degradeability</li> </ul>	<ul style="list-style-type: none"> <li>▪ Sulphur free</li> <li>▪ Sinificantly better carbon footprint compared to fossil fuel</li> <li>▪ No engine and periphery modifications necessary</li> <li>▪ Tax benefits in different markets</li> </ul>
<b>Disadvantage</b>	<ul style="list-style-type: none"> <li>▪ High tax duty</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lower energy content than standard diesel, therefore higher consumption</li> <li>▪ Reduced engine power</li> <li>▪ Reduced fuel evaporation</li> <li>▪ Reduced service intervals (Engine oil, DPF)</li> <li>▪ OEM approval uncertain</li> </ul>	<ul style="list-style-type: none"> <li>▪ Partial availability</li> </ul>



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engine- D15 (SCR only)

## MAN D15 engine



## New engine generation MAN D15

### Positioning

- Official name: MAN D1556 LOH
- 9-l- engine D1556 LOH Euro 6d with 280, 330 and 360 bhp as ideal size, completing
  - 6,8-l- engine D0836 LOH Euro 6d with 290 bhp and
  - 10,5-l- engine D2066 LUH Euro 6d with  $\leq 400$  bhp
- concept:
  - **one** engine suits for all city buses
  - **one** model (vertical) reduces number of variants
  - **one** exhaust gas aftertreatment system
- Integration of vertical engine in „engine tower“ in the left rear

The new 9-litre- engine represents the perfect ratio in terms of engine size/ weight and power/ fuel consumption



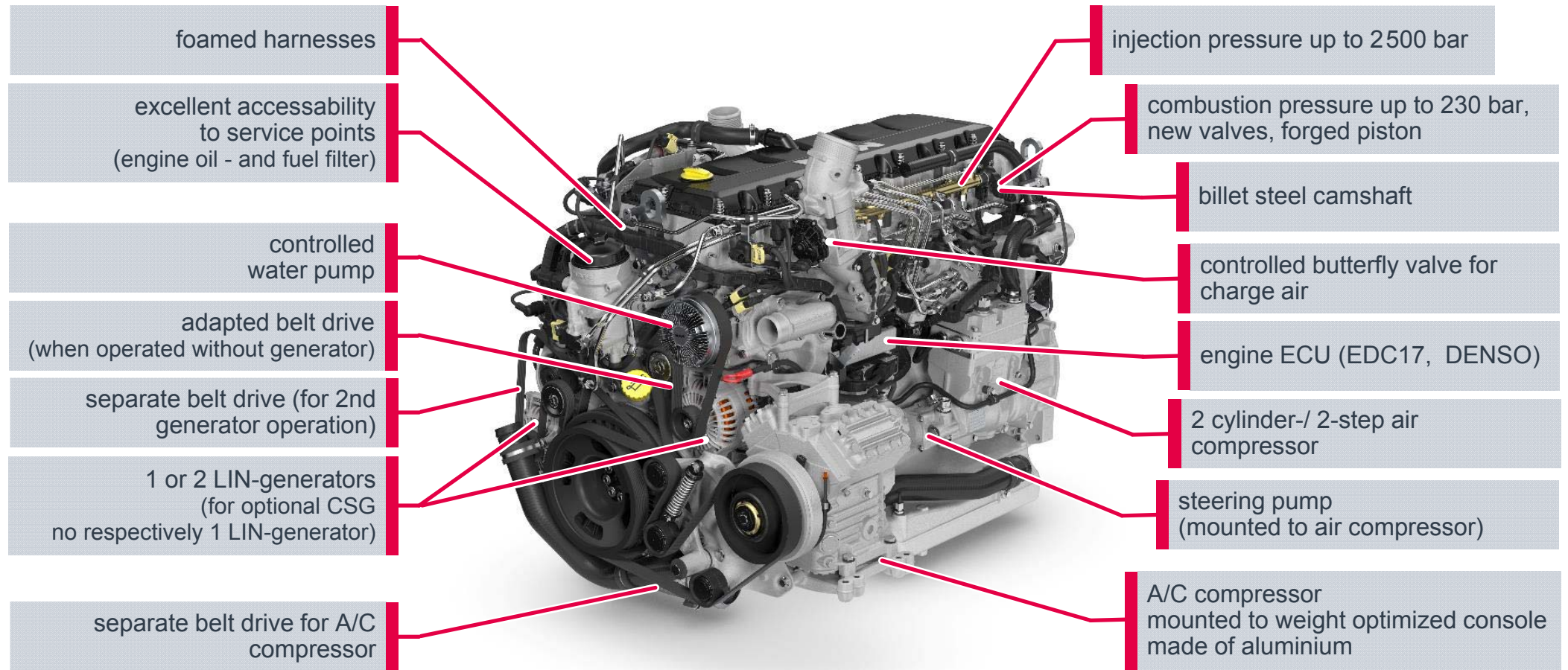
## New engine generation MAN D15

### Customer benefits

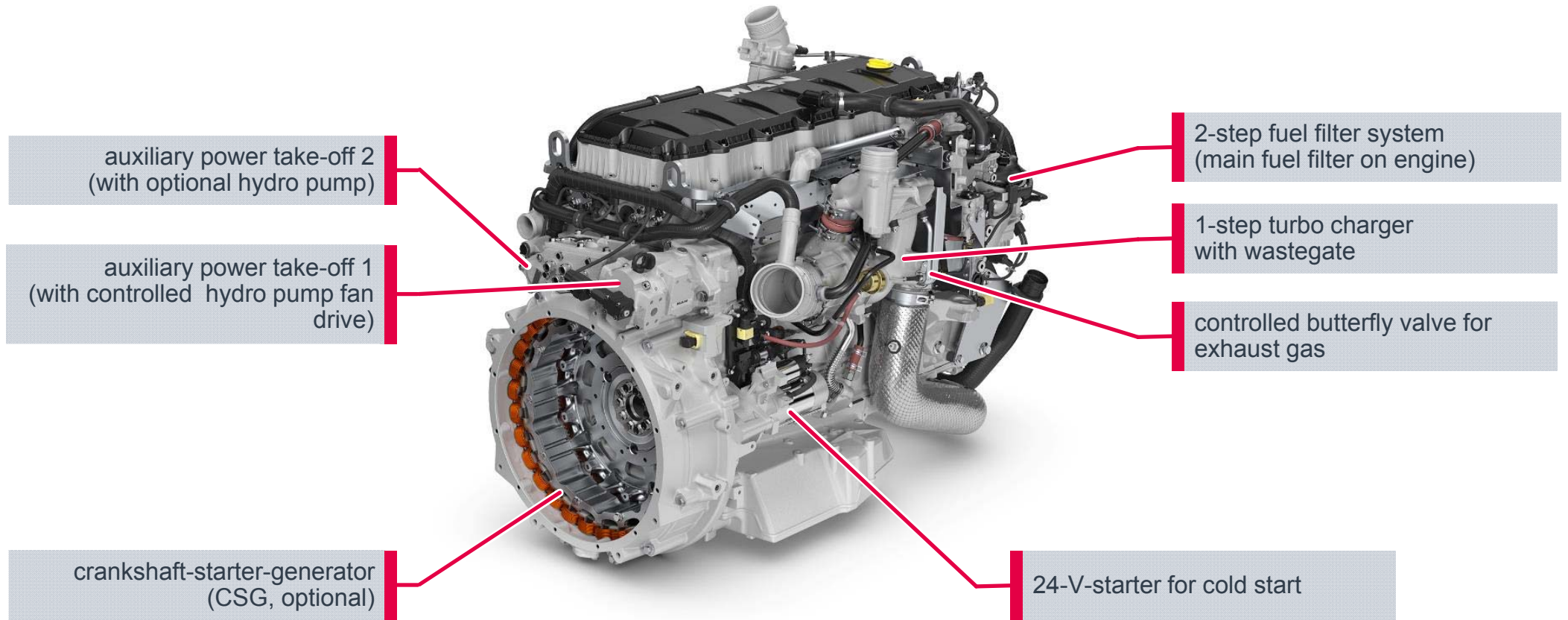
- Higher payload due to reduced engine weight allows for increased passenger number (D15 LOH versus D20 LUH).
- Down-sized and thermodynamic optimized engine allows for reduced fuel consumption
- Easy access to all engine service points allows for simplified repair and maintenance
- Modular engine design reduces R & M costs



## Technical details



## Technical details



## Technical details

Engine	D1556		
Emission	Euro 6d		
Number of cylinders / Design / Valves per cylinder	6 / in-line / 4		
Displacement (l) / Stroke (mm) / Bore (mm) / Compression ratio	9 / 145 / 115 / 21:1		
Injection system	Common Rail		
Rated power (kW/bhp)	206/280	243/330	265/360
Internal engine name	LOH12	LOH11	LOH10
Rated speed (1/min)	1 800	1 800	1 800
Rated torque (Nm)	1200	1400	1600
At engine speed (1/min)	800 – 1600	900 – 1600	900 – 1550
Minimum idle speed (1/min)	550	550	550
Engine weight <sup>1)</sup> (kg)	app. 900	app. 900	app. 900
Engine oil volume without / with oil filter (l)	39 / 40,5	39 / 40,5	39 / 40,5
Oil change interval <sup>2)</sup> / cleaning interval DPF <sup>3)</sup> (km)	up to 80000 / 470 000	up to 80000 / 470 000	up to 80000 / 470 000
Injection pressure / Combustion pressure (bar)	up to 2500 / 230	up to 2500 / 230	up to 2500 / 230
Cold start (°C)	up to –32	up to –32	up to –32

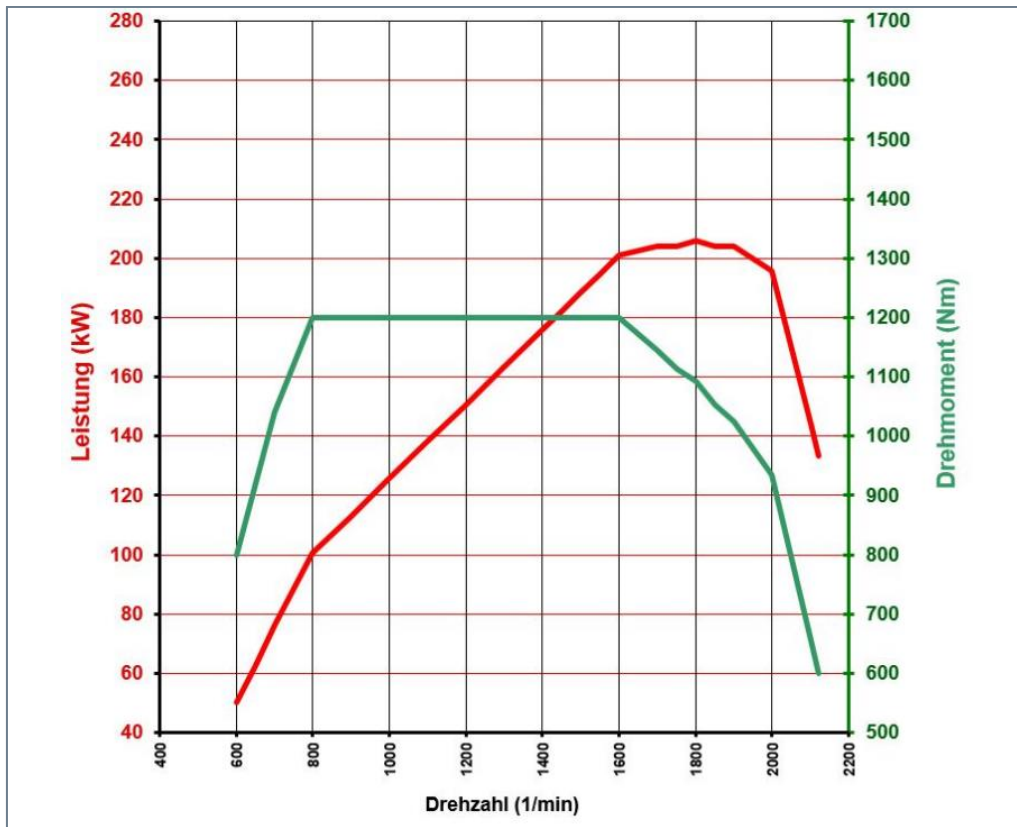
1) Engine weight without oil & coolant

2) Only with engine oil according to M 3677 standard.

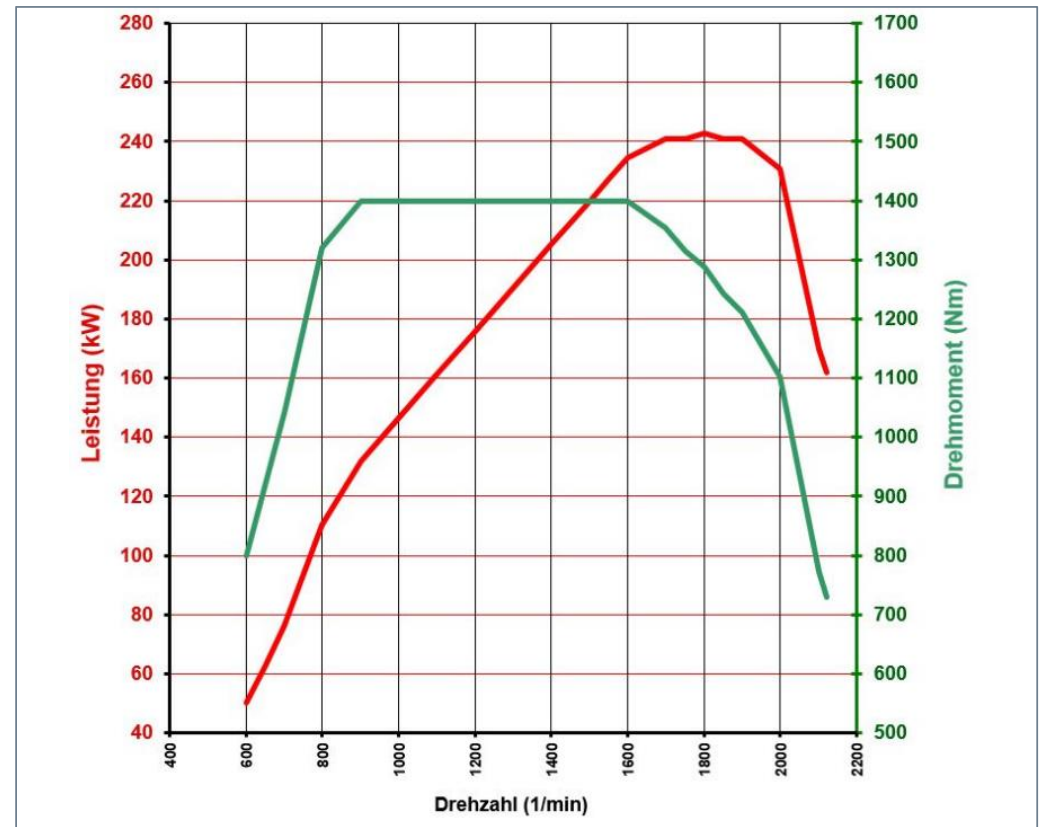
3) Under ideal operational conditions, figures can even be exceeded.

# Engine performance diagrams

D1556 LOH12 206 kW/280 bhp



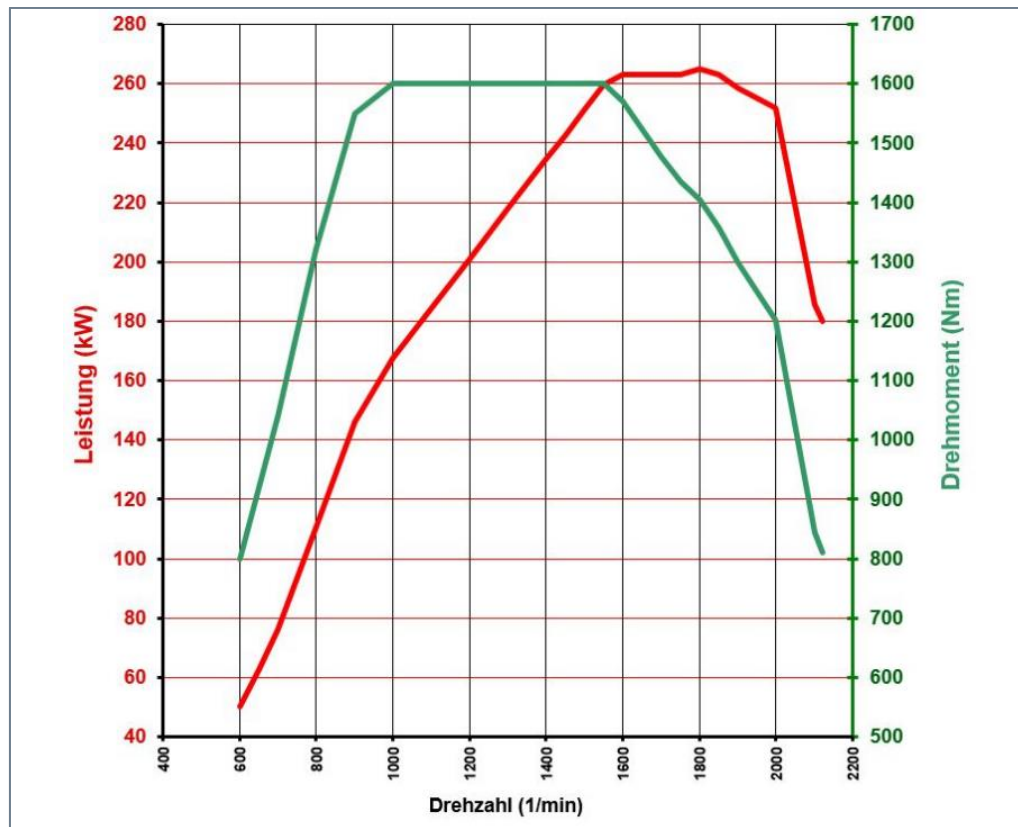
D1556 LOH11 243 kW/330 bhp





# Engine performance diagrams

D1556 LOH10 265 kW/360 bhp



# The new Lion's City with optional MAN EfficientHybrid

## System concept

- The optional MAN EfficientHybrid equipment provides the new Lion's City with an intelligent energy management system for increasing efficiency and improving travel comfort.
- The central component of this innovative hybrid system is the crankshaft starter-generator (KSG) incorporated in the drivetrain between the engine and the transmission.

## Advantages

- The crankshaft-starter generator is a robust and non-wearing electric motor that can operate both as a generator (alternator) during propulsion or braking and conversely also as a starter.
- The electrical energy stored in the electric rooftop components of the hybrid system can also be used to supply consumers in the 24V electrical network of the new Lion's City.

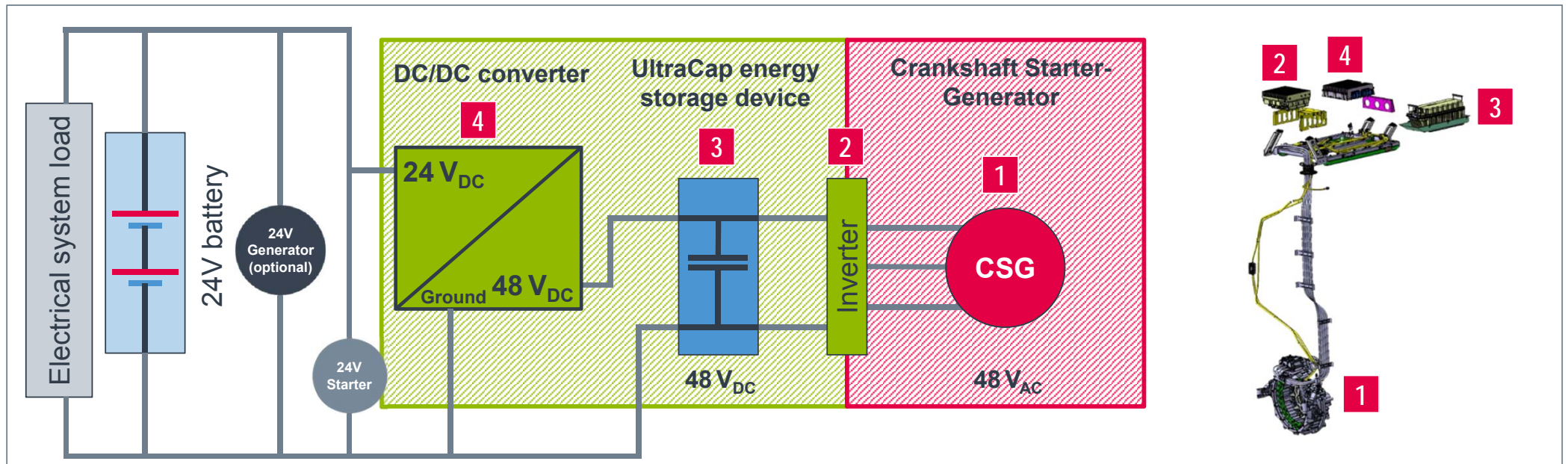
## Customer benefits

- Start-stop operation creates additional fuel savings and enhanced travel comfort
- When the engine stops, no pollutants are emitted at the bus stop, and the bus starts quickly and silently when moving off again



# System overview

## The new Lion's City with optional MAN EfficientHybrid



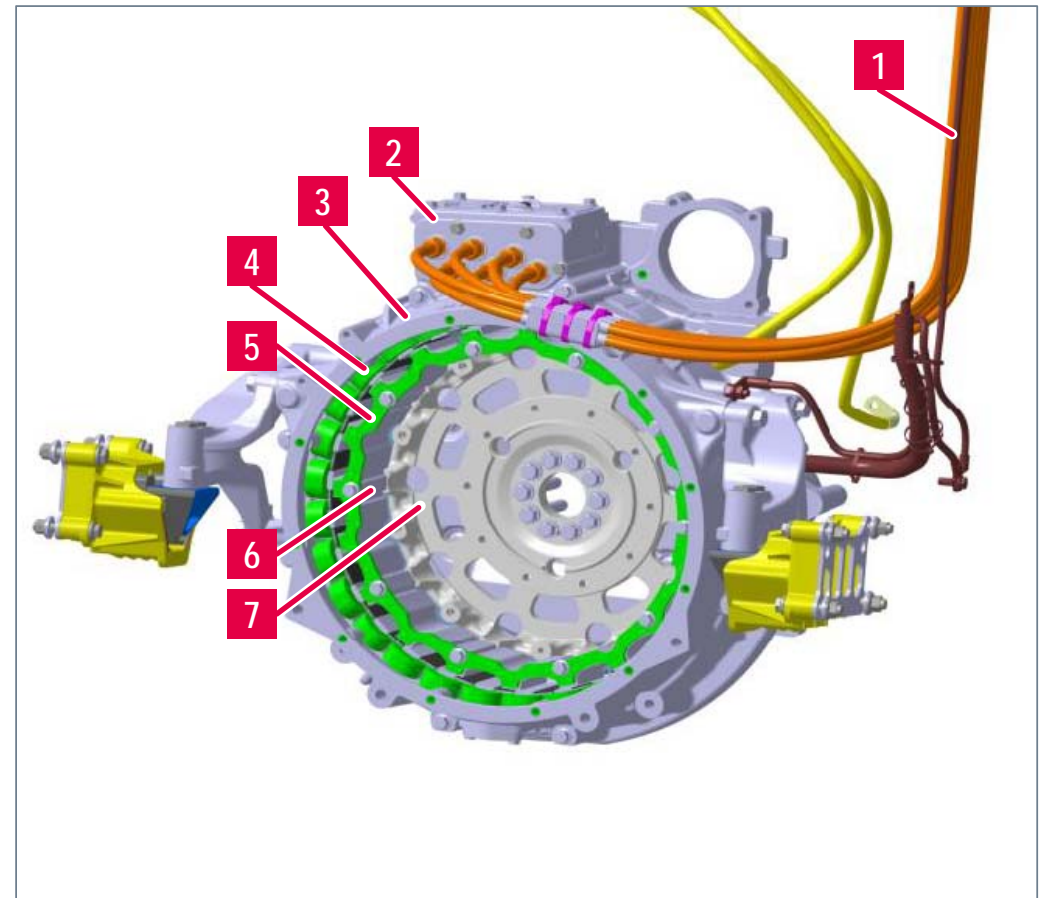
<b>System:</b>	48 V <sub>DC</sub> , grounded
<b>Components:</b>	DC/DC converter, UltraCap energy storage device, inverter, crankshaft starter-generator (KSG), wiring
<b>Operation:</b>	Stop/start, recuperation, 24V vehicle electrics supply

# System components

## Crankshaft Starter-Generator

### Construction

- 1** Connecting cables
- 2** Terminal box
- 3** Housing
- 4** Stator
- 5** Rotor: Mounting ring
- 6** Rotor: Laminated core
- 7** Rotor: Rotor carrier (= flywheel)

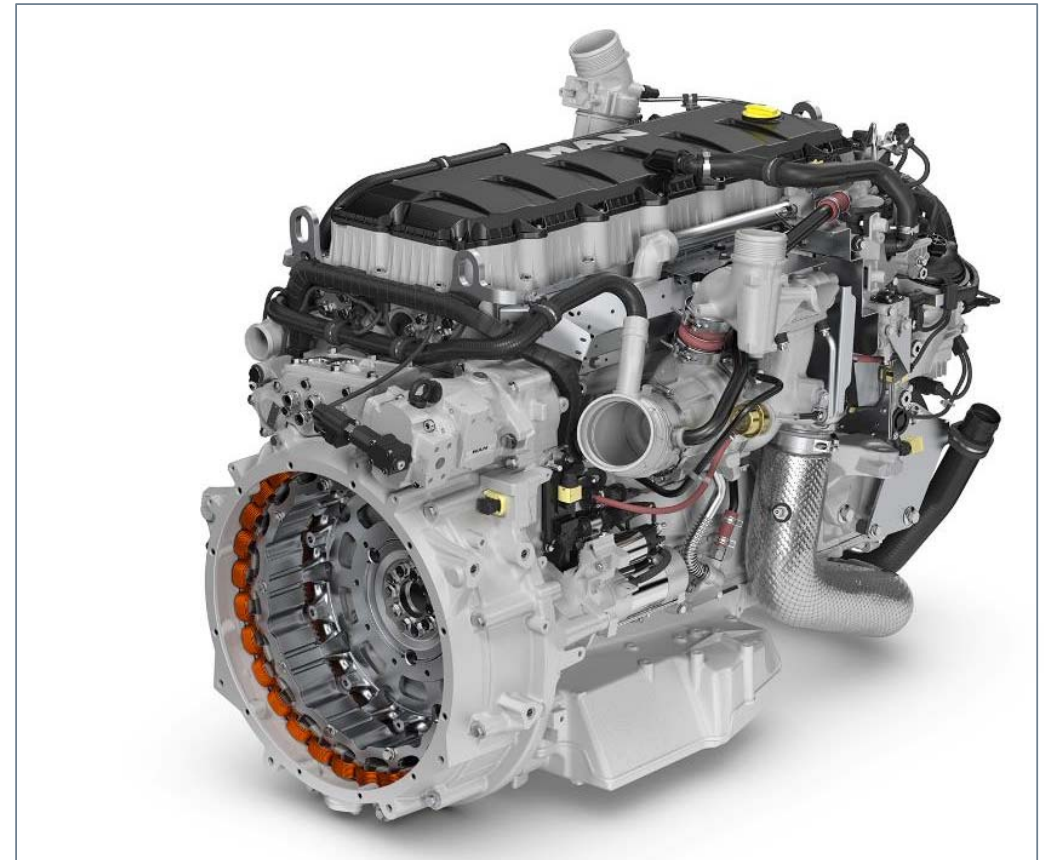


# System components

## Crankshaft Starter-Generator

### Technical specifications

- Type of motor:  
Air-cooled reluctance motor, three-phase switched
- Power:  
 $P_{\text{Cont}} = 8\text{kW}$  (continuous power)  
 $P_{\text{Peak}} = 12\text{kW}$  (peak power)
- Starting torque:  
520Nm



Crankshaft starter-generator fitted to D1556 engine

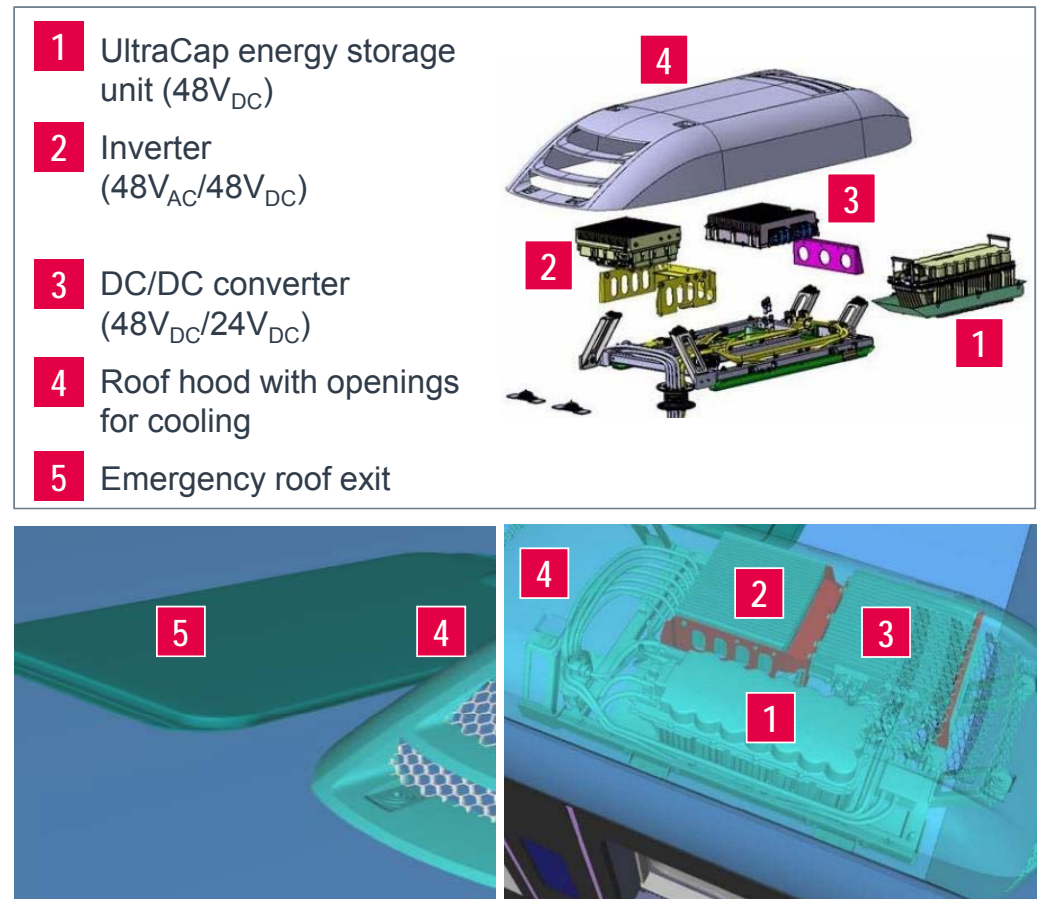
# System components

## System components on vehicle roof

- To facilitate optimum cooling, electric and electronic power components for energy storage and conversion are placed beneath the roof hood of the new Lion's City with MAN EfficientHybrid (4).

## Advantages

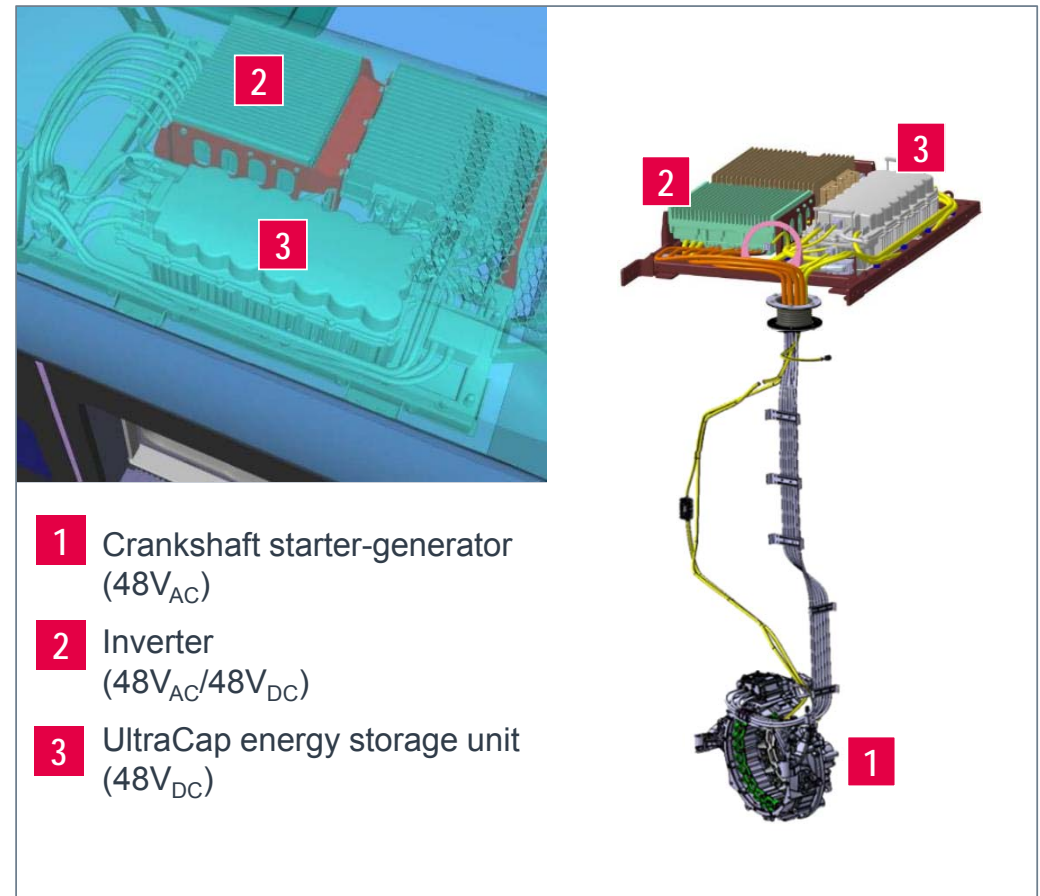
- The roof hood:
  - Provides mechanical protection of the power components (1) to (3),
  - Contains aerodynamic openings for optimum flow of cooling air flow
  - Acts as a touch guard when using the roof emergency exit located at the rear (5).



## System components

### Inverter ( $>30V_{AC}/<60V_{DC}$ )

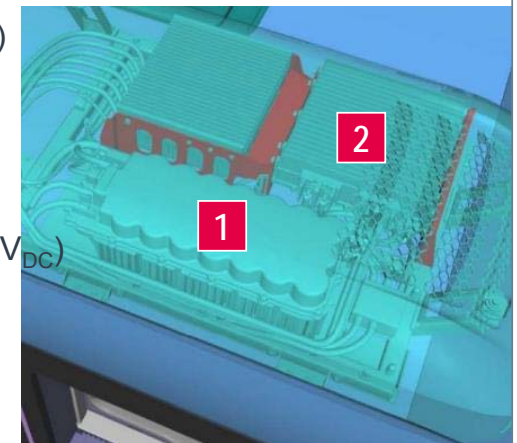
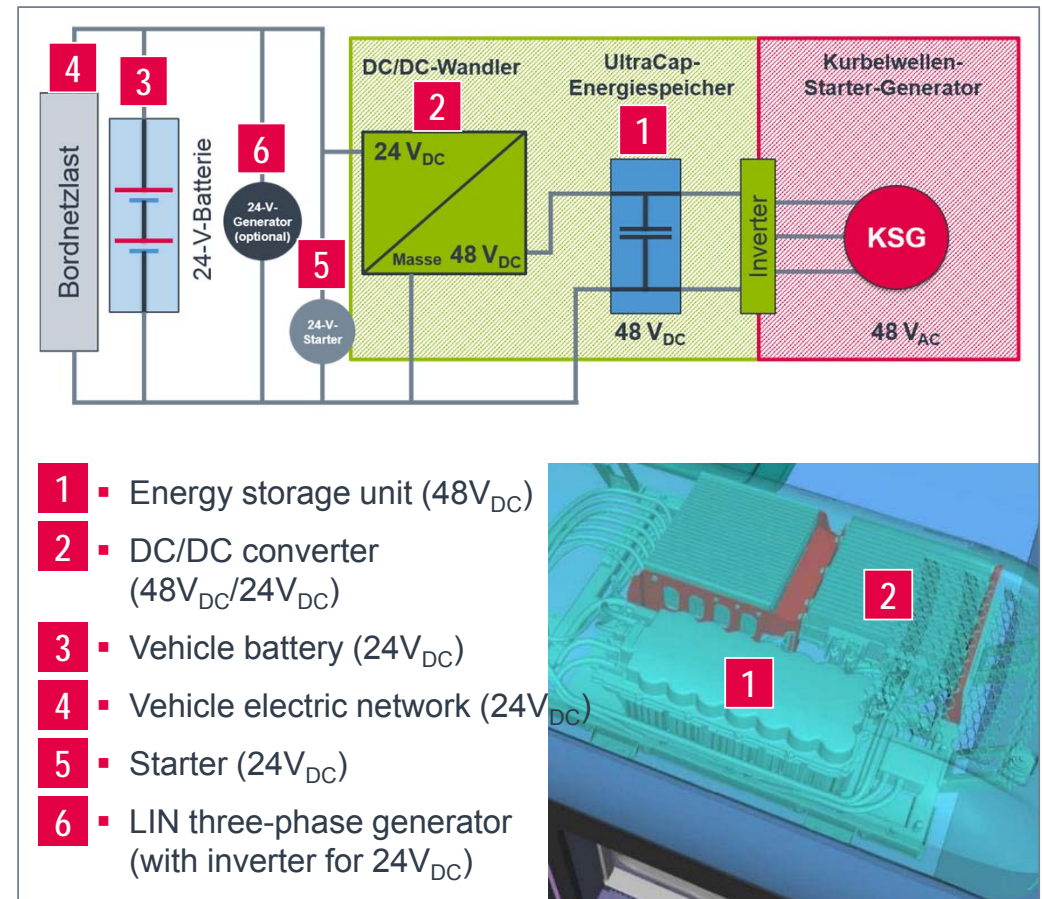
- The inverter (2) transforms the electrical energy between the crankshaft starter-generator (1) and the UltraCap energy storage module (3).
- **Propulsion phase (recuperation of braking energy):**  
The three-phase alternating voltage of  $>30V_{AC}$  produced by the crankshaft starter-generator in generating mode is converted to the UltraCap DC voltage of  $<60V_{DC}$ .
- **Startup phase:**  
UltraCap DC voltage of  $<60V_{DC}$  is converted back to the three-phase alternating voltage of  $>30V_{AC}$  required by the crankshaft starter-generator.



# System components

## DC/DC converter (<math>60V\_{DC}/24V\_{DC}</math>)

- To supply the vehicle electric network while travelling, the crankshaft starter-generator of the MAN EfficientHybrid system normally functions as a generator. The inverter converts the 48V AC voltage from the starter-generator to DC and feeds this to the 48V intermediate circuit.
- The DC/DC converter (2) transforms the energy stored (<math>60V\_{DC}</math>) in the UltraCap module (1) to the on-board vehicle electrics voltage (<math>24V\_{DC}</math>).
- The power from the UltraCap module is used for:
  - Charging the vehicle battery (3)
  - Supplying the vehicle electric network (4)
- Generator equipment:
  - 1 x 120A with optional MAN EfficientHybrid with 18m articulated bus or 12m single bus with many consumers
  - Without generator, with optional MAN EfficientHybrid with 12m single bus



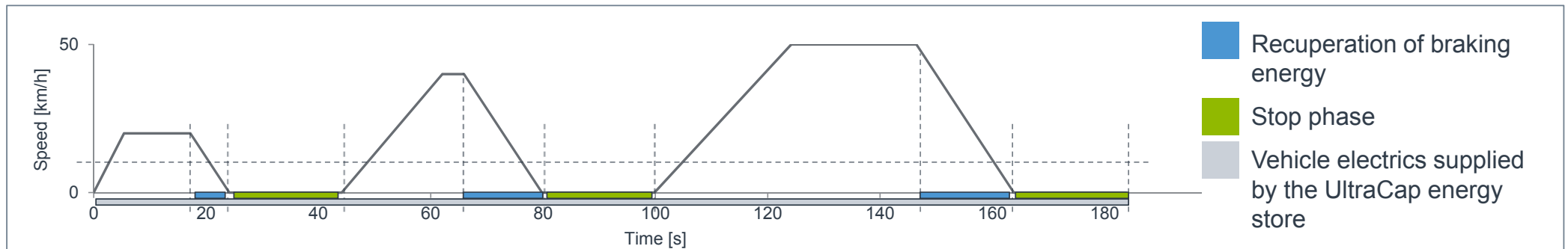


# System function

## MAN EfficientHybrid with stop-start function and recuperation

- In propulsion phases, the starter-generator generates electrical energy, which is stored in the UltraCap module ( $48V_{DC}$ ).
- When the vehicle is at a standstill, the combustion engine is shut down; it starts up again immediately before moving off. During the stop-phase, the electrical system is supplied by the DC/DC converter ( $48V_{DC}/24V_{DC}$ ) from the UltraCap power storage unit. Similarly, the energy required for starting the combustion engine by the crankshaft starter-generator operating as a motor ( $48V_{AC}$ ) is supplied from the UltraCap unit by the inverter ( $48V_{DC}/48V_{AC}$ ).
- When accelerating or cruising, no energy is generated for the electric system. This relieves the load on the combustion engine. The vehicle electric system is supplied by power from the UltraCap storage unit.

## Travel cycle - example of light urban traffic (SORT 2)

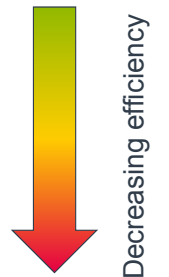


# System function

## Use of recuperated energy

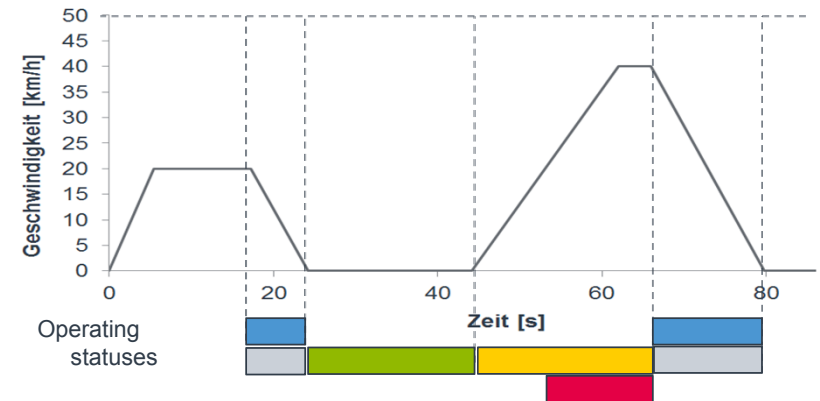
To attain the maximum savings potential with MAN EfficientHybrid as a stop-start system with recuperation, it is necessary to reuse the recuperated energy on the basis of a priority system:

- Priority 1: Vehicle electric supply during stop phase
- Priority 2: Load relief of diesel engine by vehicle electric system during travel phase (without recuperation phase)
- Priority 3: Boost operation: additional load relief of diesel engine by means of electric engine in motor mode (only when surplus energy is available in the UltraCap)



### Detail of travel cycle

- Recuperation of braking energy
- Vehicle electric supply - direct
- Vehicle electric supply from UltraCap during stop phase
- Vehicle electric supply from UltraCap during travel phase
- Optional boost operation



# System function

## Schematic diagram of drivetrain with MAN EfficientHybrid

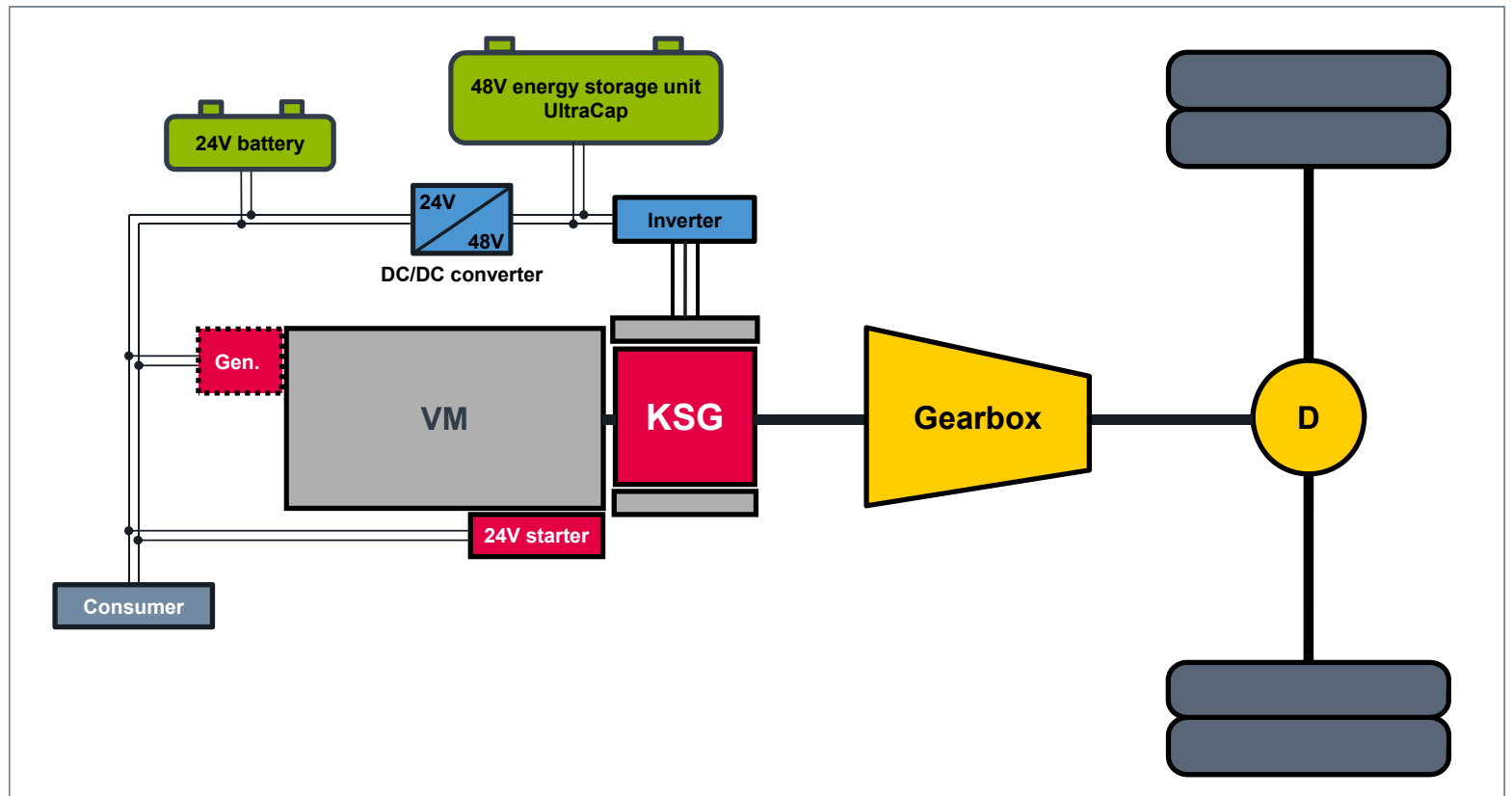
### Abbreviations

VM = combustion engine  
(diesel  
MAN D15)

CSG = crankshaft starter-  
generator

D = Differential

LIMA= Alternator  
(24V generator  
built into  
articulated bus)



# Engine concept

## New Common-Rail-injection system

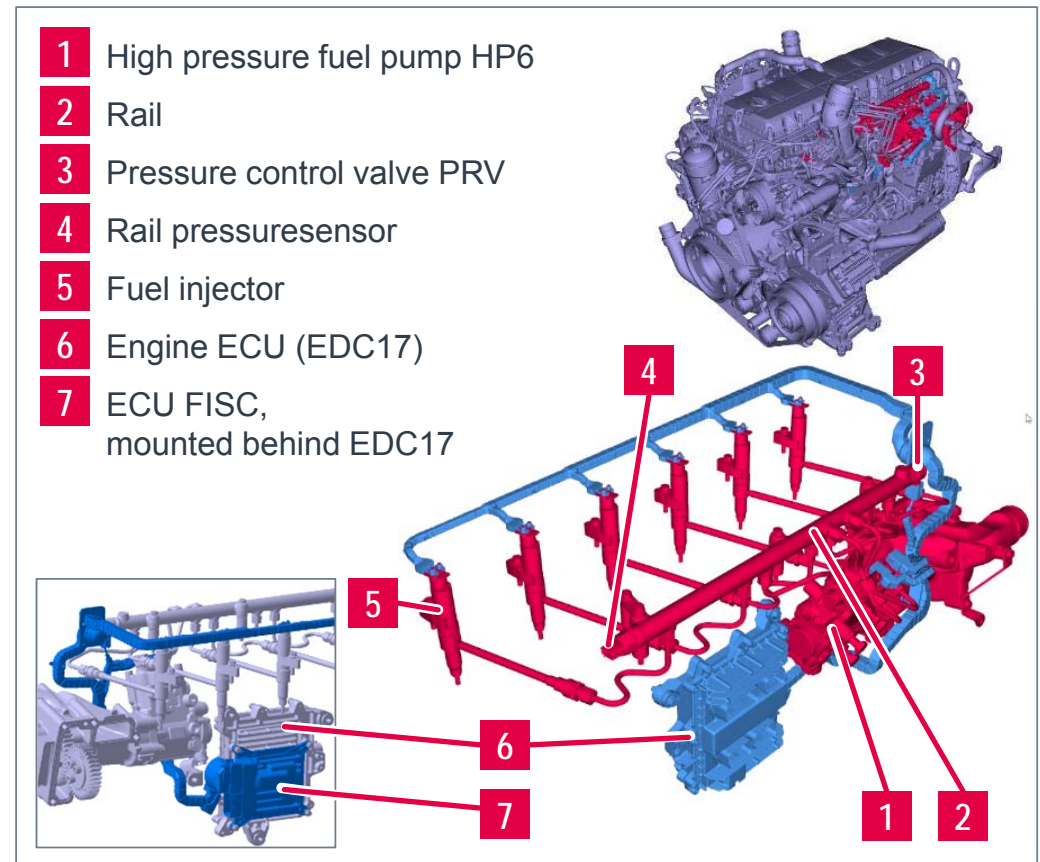
- The new Common-Rail-System for MAN D15 engine is supplied by DENSO
- Engine is controlled by EDC17-ECU. High pressure components are no longer connected to EDC17, but to upstream FISC (also supplied by DENSO), which communicates with EDC17.

## advantages

- High injection pressure of 2500 bar delivers optimized evaporation and most efficient combustion.
- High pressure pump HP6 (1) delivers high efficiency by means of 1:1 ratio as well as electronic controlled suction valves
- Injectors (5) are leakage-free and require very little control volume

## Customer benefit

- Reduced fuel consumption and CO<sub>2</sub>- emission



New Common-Rail-Injection system for D1556 engine

# Engine concept

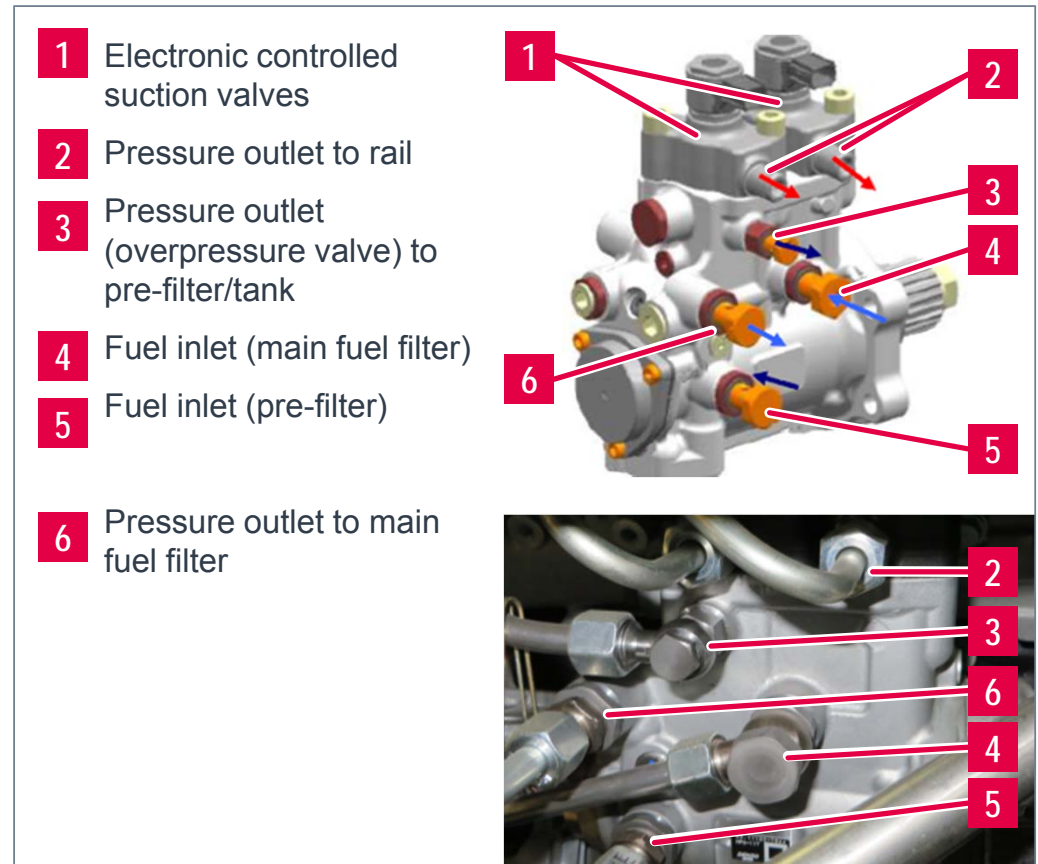
## New Common-Rail-components

### High-pressure fuel pump HP6

- New HP6 utilizes 2 pistons, working in parallel.
- Mechanically driven by flywheel gear.

### Advantages

- High-pressure pump delivers 2 500 bar , enabling optimized evaporation & combustion
- High efficiency due to 1:1 ratio and leakage-free injectors
- Fuel lubricated pump equipped with electronically controlled suction valves
- Integrated in new optimized fuel filter concept



Common-Rail- high pressure fuel pump HP6 for D1556 engine

# Engine concept

## New Common-Rail-components

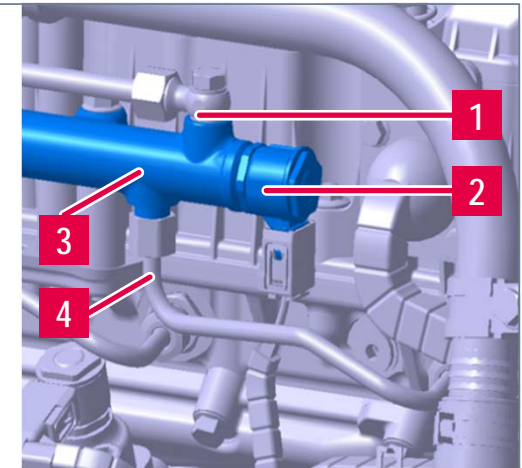
### PRV (Pressure Relief Valve)

- PRV enables constant fuel pressure in rail, independent from engine operation.

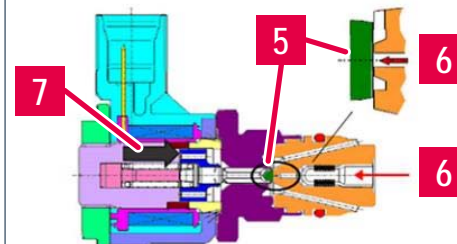
### Working principle

- During normal operation PRV is de-energized (closed) by spring force, ensuring max. fuel pressure in rail
- During dynamic operation, such as load release (shifting or engine stop) PRV is energized (opened). Fuel released from rail enables drop of pressure to desired level.

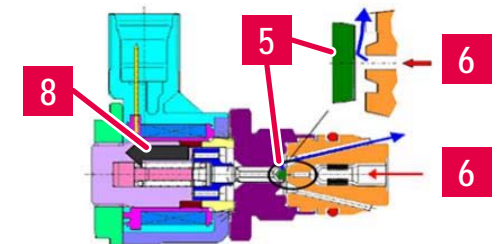
- 1 Fuel return line (to tank)
- 2 Pressure relief valve PRV
- 3 High pressure rail
- 4 Injector line
- 5 Valve seat
- 6 Fuel flow direction
- 7 Spring force
- 8 Magnetic force



Normalbetrieb (geschlossen)



Dynamischer Betrieb (geöffnet)



Common-Rail-Druckregelventil PRV am Motor D1556

## Engine concept

### Exhaust gas aftertreatment Combined CRT and SCR system

Exhaust gas aftertreatment for MAN D15 engine was designed as a SCR-concept. It includes

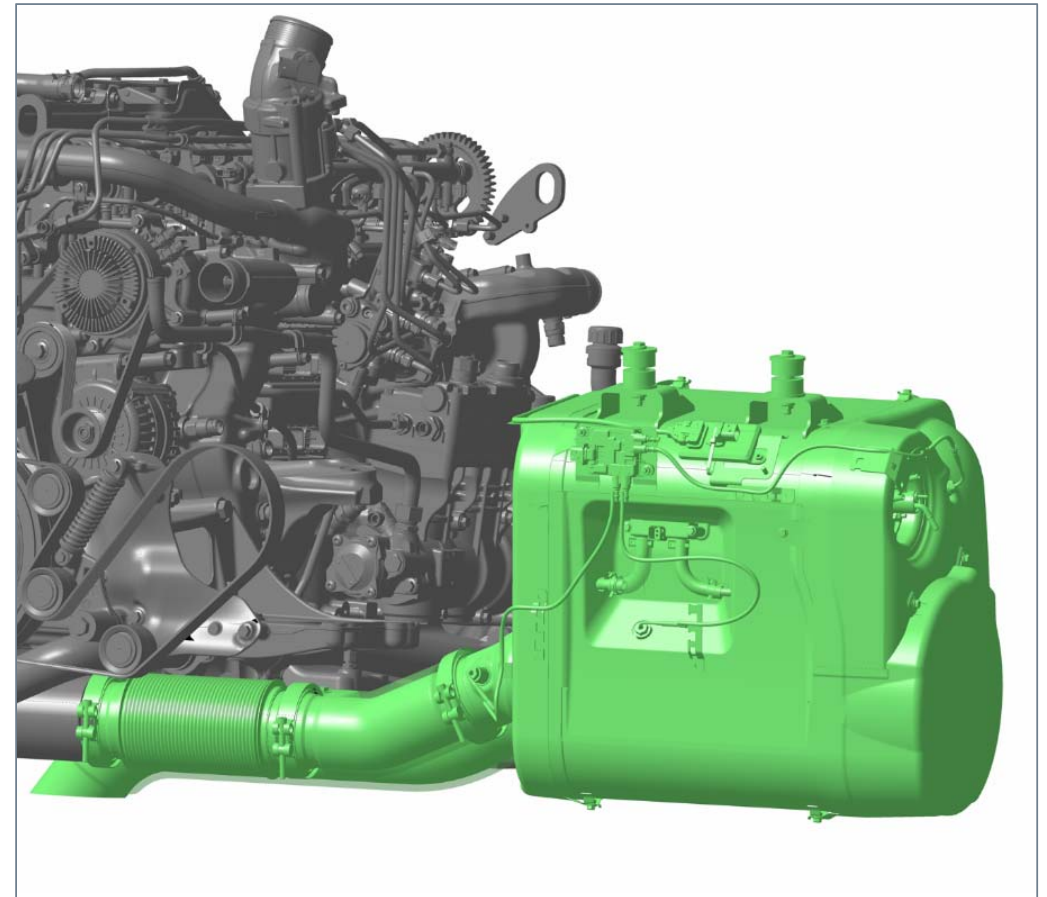
- A continuously regenerating filter system  
MAN CRT (Continuously Regenerating Trap)
- A selective catalytic reduction system SCR

### Advantages

- Reduction of der emissions below Euro 6d (separate chapter „EGA-System“)

### Customer benefit

- Meets Euro6d demands valid from 01.09.2018



# Engine concept

## Weight reduction

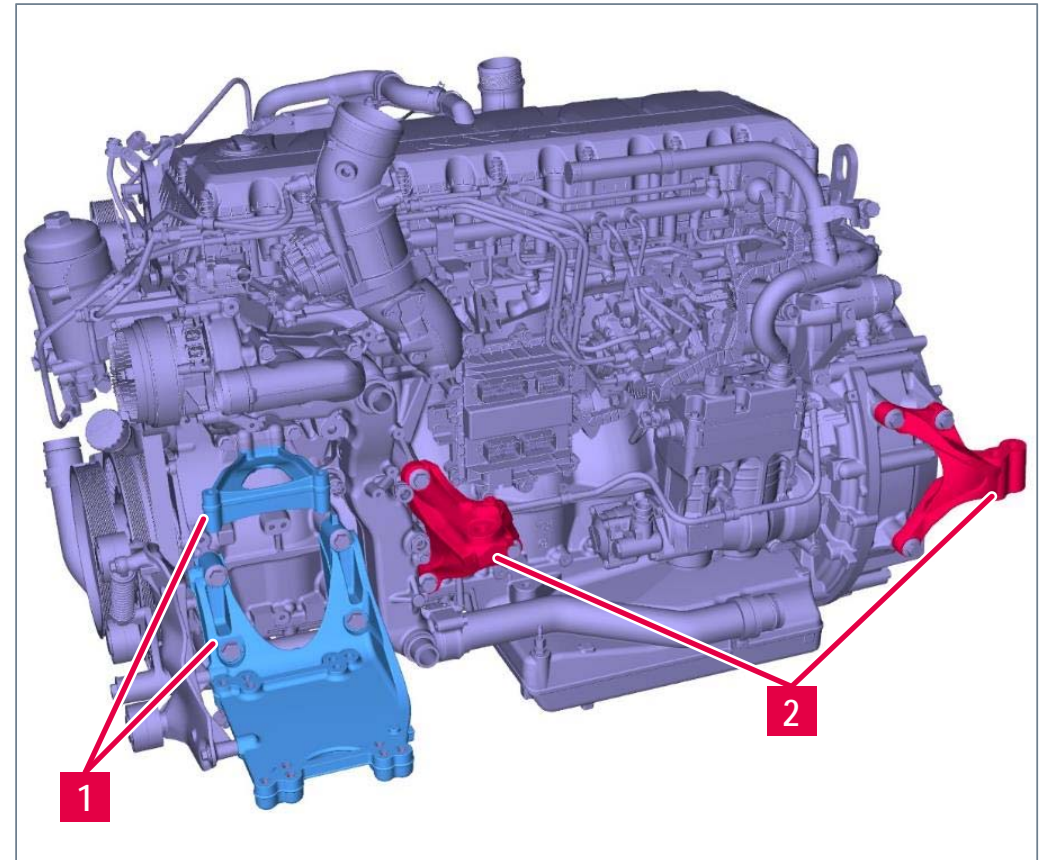
- State-of-the-art simulation methods were used for several components for new MAN D1556 engine. This allows for extended lifetime despite reduced component weights.
- Alloy cast instead of iron cast for A/C compressor (1), engine bracket (2) and straight mounting of engine components to engine block saves weight

## Advantages

- Power-to-weight ratio of MAN D1556 LOH was significantly optimized. 360 bhp engine comparison:
  - D1556 LOH = 3,40 kg/kW (2,50 kg/bhp)
  - D2066 LUH = 3,88 kg/kW (2,86 kg/bhp)

## Customer benefit

- Reduced fuel consumption
- Higher vehicle load capacity due to reduced vehicle weight



Optimized components for D1556 engine, using modern simulation tools



## Charge-air and exhaust gas system

### Optimized 1-step turbo charger

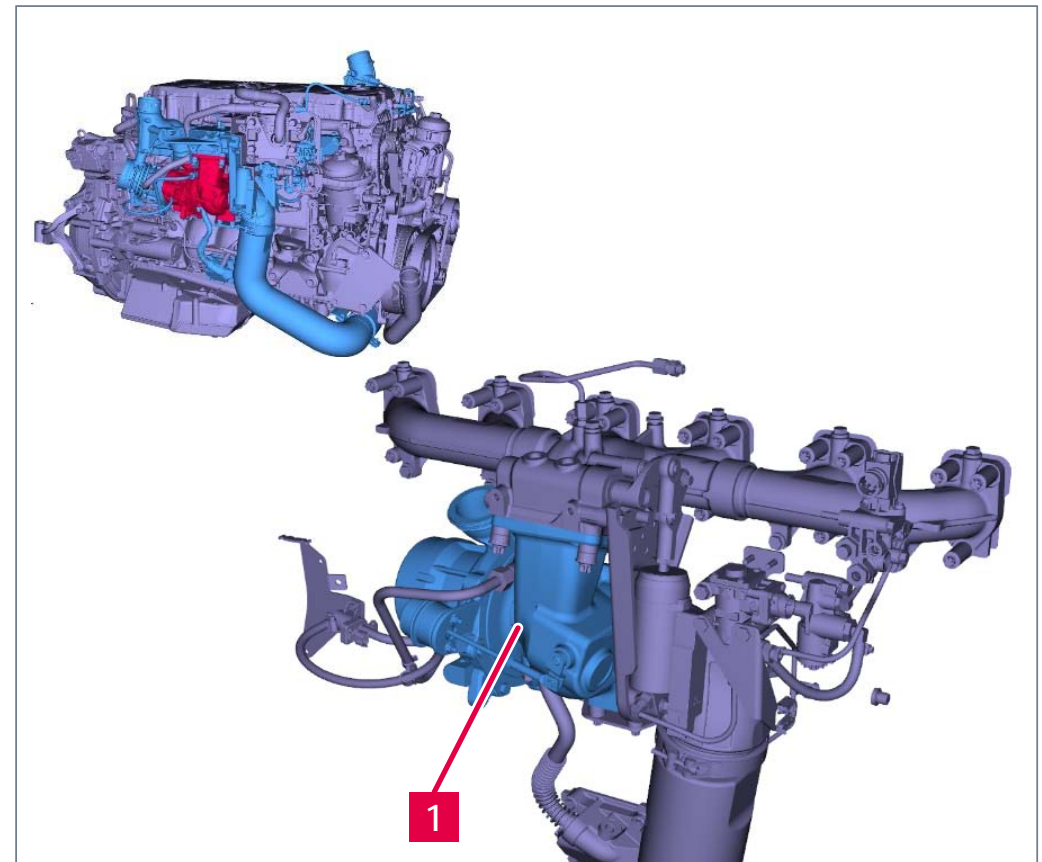
- New step turbocharger (1) allows for ideal power evolvement and excellent load response.

### advantages

- Different to engines with EGR concept, SCT utilizes total exhaust gas mass for efficiency – enhancement

### Customer benefit

- Dynamic „load response“



Optimized 1-step turbo charger for MAN D1556 engine

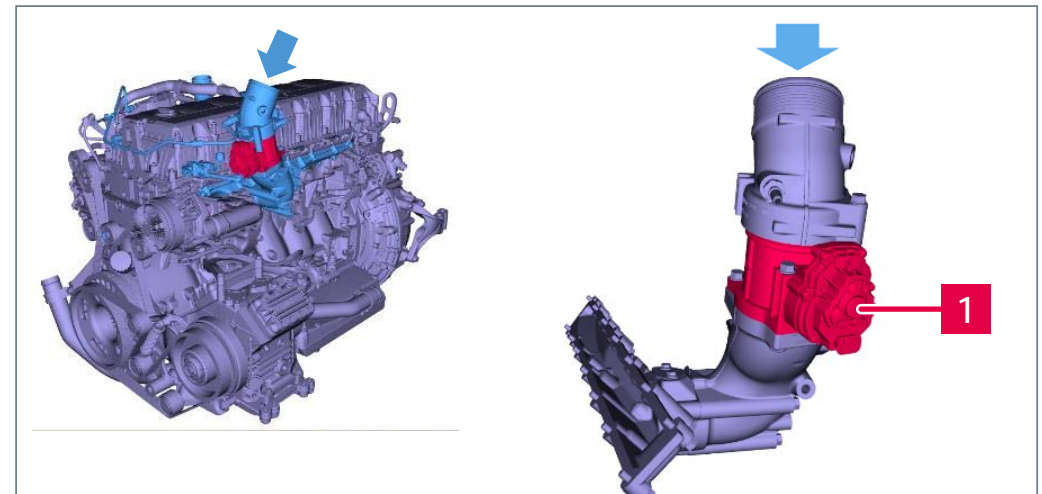
## Charge-air and exhaust gas system

### Controlled butterfly valve for charge air (upstream engine)

- SCR exhaust gas aftertreatment concept requires high exhaust gas temperatures – especially during partial load or idling.
- In order to keep exhaust gas temperatures high during all operation/load modes an additional charge air butterfly valve(1) was introduced – in addition to existing exhaust gas butterfly valve.

### Advantages

- New charge air butterfly valve speeds up engine warm-up, supporting high exhaust gas temperature levels



Controlled butterfly valve for charge air (upstream engine) - D1556 engine

### Customer benefit

- Significantly reduced warm-up phase
- Consistently low fuel consumption due to constant exhaust gas temperatures
- Reduced thermal fluctuation reduces engine wear

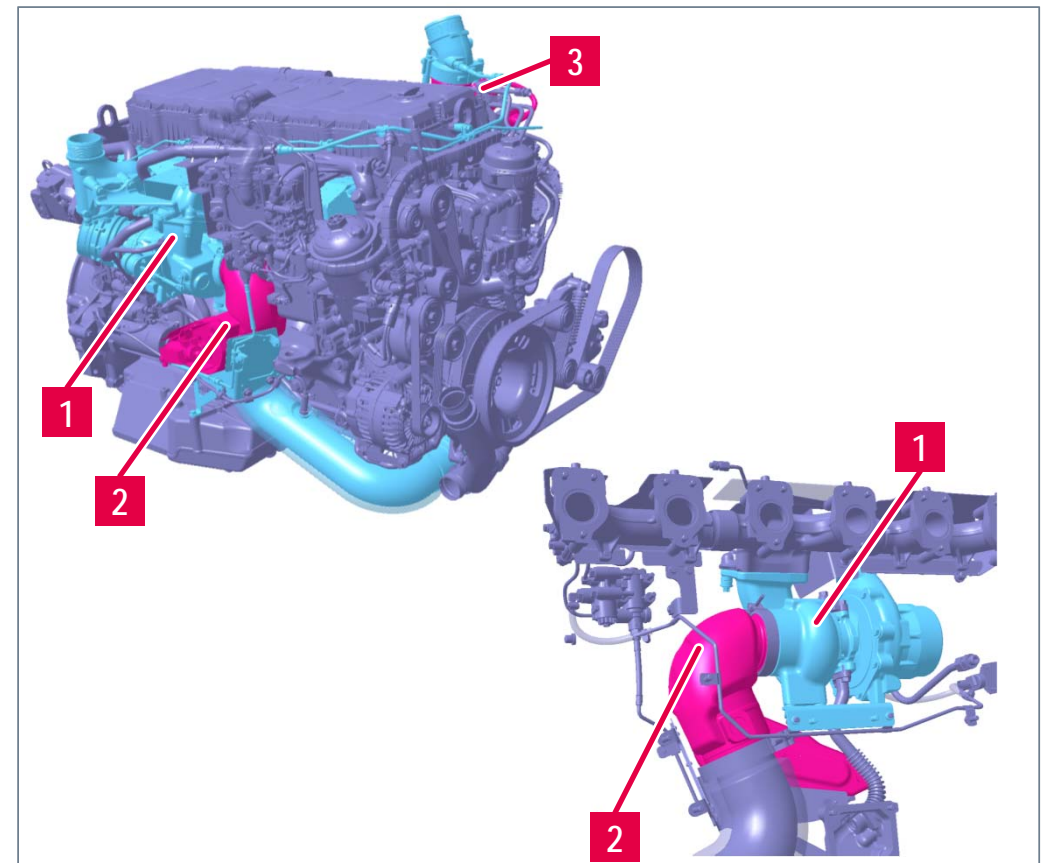
## Charge-air and exhaust gas system

### Controlled exhaust gas butterfly valve (downstream engine)

- Butterfly valve(2) located downstream of turbo charger(1) for D15 engine.

### Advantages

- Valve enables high engine temperature during low load operation.
- Controlled valve as well as charge air butterfly valve(3) are integral components of engine thermal management



Controlled exhaust gas butterfly valve

# Fuel system

## 2- step fuel system

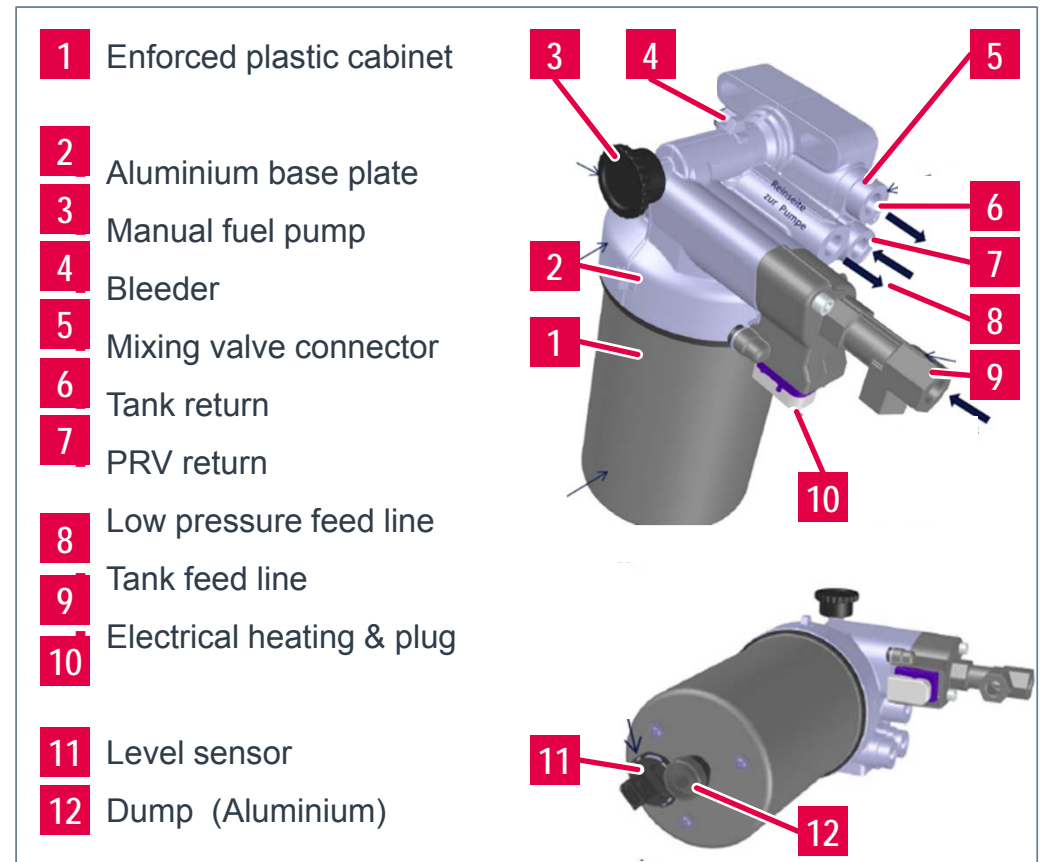
- New D15 engine is equipped with entirely new 2- step fuel filter system made by HENGST.

## Fuel pre-filter

- Pre-filter located at the fuel tank consists of:
  - Electric fuel heating
  - First step of particle separation
  - Water separation

## Advantages

- Manual fuel pump (3) is no longer mounted to main fuel filter but integrated in new pre-filter
- Integration of mixing valve, particle pre-filter and water separator allows for improved cold-start ability, extended main filter lifetime and effective water separation (2- step water separation)
- Water level sensor (11) controls reservoir, triggering display warning if necessary



Fuel pre-filter located at fuel at tank ( new Lion's City)

# Fuel system

## 2- step fuel filter system

### Fuel main filter

- Modifizierte fuel main filter (mounted to engine) ensures highest cleanliness necessary for reliable Common-Rail- injection by means of
  - 2nd step of separation
  - Electric fuel heating

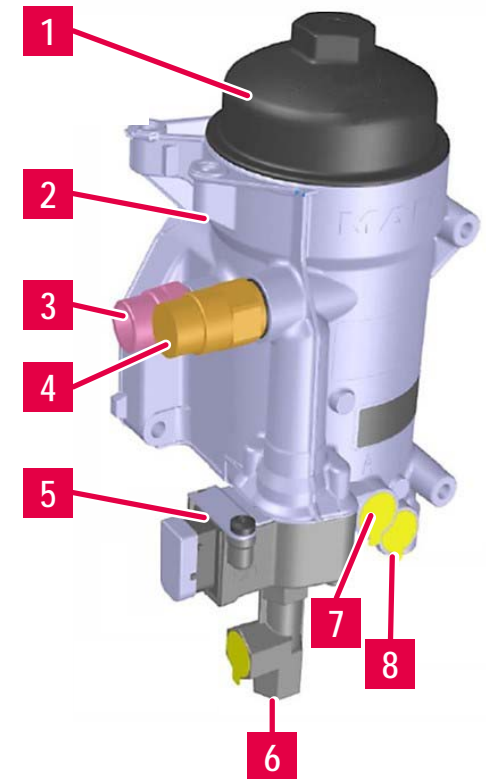
### Advantages fuel main filter

- Engine-mounted main filter enables low pressure circuit fine filtering pre-filter and manual pump mounted to vehicle
- 2- step filtering allows for better particle separation as well as higher lifetime.
- Electric fuel heating (5) supports improved cold start ability down to  $-32\text{ }^{\circ}\text{C}$ .

### Customer benefit

- Highest reliability and very good cold start ability

- 1 Aluminium cover
  - 2 Aluminium socket
  - 3 Pressure sensor
  - 4 Temperature sensor
  - 5 Heating and plug box
  - 6 Connector
  - 7 Low pressure feed
  - 8 High pressure feed
- Fuel dump (Aluminium optional)



Main fuel filter for D1556 engine

## Engine electrical system / electronics

### Foamed harnesses

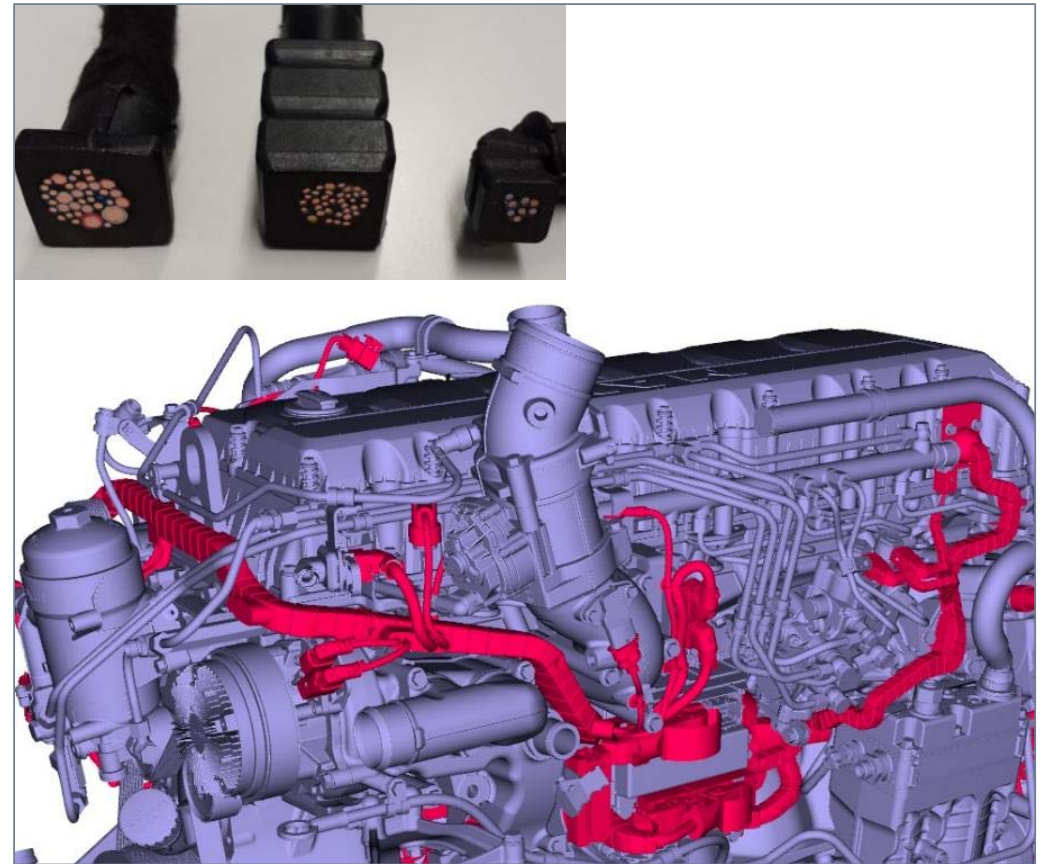
Harnesses covered with plastic foam

### Advantages

- No internal friction, cables resist vibration
- Perfect shaping and exact wiring
- Mechanical robustness and protected against damage

### Customer benefit

- High reliability & longevity



Foamed harnesses for MAN D1556 engine

## Engine electrical system / electronics

### 24-V-generator with LIN-interface

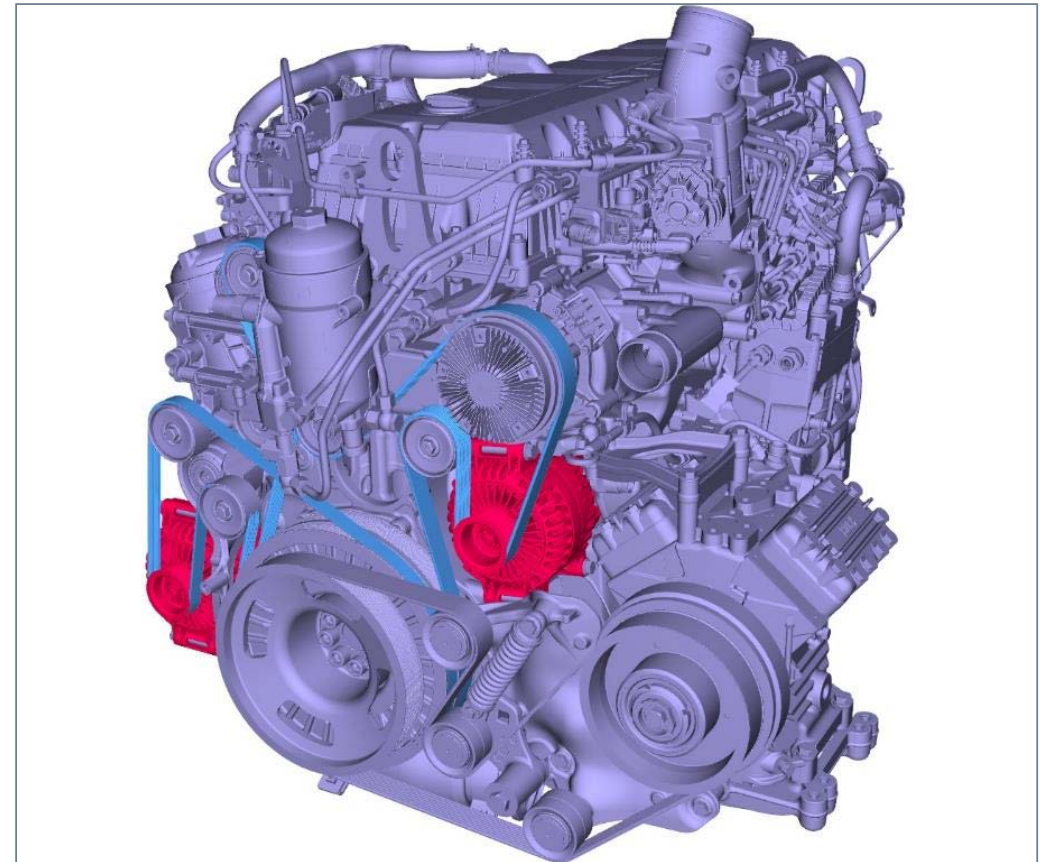
- All-new 24-V-generators come with a LIN-interface(engl.: LIN = Local Interconnect Network). Generator performance for vehicle battery charging is controlled via interface

### Advantages

- When pulling off, accelerating as well as during normal drive operation, solely 24-V-consumers are supplied. This minimizes generator power loss.
- While slowing down or braking LIN-generator is set to max charging power. This allows for high efficient battery charging.

### Customer benefit

- Fuel saving due to generator power on-demand



2-generator setting with separate belt drives for D1556 engine

## Engine electrical system / electronics

### Generator configurations

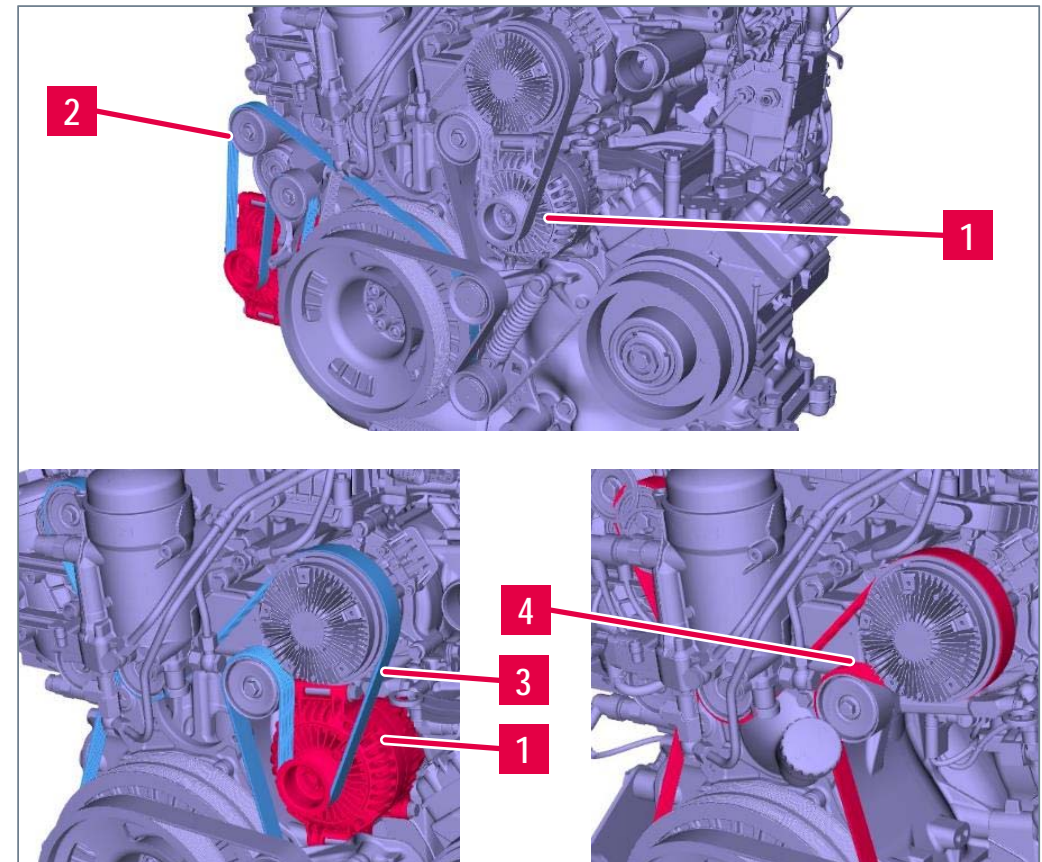
- D15-engine ready for following variants:
  - 2 x 120 A (2 x 190 A for special requirements)
  - 1 x 120 A (1 x 190 A depending from consumers)
  - 1 x 120 A with optional MAN EfficientHybrid (18-m-articulated bus or 12-m- solobus with many consumers)
  - Without generator for optional MAN EfficientHybrid (12-m- solo bus)

### Advantages

- Reduced number of variants.
- 2nd generator equipped with separate belt drive (2).
- 1st generator (1) utilizes identical drive (3) as water pump.

### Customer benefit

- Cost optimized variant available, depending from customers' requirements



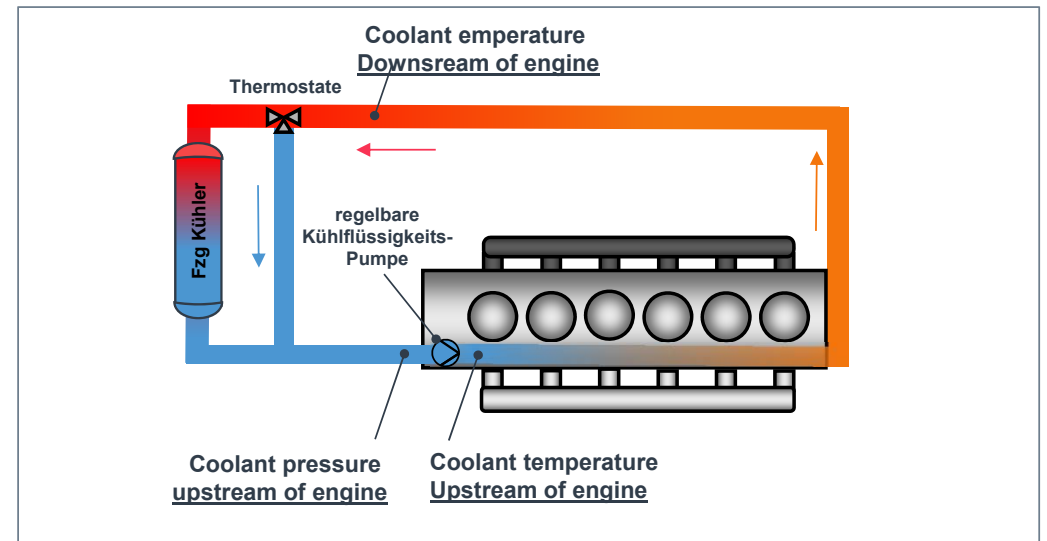
LIN-generator variants for D1556 engine



# Engine cooling

## Thermal management

- MAN D15 engine is equipped with new components which allow for advanced thermal control.
- Fan drive and water pump are integral components.
- In addition to coolant temperature sensing also cooling system pressure is sensed
- Pressure monitoring allows for water pump performance control in case of pressure drop. Component damage can be avoided
- Short term increase of coolant temperature is permissible and allows for delayed fan activation.



Temperature- and pressure monitoring for D1556 engine

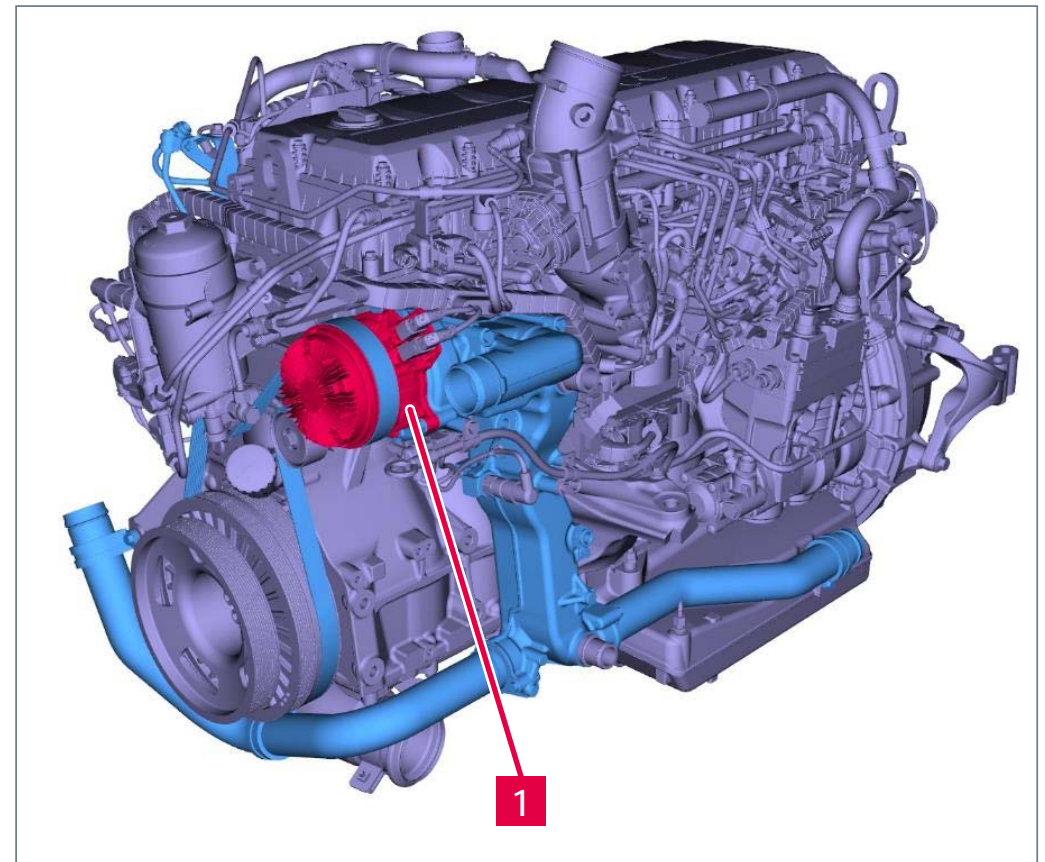
## Customer benefit

- Fuel savings due to more efficient engine operation
- Higher operational reliability by means of improved engine temperature control
- Improved diagnostics

## Engine cooling

### Controlled coolant pump

- Unlike many other OEM MAN equipped the new D15 engine with a continuously controllable coolant pump (1). This enables significant fuel savings.
- Coolant pump is equipped with a visco-clutch which allows speed control from 20 to 95 %
- Variable speed control allows for reduction of driving power up to 3 kW



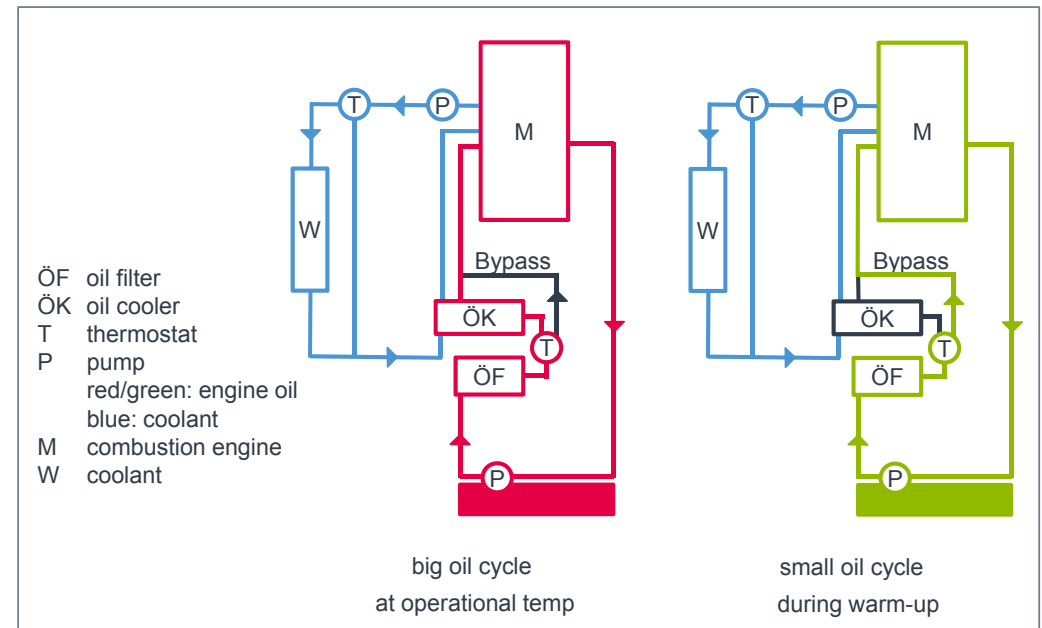
Controlled coolant pump for D1556 engine

# Engine lubrication

## Optimized engine oil cooler with thermostat II

### Advantages

- Oil volume control enables three important targets:
  - Quick attainment of desired engine oil temperature allows for reduced internal engine friction. The new integrated thermostat works as a bypass which opens the big lubrication cycle if needed
  - Oil cooler can be bypassed during low load operation and low cooling demands..



engine oil circulation including bypass-control for D1556 engine

### Customer benefit

- Fuel saving due to reduced internal engine friction
- On-demand engine oil cooling

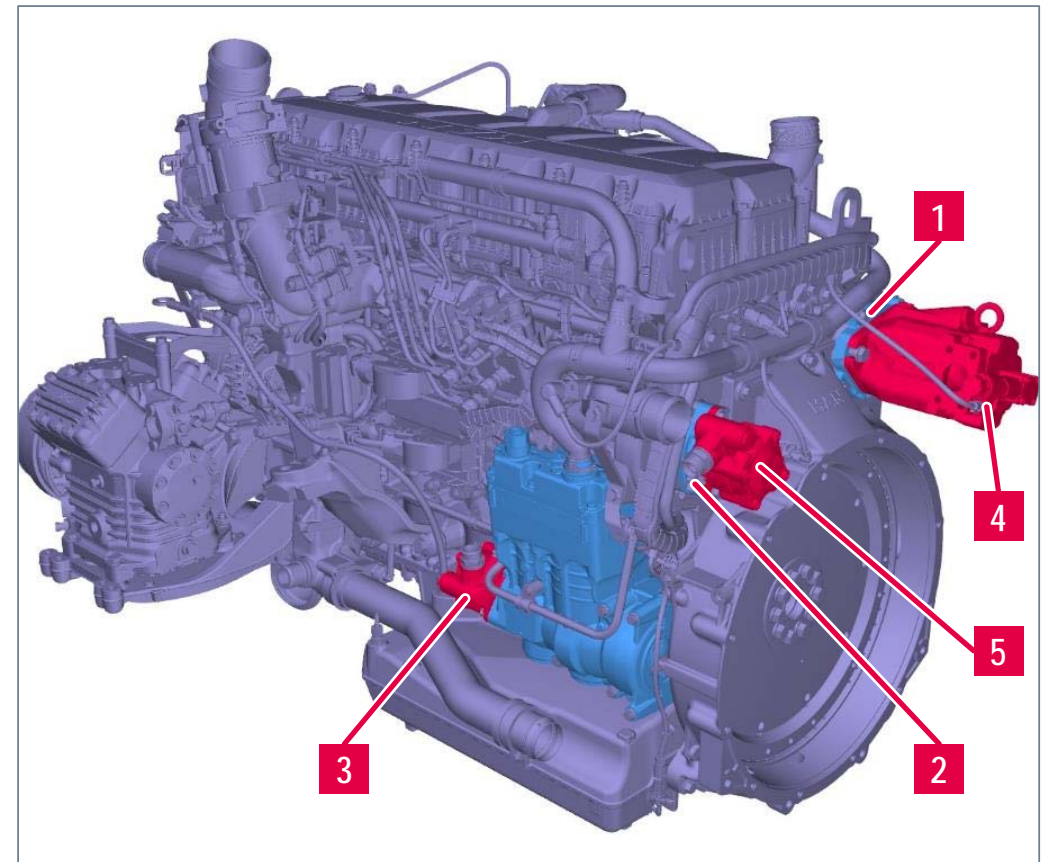
## Engine auxiliary components

### Available power take-off variants for new D15 / new Lion's City

- Flywheel power take-off (1)
  - Connection for hydraulic fan drive pump (4) as a very compact city bus solution
- Power take-off (2) gear for CR-high pressure fuel pump
  - very compact city bus solution
  - optionally available for additional hydraulic drive (A/C compressor for passenger compartment)
  - power take-off (3) located at 2-cylinder- air compressor
- Hydraulic steering pump mounted (new Lion's City)

### Customer benefit

- Availability of all necessary power take-off variants for city bus application



Power take-off variants for D1556 engine



Thank you for your attention!

