

Construction Machinery Systems

From Less to Zero



The Future of Construction. NOW.

Contents

From Less to Zero	4
ZF is Efficiency	6
Electrification	26
Vehicle Intelligence	44
Braking Technology	46
Chassis Technology	48
ZF Aftermarket	50

The Future of Construction

Electrification

Efficiency

Vehicle
Intelligence

Safety

FROM LESS TO ZERO

INTELLIGENT SYSTEM SOLUTIONS

More
information
[www.zf.com/
futureofcon-
struction](http://www.zf.com/futureofconstruction)

From Less to Zero

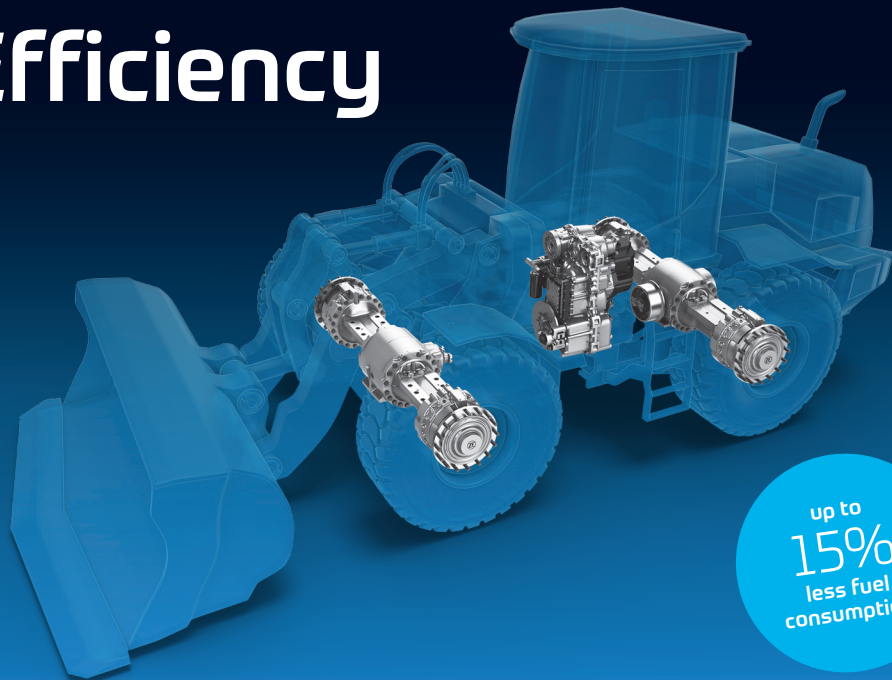
Vision Zero for the Future Construction Site

According to estimates, by 2050 two thirds of the world's population will live in large cities. This development also comes with disadvantages: fine dust, fuel emissions and noise impact the environment and inhabitants alike. ZF knows: ideally, the construction site of the future should not only be climate neutral, but it should also operate safely and efficiently.

These objectives are reflected in the guiding principle of "Vision Zero" that ZF strives to achieve in all of its divisions: a world of mobility without local emissions, without accidents and without technical failures. To that end, the company is already developing future-oriented technologies today.

Zero
emissions
accidents
downtime

Efficiency



up to
15%
less fuel
consumption

ZF is Efficiency



Despite the development of emission-free off-highway machinery, diesel vehicles will continue to dominate the global market for a long time to come. But they too must meet requirements for lower fuel consumption and CO₂ emissions. This is where ZF comes in with its solutions for reducing emissions and saving energy that also work to increase efficiency and productivity.

Whether its wheel loaders, dumpers, graders, forest applications or material handling – in its customized **EFFICIENCY PACKAGE** ZF unites its expertise in transmission, axle and software development to offer more than the sum of the advantages of individual applications.

System components such as ZF axles and transmissions are optimized for compatibility, enable greater efficiency and easy handling.

The options of the **EFFICIENCY PACKAGE** provide increased productivity and enhanced operating and riding comfort for the driver associated with a reduction of the operating and maintenance costs for the vehicle owner.

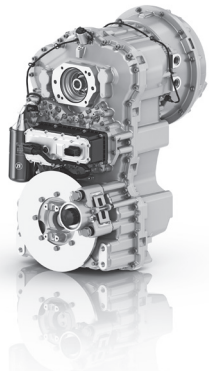
ZF is Efficiency

ERGOPOWER Transmissions

- Fully automated or manual powershift transmission
- No traction interruption during shifting
- Reduction of operating costs
- Comfortable, easy and ergonomic handling
- Less noise emission due to deep-toothed helical gears
- Low fuel consumption
- Cost saving due to the modular and compact construction

ERGOCONTROL II

- New software platform enabling integration into OEM service tools
- Standard CAN interface for easy maintenance and service
- UDS (Unified Diagnostic Services, ISO 14229)
- Fulfills latest safety requirements up to level D (ISO13849)
- Maximum of functionalities, while minimizing installation effort

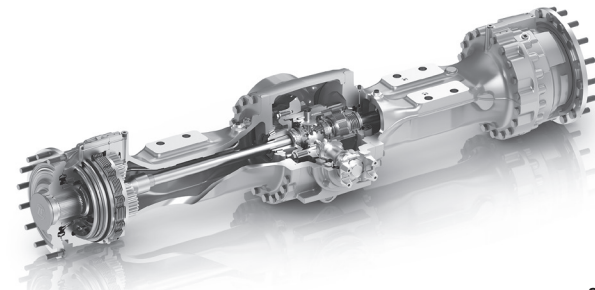


ZF is Efficiency



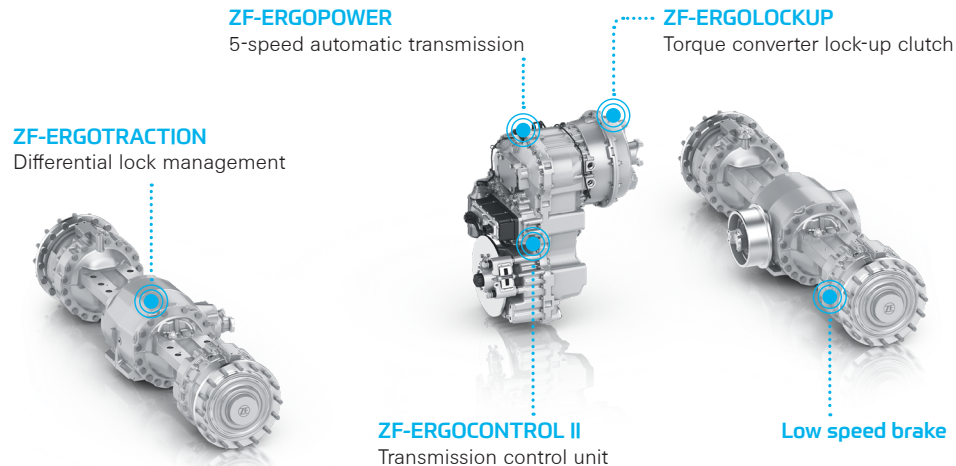
MULTITRAC Axles

- More than 45 years of experience with a production volume of 360,000 axles
- Flexible modular design
- Multi disc wheel speed brake for higher vehicle speeds and efficiency
- Axle housing for highest dynamic and static loads
- Cost reduction (oil + life cycle)
- Less power loss and fuel consumption



ZF is Efficiency

ERGOPOWER with EFFICIENCY PACKAGE



ZF is Efficiency



ERGOPOWER with EFFICIENCY PACKAGE

ZF DIRECT DRIVE

5-speed with lock-up: 100 % torque already in 2nd gear, no losses.
A torque converter lock-up clutch ensures that the torque flow between the engine and the transmission can be designed in a loss-free and thus, completely direct way (Direct Drive).

ERGOTRACTION

ensures that the diff-lock is always engaged when needed and automatically switches off when it is not necessary. Therefore, optimal traction is guaranteed under all driving conditions.

Engine De-Rating

prevents torque spikes through active engine control via CAN.

The intelligent clutch cut-off function **POWERINCH** is an advanced driveline management feature to improve truck loading or tight corner operation by limiting vehicle tractive effort to the minimum required to hold the vehicle.

Operating Mode Selection

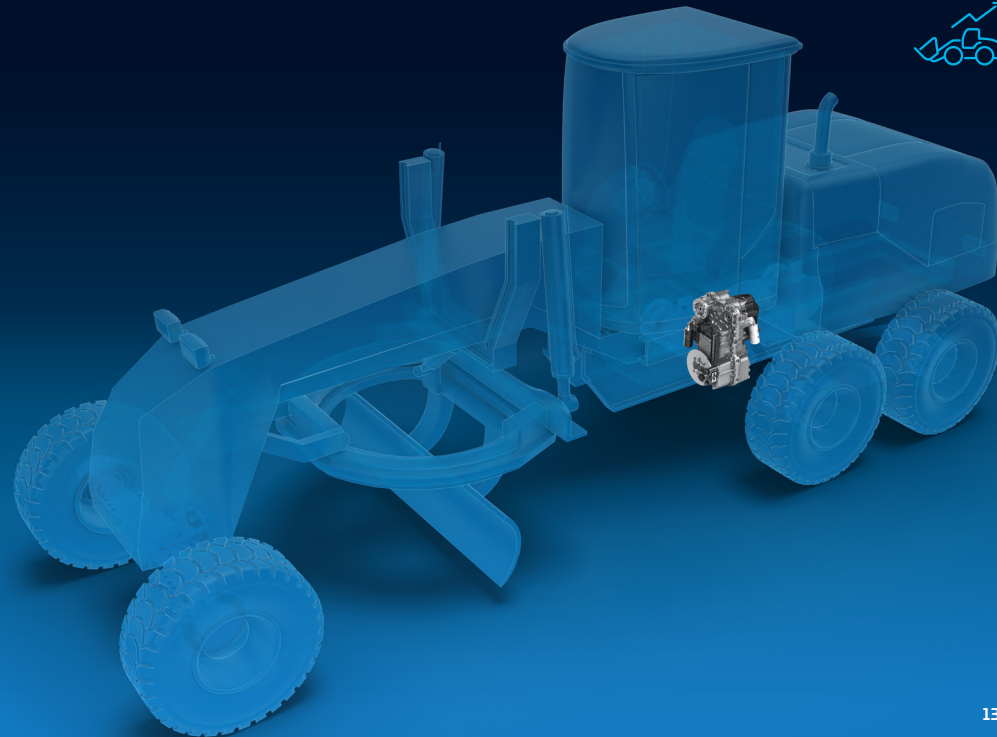
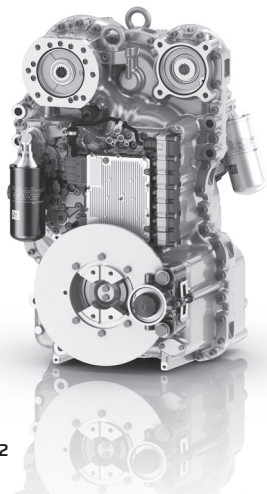
provides a selection of shift-point curves to accommodate various operating conditions or multiple engine curves.

ZF is Efficiency

cPOWER – Continuously Variable Transmission

- Continuously variable drive over complete drive range forward and reverse
- Smooth, hydraulic start due to continuously variable power-split technology
- High efficiency through low engine speeds, independent of vehicle speed
- Up to 10% less fuel consumption
- No wear through heavy loads as there is no mechanical connection between engine and driveline
- Also available for forestry, grader and material handling

Ready for
alternative
fuels



ZF is Efficiency

Sample cPOWER Savings

Based on average lifetime
of 10,000 hours

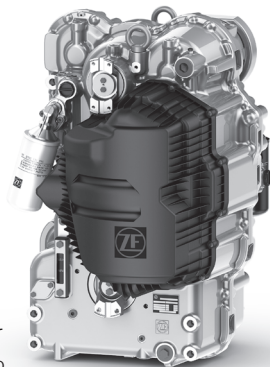
24 to wheel loader

Operating hours/lifetime: 10,000

Price per liter diesel: 2.0 Euro

Fuel savings: 3 liters/hour

Savings per lifetime: 60,000 Euro



30,000 liters less fuel

Average of 20% less fuel

10,000 operating hours

90 tons less CO2



ZF EFFICIENCY PACKAGE – Less Fuel and Higher Productivity



Fuel savings
up to

CVT technology

+5% with cPOWER & EFFICIENCY PACKAGE

+10% with change to cPOWER technology

+15% with 5-speed ERGOPOWER & EFFICIENCY PACKAGE

4-speed ERGOPOWER sets the standard

Powershift technology



Refill

Refill

Refill

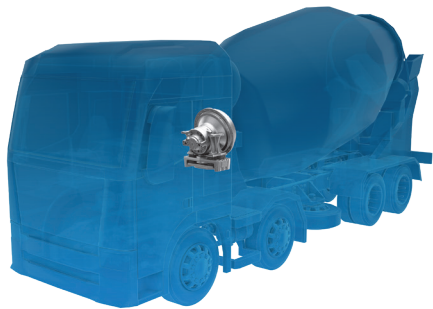
Refill



Productivity /
working hours

ZF is Efficiency

ECOMIX II Series – CML 10/12



- Cutting-edge technology unique by ZF
- 40% smaller and 25% lighter than the equivalent standard mixer drive transmissions in the market, with no loss in strength
- Elastomer base for shock absorbance and noise reduction
- 2-tapered roller bearings are 38% stronger than single self-aligning roller bearings
- Cassette seals provide much tougher sealing solution
- Heavy-duty cover introduced in 2015
- Highest-efficiency drive in market
- Up to 15.7 yd³ (12 m³) mixing capacity
- Up to max. output torque 59,000 lbf ft (80,000 Nm)

EFFICIENT: Up to 0.13 gallon (0.5 l/h) fuel savings for end user

TOUGH: Increased lifetime, improved robustness

SILENT: Up to 10 db noise reduction

ZF is Efficiency



For over 40 years, ZF has been advancing the application of mixer drive transmission technology. One ready-mix load at a time.

ECOMIX I vs. ECOMIX II

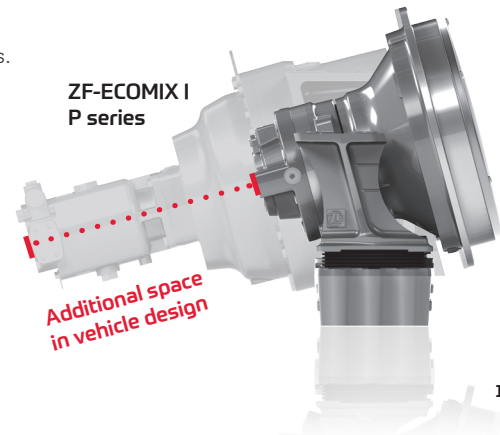
ZF has been the market leader in mixer drives for more than 40 years now, by providing the long-proven performance and reliability of our ZF ECOMIX for numerous concrete applications.

We know that economically-optimized, low-maintenance operation of your mixer truck fleet is critical, especially when under the highest stresses.

We understand that any reduction in weight means a higher payload and less fuel costs, that higher output force and drum capacity means increased overall efficiency.

ZF-ECOMIX II CML series

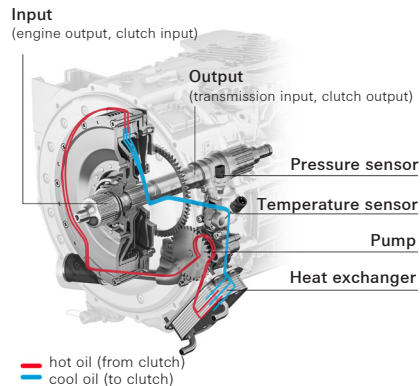
ZF-ECOMIX I P series



Additional space
in vehicle design

ZF is Efficiency

TraXon DynamicPerform



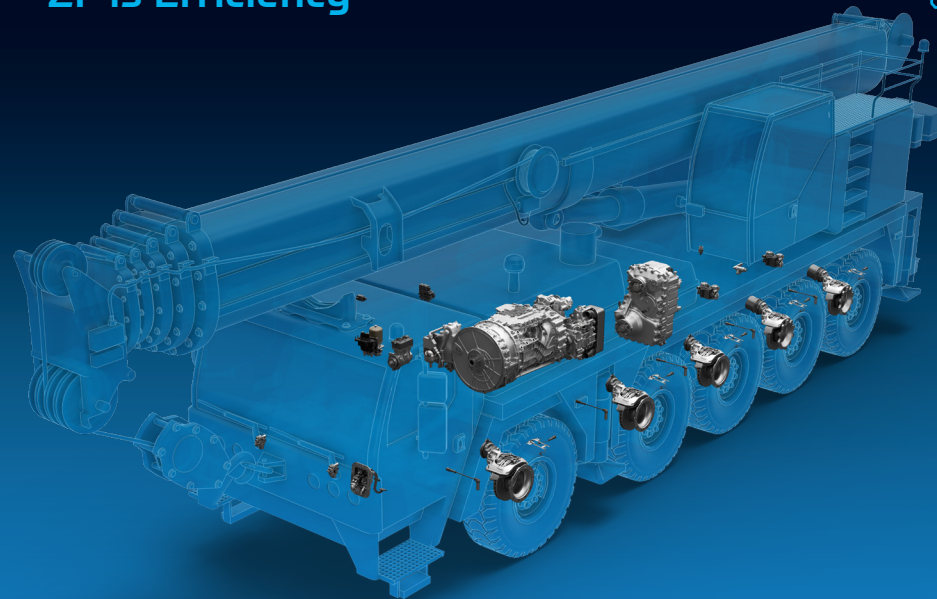
- Constant cooling of the clutch enables
 - almost wear-free maneuvering for any length of time
 - repeatable maneuvering behavior
 - high maneuverability
 - no standstill and cooling down periods thanks to rapid cooling down of the clutch
 - no overheating of the clutch
 - no clutch replacement necessary
- Reliable operation of the vehicles on the construction site
- Extension with TraXon units and power take-offs possible (e.g. Intarder, PTOs)

WEAR-FREE: Multidisk clutch ensures durable maneuvering

EFFICIENT: Maximum availability of vehicles on construction site

READY FOR USE: Constant oil cooling prevents overheating and standstill

ZF is Efficiency



ZF is Efficiency

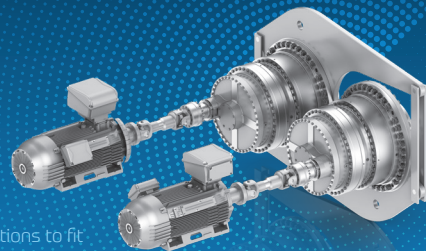
Redulus^{4F} Power Packs for the Future – Next Generation of ZF Industrial Gearboxes provides a significant increase in torque density of up to 40% and enhanced flexibility for adapting required customer specifications.



Extended load capacity
Increased lifetime and performance



Flexible concept
Over 2 000 configurations to fit most applications



Compact design
and less weight reducing cost and handling effort



Advanced serviceability
Less downtimes with industry-leading ProVID based CMS and easy maintenance

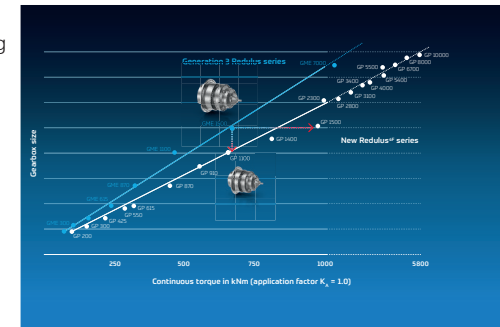
ZF is Efficiency



Redulus^{4F} for Stationary Mining Machines – Power Packs for the Future

ZF's newest Redulus^{4F} gearbox is designed to be integrated in multiple large applications for the mining industry like conveyor systems, apron feeder or large crushing devices but also in high pressure grinding roller mills (HPGR) and other large industrial applications.

The flexible and compact design offers over 2,000 customized possibilities, all guaranteeing maximal output. 20 sizes support an optimized selection of torque and size. Up to 40% more torque compared to the previous generation covers a broad torque range from 100.000 Nm up to 6 Mio Nm. In the end, the higher torque capacity of the Redulus^{4F} Series results for the application in a smaller gearbox size with less weight or in much higher safety margin and lifetimes. The Total Cost of Ownership (TCO) is reduced significantly.



ZF is Efficiency

GPT4F Drive Gearboxes for Mobile Mining Applications and Large Construction Machines

Based on the Redulus^{4F} for the industrial applications, ZF transferred the successful 4F measures for future gearbox generations to their mobile drives, with the verified outcome of significant higher torque densities per size shown by GPT^{4F} series.

This results in increased lifetime, robustness, availability and efficiency for higher working force.



ZF is Efficiency

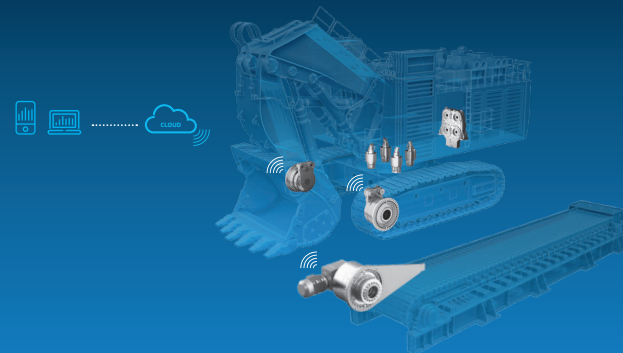


Remote Observance: Complete the Hardware with Intelligent Condition Monitoring ProVID

The 4F gearboxes are designed with an eye on minimal maintenance efforts. The easy access to the main components is also linked to ZF's condition monitoring system ProVID.

The system is based on many years of application experience and expertise in the field of vibration measurement and additional analyses.

Thanks to remote monitoring, permanent status reports are provided worldwide.



Construction Machinery Systems

Wheel Loaders



Backhoe Loaders



Telescopic Handlers



Concrete Mixers



Forest applications



Compact Vehicles



Mobile Excavator



Dump Trucks



Graders



Rail Maintenance and Construction Vehicles



Crane Vehicles



The Future of Construction. **NOW.**

Electrification



Vision Zero



Next Generation Mobility

Urbanization is a megatrend, the influx into metropolitan areas remains unbroken worldwide – with negative consequences for air quality and quality of life. Only tailored concepts deliver an efficient contribution to climate protection. ZF offers a wide range of solutions and technologies. The future belongs to electric mobility and zero-emission zones.

The trend towards electromobility is not confined to passenger cars. Thanks to ZF technology, work on urban construction sites and in buildings will also be possible in the future - despite strict standards concerning emissions: ZF takes care of climate-friendly operation, neutral in terms of CO₂ emissions and offers E-Mobility Solutions for various applications.

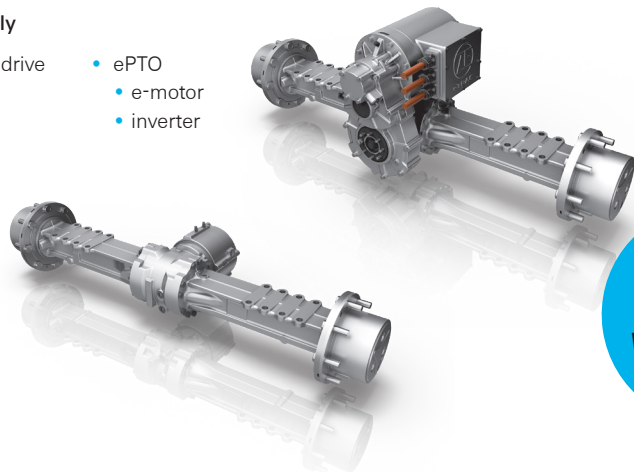
Electric
Mobility. **NOW.**

Electrification

ZF starts volume production of new electrified driveline for compact wheel loader. The 48V system is the basis of a modular platform which can be scaled up to 650V and can cover compact vehicle loaders from 4 to 8 to.

ZF scope of supply

- Electric central drive
 - e-motor
 - transmission
 - dropbox
 - inverter
- Axles
- ePTO
 - e-motor
 - inverter



**ZERO
EMISSIONS**

100% Electric – ZF eTRAC

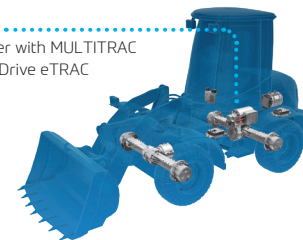


Intelligent System Solutions

- ZERO EMISSION
- Superior performance
- Efficient electrical components
- Robust and reliable mechanical driveline
- Compact installation space

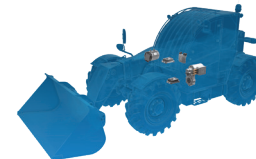
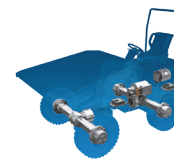
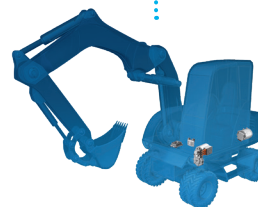
eTRAC drive system

Electric compact loader with MULTITRAC axles, electric Central Drive eTRAC (eCD20-60) and ePTO



Electric Central Drive eTRAC

for compact loaders, excavators, dumpers and telehandlers

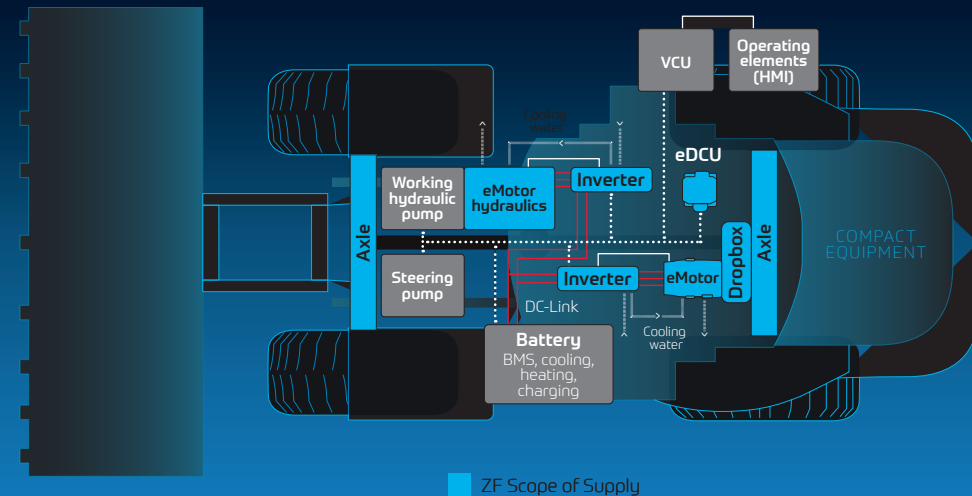


Electrification

Electric Compact Equipment Technology – Electric Central Drive eTRAC eCD 20 – 60

- A 'best in class solution' for power density in electric compact loaders
- The solution is unrivalled on the market in the 20 kW (continuous performance) and 48 V performance classes
- New, high-speed transmission complements the ZF modular kit
- Operating voltage of 48 V offers advantages in regards to components selection and reduces maintenance costs
- The use of liquid coolant in the traction motor and the power electronics also ensures continued performance in construction machinery applications
- In addition to its driveline, ZF also offers a drive consisting of an e-motor and pump for the working hydraulics system
- Continued performance of 60 kW and an operating voltage of 650 V
- The project for compact loaders aims at developing a system solution for machines with an unladen weight of up to 8 t

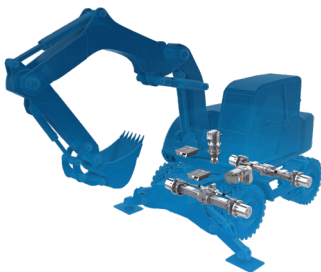
System Structure



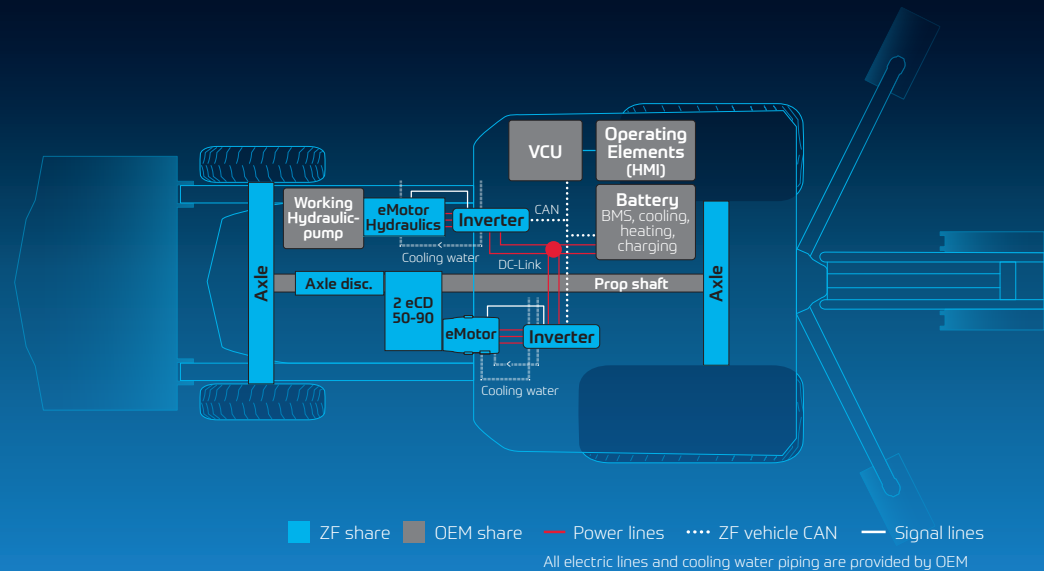
Electrification

Electric Mobile Excavator Technology – Electric Central Drive eTRAC eCD 50 – 90

- Modular platform for 650V
- Liquid cooled PSM e-motor
- 2 speed powershift transmission
- Integrated park brake
- Optional axle disconnect (2WD/4WD)
- One supplier for transmission, eMotor and inverter
- Compact installation space
- Robust and reliable mechanical driveline
- „Best in class solution“ for power density
- Available for various vehicle applications



System Structure

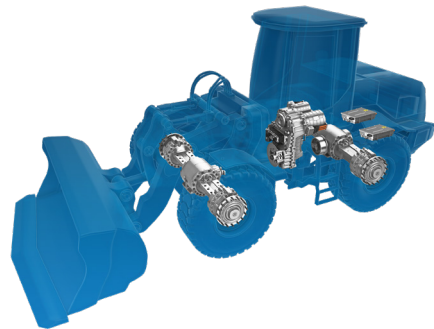


Electrification

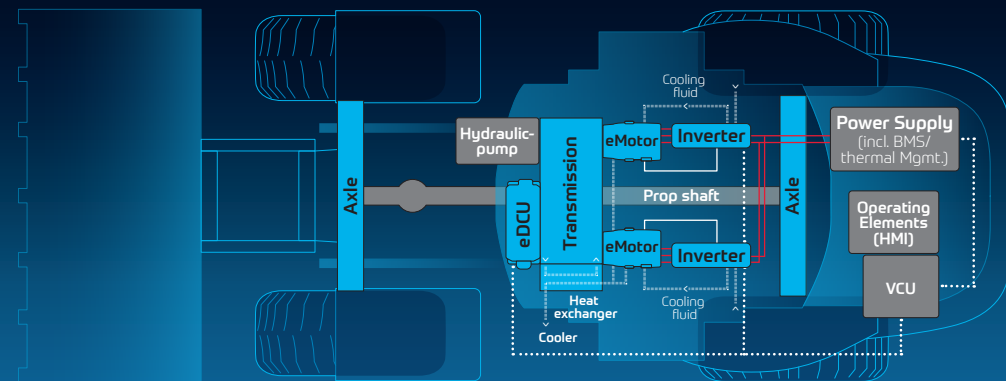
Electric Wheel Loader Technology – Electric Central Drive eTRAC eCD 110 – 210

- Electromechanical powershift transmission with one eMotor for traction and one for PTO
- Drivetrain with reliable components and optimized system performance
 - Transmission: based on ERGOPOWER technology
 - e-drive: 650 V (50-120 kW continuous power)
 - ePTO: 650 V (30-70 kW continuous power)
 - eDCU: Drive Control Unit for overall system performance and power management
- Drop-In replacement for current conventional driveline
- Available for various vehicle applications

Electric
drive
solution



System Structure



■ ZF share
 ■ OEM share
 — Power lines
 ... ZF vehicle CAN
 — Signal lines
 All electric and hydraulic lines provided by OEM

Electrification

Electric Mixer Truck for the Urban Construction Site of the Future

The demand for lower gas and noise emissions sees manufacturers of off-highway applications operating in an increasingly challenging environment. Legislative changes and new guidelines for improving air quality mean that driving restrictions in cities, particularly for diesel engine vehicles, will continue to grow. To that end, ZF is developing low-emissions solutions for mixer applications.

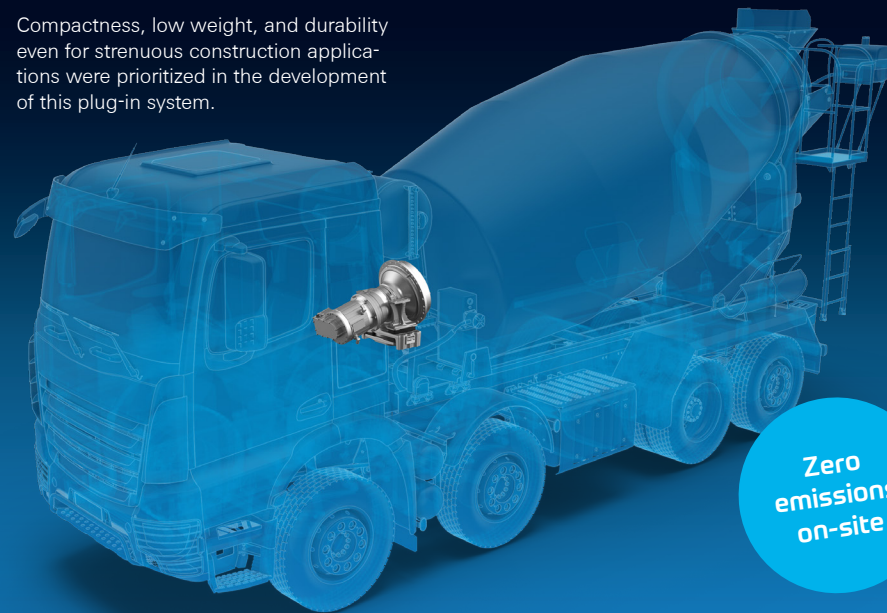
Electromechanical Drive System CMe

Clean air, less noise, more comfort – The CMe ECOMIX Electric Mixer drive enables to bring mixers with zero emissions to downtown construction sites. Hereby ZF benefits from the synergy effects resulting from the Group's diverse product portfolio and raises the bar for efficiency, productivity and noise without neglecting the total cost of ownership.

The new plug-in hybrid concept replaces the hydraulic pump with a generator and the hydraulic motor with an electric motor upstream of the mixer transmission.

This means that the truck can park its engine on the construction site as well as in the mixing plant and let the drum run independently and emission-free powered by the high-voltage (HV) battery.

Compactness, low weight, and durability even for strenuous construction applications were prioritized in the development of this plug-in system.

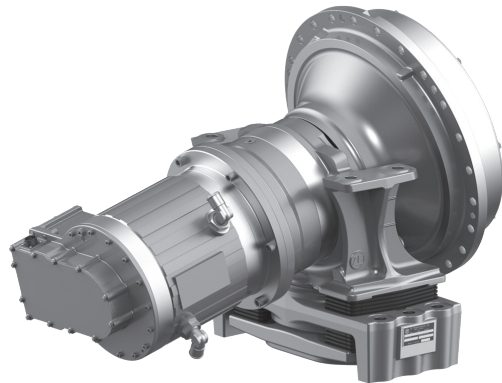


Zero
emissions
on-site

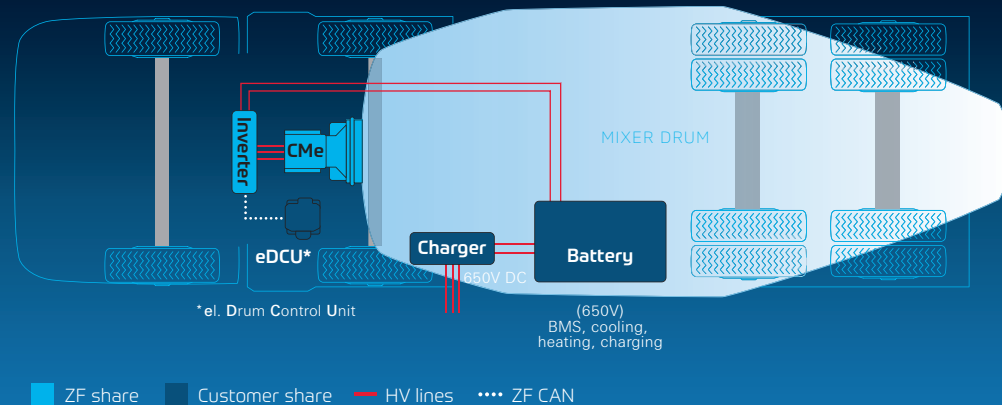
Electrification

Electromechanical Drum Drive CMe

- Up to 12 m³ mixing capacity
- Up to 64,000 Nm output torque
- Max. motor power 100 kW
- Emissionfree operation on-site
- Less consumption
- Low noise
- Lower CO₂ emissions
- Financial savings through a reduction in diesel fuel requirement



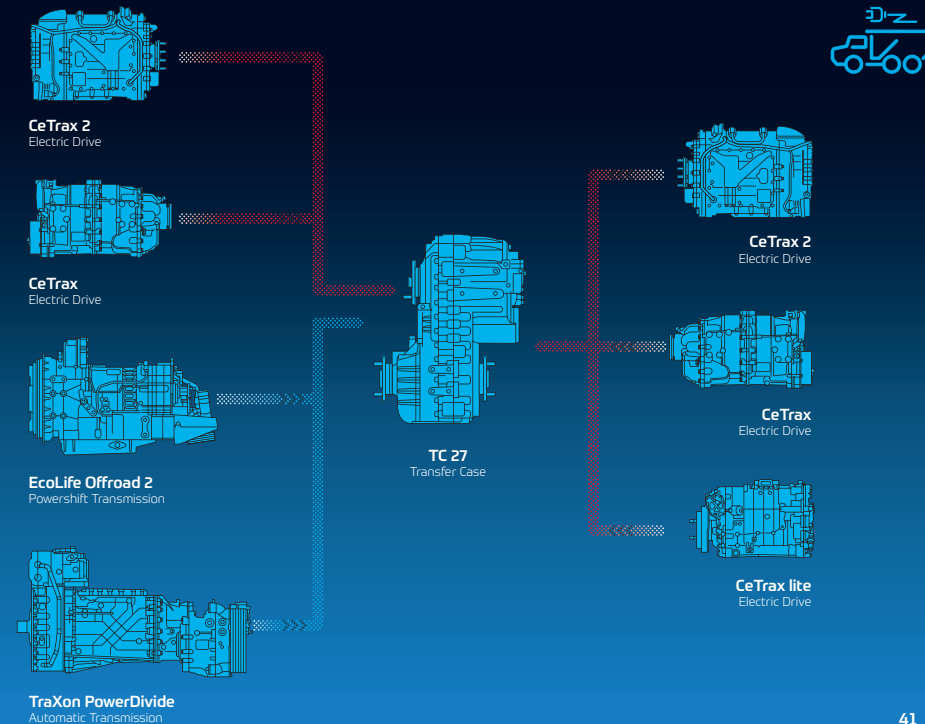
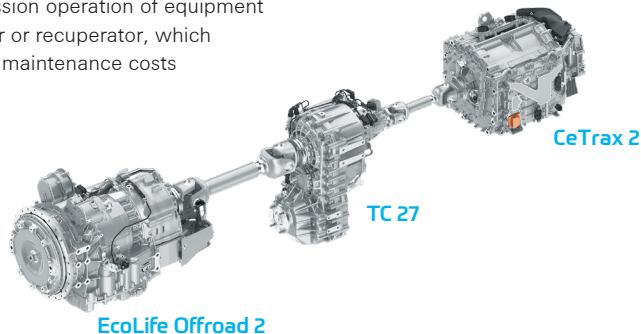
System Structure



Electrification

Modular Drive System

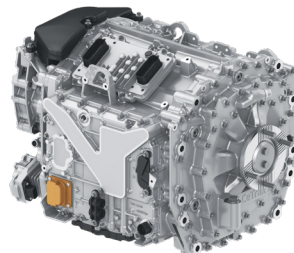
- Flexible modular system from proven ZF volume production components
- Maximum flexibility: Conventional, electric, or combined drive
- System solution from a single source: drive, integrated power electronics, and function electronics
- Electric motor enables hybrid drive as well as purely electric driving, boost function, and zero-emission operation of equipment
- Electric motor acts as retarder or recuperator, which reduces brake wear and thus maintenance costs



Electrification

CeTrax 2

- Delivers powerful acceleration and seamless torque delivery
 - High electrical efficiency helps extend vehicle operational range
 - Features compact design and light weight
 - Fulfills regulatory cyber security requirements and functional safety
 - Enables zero emissions for battery electric and fuel cell vehicles
 - Optimizes driving experience with quiet and smooth operation
- **EFFICIENT AND POWERFUL:** Integrates e-motor, inverter, ECU, e-actuators and gearbox
 - **ONE-BOX-SOLUTION:** Enables simplified electrification of given vehicle platform
 - **AUTOMOTIVE EXPERTISE:** Builds on ZF's driveline, e-mobility, and CV experience costs

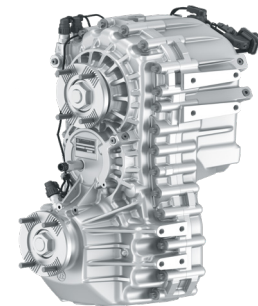


Electrification



TC 27

- Weight-optimized thanks to aluminum housing
 - Higher payload or reduced fuel consumption due to lower weight
 - New suspension method reduces installation cost
 - Compact design
 - Improved efficiency
 - Noise-optimized
 - Optional:
 - Central electrical / pneumatic connection
 - With control unit directly on transmission, all types of software applications can be implemented
 - Oil level and oil temperature sensors
- **LIGHTWEIGHT:** Weight-optimized thanks to aluminum housing
 - **POWERFUL:** Higher payload and less fuel consumption
 - **EFFICIENT:** Noise-optimized and improved efficiency



Vehicle Intelligence

SAFETY
Short-range
radar
technology

Rear Observation Assist
Pedestrian detection with
rear traffic alert

// Short-Range Radar //

Vehicle Intelligence



Rear Observation Assist – Radar Technology for Environment Detection

Ideally, the future of construction should not only be climate neutral, but it should also operate safely and efficiently. To ensure this, ZF is already developing future-oriented system solutions for smart construction sites. Based on all the activities in the passenger car and commercial vehicle segment, a broad portfolio of Know-How and products can be re-used for Off-Highway vehicle applications. Radar-based environment perception, being just one example to ensure safe vehicle operation.

Gen5 Short-Range Corner Radar sensors support functions such as the „Observation Assist“. Environment can be detected within a range of up to 90 meters in a grid of 20 centimeters and an opening angle of +/- 80 degrees.

- Short-Range Radar sensor for an extended environment detection
- New high-performance radar system for early object detection

Braking Technology

Working to the highest standards of the commercial automotive industry, ZF braking technology offers the same level of quality and service to the world's Off-Highway workhorses – bringing greater safety and efficiency to construction sites, fields, and mines.

Accumulator Charging Valve (ACV)

- Energy efficient charging cycles reducing operating costs
- Used in open center and load sensing hydraulic systems
- Designed for Mining, Construction, Forestry, Agriculture, and Municipal Applications



Modulating Valve

- Reliable brake performance in demanding off-highway conditions
- Superior brake performance through minimal leakage and low hysteresis
- Broad range of modulating valves including two stage modulation for customized pedal feel
- Split pressure design provides for different output brake pressures at upper port and lower port for customized braking solutions



Braking Technology

Electro Hydraulic Brake Valve (EBV)

- Patented design makes maximum use of the solenoid stroke and force to improve reliability and performance
- Direct acting valve simplifies design, which eliminates the continuous flow and small orifices of a pilot valve
- Low valve leakage keeps accumulator sizes small for emergency power-off braking
- High force solenoid reduces the effects of friction and contamination
- Low resistance coil allows full pressure output with low input voltage, higher temperature operation, or continuous use



Electronic Brake Pedal

- Reduces operator fatigue by removing hydraulic system noise from the cab of the machine
- Hydraulic valve can be added to the end of the pedal stroke for additional redundancy
- Allows the electrohydraulic valves to be located near the brakes for quicker system response
- Various spring packs are available to suit light to heavy pedal force requirements
- Designed for drive-by-wire, electro-hydraulic braking, machines with multiple operator stations, and propel and inching pedals for hydrostatic drive systems



Chassis Technology

Cabin Suspension and Damping Technology

Customized designs meet all customer requirements

Top working conditions in the cabin are becoming increasingly important for the success of agricultural- and construction vehicles. With its spring/damper units and systems, ZF is offering the ideal solution for almost any application, covering the whole range from the steel spring module to the air spring module and cabin air leveling module CALM, even with integrated leveling control.



Chassis Technology

Torsional Damper

Mobile off-highway machines have a high need for vibration damping measures in the chassis as well as in the powertrain. The permanent rising power density of modern engines increases the load on all components within the powertrain. At the same time the expectations towards reliability and durability as well as driver comfort grow steadily. ZF can offer with its products solutions fit for the future to effectively reduce engine vibrations in all kind of powertrains.



Next Generation Aftermarket

Global service network with more than

15,000

workshop partners in



115

countries



Your Partner in Uptime – Anywhere, Anytime

ZF Aftermarket

ZF Aftermarket is the preferred partner for fleet and aftermarket customers worldwide because the business enables attractive mobility experiences for - from spare parts to connectivity solutions, from technical and end-of-life services to guaranteed availability. ZF Aftermarket is proud of its strong brands ZF, Lemförder, Sachs, TRW and Wabco, which have always stood for a winning combination of leading innovation and OE quality as well as proven experience.

Thanks to its advanced digital mobility management and a global service network, ZF Aftermarket increases the performance and efficiency of all vehicle types throughout their entire life cycle and thus the comfort for its diverse customer base worldwide.

More information
[www.zf.com/
aftermarket](http://www.zf.com/aftermarket)

ZF Group

ZF Friedrichshafen AG

94034 Passau

Germany

sales.ia@zf.com

www.zf.com/construction