



The End of the Road is Where We Get Started

Construction Machinery Systems

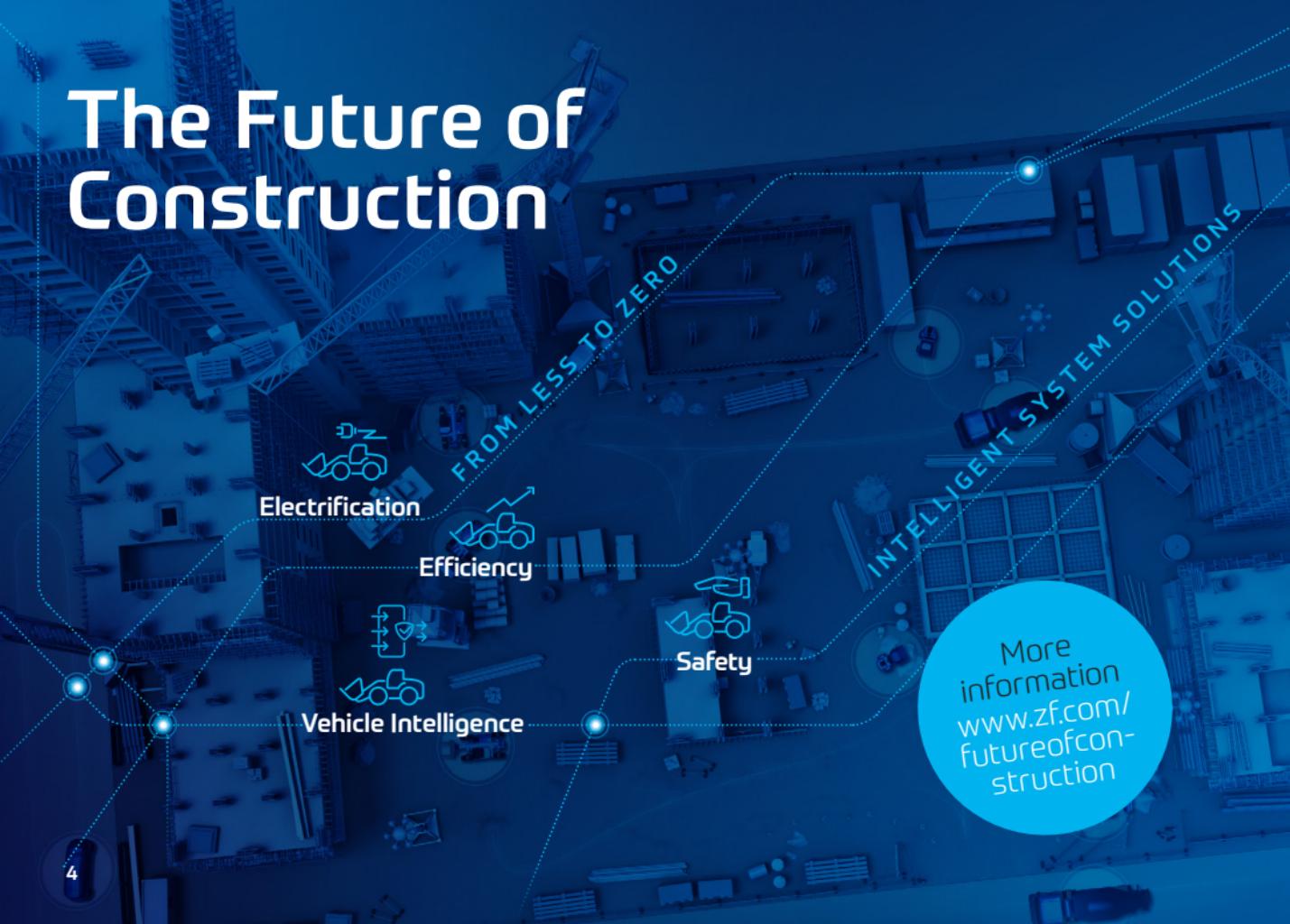




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The Future of Construction



4

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

5

Efficiency



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.

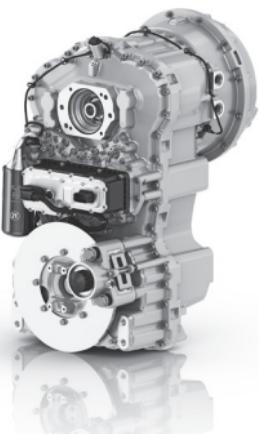
The options of the **EFFICIENCY PACKAGE** provide increased productivity and enhanced operating and riding comfort for the driver associated with a reduction of the operating and maintenance costs for the vehicle owner.





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)
- Fulfils latest safety requirements up to level D (ISO13849)
- Maximum of functionalities, while minimizing installation effort

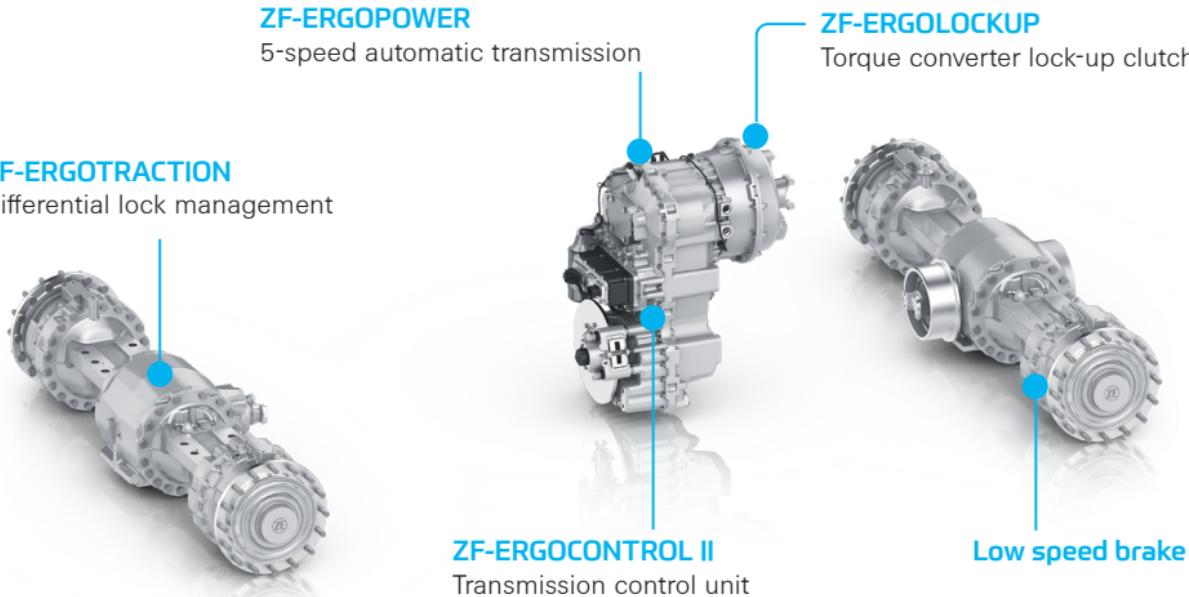
MULTITRAC Axles

- 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.

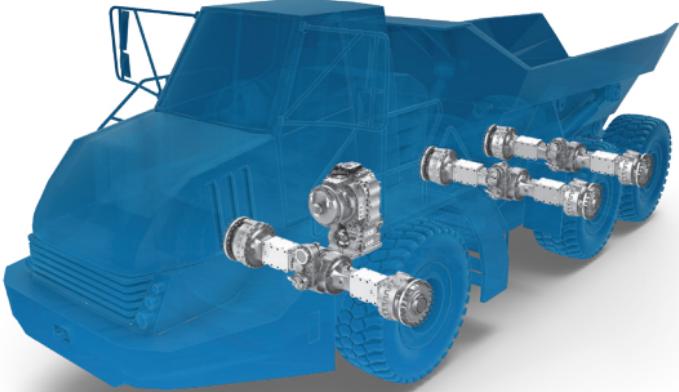
The intelligent clutch cut-off function **POWERINCH** is an advanced driveline management feature to improve truck loading or tight corner operation by limiting vehicle tractive effort to the minimum required to hold the vehicle.

Operating Mode Selection

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



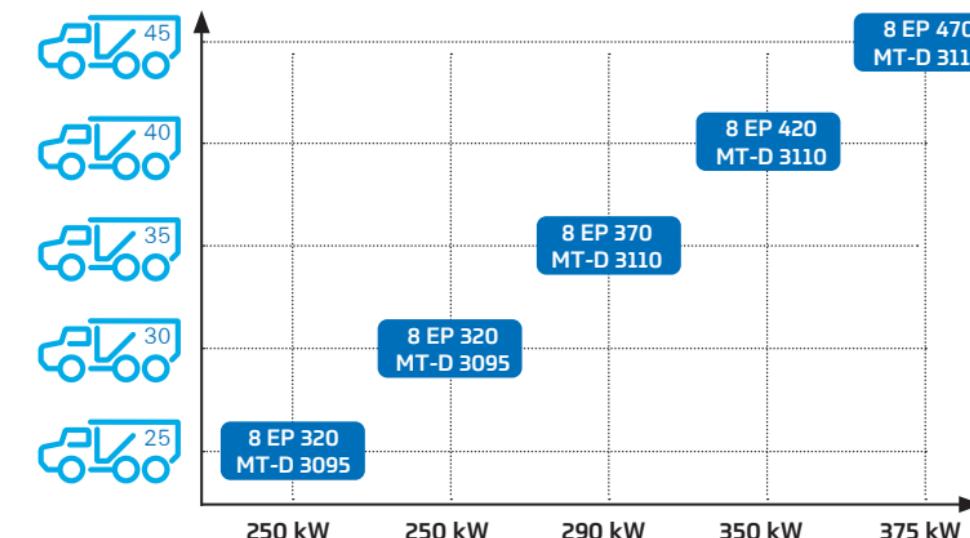
ZF Technology for Articulated Dump Trucks



- Transmissions and axles for articulated dump trucks from 30t to 45t size
- Max. machine weight 77t, max. engine power 375 kW, max. machine speed 60km/h
- High system and function integration
- Fully automated differential lock management system
- Fuel consumption benefits up to 20%

ZF Technology for Articulated Dump Trucks

short ton (907,185 kg)



Intelligent Differential Management System ERGOTRACTION III

- Optimal traction without any restrictions to maneuverability
- System functions under all ground conditions
- High efficiency and shorter work cycles
- Increased driving safety, because wheels do not block
- Optimal braking distribution during full braking
- Abusive shifting of the differential locks is not possible (component protection)
- Increased life of the drive-line components
- Less tire spin resulting in fuel consumption savings and less tire wear

Drive Situations where ERGOTRACTION III supports:

1 Reversing uphill



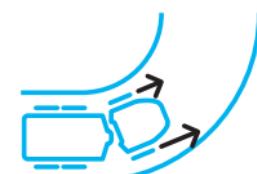
2 Hill-starting



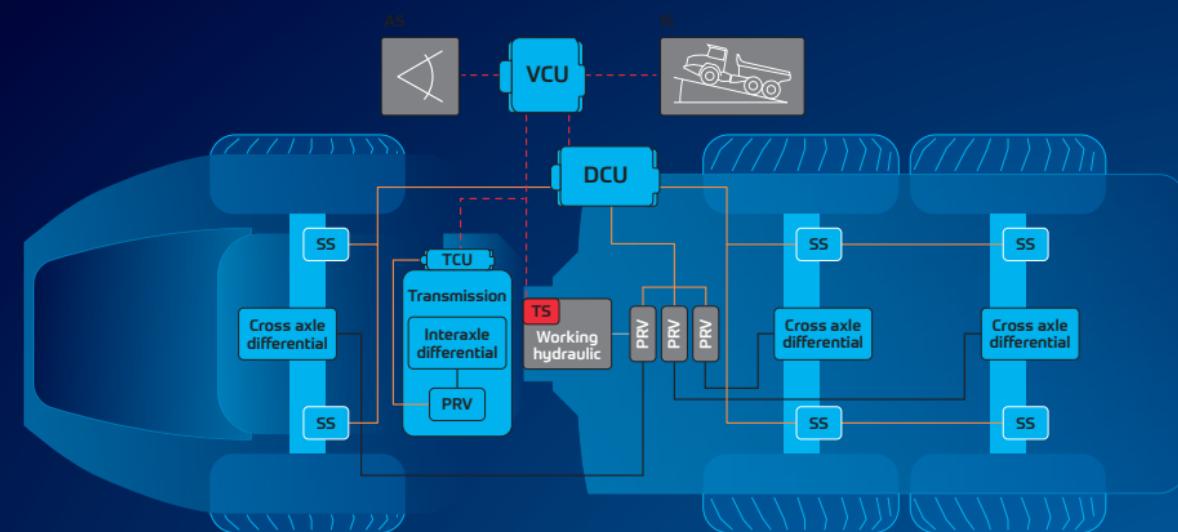
3 Driving up
slippery slopes



4 Maneuvering/
turning



System ERGOTRACTION III



— Electrical connections
— Hydraulic connections
- - - CAN signal

ZF share
OEM share
+ electric/hydraulic
connections

TS temperature sensor
SS speed sensor
AS steering angle sensor
IS inclination sensor

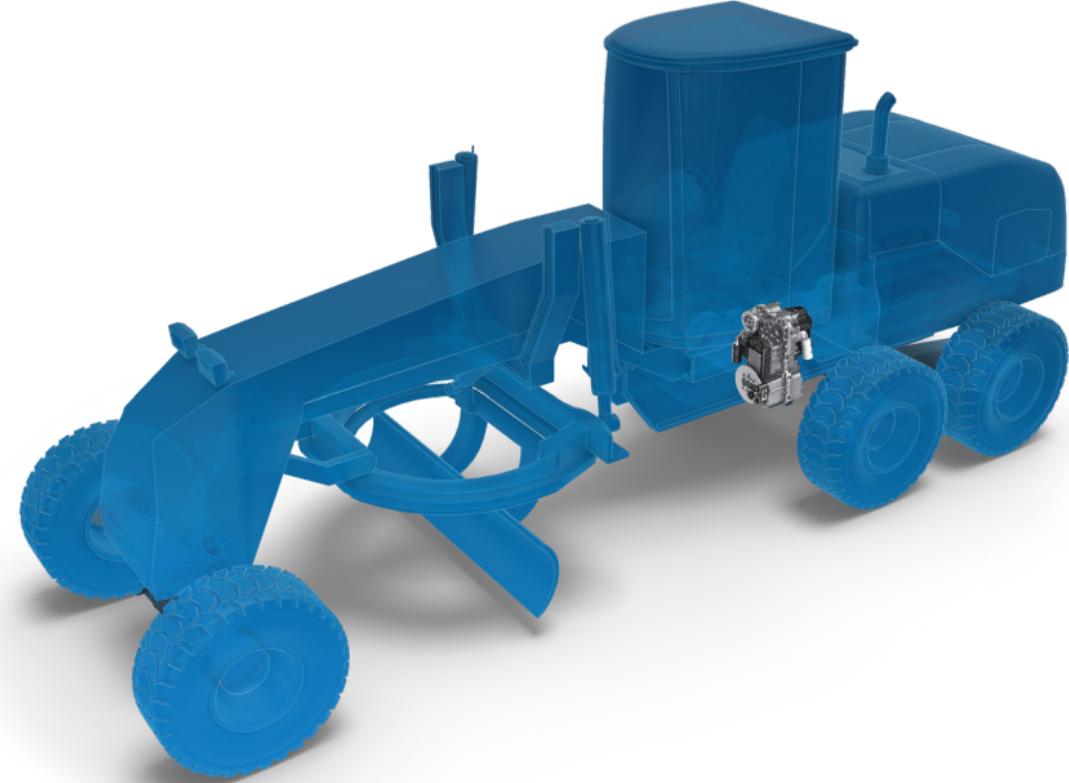
PRV proportional valve
TCU transmission control unit
DCU driveline control unit
VCU vehicle control unit



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



ZF is Efficiency

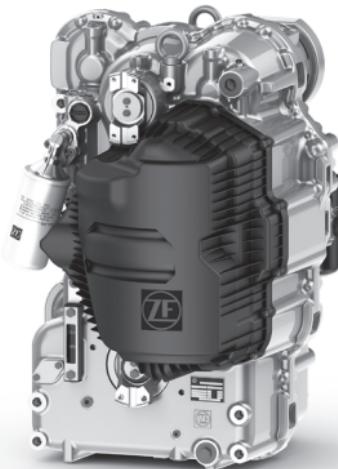
Sample cPOWER Savings

Based on average lifetime
of 10,000 hours

24 ton wheel loader
Operating hours/lifetime: 10,000
Price per liter diesel: 1.5 Euro
Fuel savings: 3 liters/hour
Savings per lifetime: 45,000 Euro

10,000 operating hours

90 tons less CO₂



30,000 liters less fuel
Average of 20% less fuel



ZF EFFICIENCY PACKAGE – Less Fuel and Higher Productivity



Fuel savings
up to

+5% with cPOWER & EFFICIENCY PACKAGE

+10% with change to cPOWER technology

+15% with 5-speed ERGOPOWER & EFFICIENCY PACKAGE

4-speed ERGOPOWER sets the standard

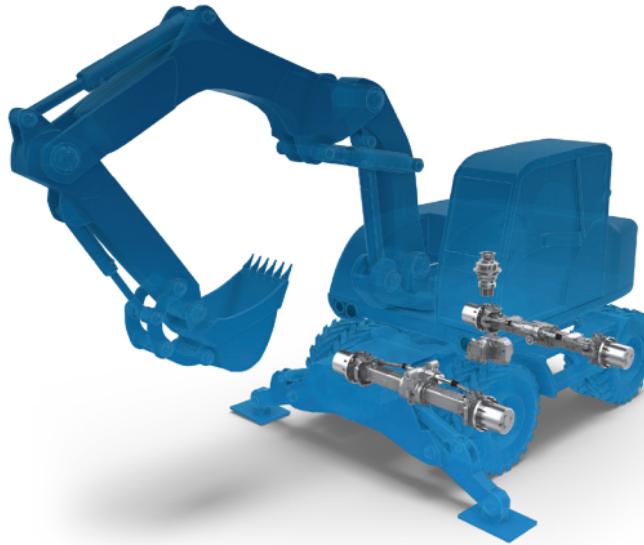
CVT technology
Powershift technology



Productivity /
working hours

ZF is Efficiency

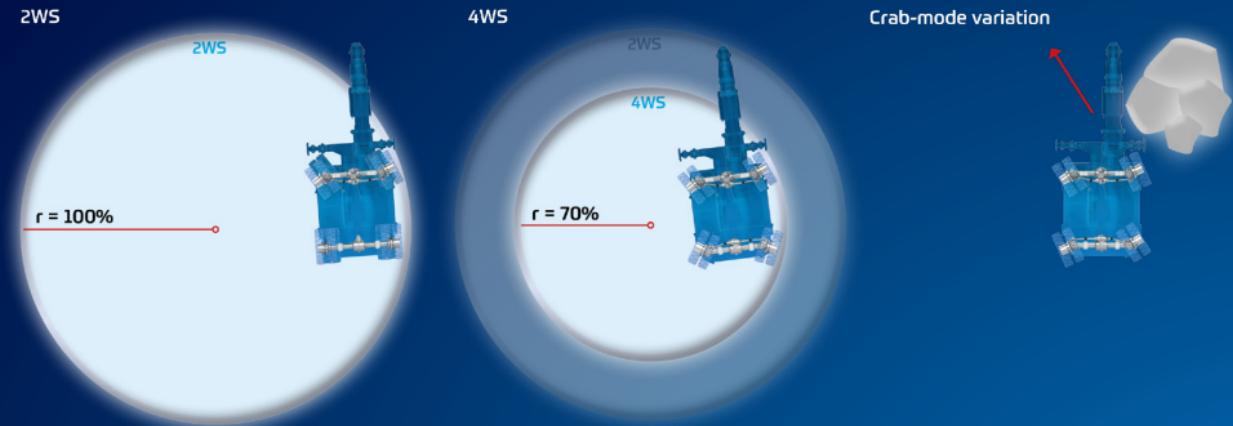
4-Wheel Steering Axles



- Designed for mobile excavator applications up to 20t
- Ready for Automated Operations: optical and high-resolution sensor available
- High reliability, well-established and proven axle design

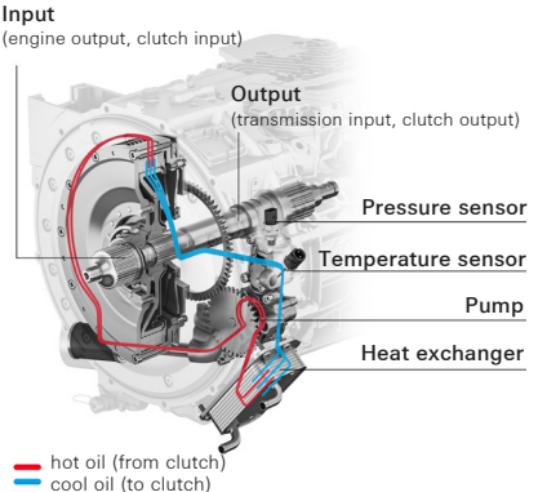
Excavator Technology

4-Wheel Steering Axles





TraXon DynamicPerform 2

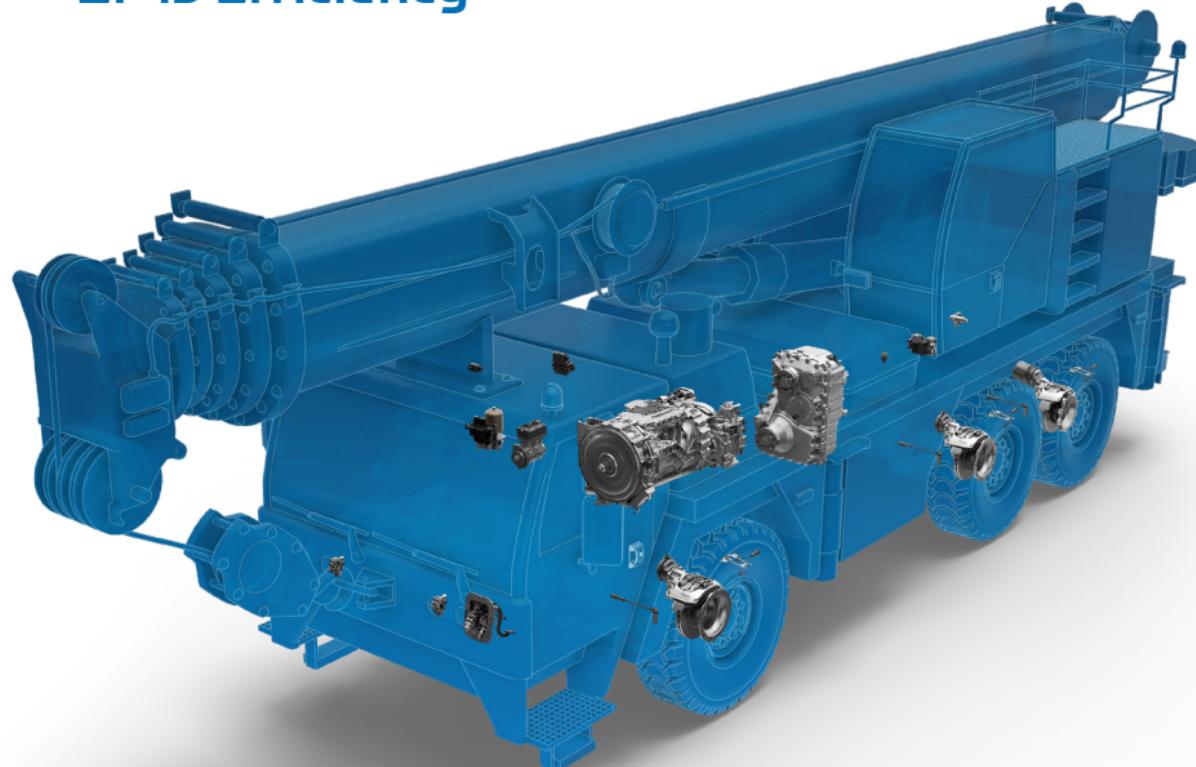


- Constant cooling of the clutch enables
 - almost wear-free maneuvering for any length of time
 - repeatable maneuvering behavior
 - high maneuverability
 - no standstill and cooling down periods thanks to rapid cooling down of the clutch
 - no overheating of the clutch
 - no clutch replacement necessary
- 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

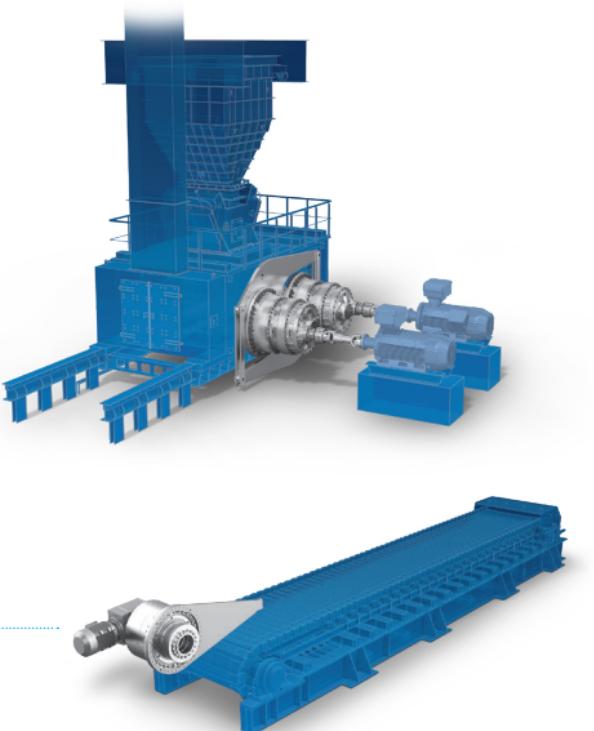
READY FOR USE: Constant oil cooling prevents overheating and standstill



ZF is Efficiency

Redulus^{4F} and ProVID: Power for the future

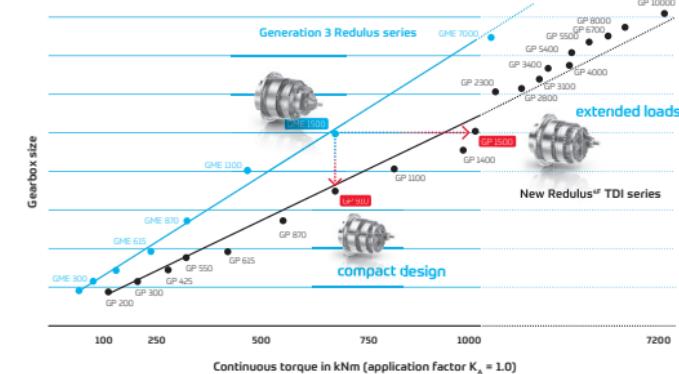
The unique design of Redulus^{4F} includes 20 sizes (9 more than the former series) which supports an optimal graduation of torque and size. This delivers up to 80% torque increase per size and covers a broad torque range from 100 kNm up to 7,200 kNm.



ZF is Efficiency

Redulus^{4F} and ProVID: Power for the future

Enhanced output torques at identical space requirements enable the deployment of a smaller gearbox size – without concessions regarding reliability or lifetime.



Combined with the CMS ProVID ZF offers lots of advantages like higher availability, reduced operation costs or an increased transparency of service situation for operators.



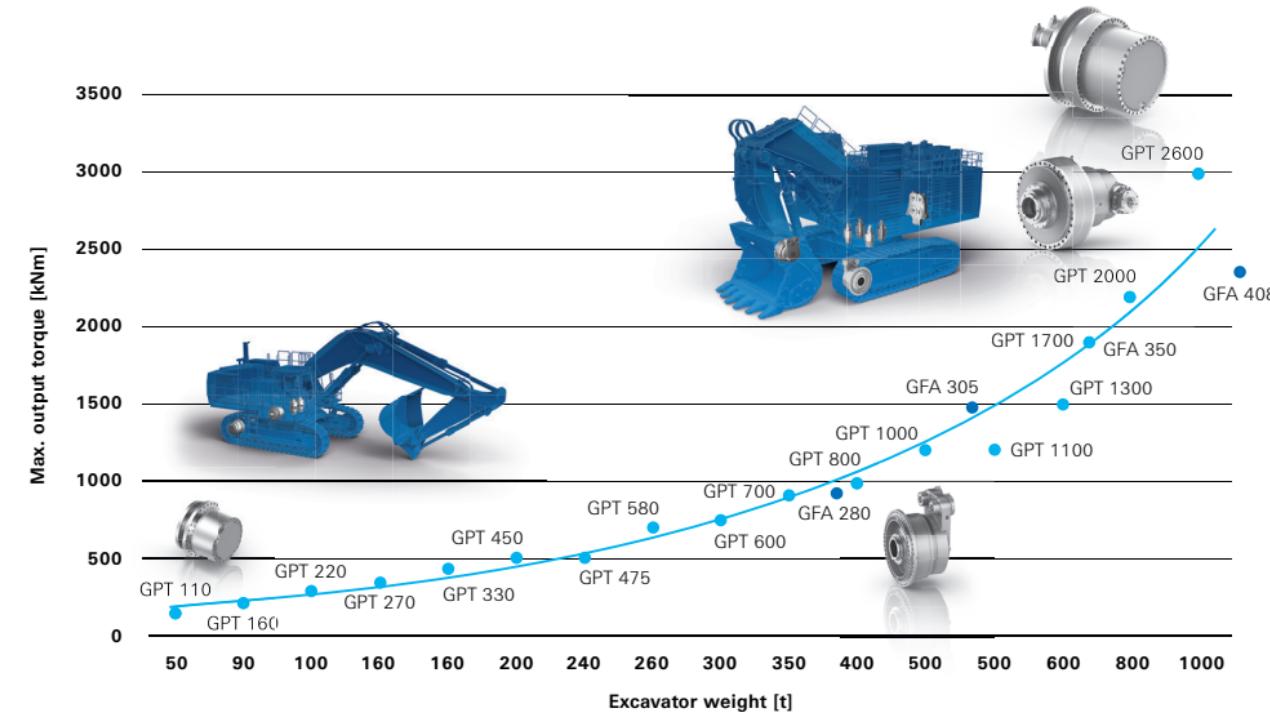
ZF is Efficiency

GFA and GPT^{4F} Drive Gearboxes for Mobile Mining Applications and Large Construction Machines

For every track driven machine from 50 up to 1,000 tons and more, ZF is present with their large planetary drive gearboxes GFA and GPT^{4F}.

Based on the EFFICIENCY strategy, ZF Witten presents modifications of their products with a significant increase of load densities and robustness and thus higher lifetime, robustness, availability and efficiency for higher working force.

ZF is Efficiency



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



Electrification



Vision Zero

Off-Road Electric 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.

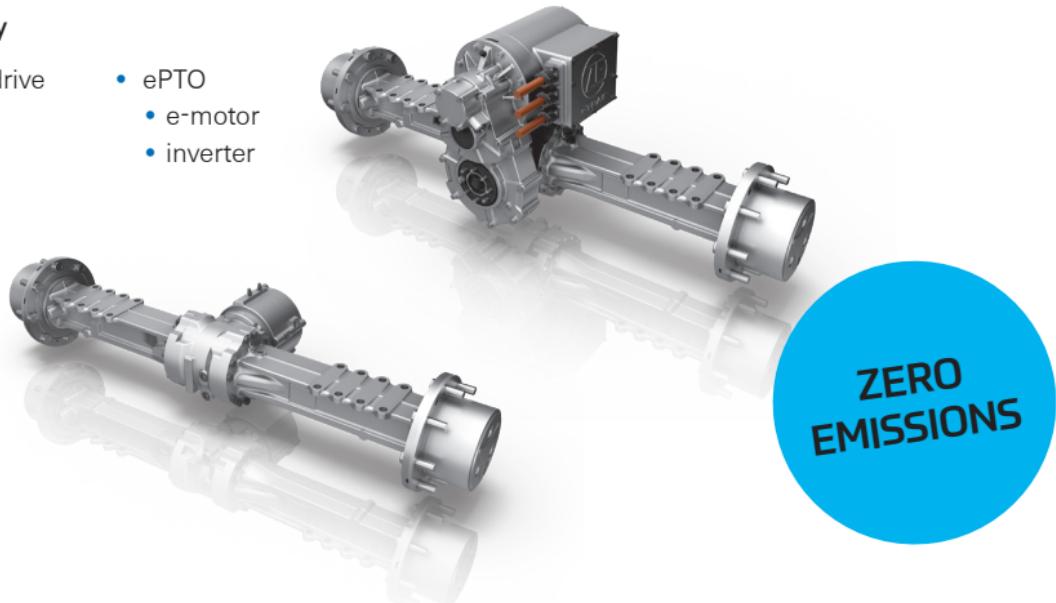
The trend towards electromobility is not confined to passenger cars. Thanks to ZF technology, work on urban construction sites and in buildings will also be possible in the future - despite strict standards concerning emissions: ZF takes care of climate-friendly operation, neutral in terms of CO₂ emissions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

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 3 to 10 ton.

ZF scope of supply

- Electric central drive
 - ePTO
 - e-motor
 - transmission
 - dropdown
 - inverter
- Axles
- eDCU



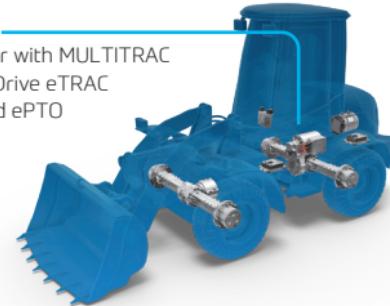
100% Electric – ZF eTRAC

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 (eCD 20/30/40/60) and ePTO



Electric Central Drive eTRAC

for compact loaders, excavators, dumpers and telehandlers



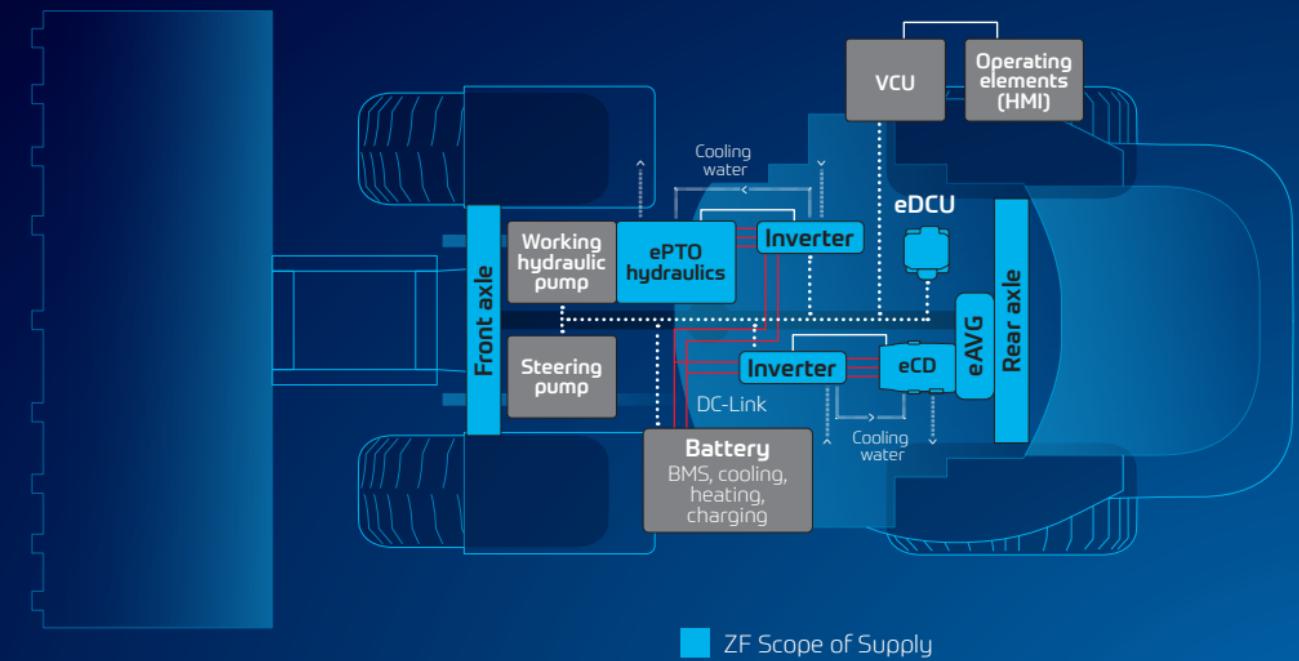
Electrification



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 10 t

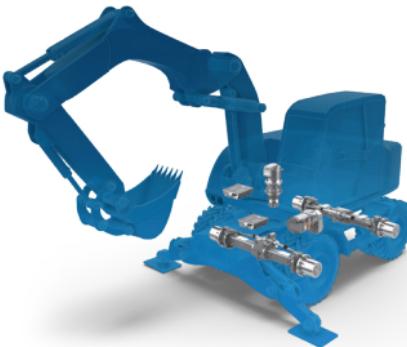
System Structure



Electrification

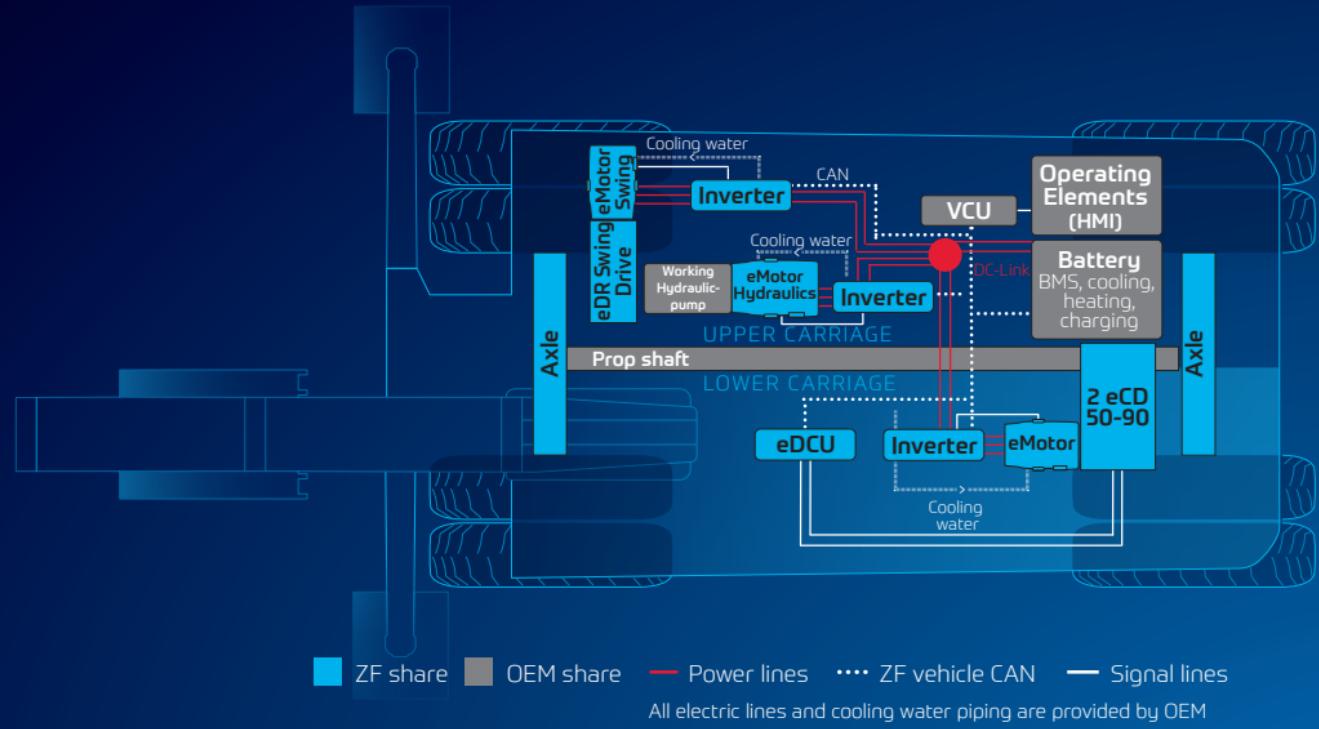
Electric Mobile Excavator Technology – Electric Central Drive eTRAC eCD 50 – 90

- 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, inverter, and drive control unit
- Compact installation space
- Robust and reliable mechanical driveline
- „Best in class solution“ for power density
- Available for various vehicle applications

System Structure

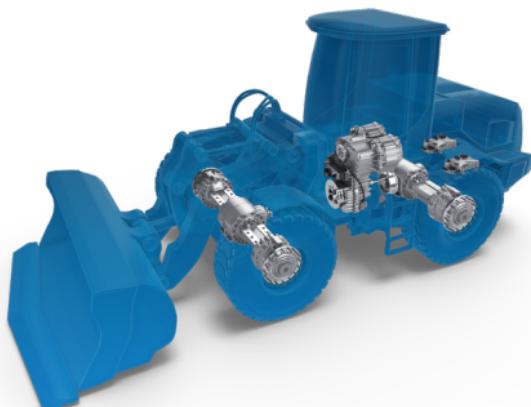


Electrification

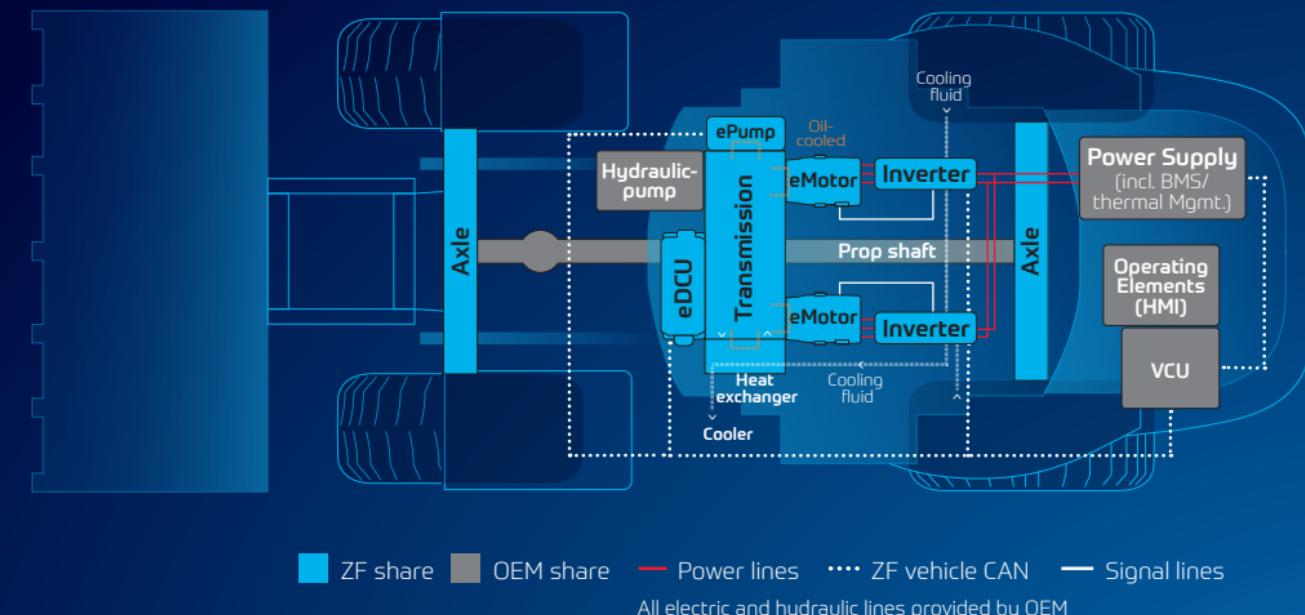
Electric Wheel Loader Technology – Electric Central Drive eTRAC eCD 110 – 230

- 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 (90-180 kW power)
 - ePTO: 650 V (105-175 kW 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

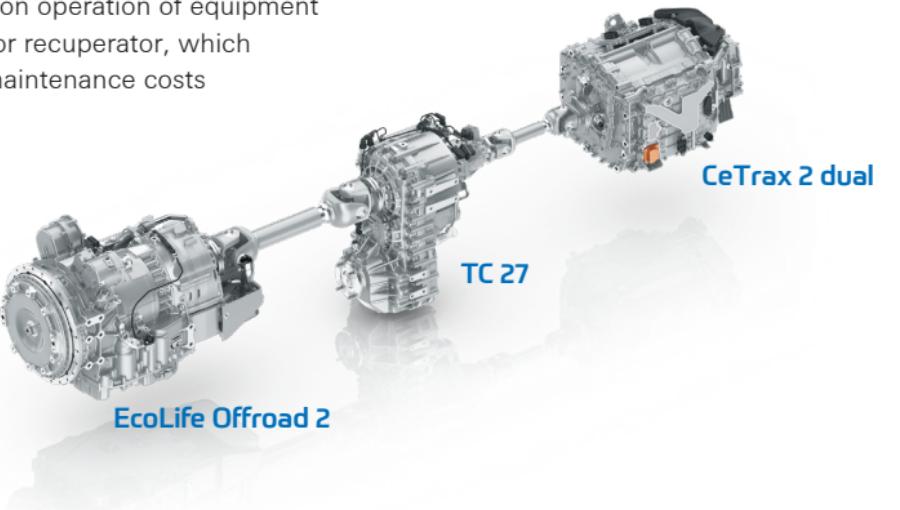


Electrification

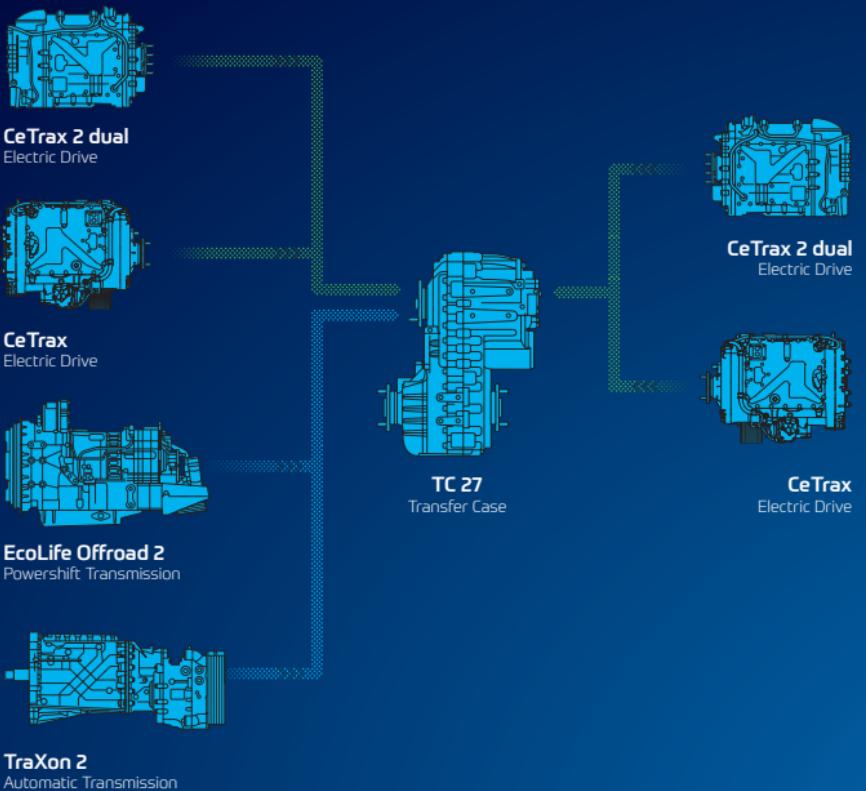


Modular Drive System

- 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



Modular Driveline



Electrification

CeTrax 2 dual

- Delivers powerful acceleration and seamless torque delivery
- High electrical efficiency helps extend vehicle operational range
- Features compact design and light weight
- Fulfils 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:** Delivers up to 380kW continuous power
- **ONE-BOX-SOLUTION:** Integrates e-motors, inverters, ECU, e-actuators and transmission
- **AUTOMOTIVE EXPERTISE:** Builds on ZF's powertrain, 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



Cyber Security



Cyber Security



Drive Control Unit EC5

In today's interconnected world, safeguarding sensitive data and systems from cyber threats is essential. Cybersecurity is especially critical in vehicles to ensure the safety and integrity of their systems. ZF addresses this challenge with its Drive Control Unit EC5, which is "cyber security ready" and adheres to upcoming cybersecurity standards. This includes compliance with both the Cyber Resilience Act and the Machine Regulation which will become effective in 2027.

- SW CAN Interface to the OEM will be unchanged compared to previous drive control unit models
- Hardware will be plug and play
- Same connectors, form and fit

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.

Electronic Brake Pedal

Communicates brake pedal position to the ECU

Electronic Brake Platform ECU

Enables advanced braking functions with configurable inputs and outputs

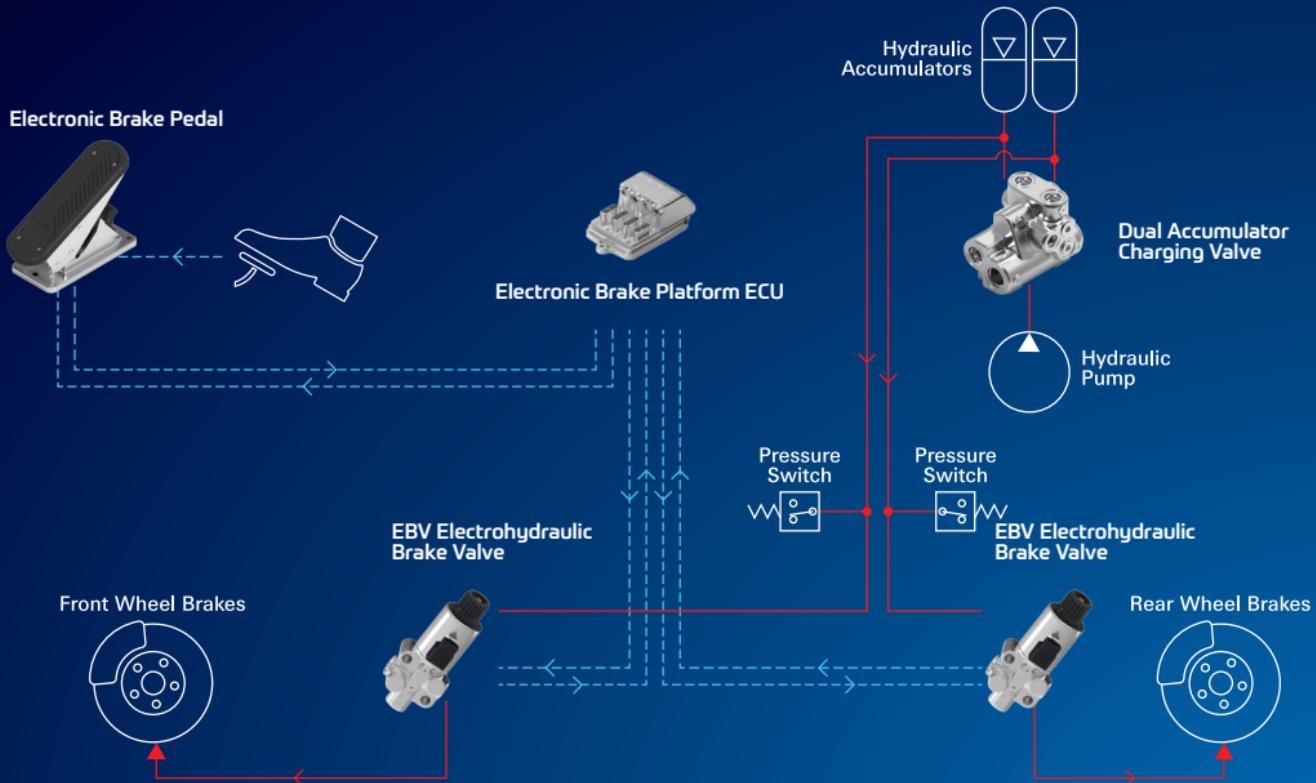
Dual Accumulator Charging Valve

Controls the energy stored in the accumulators

EBV Electrohydraulic Brake Valve

Controls the modulated hydraulic fluid flow to the brakes

Braking Systems



Chassis Structure

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.

Driveline 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

20,000

workshop partners in



115
countries



More information
[aftermarket.zf.com/
construction-machinery](http://aftermarket.zf.com/construction-machinery)

ZF Aftermarket

The global population is growing, increasing the need for new homes, buildings, and infrastructure. This demands robust machinery capable of handling high workloads daily and operating in all weather conditions. ZF has been developing and producing parts for these vehicles for over 70 years, focusing on strength, durability, and performance. All products are designed with the needs of customers and their operating environments in mind.

ZF Aftermarket is the preferred partner for fleet and aftermarket customers worldwide, offering a range of solutions from spare parts to digital solutions, and technical services. ZF Aftermarket is proud of its strong brands: ZF, LEMFÖRDER, SACHS, TRW, and WABCO, which stand for innovation, OE quality, and proven experience.

ZF Aftermarket offers a wide range of spare parts essential for the performance and longevity of construction machinery. Choosing ZF Genuine Parts means choosing quality you can rely on. Only the strongest, highest-grade materials are used to offer a longer lifetime, employing the cleanest and most efficient manufacturing processes. Every part is extensively tested before leaving dedicated facilities, ensuring reliability and performance. Additionally, with ZF Aftermarket's remanufacturing portfolio, customers benefit from a cost-efficient solution that offers the proven ZF quality at a more favourable price.

Thanks to its global service network, ZF Aftermarket enhances the performance and efficiency of all vehicle types throughout their life cycle. Comprehensive service offerings include practical training and digital information platforms, ensuring that service technicians and operators are well-prepared to handle ZF products efficiently, leading to less downtime and increased productivity.



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