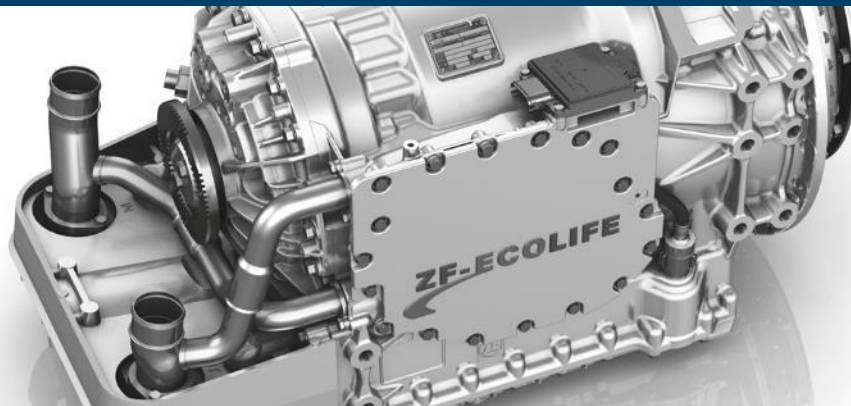




# EcoLife – The New Generation of Automatic Transmissions

Commercial Vehicle Technology



# Agenda

1. Product and Sales, Benefit
2. Technology
3. Operation
4. Competition Topics



# 01

## Product and Sales, Benefit

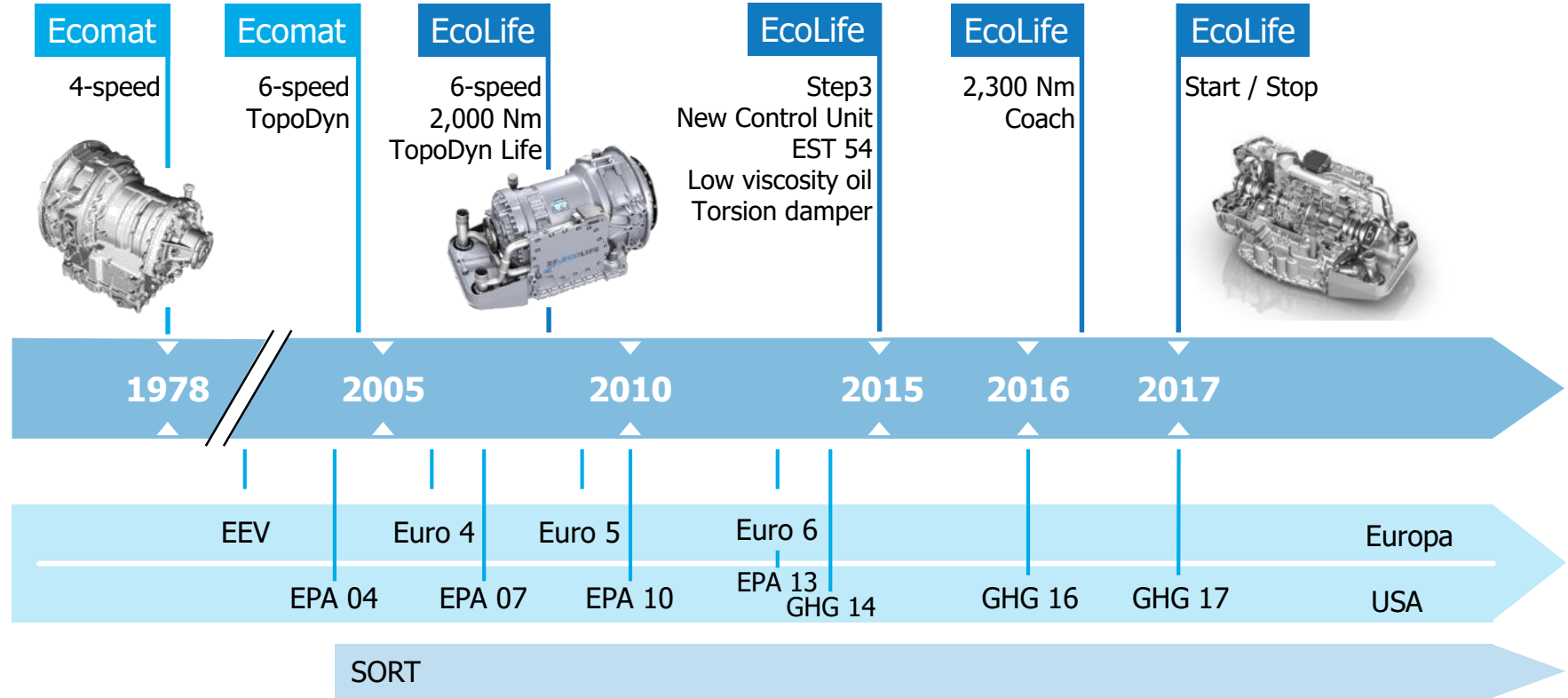


# Development

## ZF Automatic Transmissions for Commercial Vehicles

| System        | Soden<br>Manual<br>Pre-selection                                                                 | 3 HM<br>40/60/70<br>"Hydromedia"                                                                 | 2 HP 45<br>Automatic transmissions<br>"Busmatic"                                                  | Ecomat<br>Automatic<br>transmissions                                                               | EcoLife<br>Automatic<br>transmissions                                                              |
|---------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Application   | Passenger car                                                                                    | City bus                                                                                         | City bus                                                                                          | City bus<br>Coach<br>Truck                                                                         | City bus<br>Intercity bus<br>Coach<br>Truck                                                        |
| Automation    | Pre-selection                                                                                    | Semi-automatic,<br>Fully automatic                                                               | Fully automatic                                                                                   | Fully automatic                                                                                    | Fully automatic                                                                                    |
| Shift control | Mechanical                                                                                       | Electric                                                                                         | Electrohydraulic                                                                                  | Electr.-hydr./<br>Electronic                                                                       | Electr.-hydr./<br>Electronic                                                                       |
| ECU           | Without                                                                                          | Separate                                                                                         | Separate                                                                                          | Separate                                                                                           | On the transmission                                                                                |
|               | <b>1921</b><br> | <b>1954</b><br> | <b>1961</b><br> | <b>1978</b><br> | <b>2007</b><br> |

# Technology Stages ZF Automatic Transmissions



# The Product Name: EcoLife

## ECO

- **Ecological**  
Optimized in terms of noise, emissions, and consumption
  
- and
  
- **Economical**  
Optimized in terms of service life, maintenance, consumption, and comfort

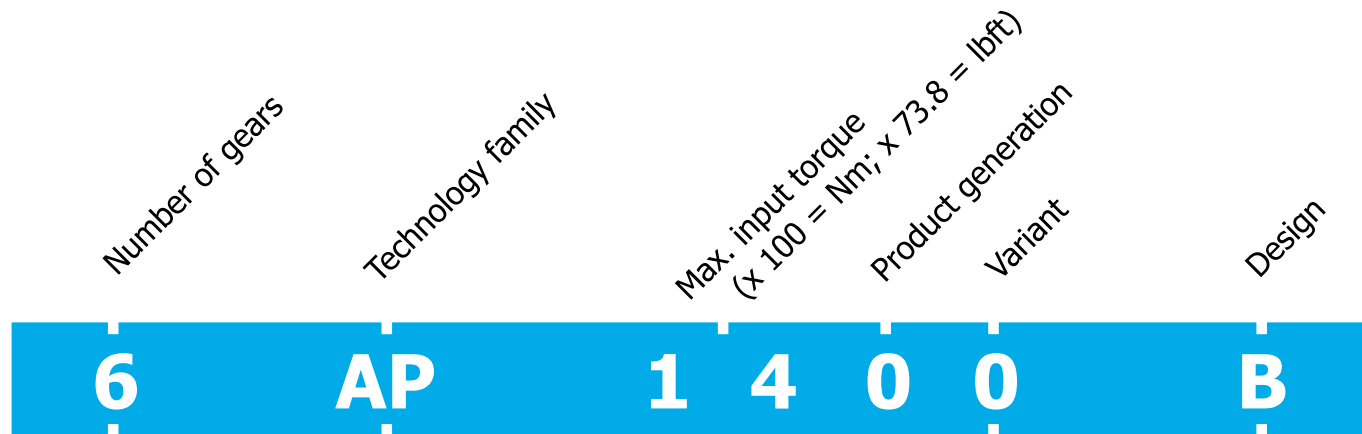
## LIFE

- Focuses on longer service life at increasing temperature and performance requirements of future engine generations

**ZF-ECOLIFE**

**EcoLife** stands for a holistic profitability analysis over the entire service life of the vehicle – according to the LCC principle (LCC: Life Cycle Costs)

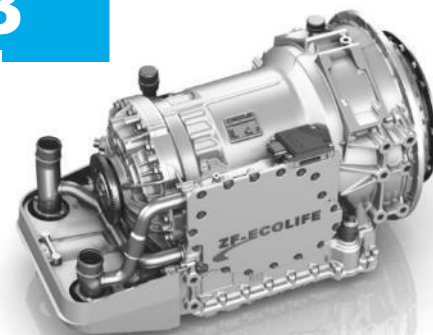
# The Designation



AP = Automatic Powershift

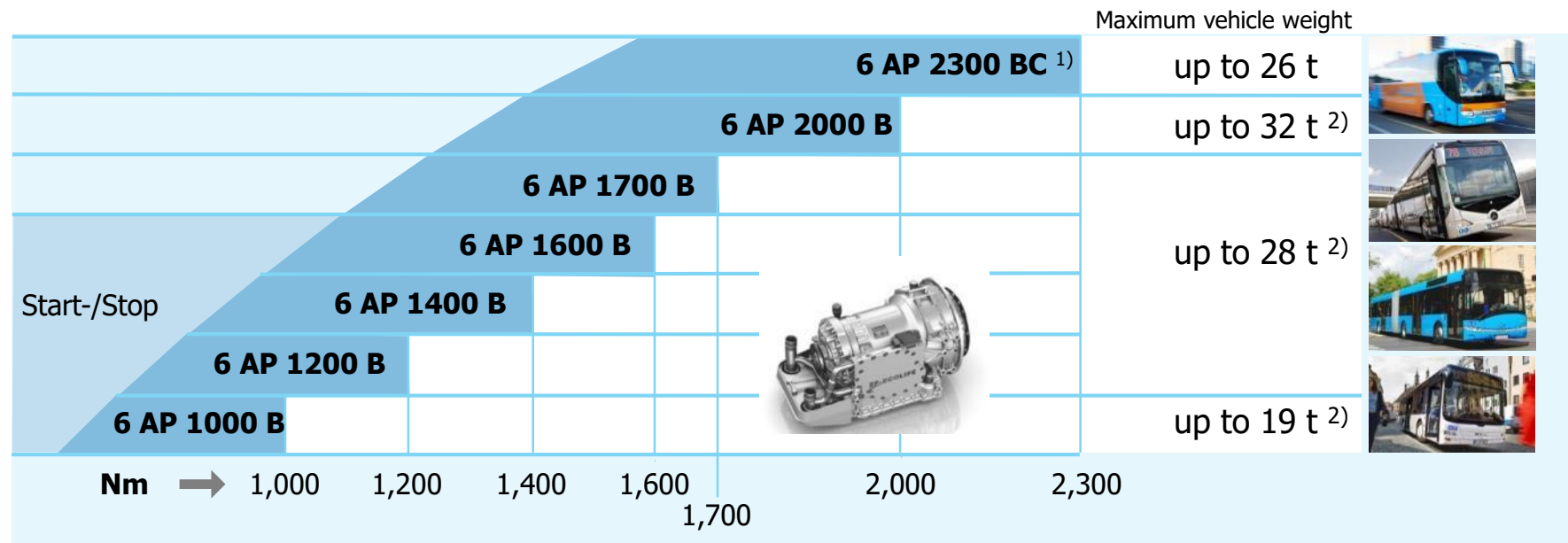
0 = Standard (coax);  
2 = With angle drive (LHD)\*;  
3 = With angle drive (RHD)

B = Bus



\* In development

# Transmission Types



<sup>1)</sup> Exclusive for coach application

<sup>2)</sup> Applications for higher vehicle weights upon request





# Basic Technical Data

| Transmissions                             |                                                                                                                    |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Input torque                              | Max. 2,300 Nm                                                                                                      |
| Number of gears                           | 6                                                                                                                  |
| Weight                                    | 346-379 kg (763 - 836 lb), without oil                                                                             |
| Oil quantity                              | approx. 42 l (11.1 gal (US))                                                                                       |
| Ratios                                    | 3.36 (7.80 hydr.) • 1.91 • 1.42 • 1.00 • 0.72 • 0.62 • R 4.24 (9.84 hydr.)<br>(max. tractive force as in 1st gear) |
| Stall torque ratio ( $\mu_v = 0$ )        | 1.9 ... 2.3                                                                                                        |
| Spread [ $\varphi_{\text{mech}}$ ]        | 5.47                                                                                                               |
| Total spread ( $\varphi_{\text{total}}$ ) | <b>10.4 ... 12.6</b>                                                                                               |



# Key Data

## Bus Applications (Europe)

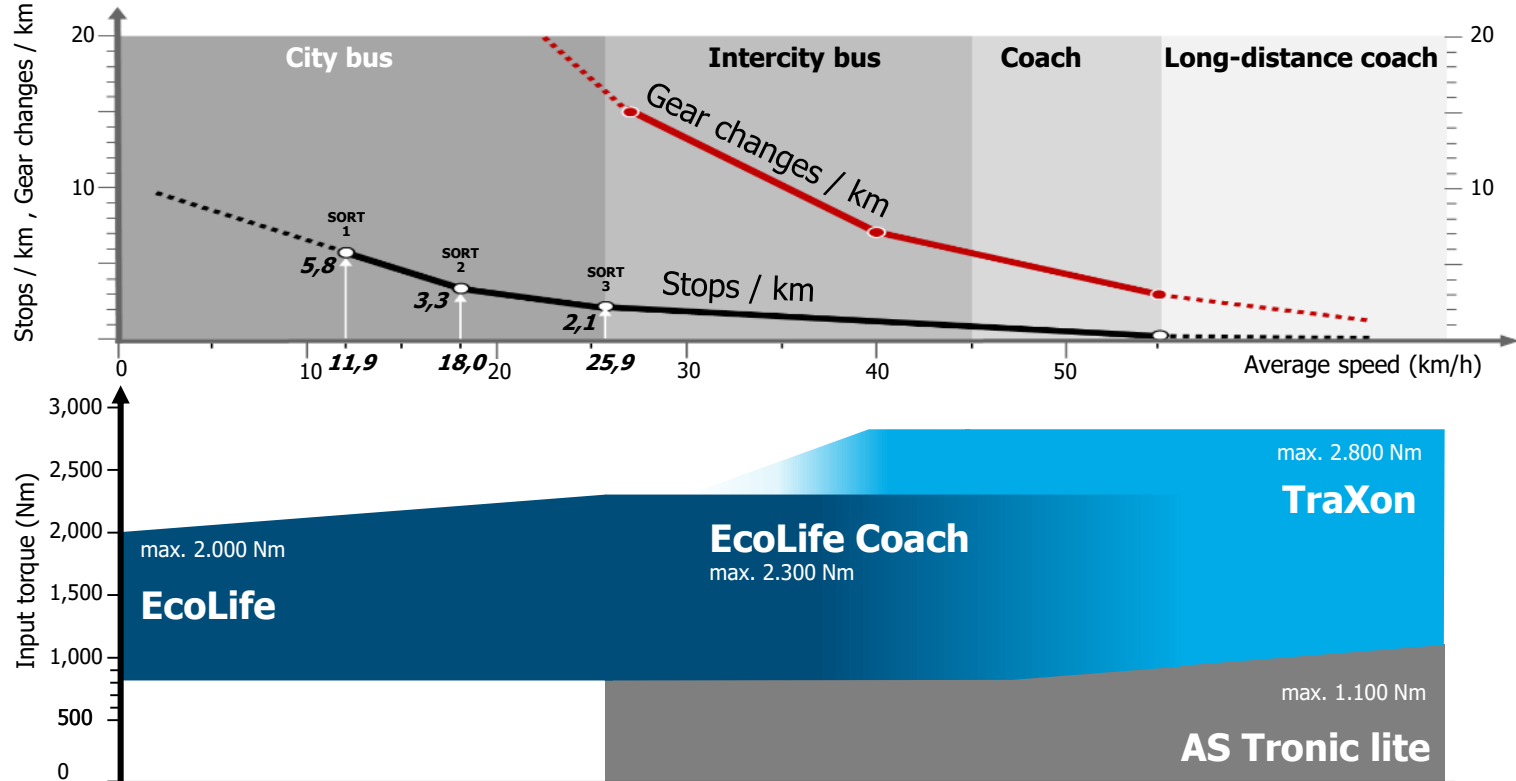
| Transmission selection        |       | 6 AP | 1000 B                                               | 1200 B   | 1400 B | 1600 B | 1700 B              | 2000 B | 2300 BC <sup>1)</sup> |
|-------------------------------|-------|------|------------------------------------------------------|----------|--------|--------|---------------------|--------|-----------------------|
| Engine torque                 | Nm    |      | 1,000                                                | 1,200    | 1,400  | 1,600  | 1,700               | 2,000  | 2,300                 |
| Engine power (max.)           | kW    |      | 140 ... 260                                          |          |        |        | 230 ... 340         |        | 365                   |
| Input speed                   | 1/min |      | 2,800 <sup>3)</sup>                                  |          |        |        | 2,600 <sup>3)</sup> |        |                       |
| Mass of vehicle <sup>2)</sup> | t     |      | up to 19                                             | up to 28 |        |        | up to 32            |        | 26                    |
| Drive axle ratio              | i =   |      | 4.6 ... 7.2 for city buses • 3.8 ... 5.7 for coaches |          |        |        |                     |        |                       |

- 1) Exclusive for coach applications
- 2) Applications for higher vehicle weights upon request
- 3) In 6th gear limited to 2,100 rpm



# Bus Applications

## ZF Transmission Application Limits



# Customers

## Start of production:

2006, with introduction of  
Euro 4 engines

## First application:

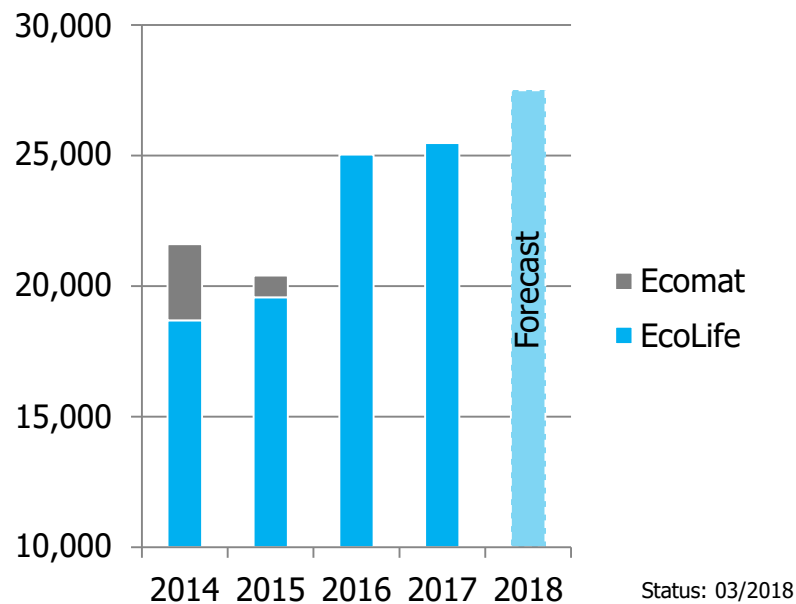
Volvo double-decker bus,  
type B9TL



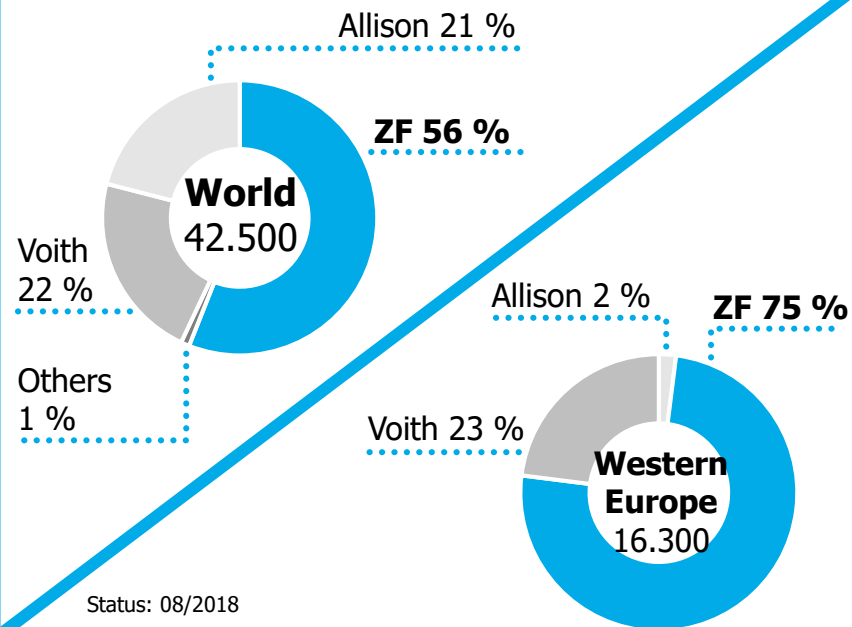
# ZF-Automatic Transmissions

## Production Figures and Market Shares

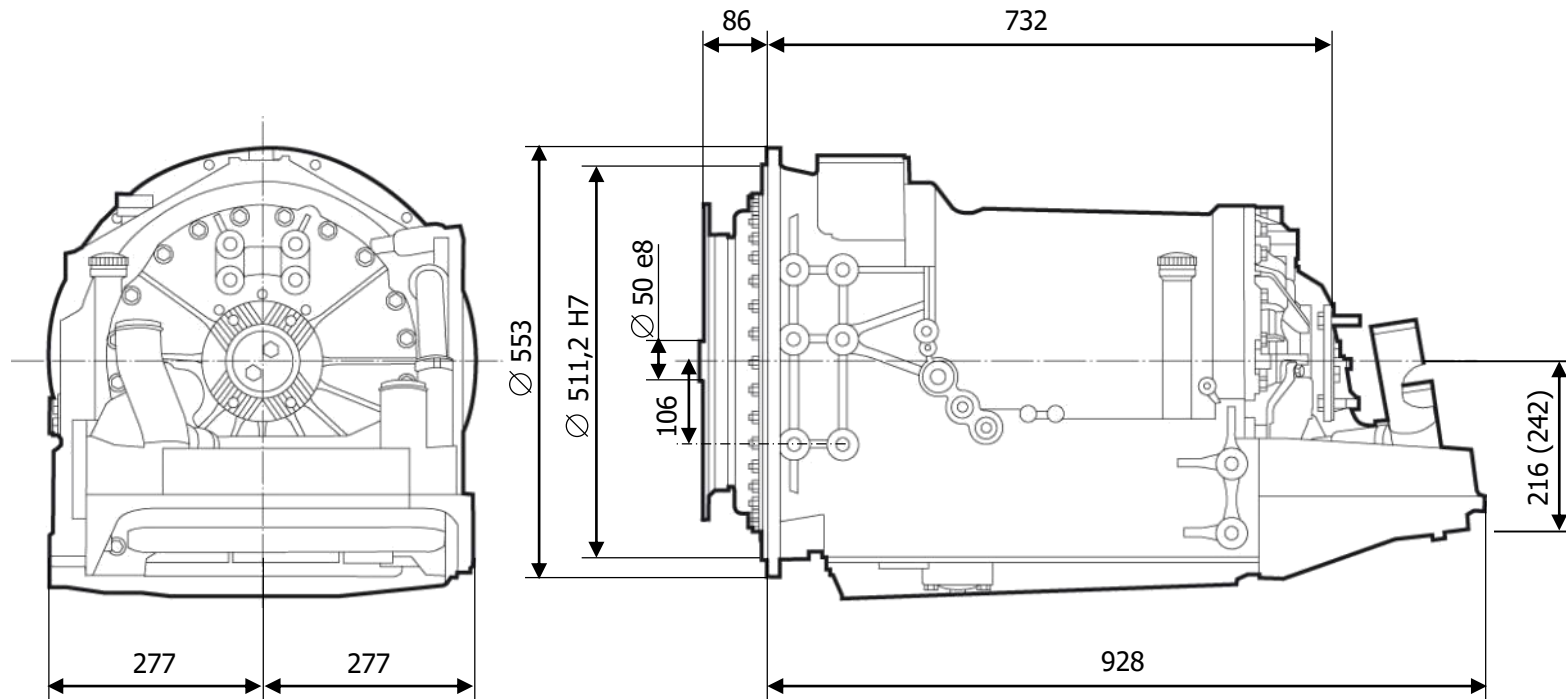
### ZF-Automatic Transmissions



### 2017 Market Shares Bus > 16 t



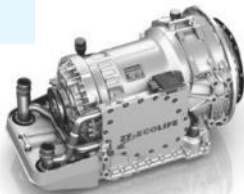
# Main Dimensions



# Highlights Top Ten

|                                                                                         |               |
|-----------------------------------------------------------------------------------------|---------------|
| • <b>Fuel</b>                                                                           | <b>- 10 %</b> |
| • <b>Service life</b>                                                                   | <b>+ 40 %</b> |
| • <b>Retarder performance</b>                                                           | <b>+ 40 %</b> |
| • <b>Shifting quality</b>                                                               | <b>+ 50 %</b> |
| • <b>Oil change interval</b>                                                            | <b>+ 20 %</b> |
| • <b>Simple diagnosis</b>                                                               | <b>100 %</b>  |
| • <b>Low-noise</b>                                                                      | <b>- 50 %</b> |
| • <b>Optimized driving performance</b>                                                  | <b>100 %</b>  |
| • <b>Standard:</b><br>TopoDyn Life<br>Torsional vibration damper<br>Dual cooling system | <b>100 %</b>  |

**ZF-ECOLIFE**





# Fuel Economy

- **Savings of 5 - 7 percent**  
compared to 6-speed Ecomat with TopoDyn
- **Savings of 5 - 15 percent**  
compared to conventional transmission technology  
(5 or less gears and without TopoDyn)
- **EcoLife reduces fuel consumption**
  - 6-speed powershift transmission
  - TopoDyn Life
  - Torque converter with economical characteristics
  - Additional, fuel-saving functions
  - ZF recommendation: Rear axle ratio only upon prior consultation





# Product Advantages

## Topic: Cost Advantages

### **EcoLife improves the cost-effectiveness of the bus**

- ZF Plus service package reduces operating costs
- High lifetime
- Long oil change and service intervals
- Powerful retarder reduces wear on the service brakes



EcoLife – The New Generation of Automatic Transmissions



# Product Advantage

## Topic: Comfort and Dynamics

### **EcoLife offers excellent driving characteristics:**

- Fast, comfortable gearshifts without torque interruption
- Quiet operation thanks to helical-cut planetary gears
- Integrated torsional damper for smoother running
- Torque converter for high starting acceleration and excellent comfort
- Little influence of the driver on fuel consumption



# Product Advantages

## Topic: Environmental Protection

### EcoLife goes easy on the environment

- EcoLife reduces all vehicle emissions:
  - Engine (CO<sub>2</sub>, NO<sub>x</sub>, etc.)
  - Brake dust
  - Used oil
  - Vehicle noise



EcoLife – The New Generation of Automatic Transmissions





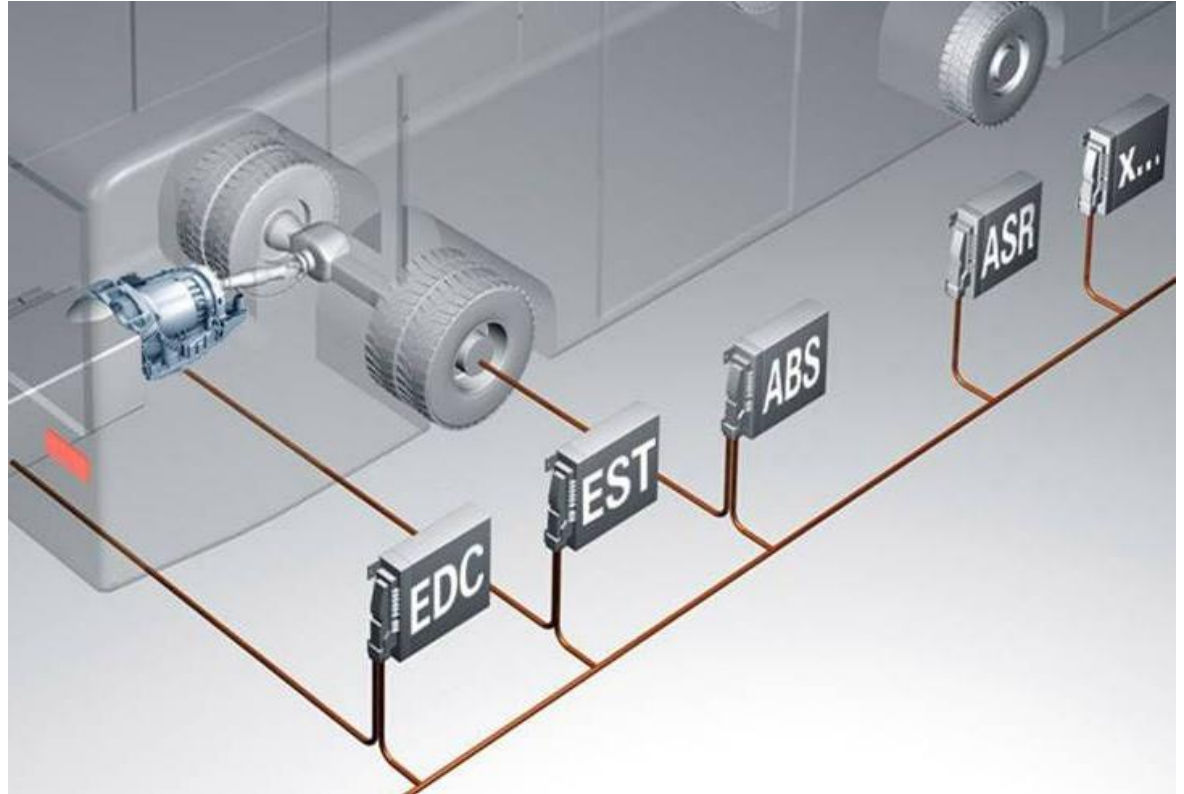
# 02

## Technology

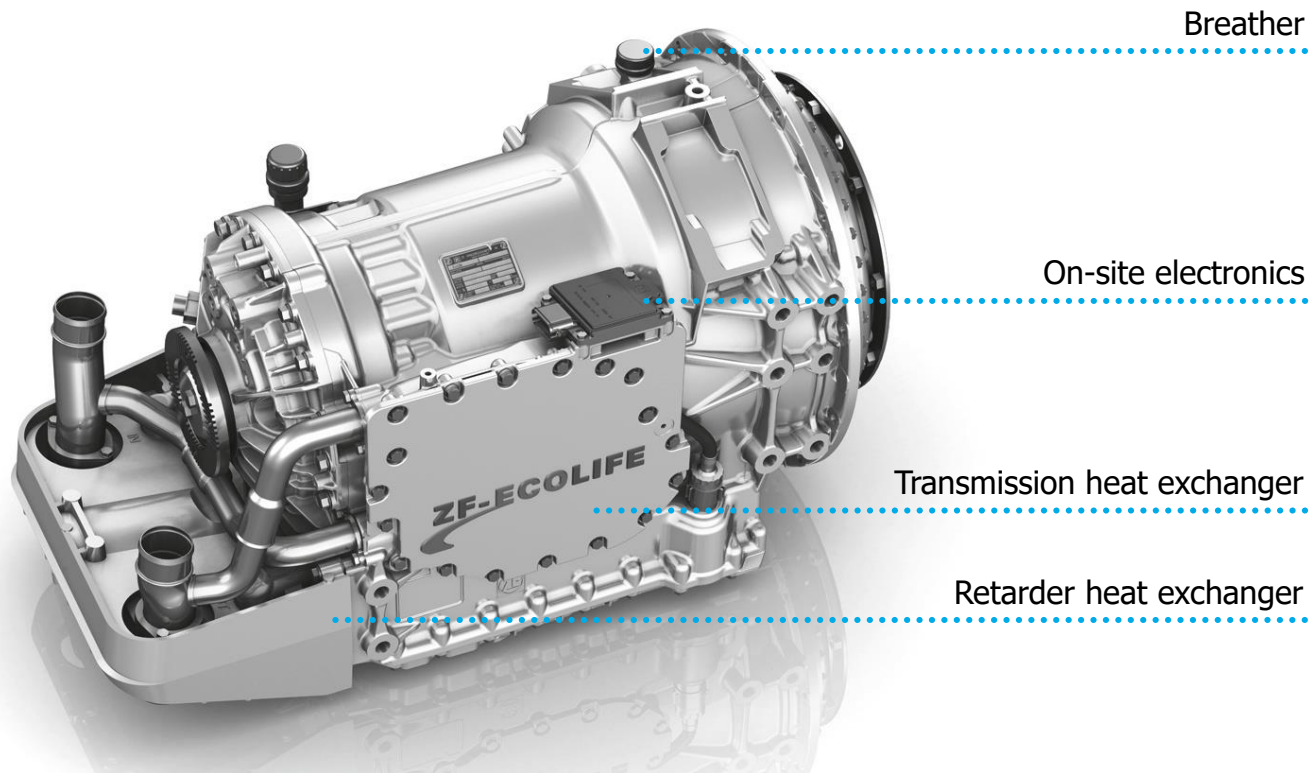


# Communication in the Driveline

## Integration into the vehicle CAN system

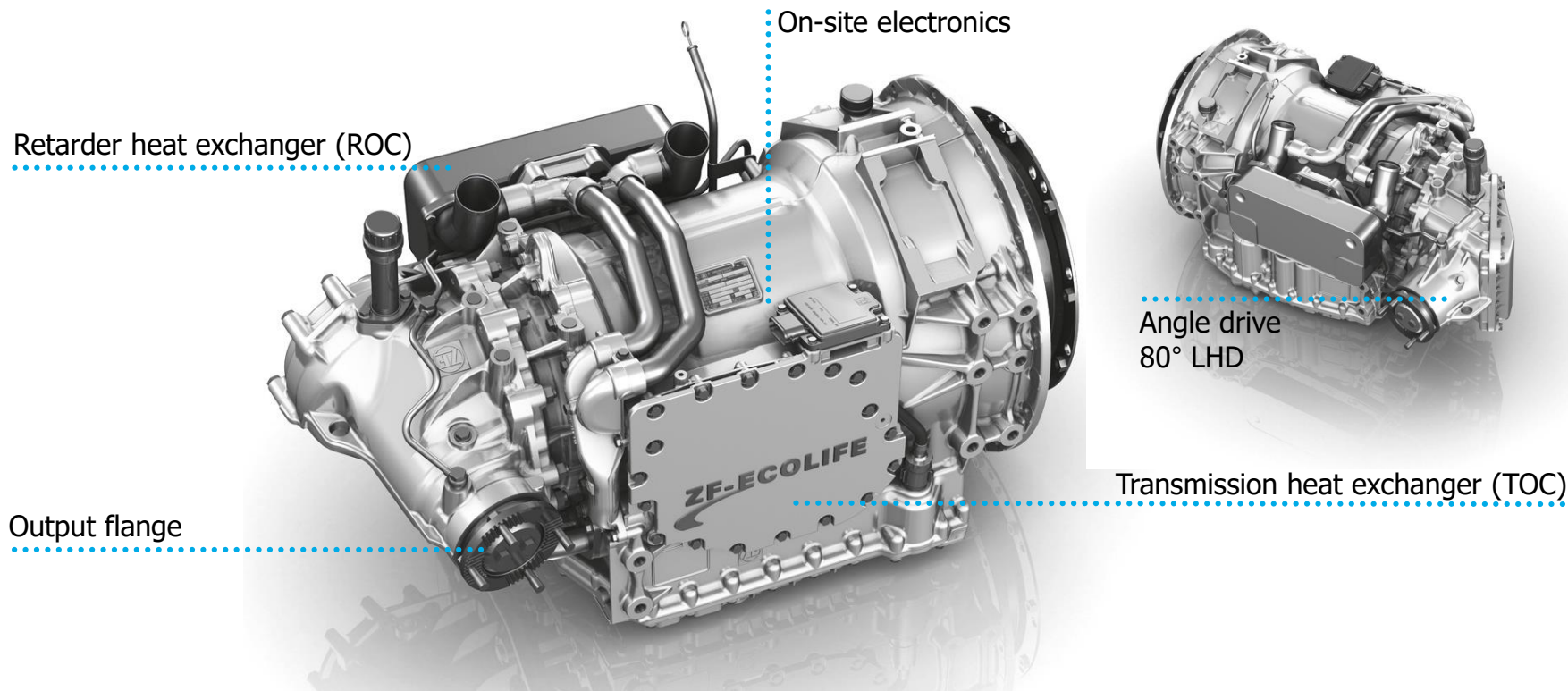


# Standard Transmissions (Coaxial Output)



# Transmissions With Angle Drive RHD

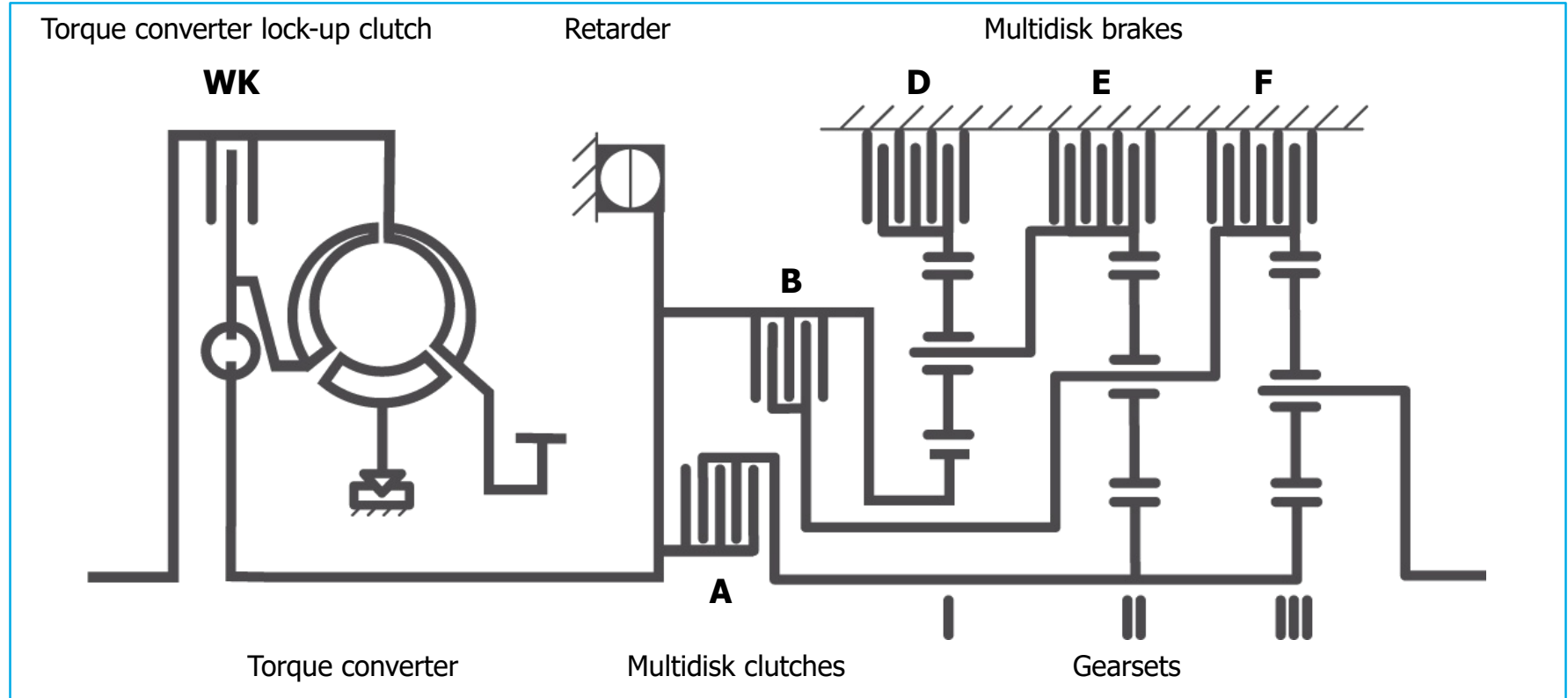
## Right Hand Drive (RHD) / Left Hand Drive (LHD)





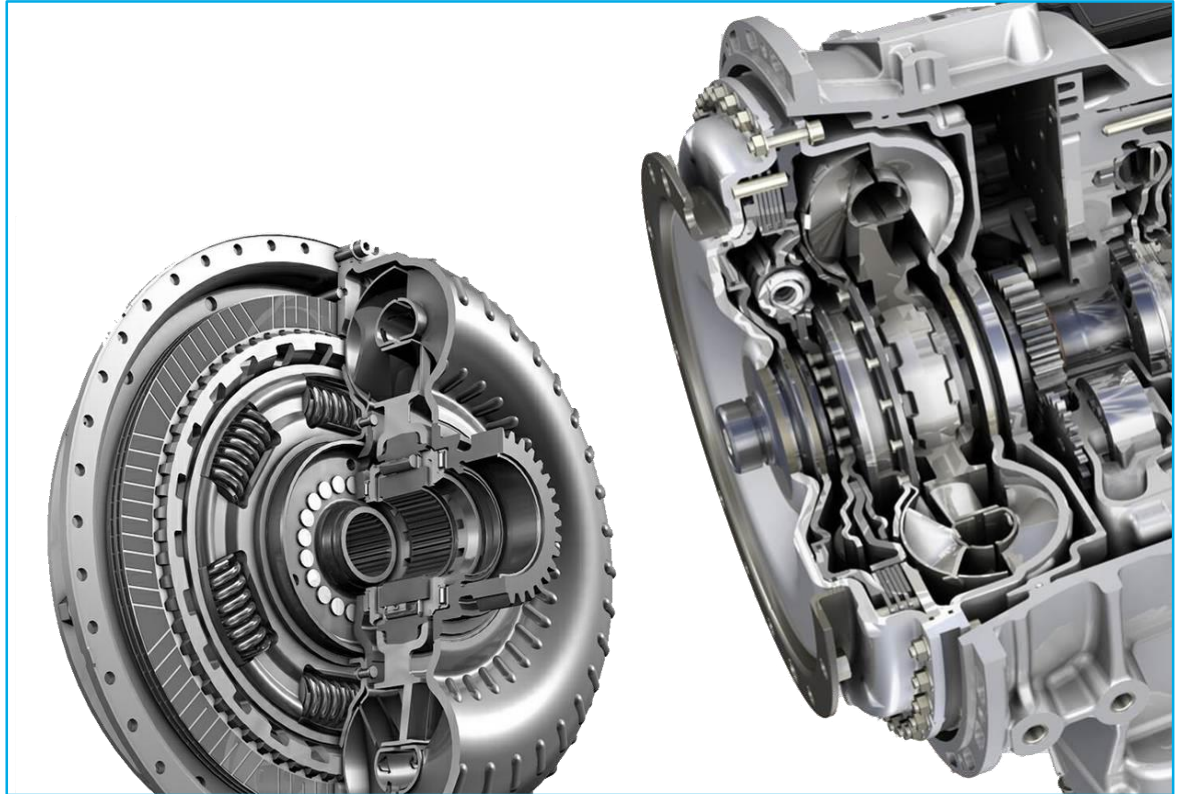
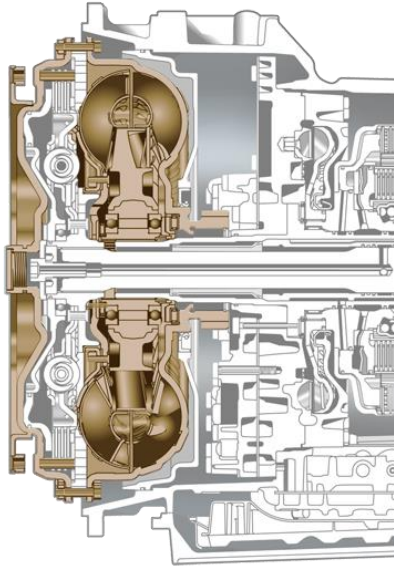
# EcoLife

## Transmission Diagram



# Hydrodynamic Torque Converter Setup

- Wear-free
- Trilok principle
- Effective, brief working phase



# Hydrodynamic Torque Converter Innovations

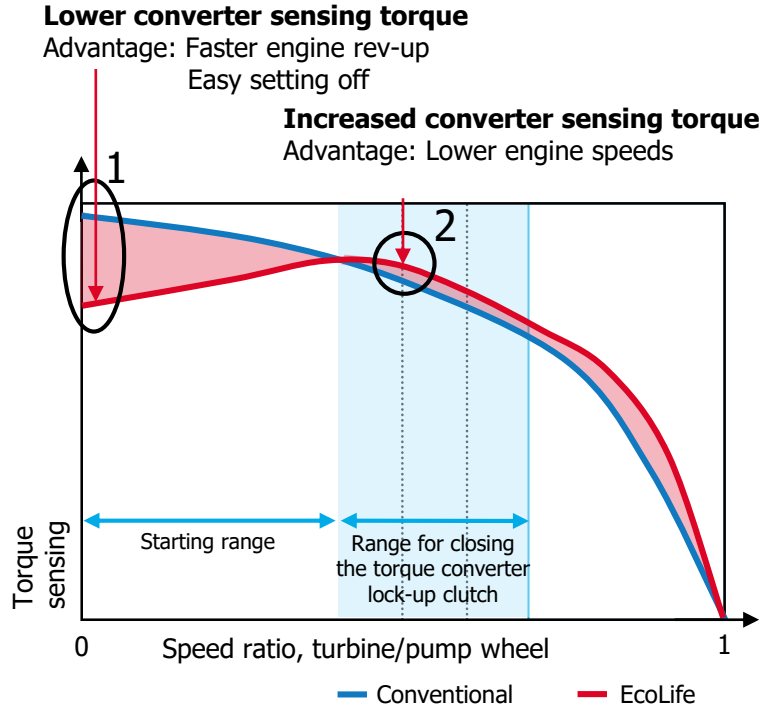
- **New: design**
  - Sheet-metal design
  - Horizontally-vertically shaped circuit
- **New: converter characteristics**
  - For high engine torques
  - Better acceleration
- **New: standard turbine torsional damper**
  - Low engine speeds
- **New: controlled torque converter lock-up clutch**
- **Two torque converter sizes**
  - For the complete speed range (W419 and W370)



# Torque Converter

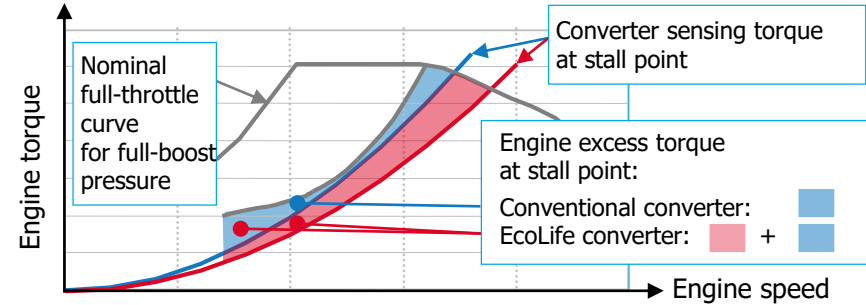
## Converter Characteristics

### EcoLife converter characteristic



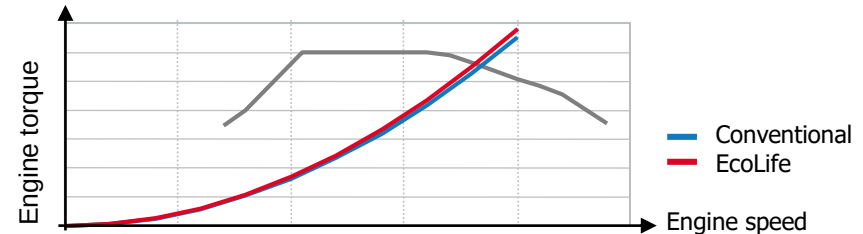
### 1 Higher excess torque at stall point

**Example:** Stall point



### 2 Roughly the same engine speed for higher speed ratios

**Example:** Engine speed at full throttle. Speed ratio 0.5



# Torque Converter

## Turbine Torsional Damper

### Torque converter with integrated turbine torsional damper:

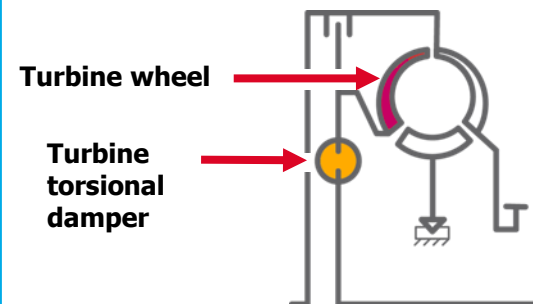
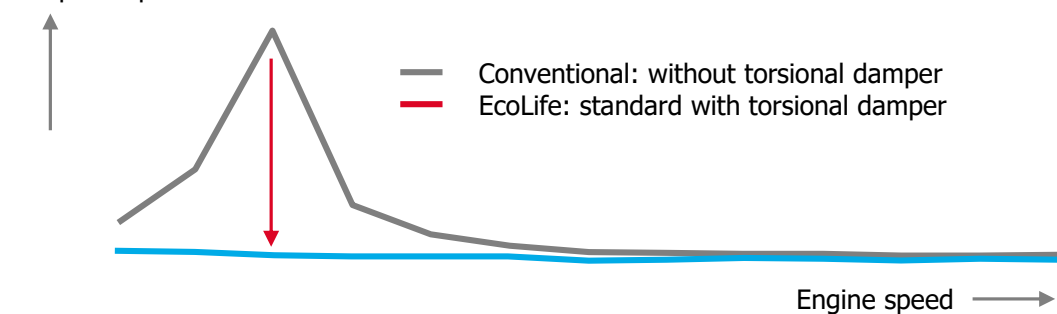
#### New design

- Reduced engine vibrations: smoother running
- Lower shifting speeds: less fuel consumption

### Turbine torsional damper:



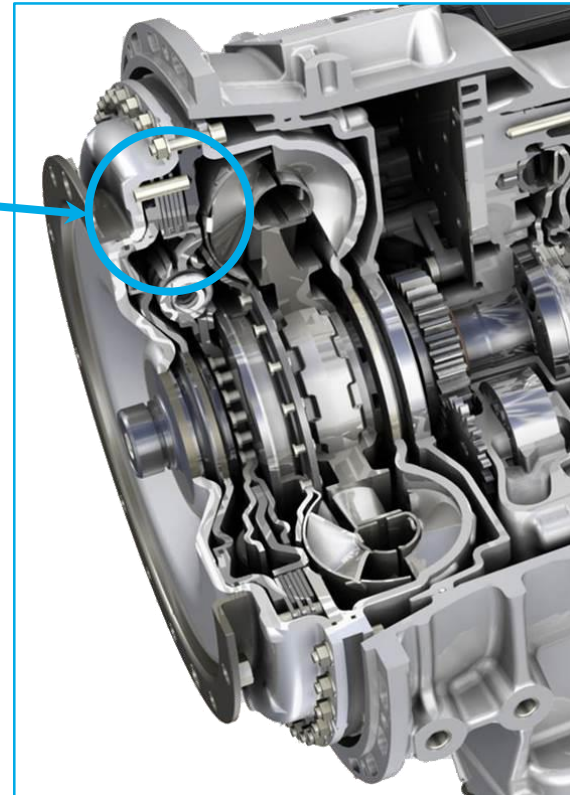
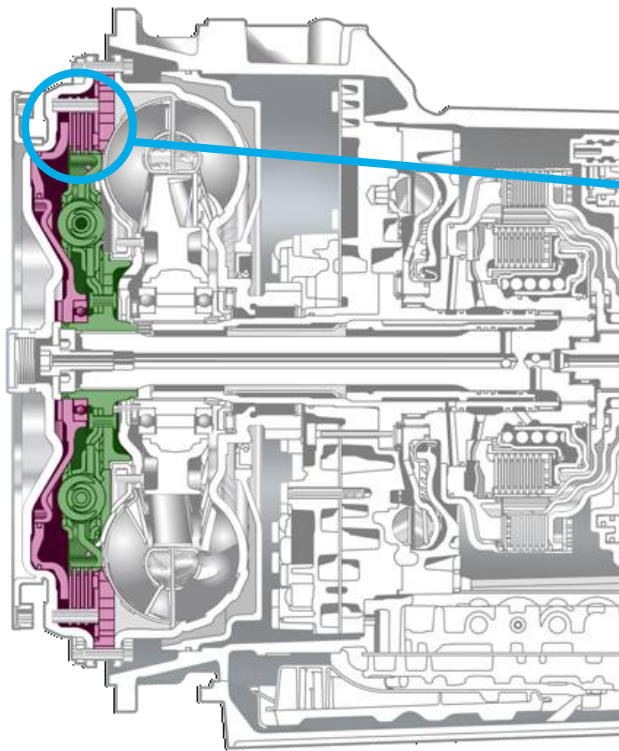
Torque amplitude



# Torque Converter

## Structure of Lock-Up Clutch

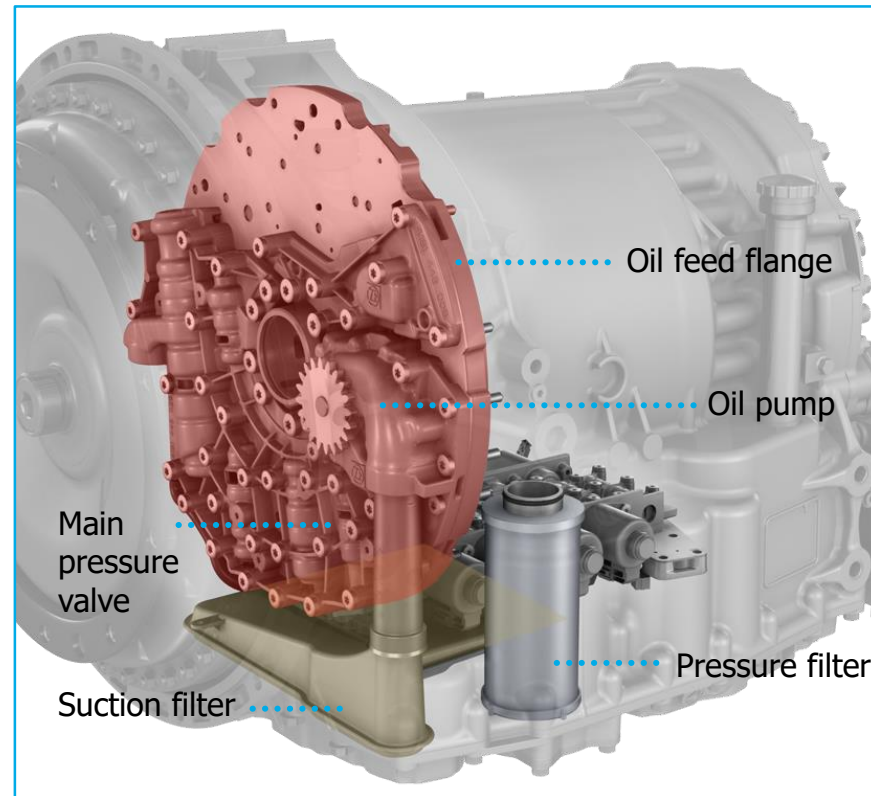
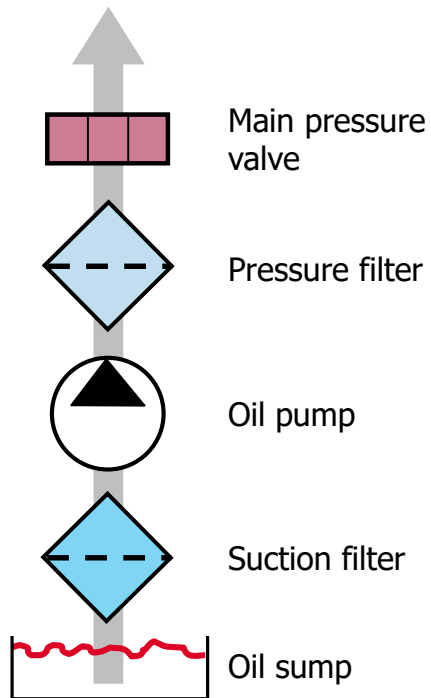
- Electronically controlled pressure regulation
- Smooth opening and closing





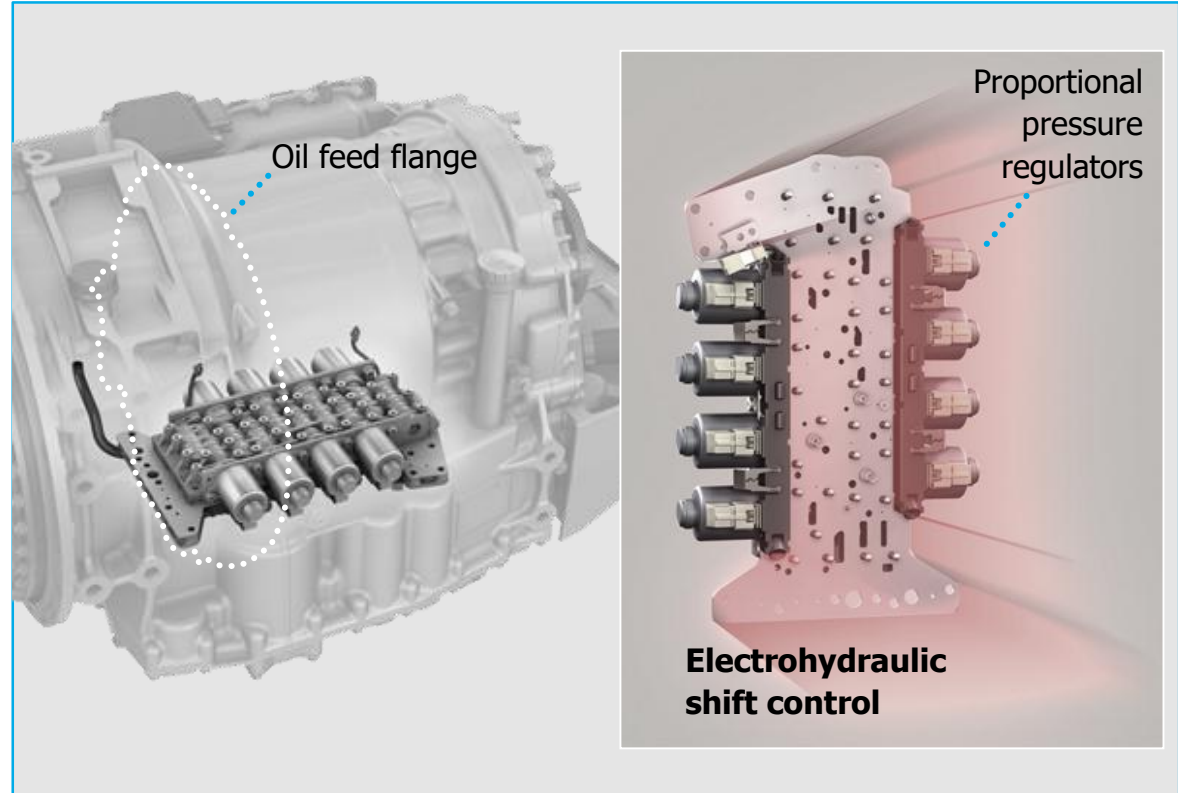
# Oil Supply

- Cleaned oil from the transmission oil sump
- High oil feed rate
- Micro-filtered oil for the hydraulic shift control



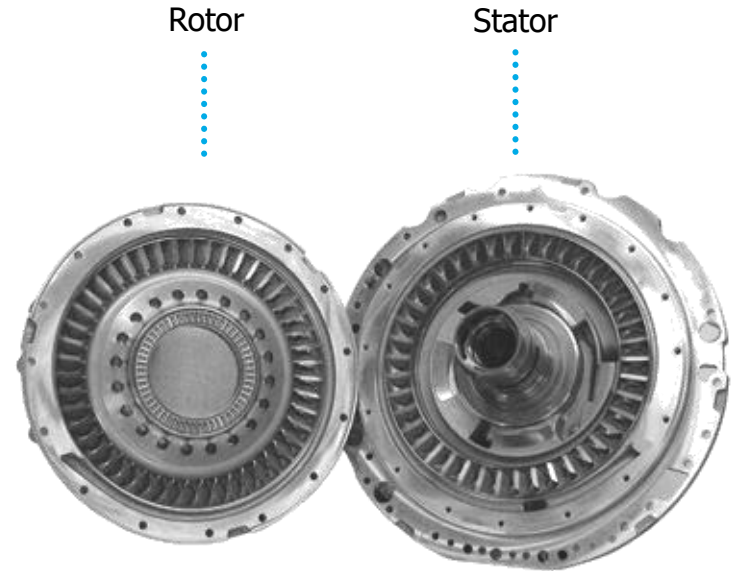
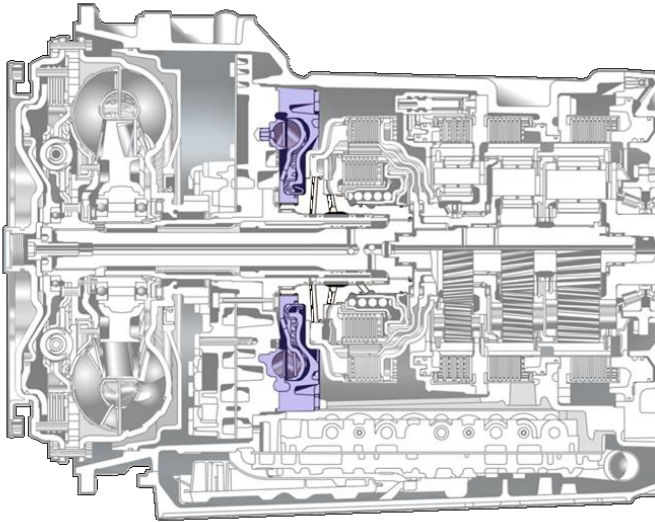
# Elektro-hydraulische Schaltsteuerung

- Proportional valves for each shift element
- Flow-enhancing oil feed with short distances
- Efficient transmission lubrication with cooled oil
- Microfiltered oil for the hydraulic control unit
- Hydraulic accumulator for fast retarder filling



# Primary Retarder Principle

- Wear-free continuous brake
- Primary retarder principle
- Electronic control



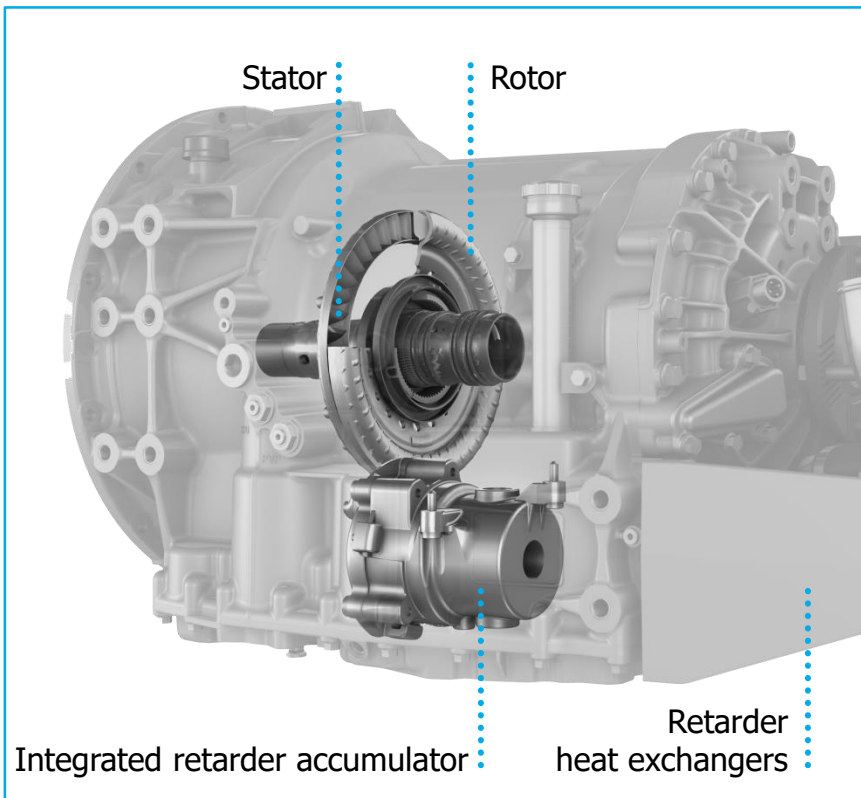
# Primary Retarder

## The EcoLife CityBus retarder:

- Integrated primary retarder
- Electric control
- Integrated retarder accumulator

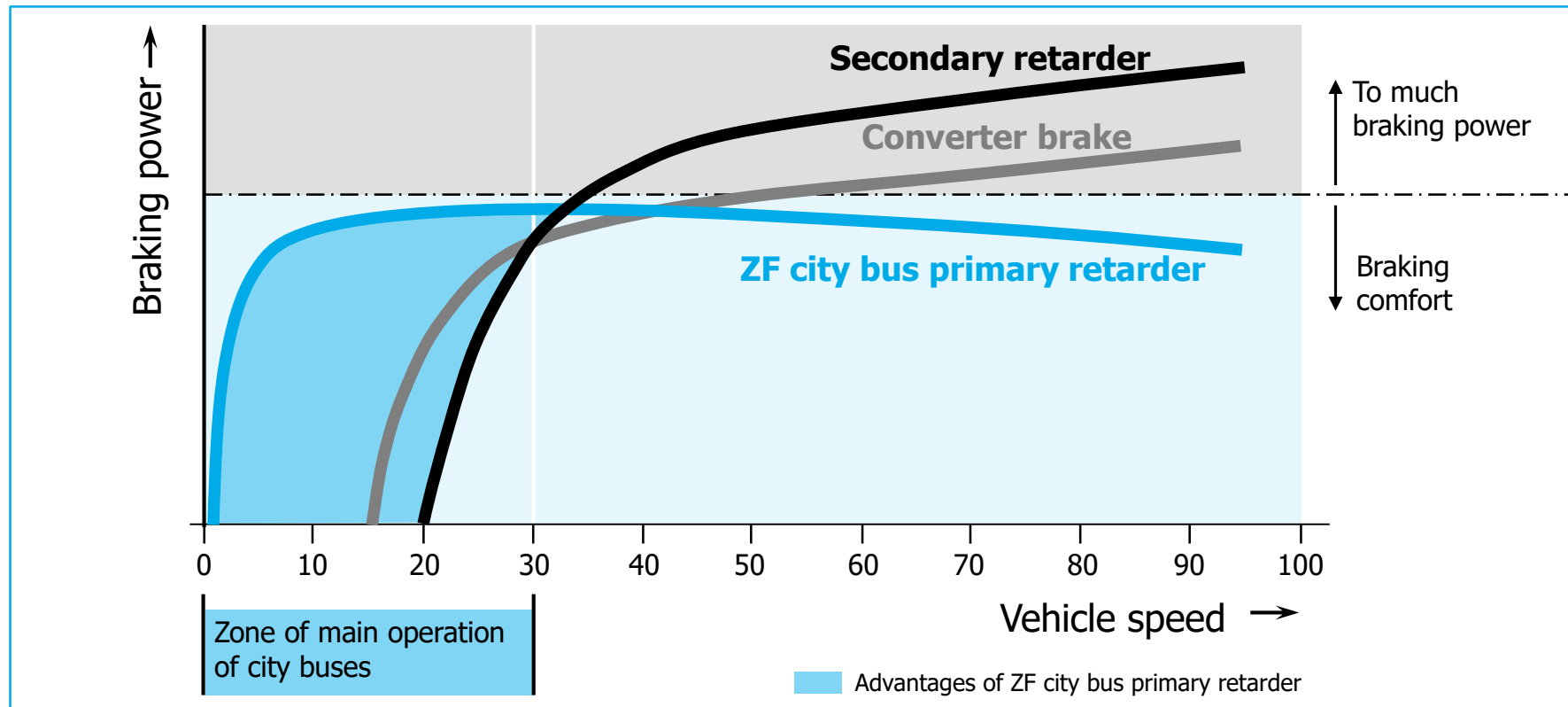
## Technical characteristics:

- High brake torques
  - Rotor brake torque = 1,900 Nm  
(= 1,401 lbft)
  - Total braking torque = 2,650 Nm  
(= 1,955 lbft)
- High power-to-weight ratio



# ZF city bus primary retarder

## Characteristics of braking



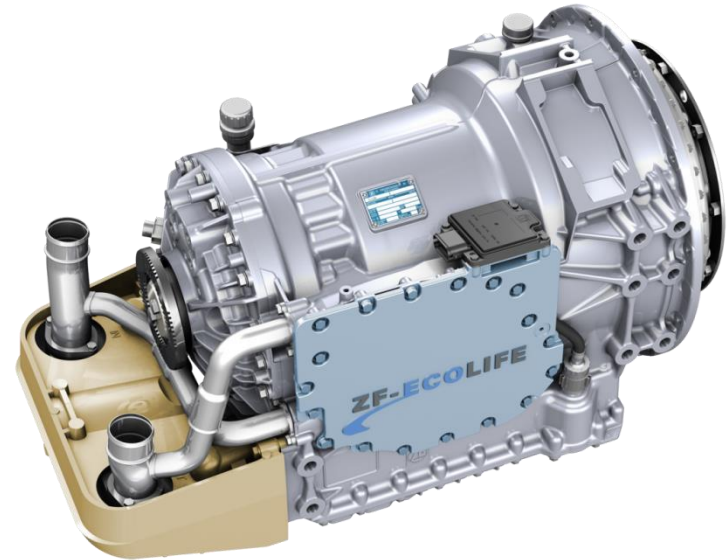
# Cooling System Overview

## Facts:

- Dual cooling system with two heat exchangers
- High cooling power
- New high-performance oil
- Improved oil supply

## The advantages:

- High thermal loads possible
- High retarder availability
- Increased reliability
- Reduced fuel consumption

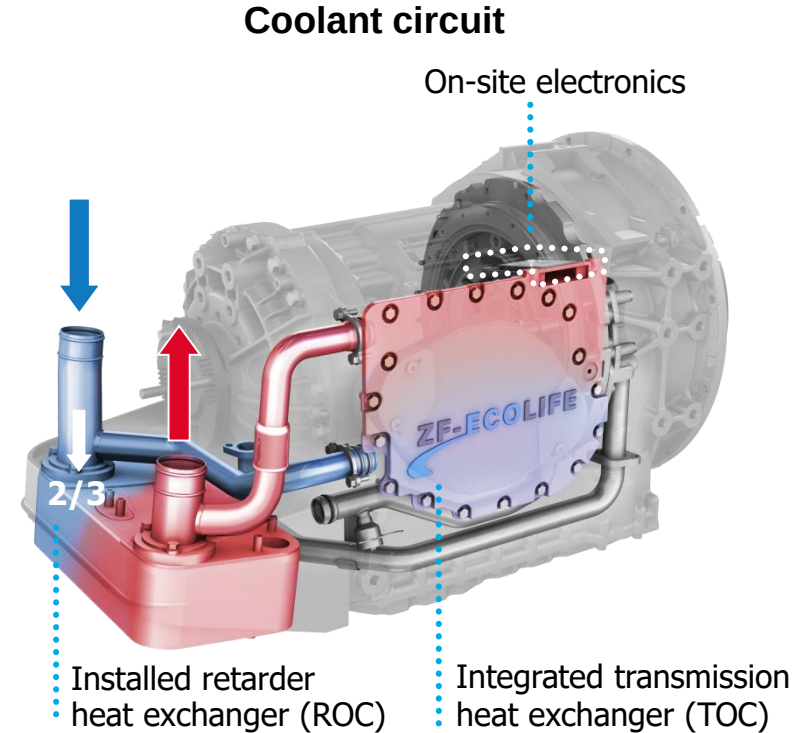




# Dual Cooling System Coolant Circuit

## Dual cooling system with two heat exchangers (ROC / TOC)

- Transmission heat exchanger (TOC) integrated
- Mounted retarder heat exchanger (ROC)
- High cooling power
- Optimized oil circuits for driving and retarder operation
- Thermally stable position of on-site electronics



# Ecofluid Life

## Transmission Oil for Highest Requirements

**Requirement: continuous temperatures > 105 °C (221 °F)**

### **New development (with ZF) especially for city bus applications:**

- Oil change interval:
  - 240,000 km (up to 100 °C / 212 °F oil sump temperature)
  - 180,000 km (up to 105 °C / 221 °F oil sump temperature)
  - 120,000 km (up to 110 °C / 230 °F oil sump temperature)

### **Advantages:**

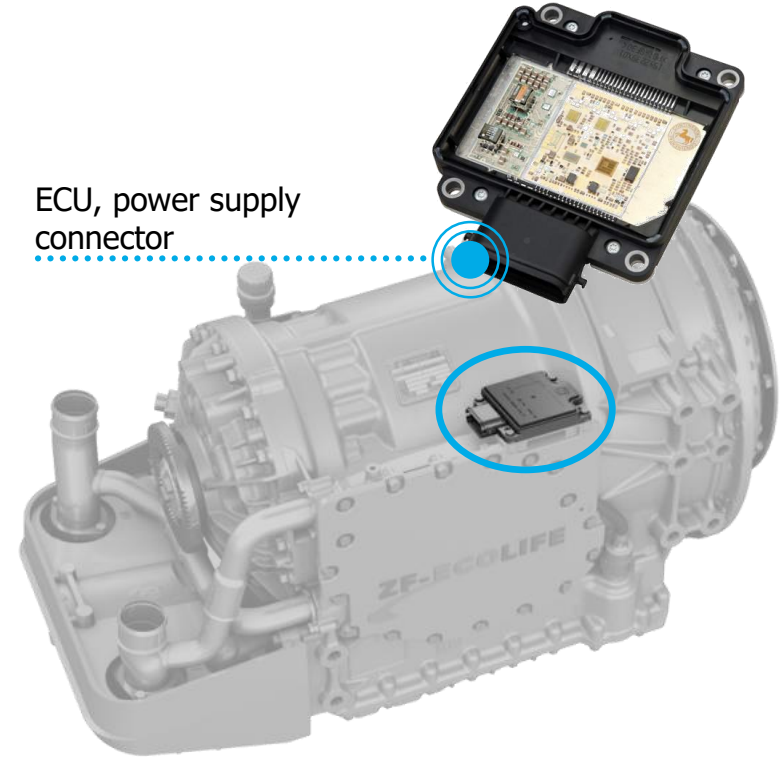
- Lower service costs
- Very reliable
- Improved formula
- Environmentally friendly

**ZF-ECOFLUID**  
*Life*

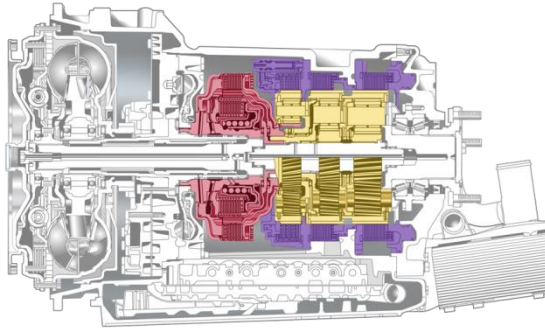


# On-Site Electronics

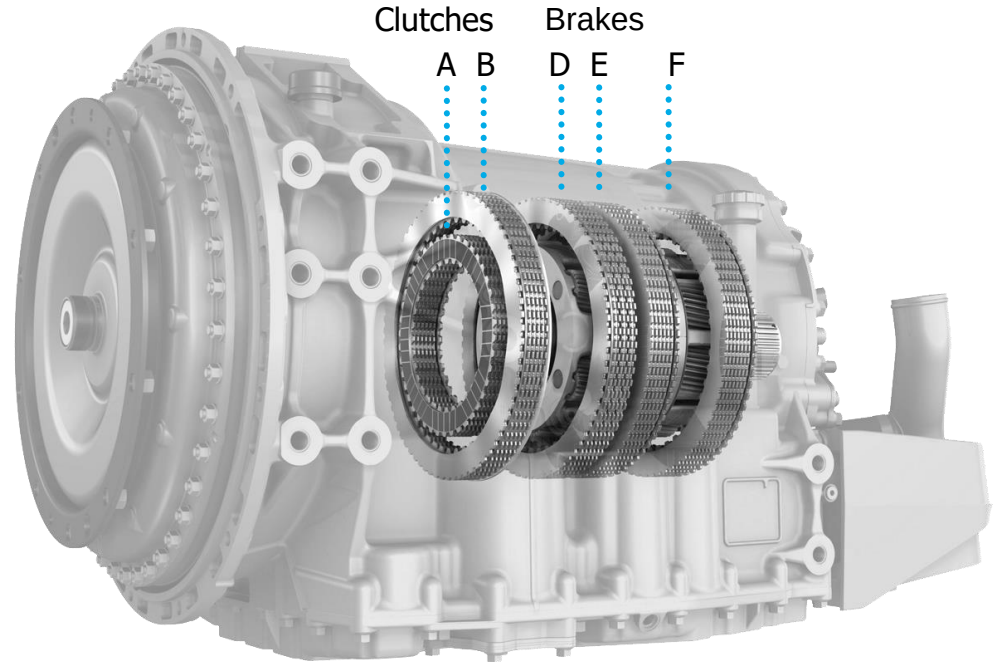
- Transmission and electronics constitute a single unit
- Heat-resistant
- Consistently high gearshift quality
- Extended set of functions and very reliable
- Integrated in the vehicle's CAN communication
- Suitable for various diagnosis protocols
- Huge statistical data memory



# Planetary Gearset and Shift Elements



- Planetary gearset with 6 mechanical forward gears + R gear
- Multidisk clutches (A, B; rotating)
- Multidisk brakes (D, E, F; stationary)



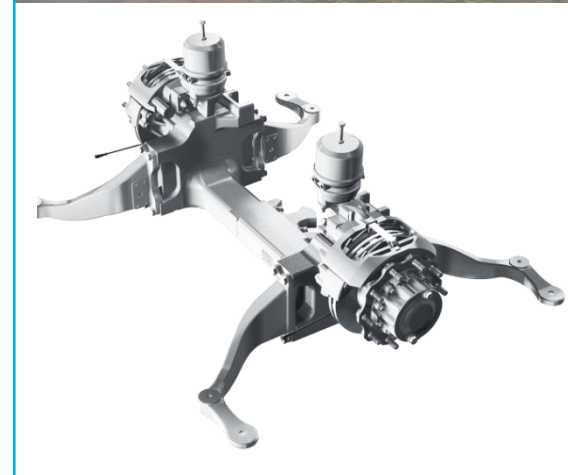
# Axle Setup

## Choosing the suitable axle for the driveline with EcoLife transmission

**Recommendation:** Rear-axle ratio only upon prior consultation with the ZF application experts.

The following table provides a first reference:

|           |                   | City bus application  |             |                       |             |
|-----------|-------------------|-----------------------|-------------|-----------------------|-------------|
|           |                   | < 50 km/h<br>< 31 mph |             | < 60 km/h<br>< 37 mph |             |
| Engine    | i <sub>Axle</sub> | Solo                  | Articulated | Solo                  | Articulated |
| 12 liters | 5.27              |                       |             | ●                     |             |
|           | 5.77              | ●                     | ●           |                       | ●           |
|           | 6.21              |                       |             |                       |             |
| 7 liters  | 5.27              |                       |             | ●                     |             |
|           | 5.77              | ●                     |             |                       | ●           |
|           | 6.21              |                       | ●           |                       |             |



# 03

## Operation





# EcoLife

## Operating Concept

**The contents of the following pages provide information on the essential functions required to operate the transmission.**

**The information is not complete and does not replace the applicable operating instructions!**

# Operating Elements

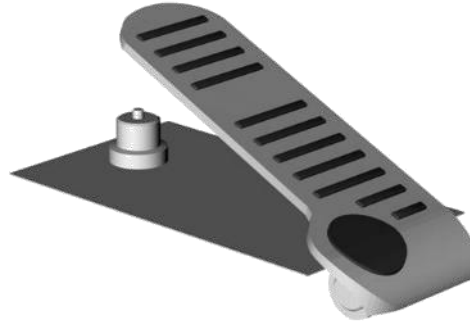
## Pushbutton switch



3-button switchboard  
or 6-button switchboard,  
horizontal or vertical  
installation

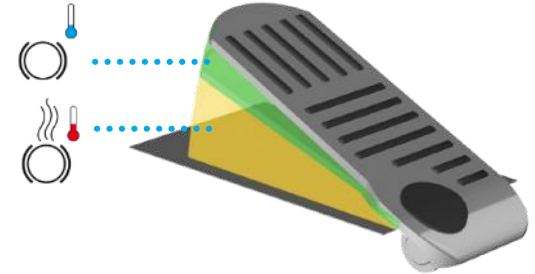
- Selecting the driving range

## Accelerator pedal



- Accelerator pedal with  
kickdown function

## Brake pedal and retarder actuation



- Brake pedal



and / or

- hand lever on steering column

# Starting Engine and Setting Off

Vehicle is standing, parking brake closed

Select driving range "N" select (no gear is engaged)

Start engine

Select driving range (e.g. "D")

Wait for 1 to 2 seconds

Release parking brake and accelerate



## Start engine



# Changing Direction of Travel

**Before changing the driving range**  
(shift from forwards to reverse or vice versa)

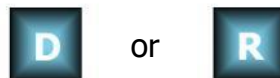
**Stop the vehicle**  
(vehicle stands still / service brake)

**Engine idling speed**  
( $n_{\text{eng}} < 900$  rpm)

**Speed range selector in neutral position**

**Then select new driving range**

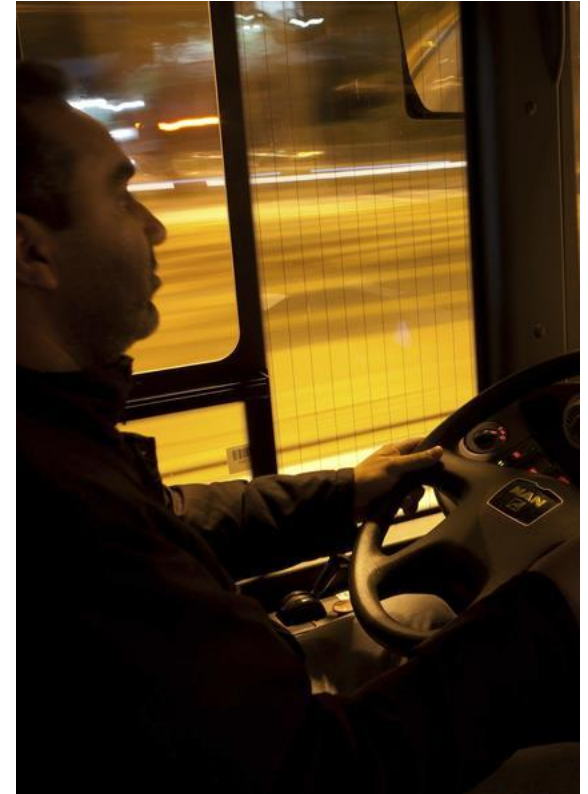
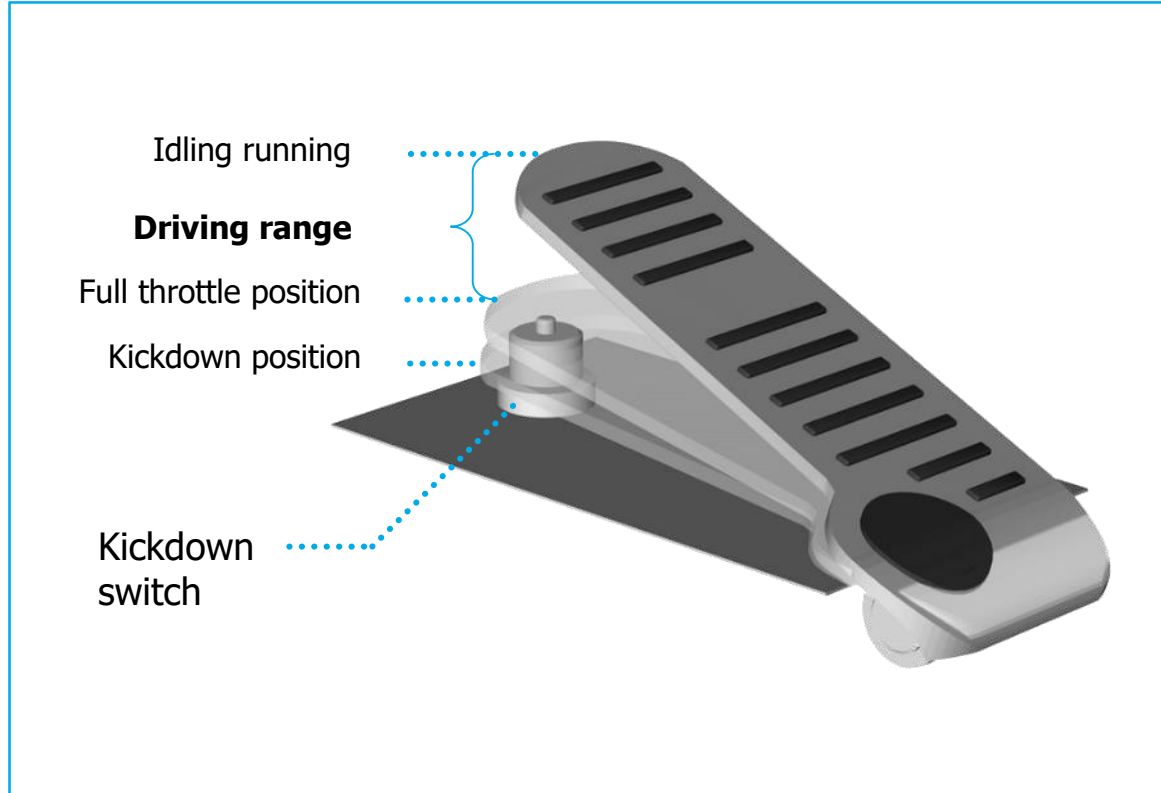
**Release the service brake and accelerate**



## Changing direction of travel

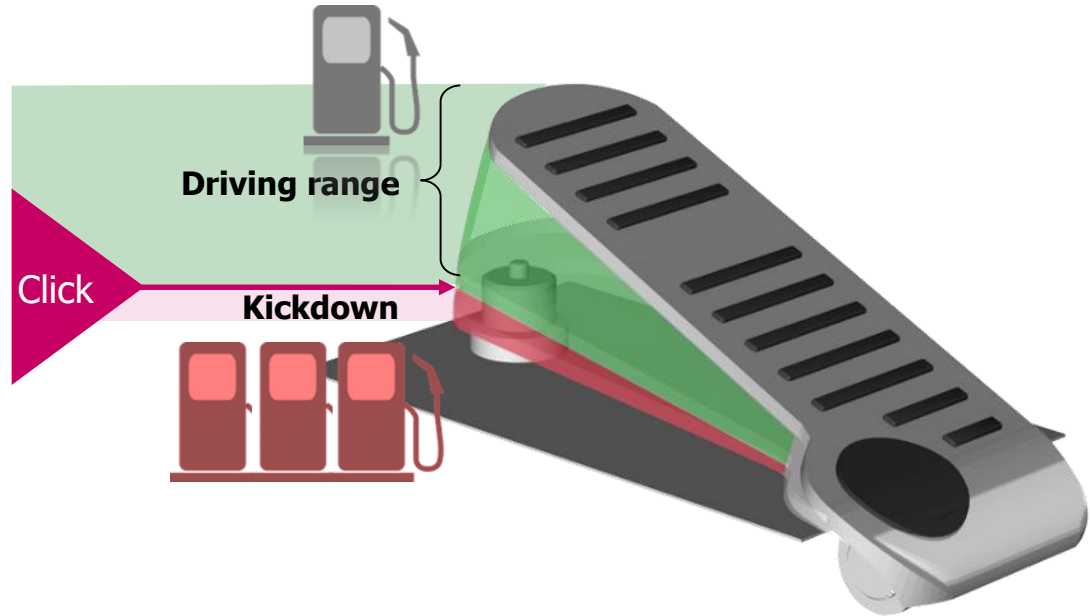


# Accelerator Pedal With Kickdown Function



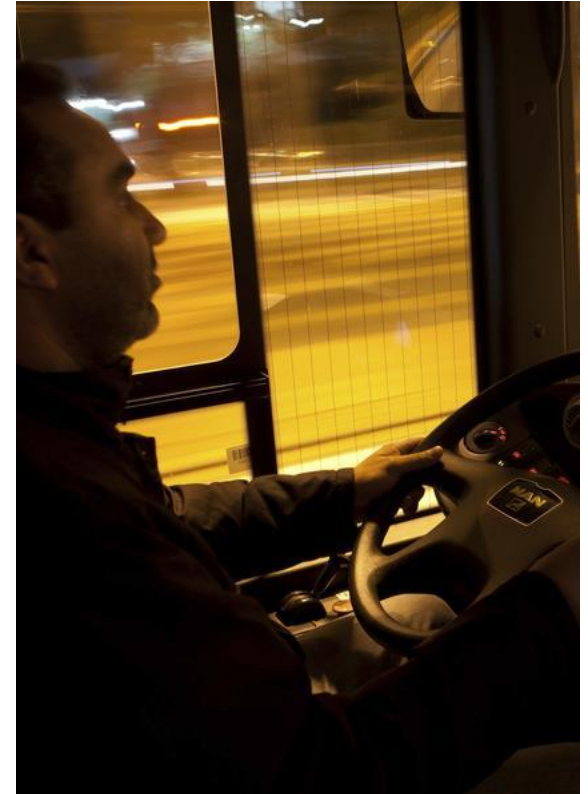
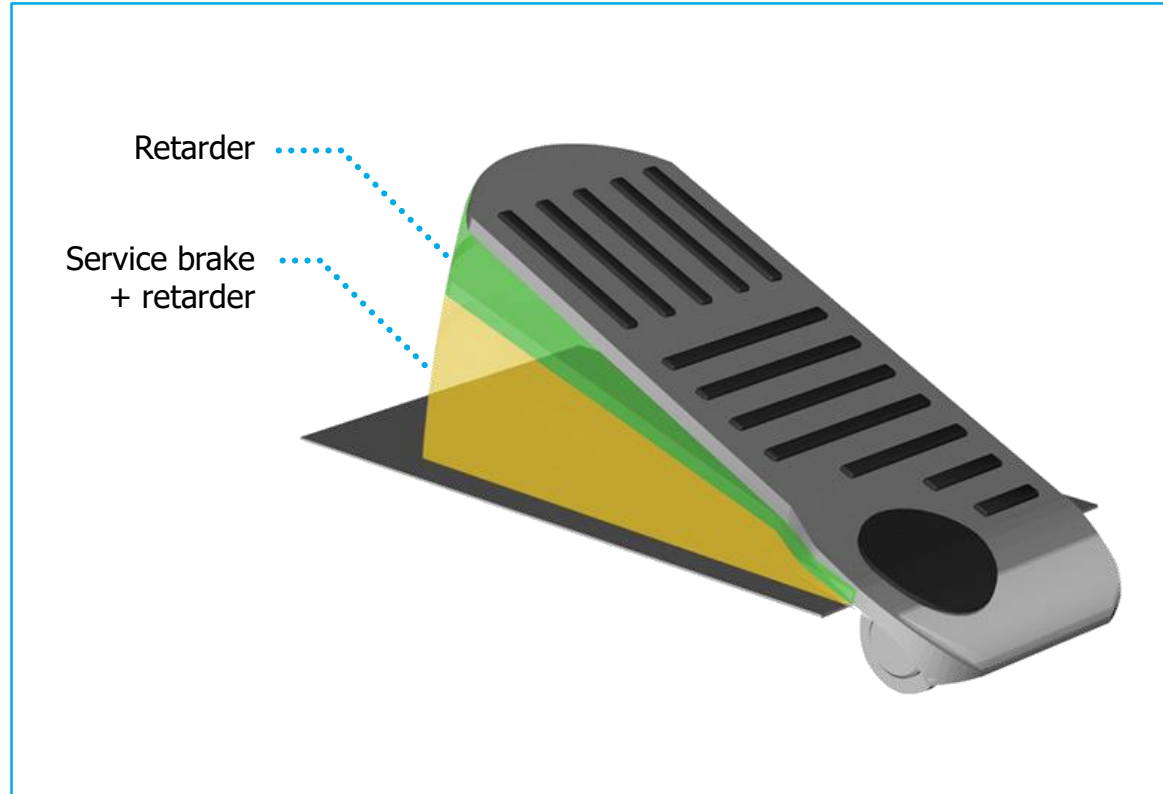
# Accelerator Pedal

## Accelerator pedal with kickdown function



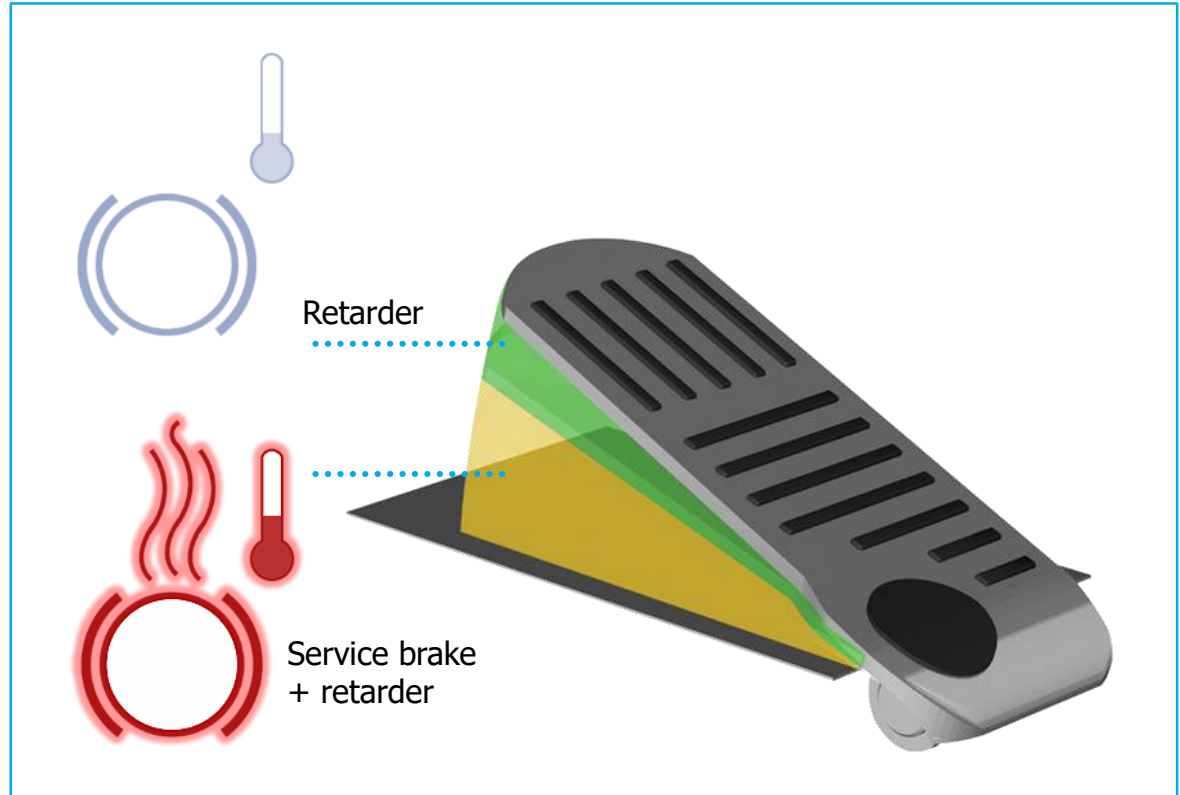


# Brake Pedal and Retarder Actuation



# Brake pedal

## Brake pedal and retarder actuation

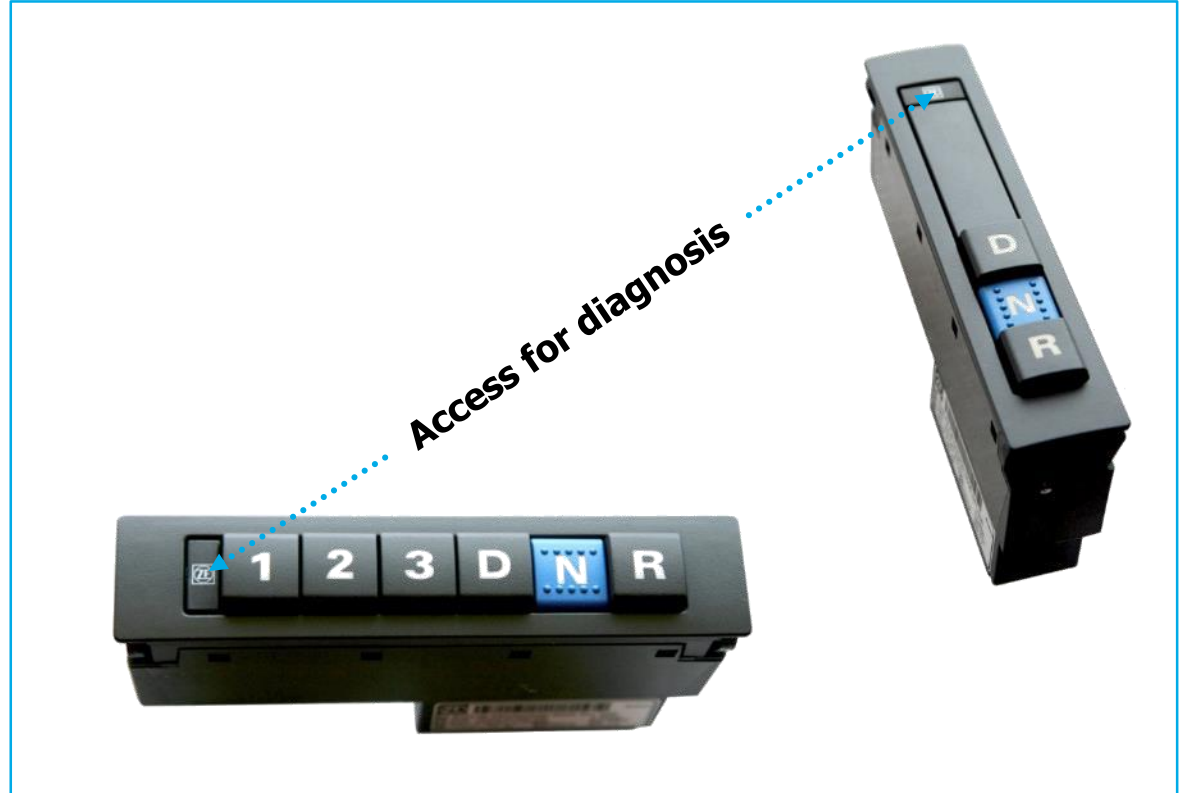


# Operating Elements

## Speed Range Selector

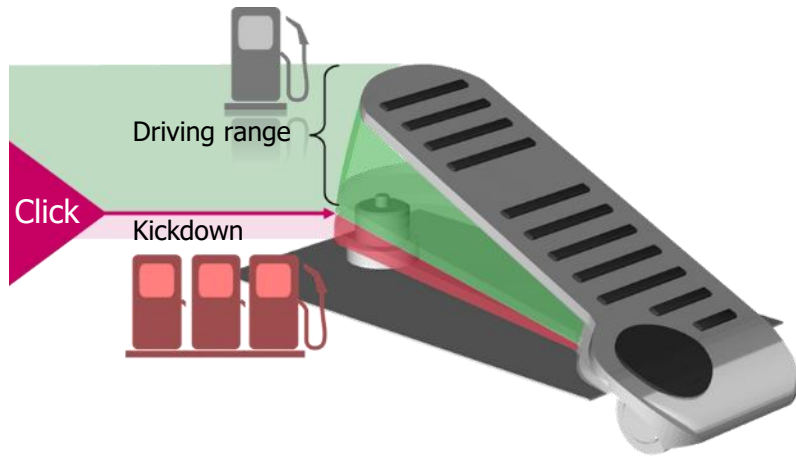
### Pushbutton switch

- As 3 or 6-button switchboard, for horizontal or vertical installation
- Diagnosis access below the ZF logo



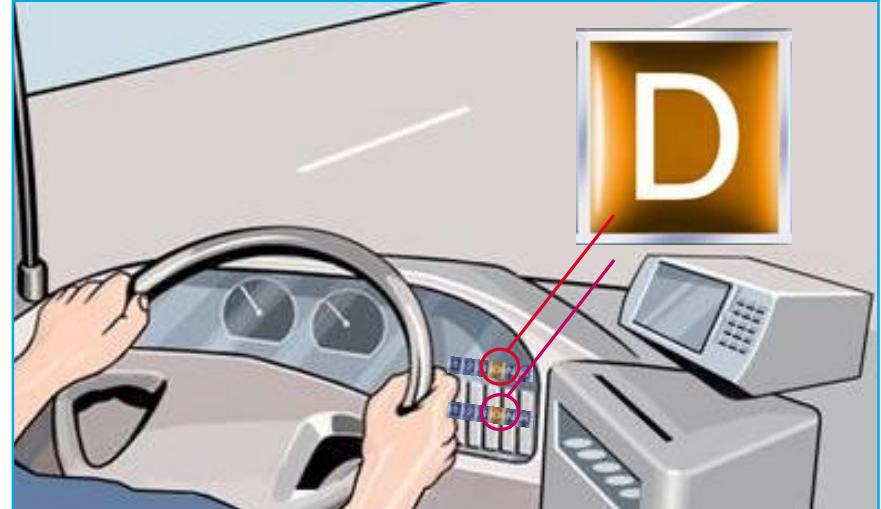
# Driving Tips 1 and 2

## Tip 1: Set off quickly!



Quickly quit the torque converter range (from approx. 10 km/h). Then continue at a steady speed. Avoid kickdown starts!

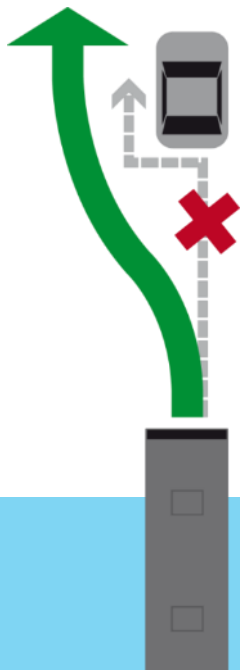
## Tip 2: Drive automatically!



Only use buttons 1 2 3 in exceptional cases!

# Driving Tips 3 and 4

## Tip 3: Drive with good anticipation!



A consistent driving style saves fuel, avoids stress, and guarantees additional safety.

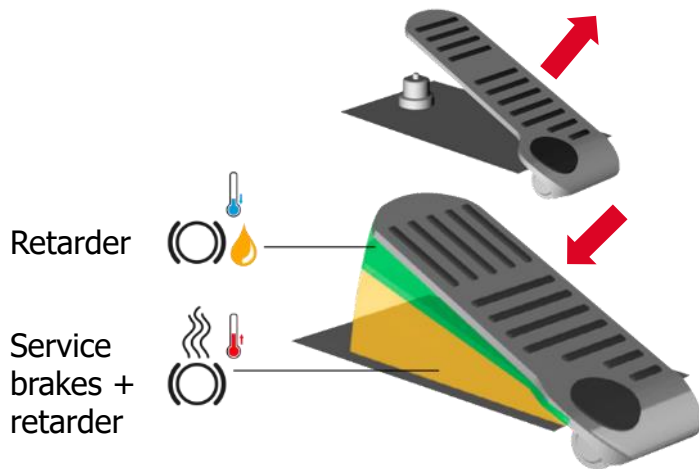
## Tip 4: Use momentum



Use the momentum of the vehicle (downhill gradients, etc.). Only brake lightly where possible (retarder).

# Driving Tips 5 and 6

## Tip 5: Slow down on time!



As a basic principle, use the retarder for soft braking (first third of the brake pedal travel) before bus stops.

## Tip 6: Change in direction of travel!



Changes in direction of travel or mode of operation (D, N, R) only when the vehicle is stationary!



# Driving Tips 7 and 8

## Tip 7: Drive steadily!



Do not make any jolting movements with the accelerator (do not "pump" it!) Drive steadily

## Tip 8: Driving in icy conditions!



Steer, accelerate, and brake in a highly sensitive and anticipatory manner!

# 04

## Competition Topics

# EcoLife – The Universal Genius

## Overview of the Benefits Compared to Voith DIWA.6

| Benefits of EcoLife                                                                   | Voith DIWA.6                                   |
|---------------------------------------------------------------------------------------|------------------------------------------------|
| Lower engine speeds, especially when setting off ....                                 | Higher speeds when setting off ...             |
| ... and thus fuel consumption savings                                                 | ... and thus higher fuel consumption           |
| ... and thus less engine noises                                                       | ... louder engine noises                       |
| Primary retarder for shorter stopping distances and intelligent braking               | Secondary retarder, which gets quickly too hot |
| TopoDyn Life shift program for fast and reliable adjustment to inclination and weight | Secondary retarder, which gets quickly too hot |
| Lower life cycle costs                                                                | Higher operating costs                         |
| Fuel savings of up to 10 % due to start-stop function                                 | No start-stop function                         |

# System Comparison EcoLife vs. Voith DIWA

**ZF-ECOLIFE**



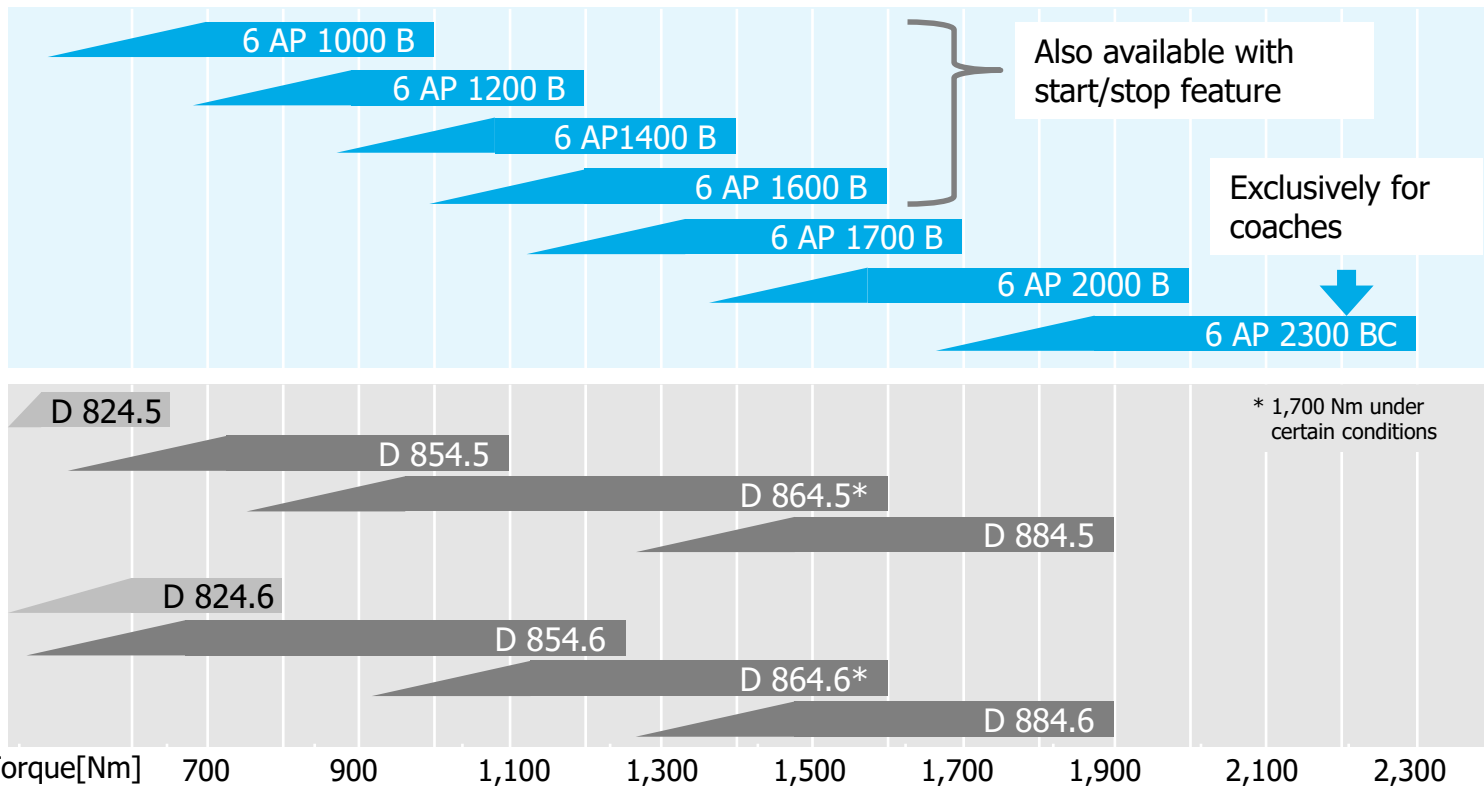
**DIWA.6**



**DIWA.5**

# System Comparison EcoLife vs. Voith DIWA

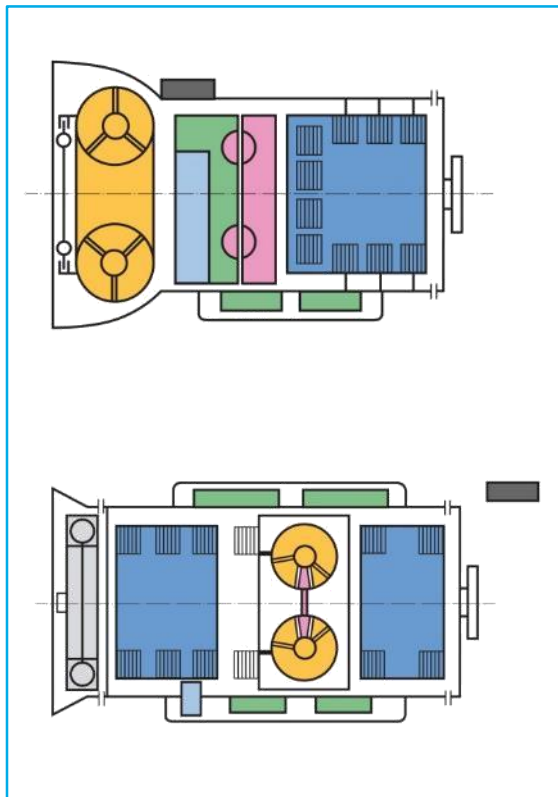
## Types and Torques



# System Comparison EcoLife vs. Voith DIWA Setup



**VOITH**  
**DIWA**



## **Torque converter**

ZF: Separate torque converter with integrated torsional damper and lock-up clutch

Voith: Converter brake, separate torsional damper

## **Oil supply and electro-hydraulic control unit**

## **Oil pump**

## **Retarder**

ZF: Primary retarder, in-house component

Voith: Braking function with converter brake, works like a secondary retarder

## **Planetary gearset**

ZF: 6 forward gears, 1 reverse gear

Voith: Power distribution when setting off  
3 forward gears, no mechanical reverse gear

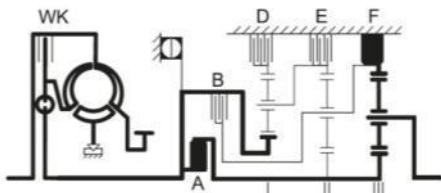
## **Electronic control unit**

# System Comparison EcoLife vs. Voith DIWA

## Setting-Off Phase

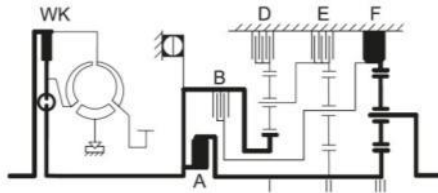


1st gear, hydraulic



Torque converter is active

1st gear, mechanic



Torque converter is shunted

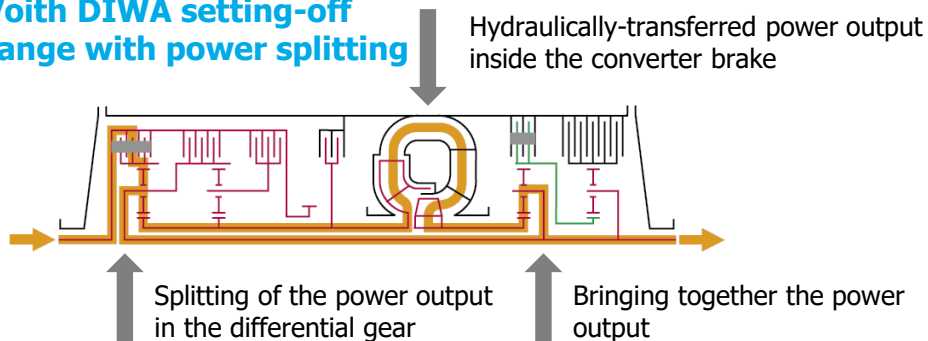
### EcoLife

- Principle just as in common automatic passenger car transmissions
- Short-term use of the torque converter for setting off, **shunting at approx. 7 km/h**

### DIWA.6

- Principle of power distribution with DIWA = **D**ifferenzial-**W**andler (differential torque converter)
- Longer setting-off phase with **torque converter use until approx. 20 km/h**

### VOITH Voith DIWA setting-off range with power splitting

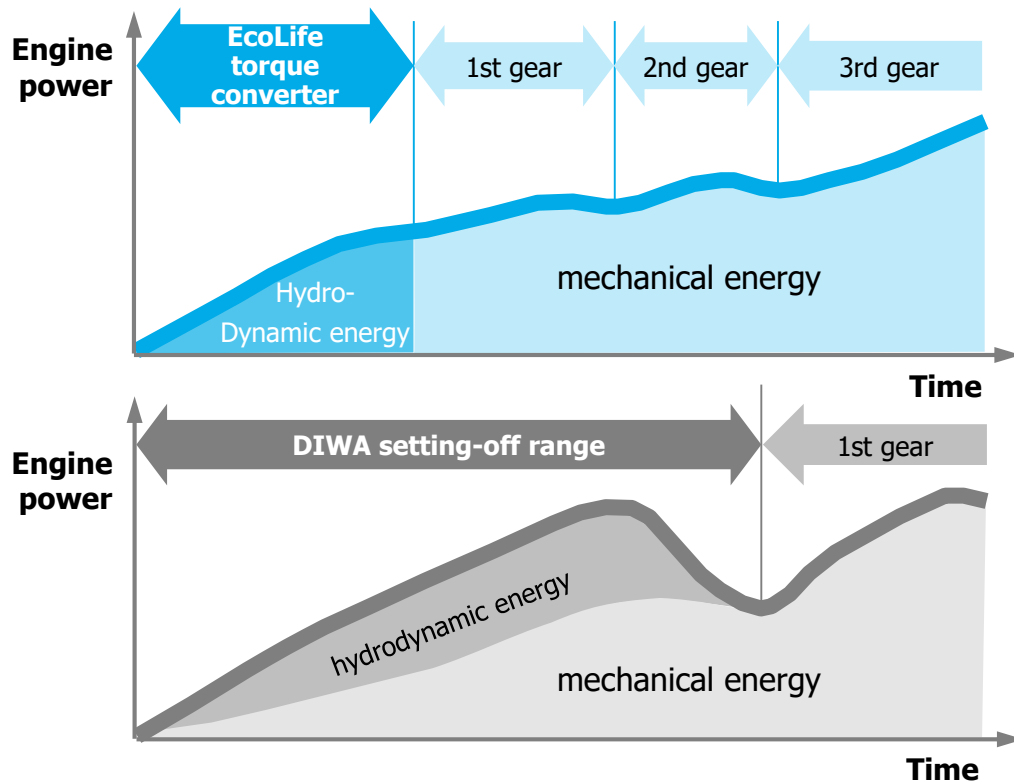


**Benefit EcoLife: Lower speed and noise levels**



# System Comparison EcoLife vs. Voith DIWA

## Setting-Off Phase, Power Transmission



**Advantage of EcoLife:**  
(at the same acceleration)

Short use of the torque converter  
(arrows)

+

Lower engine power  
(curves)

=

Less power loss  
(dark areas "hydrodynamic energy")

# System Comparison EcoLife vs. Voith DIWA

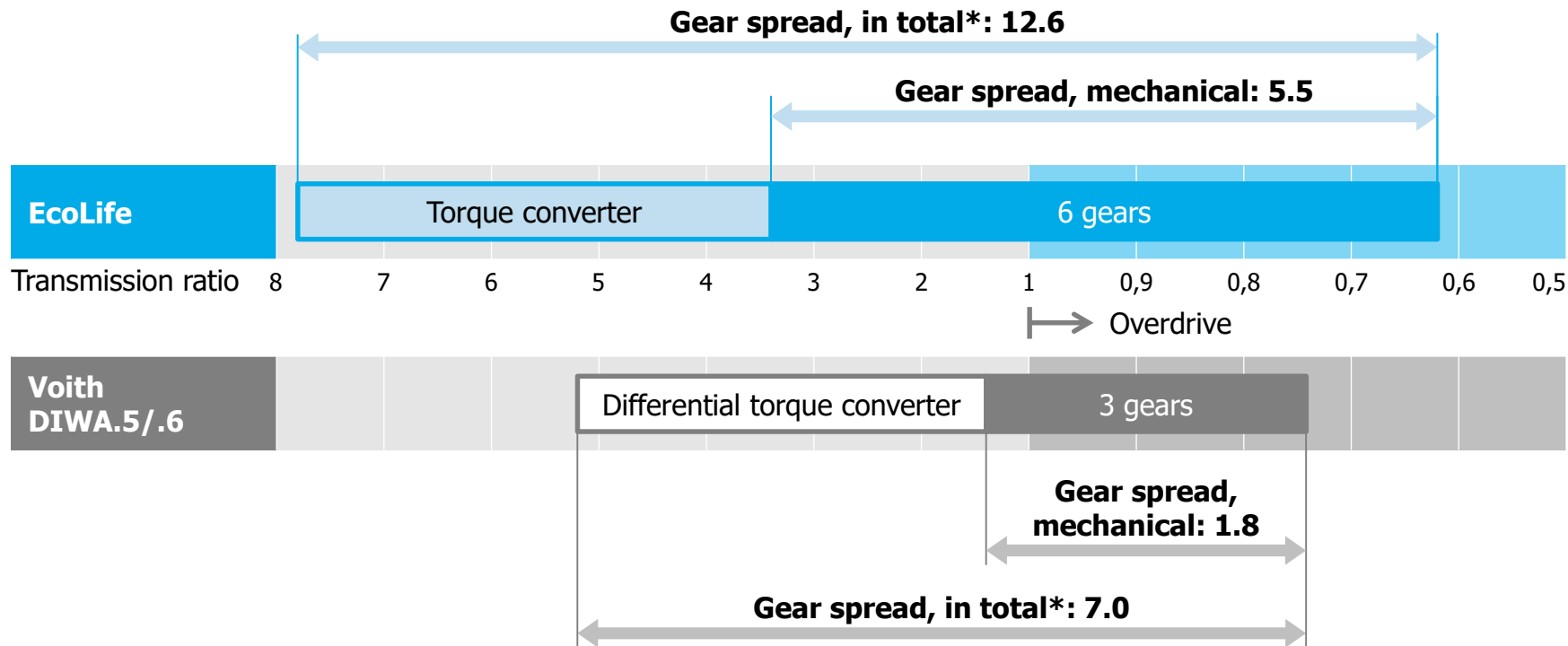
## Technical Data

|              | Transmission ratios                | Max. gear spread*                    | Ratio range                    | Retarder principle | Max. input torque                     | Installation length              |
|--------------|------------------------------------|--------------------------------------|--------------------------------|--------------------|---------------------------------------|----------------------------------|
| EcoLife      | 6 + R                              | 12.6                                 | 3.36 to 0.62<br>R 4.24         | primary            | 1,000 –<br>2,300 Nm                   | 732 mm                           |
| Voith DIWA.6 | 3                                  | 7.6                                  | 1.43 to 0.7<br>R ---           | secondary          | 800 –<br>1,900 Nm                     | 753 mm                           |
|              | 100 %<br><b>more</b><br>gear steps | 66 %<br><b>larger</b><br>gear spread | <b>genuine</b><br>reverse gear |                    | 21 %<br><b>higher</b><br>input torque | 3 %<br>(21 mm)<br><b>shorter</b> |

\* Relation of highest and lowest transmission ratio, incl. torque increase due to the torque converter

# System Comparison EcoLife vs. Voith DIWA

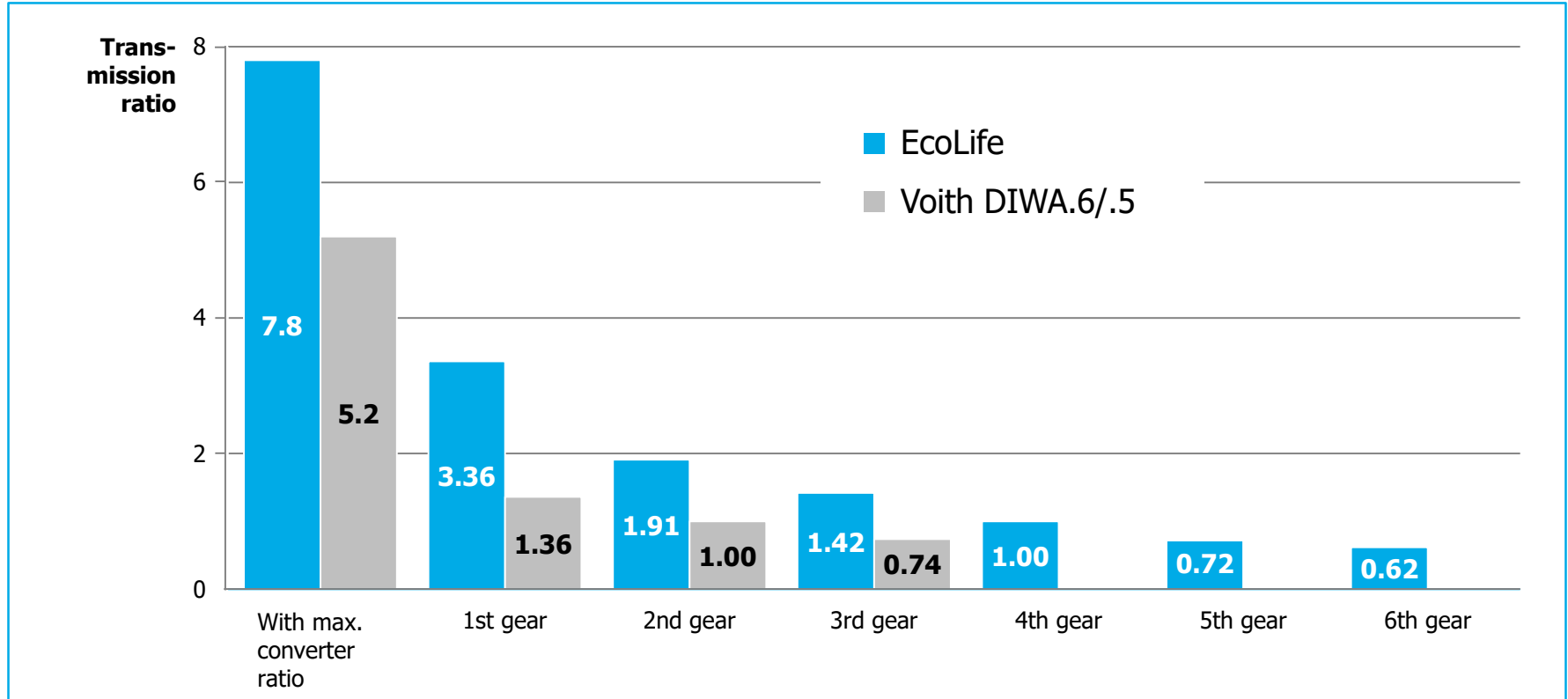
## 6 vs. 3 Gears



\* When using torque converters for comparable applications and max. torque converter ratio

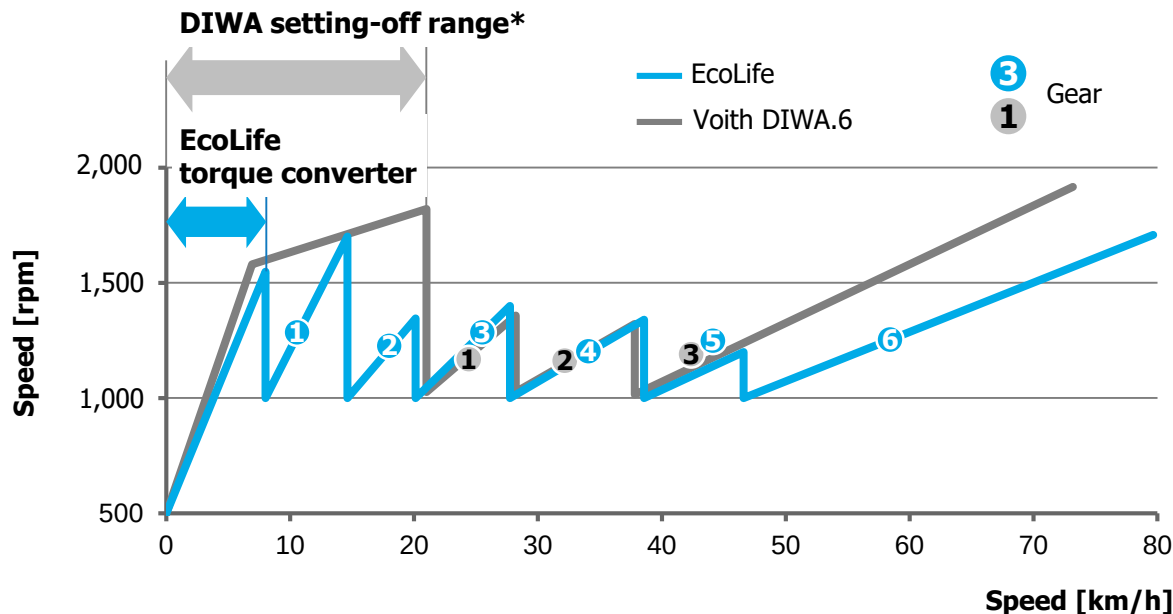
# System Comparison EcoLife vs. Voith DIWA

## Transmission Ratios



# EcoLife Reduces Engine Speeds Theory

## Engine speed under full load acceleration – Theory



\* Power output is divided into mechanical and hydraulic paths

EcoLife reduces the engine speeds altogether due to...

- ... short use of the torque converter
- ... 6 gears

**Advantage: Less fuel consumption and noises**

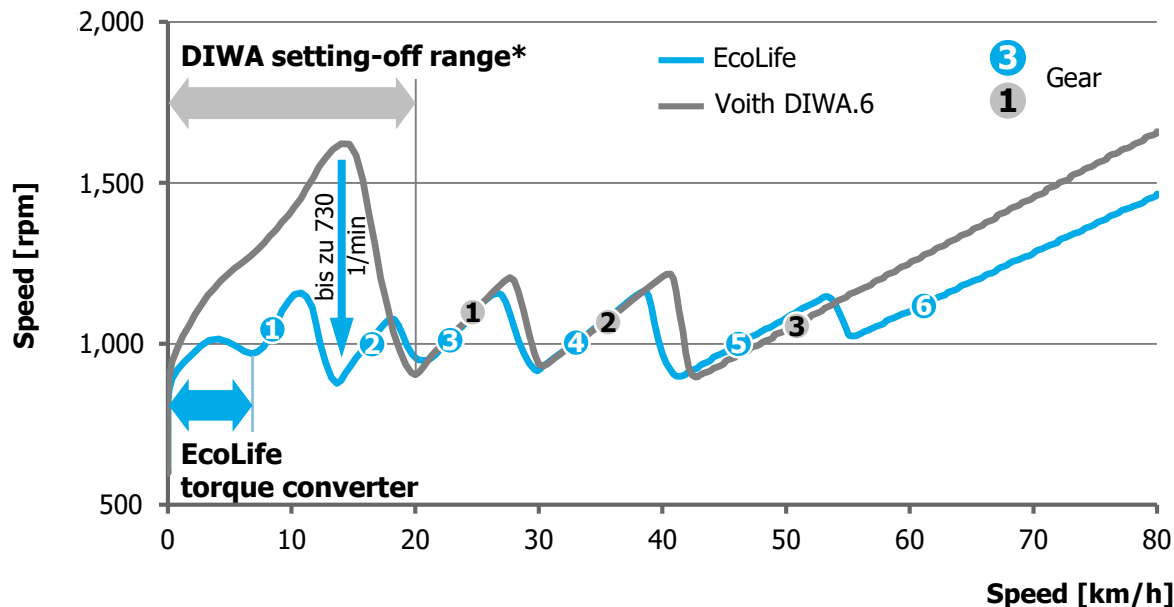
### Comparative basis:

Standard bus, fully loaded, comparable driving programs connection speed  
1,000 rpm, rear axle ratio 6.2, full-load acceleration

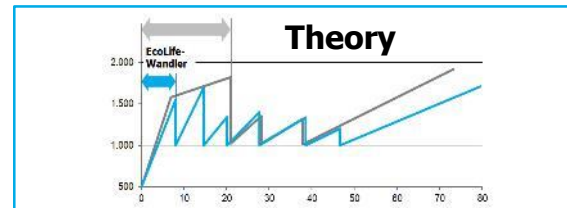
# EcoLife Reduces Engine Speeds

## Real Measured Values

### Engine speed under full load acceleration – Measurement



\* Power output is divided into mechanical and hydraulic paths



Result: EcoLife **significantly reduces engine speeds**, especially when setting off

**Advantage: Less fuel consumption and noises**

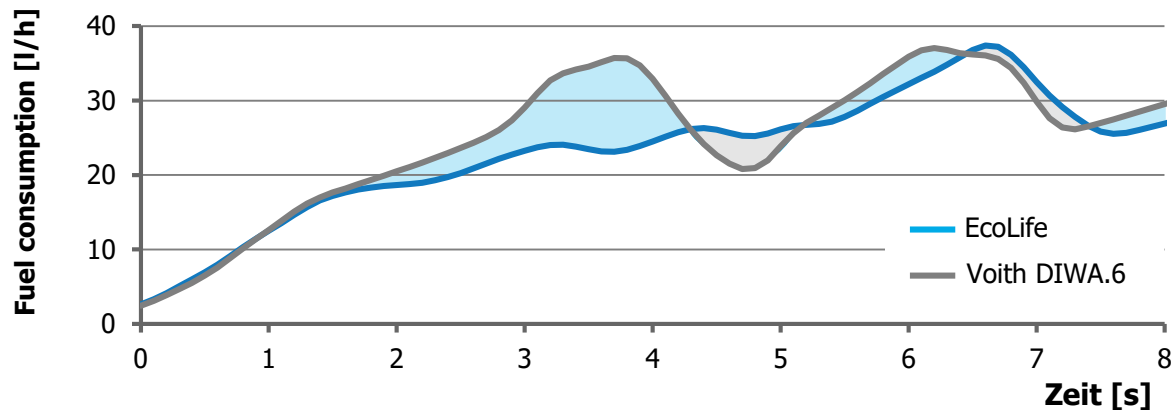
#### Measurements with:

Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, full-load acceleration

# EcoLife Reduces Fuel Consumption

## Real Measured Values, Setting off

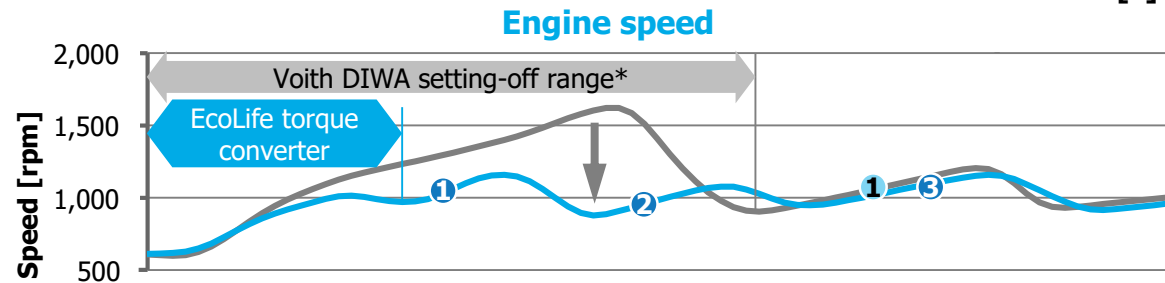
### Fuel consumption when setting off



- Consumption advantage with EcoLife
- Consumption advantage with DIWA.6

EcoLife **saves about 8 % fuel** in the first 8 seconds.

This equals **1,150 liters diesel savings** in one year.



#### Measurements with:

Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, full-load acceleration

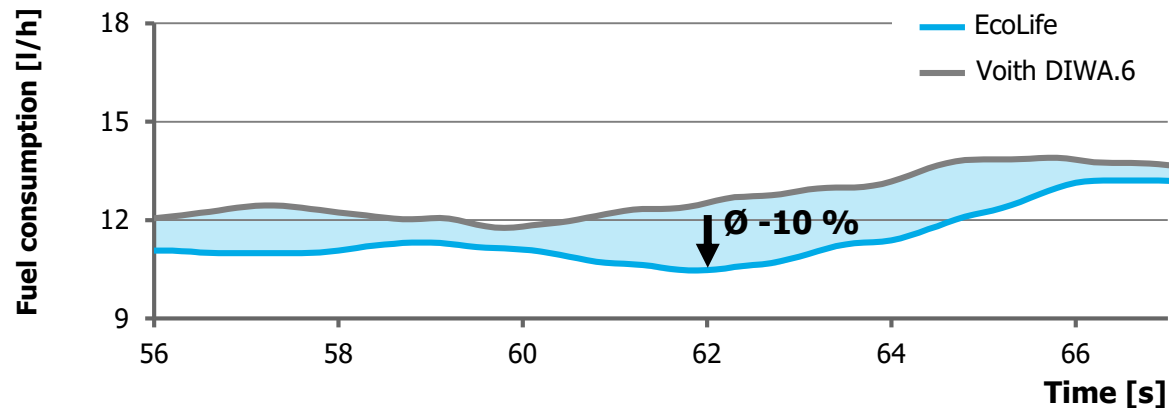
\* Power output is divided into mechanical and hydraulic paths



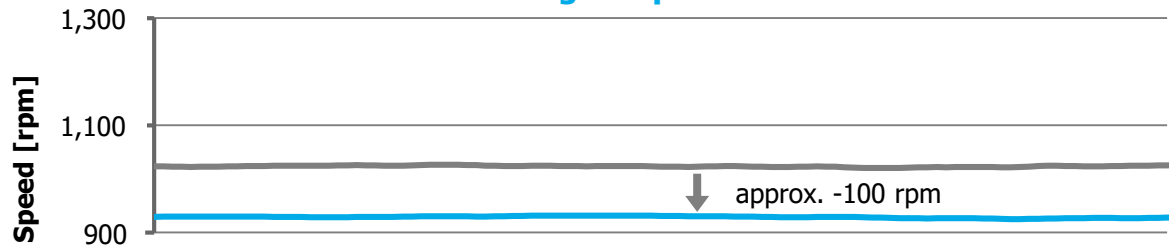
# EcoLife Reduces Fuel Consumption

## Real Measured Values, Constant 50 km/h

### Fuel consumption at constant 50 km/h



### Engine speed



Consumption advantage with EcoLife

EcoLife **saves approx. 10 % or 1.3 l/h fuel** at constant 50 km/h.

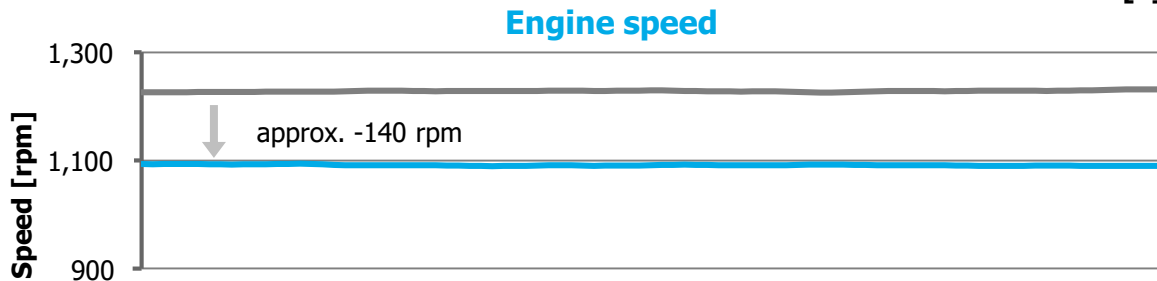
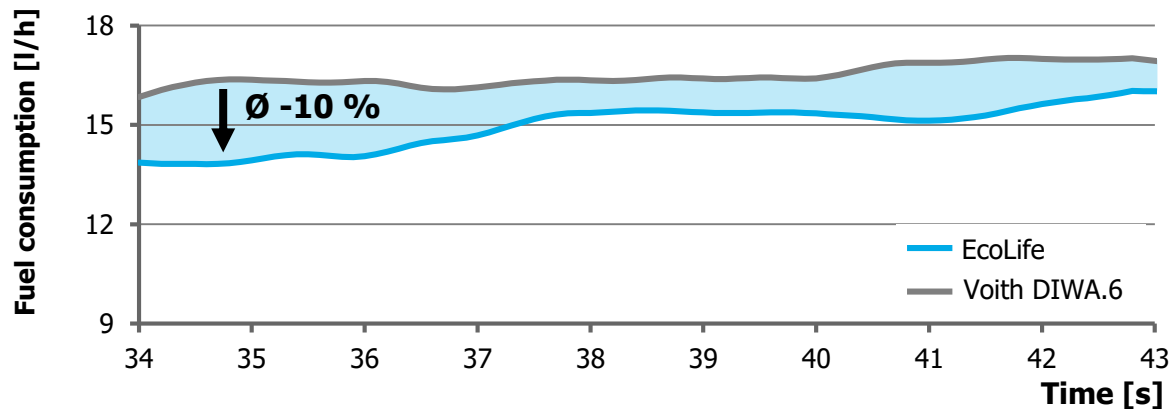
#### Measurements with:

Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, full-load acceleration

# EcoLife Reduces Fuel Consumption

## Real Measured Values, Constant 60 km/h

### Fuel consumption at constant 60 km/h



Consumption advantage with EcoLife

EcoLife **saves approx. 10 % or 1.3 l/h fuel** at constant 60 km/h.

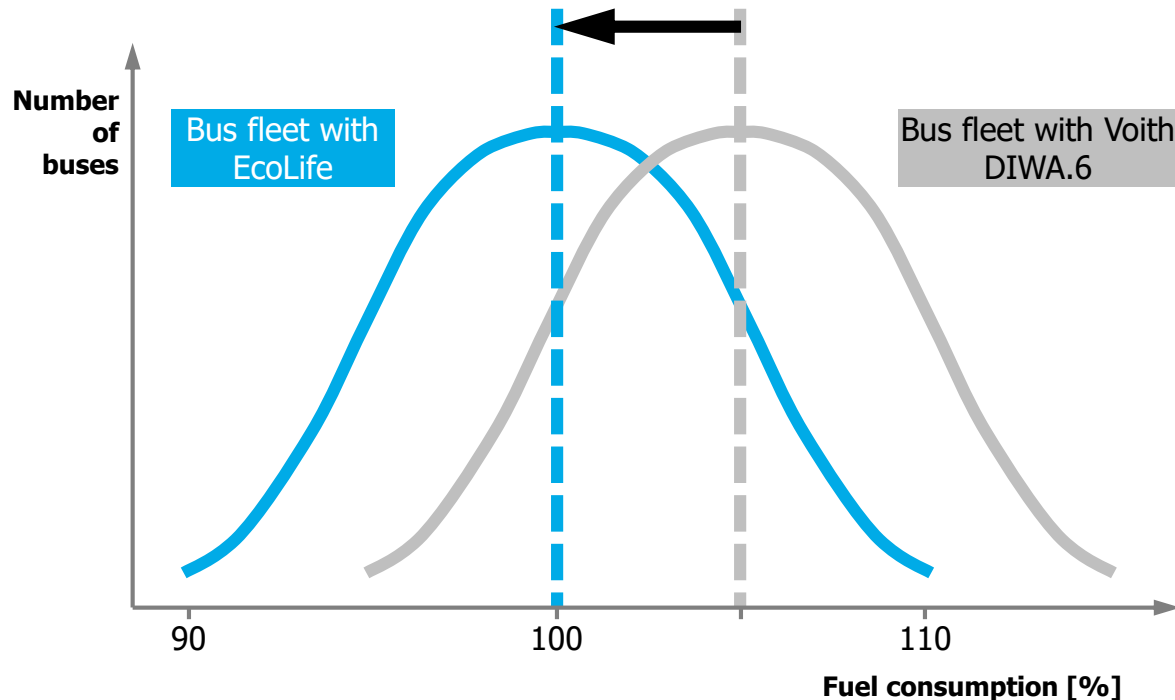
#### Measurements with:

Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, full-load acceleration

# Comparison of Fuel Consumption

## Important: Comparison of Fleets

Ø 5 % Consumption advantage with EcoLife



Statistical spread of fuel consumption values within one fleet due to vehicle handling, course of the route, loading, secondary loads etc.

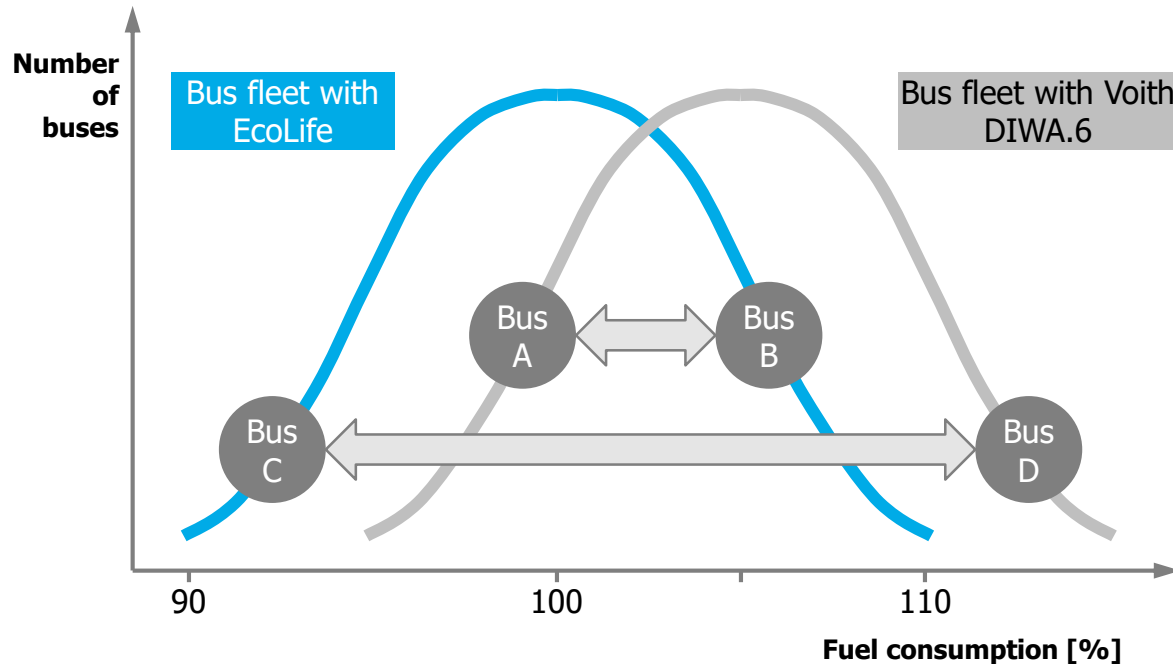
Thus: Only the **comparison of fleets** is significant

When comparing fleets, EcoLife saves **about 5 % fuel**.

# Comparison of Fuel Consumption

## Caution With Single Buses

### Comparisons without significance: two examples



Comparison of **Bus A** and

**Bus B**:

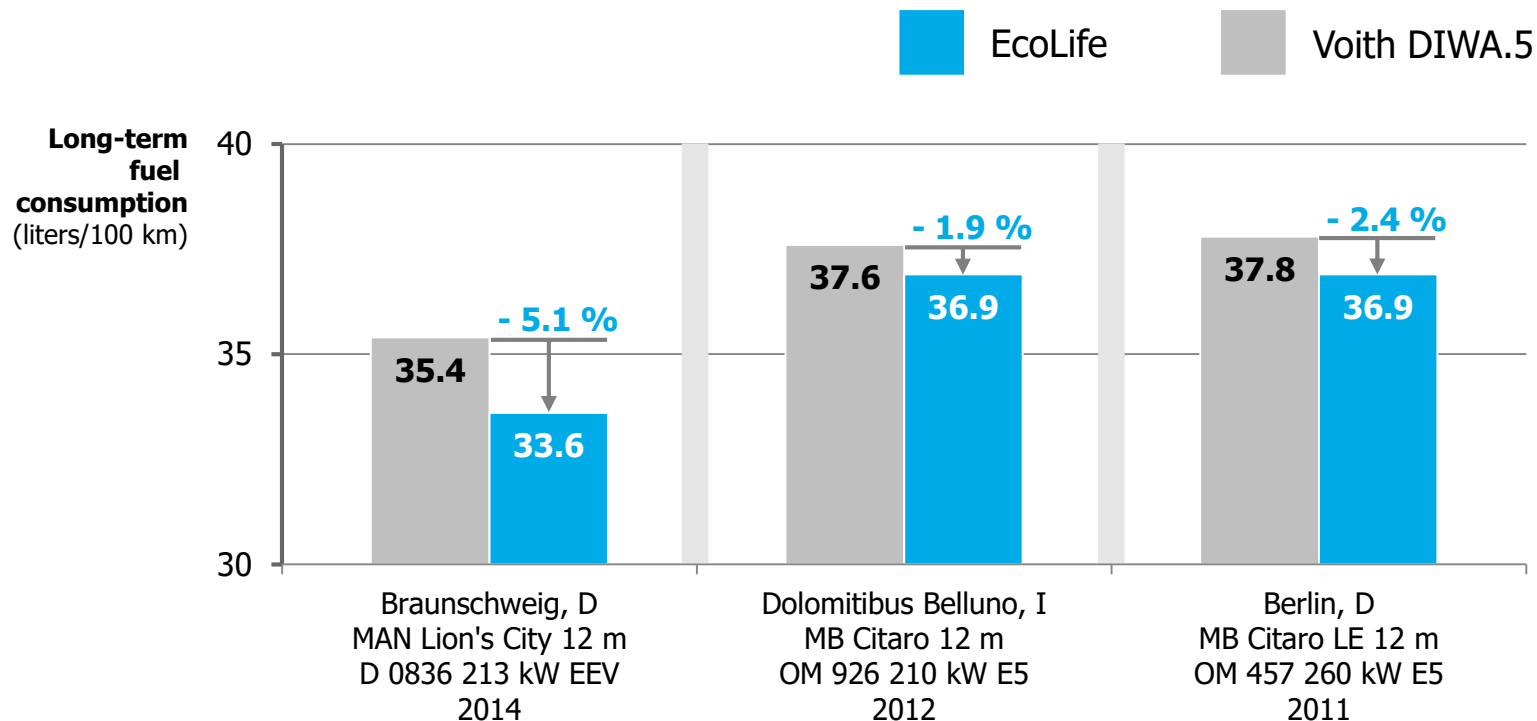
Consumption advantage with Voith DIWA

Comparison of **Bus C** and

**Bus D**:

Extreme consumption advantage with EcoLife

# Long-Term Fuel Consumption Examples



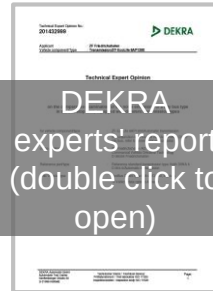
# EcoLife Makes Buses Less Noisy

## Comparative Noise Measurements

### Departure from a typical bus stop: EcoLife vs. Voith DIWA.6



Certified by the independent expert organization DEKRA:



#### Measurement conditions:

- Two comparable Mercedes-Benz Citaro 2 of the same bus company
- Engine: Euro 6, 220 kW, 1,200 Nm, same axle ratio, similar mileage
- Transmission: **EcoLife 6 AP 1200** and **Voith DIWA D 854.6**
- Full load acceleration when departing from the bus stop

#### Result:

Compared to the Voith DIWA.6, EcoLife reduces the noise **when departing from the bus stop:**

- Outside: up to **-6.0 dB(A)**
- Inside: up to **-7.6 dB(A)**

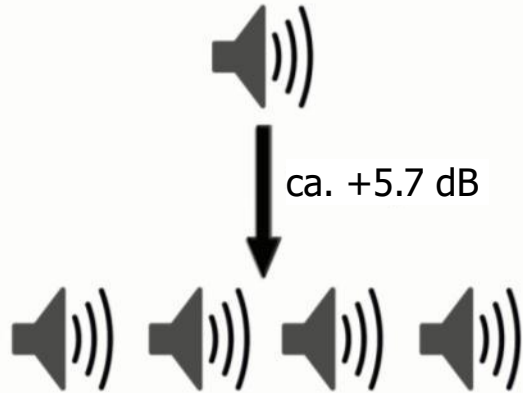
Speed reduction:  
up to **750 rpm**

Clip available on YouTube:  
click [here](#) (05:28 min.)

# EcoLife Makes Buses Less Noisy

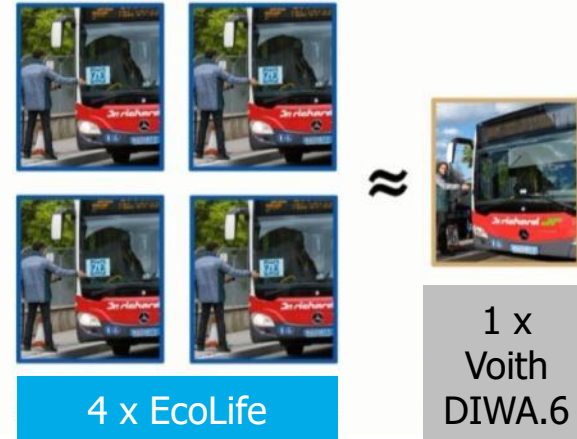
## What Does a 6 dB Difference Mean?

### Explanation:



This noise level difference roughly equals the difference between **an acoustic source** and the **sum of four equally loud acoustic sources** in the same place.

As you can see, EcoLife provides a significant advantage:



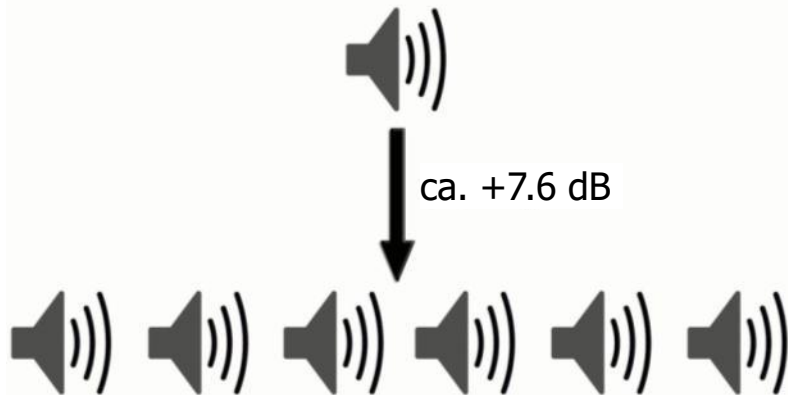
Even if **four buses with EcoLife transmissions** set off at the same time, they would just reach the noise level of **one bus setting off with a Voith DIWA.6 transmission.**



# EcoLife Makes Buses Less Noisy

## What Does a 7.6 dB Difference Mean?

### Explanation:



This noise level difference roughly equals the difference between **an acoustic source** and the **sum of six equally loud acoustic sources** in the same place.

As you can see, EcoLife provides a significant advantage:

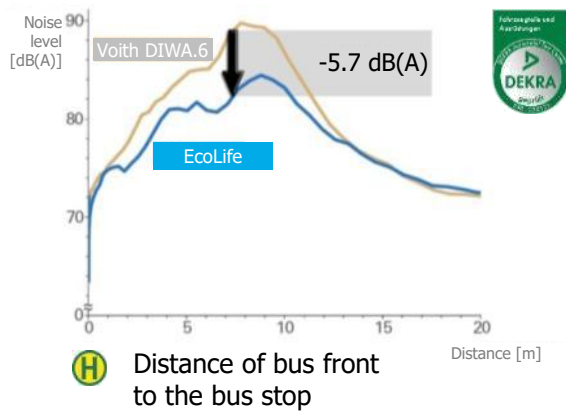


If you heard the noise emission in a bus with **EcoLife transmission six times higher**, you would approximately reach the noise level of **a bus with Voith DIWA. 6 transmission.**

# EcoLife Makes Buses Less Noisy

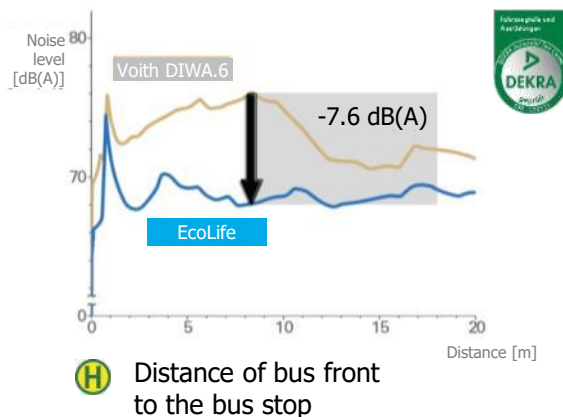
## Detailed Results: Departure From Bus Stop

### Outside microphone 5 m before the bus stop



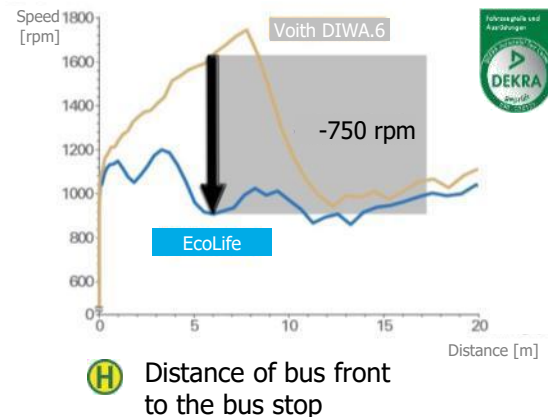
Original recordings:  
first EcoLife,  
then DIWA.6

### Inside microphone In the middle of the bus



Original recordings:  
first EcoLife,  
then DIWA.6

### Engine speed



# EcoLife Makes Buses Less Noisy

## Comparative Noise Measurements

### Drive-by at 40 km/h: EcoLife vs. Voith DIWA.6



Certified by the independent expert organization DEKRA:



#### Measurement conditions:

- Two comparable Mercedes-Benz Citaro 2 of the same bus company
- Engine: Euro 6, 220 kW, 1,200 Nm, same axle ratio, similar mileage
- Transmission: **EcoLife 6 AP 1200** and **Voith DIWA D 854.6**
- Drive-by at 40 km/h

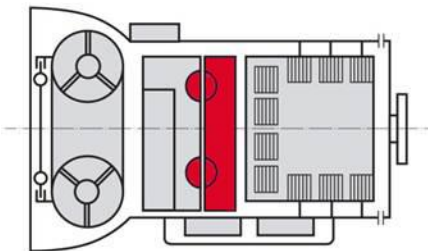
#### Result:

Compared to the Voith DIWA.6, EcoLife reduces the noise **when driving-by at 40 km/h:**

- Outside: up to **-3.2 dB(A)**
- Inside: up to **-5.4 dB(A)**

Speed reduction:  
up to **430 rpm**

# Comparison of EcoLife Primary Retarder and Voith DIWA Secondary Retarder

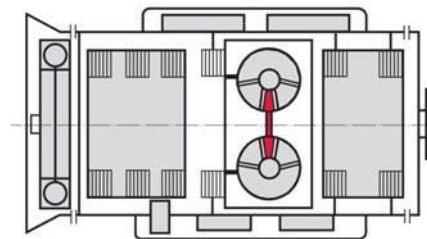


1. Functioning: primary retarder  
→ braking performance dependent on engine speed  
braking torque is raised by the transmission ratio  
(small gear = high transmission ratio)
2. Independent component  
→ optimized for the braking function

## Advantages:

- Higher performance in the speed range between 40 and 10 km/h
- Braking effect in all gears, almost until complete standstill

**VOITH**



1. Functioning: secondary retarder  
→ braking performance dependent on speed
2. One component (converter brake) must fulfill two functions  
→ compromise solution

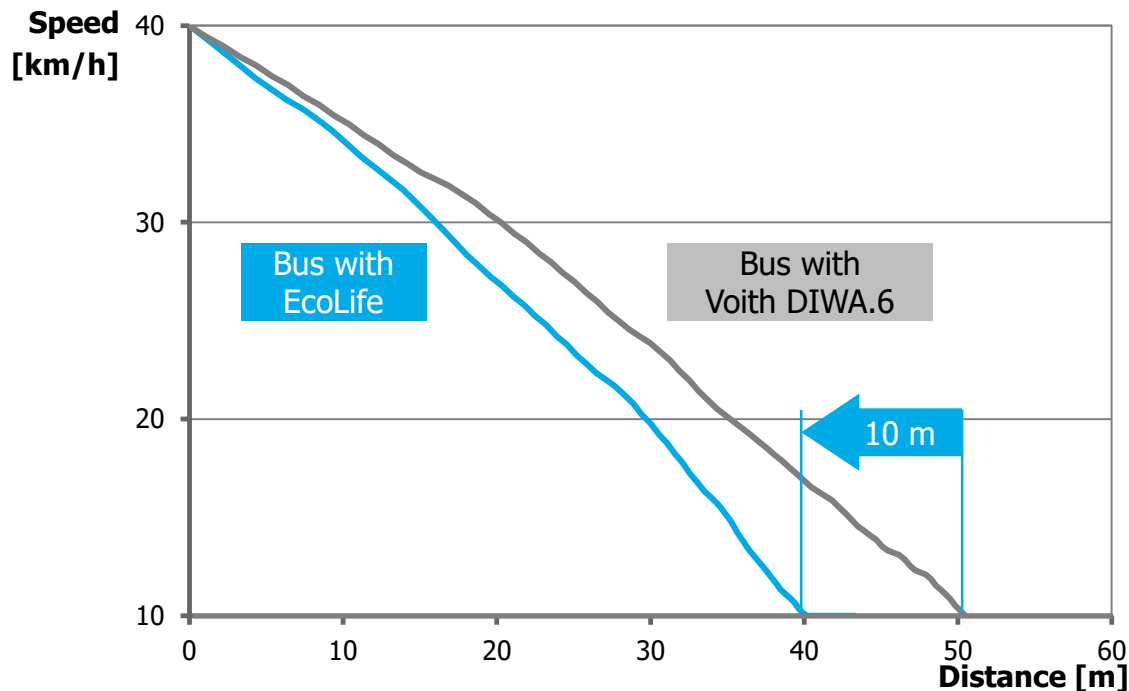
## Disadvantages:

- Lower performance in the speed range between 40 and 10 km/h
- No braking function in the Voith DIWA setting-off range

# EcoLife Retarder

## Shorter Stopping Distance

Measurement: Stopping distance from 40 km/h to 10 km/h\*



Stopping distance 10 m shorter!  
→ advantage twice the size of a passenger car!

### Measurements with:

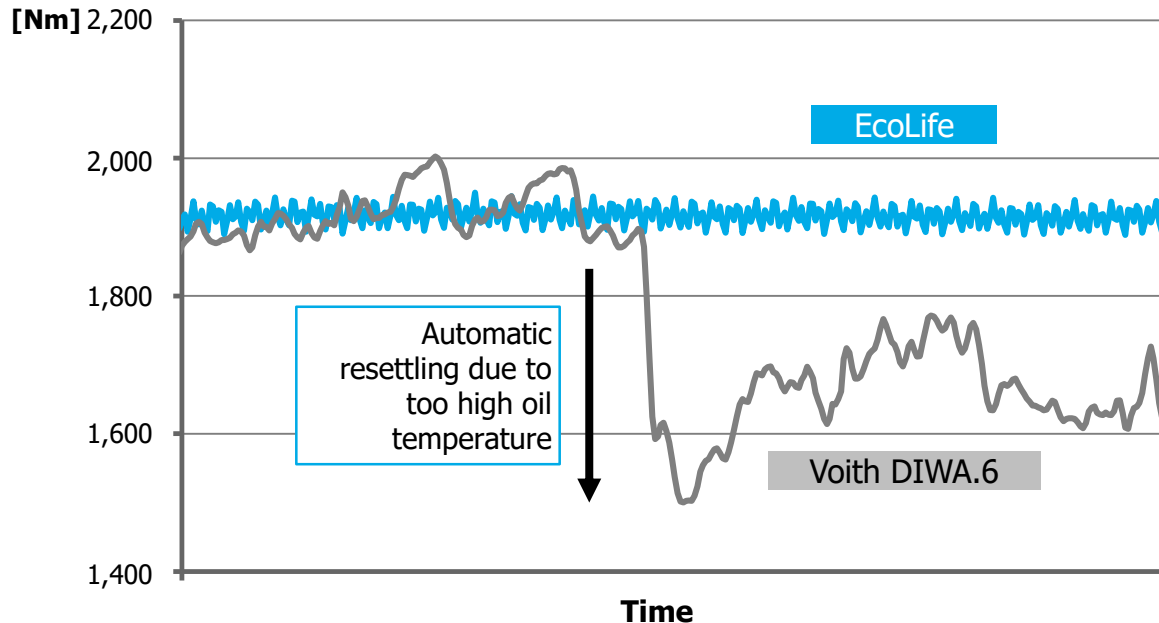
Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, 100 % retarder torque

\* EcoLife: shifting into neutral gear (AIS) at approx. 10 km/h, to save fuel

# EcoLife Retarder

## Full Brake Force at any Time

Measurement: Braking torque at a slope of 11 % and 40 km/h\*



### EcoLife

Full braking torque **over a long time period** (> 8 min.) at a stable optimum oil sump temperature of 95 °C.

### DIWA.6

Braking torque is **reduced after a short time period** (< 1 min.) because of too high oil sump temperature of up to 130 °C.

### Measurements with:

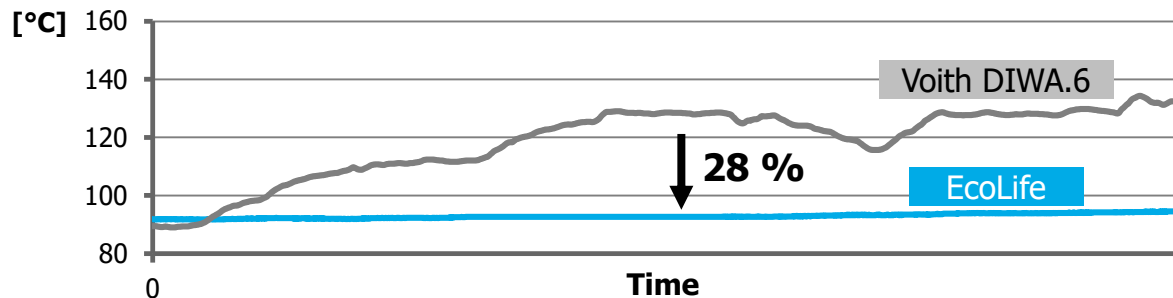
Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, target brake torque 1,900 Nm

\* Slope and total weight of 18 t were simulated with the help of a tractor vehicle

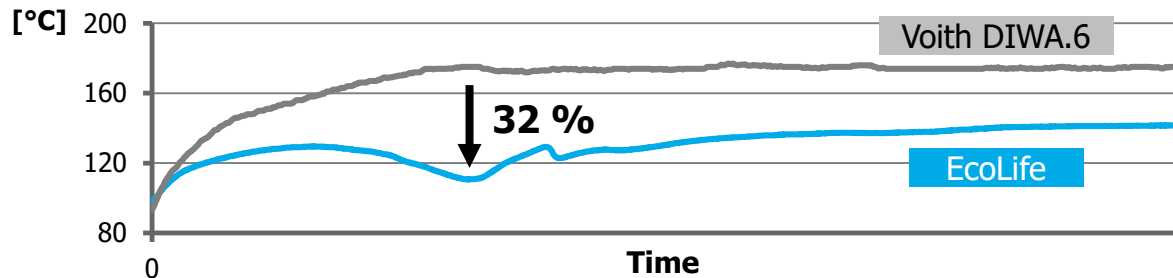
# EcoLife Retarder Dual Cooling System

## Measurement:

Oil sump temperature at a slope of 11 %, 40 km/h\*



## Measurement: retarder temperature



## EcoLife

Lower oil temperatures and thus **longer oil and component service life.**

Equipped with **two heat exchangers** and high cooling capacity for all use cases.

## DIWA.6

Only **one heat exchanger**

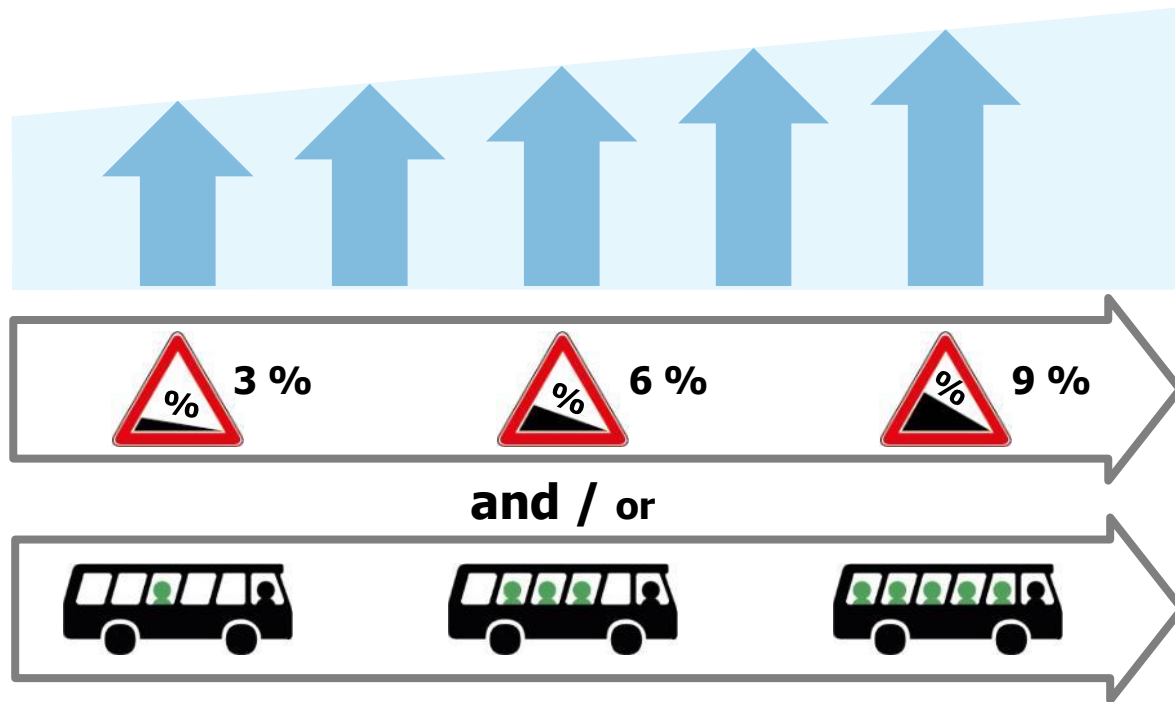
## Measurements with:

Mercedes-Benz Citaro 2, Euro 6, 260 kW, 1,400 Nm, empty, rear-axle ratio 5.27, target brake torque 1,900 Nm

\* Slope and total weight of 18 t were simulated with the help of a tractor vehicle

# TopoDyn Life Intelligent Braking

## Retarder brake torque



### EcoLife with TopoDyn Life shift program

Adjusts braking torque continuously to topography and loading.

- Smooth on level ground/empty, powerful downhill/full
- Safety, comfort, and cost-effectiveness at the highest level

### Voith DIWA.6 with SensoTop

No such function known

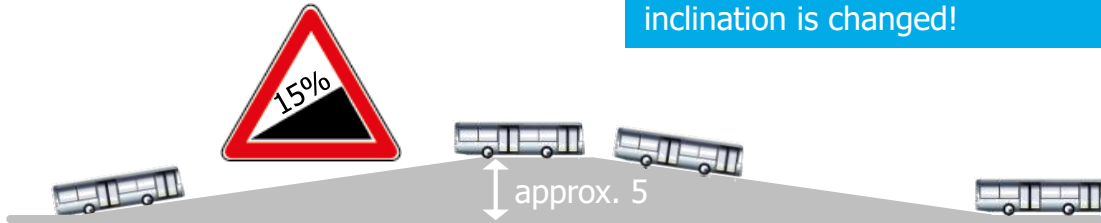


# TopoDyn Life

## Drive Program Adjustment

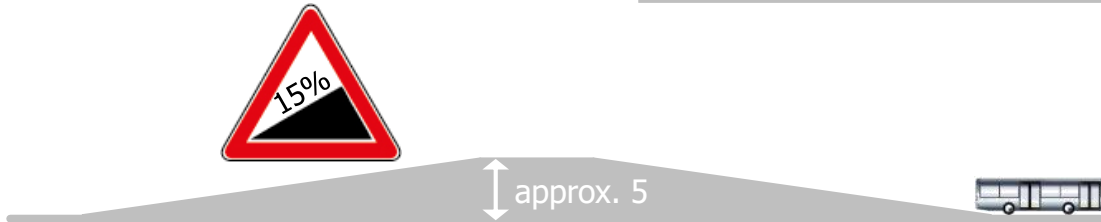
### EcoLife with TopoDyn Life

Immediate adjustment of shift points whenever the vehicle inclination is changed!



### DIWA.6 with SensoTop

No shift point adjustment until the end of the test track!



### EcoLife With TopoDyn Life

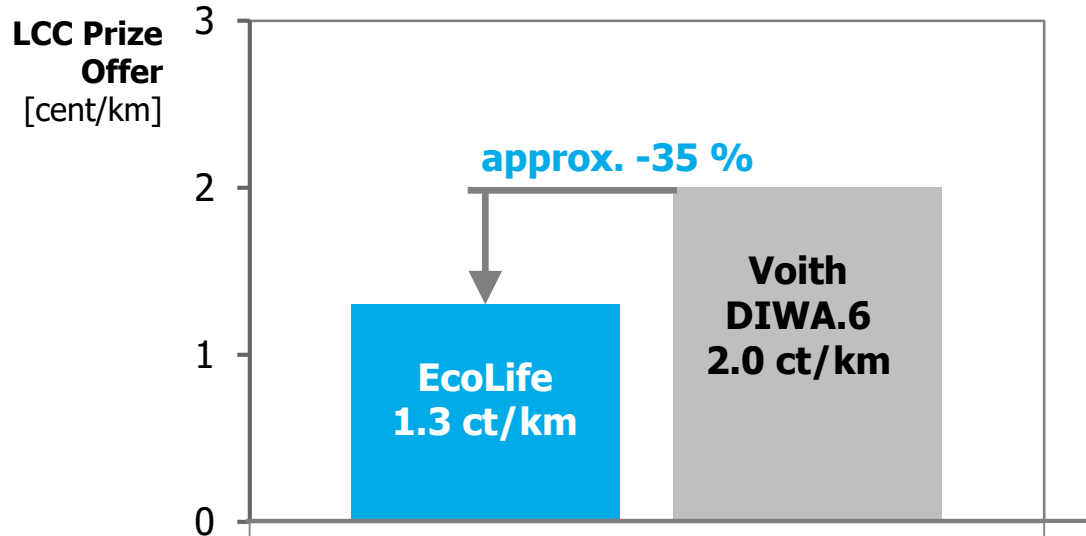
**Quick** and **reliable** adjustment of the shift points to different resistances such as slope and weight – without additional sensor

### Voith DIWA.6 with SensoTop

Uses compressed air sensor, slow reactions due to slight pressure differences

# EcoLife Saves Costs Throughout the Entire Life Cycle

## Example of a German transport operator, 2014



Savings due to LCC contract with EcoLife compared to Voith DIWA:  
**approx. EUR 5,500 per vehicle**

Comparative basis:

- Solobus
- Ø 65,000 km/year
- 12 years contract period

# Comparison of EcoLife vs. Allison Torqmatic / Bus Series

**ZF-ECOLIFE**



**Allison**  
Transmission



**Allison**  
*Torqmatic*

**Bus Series**

# EcoLife vs. Allison Torqmatic

## Overview of All Advantages

### Benefits of EcoLife

Lower fuel consumption and noises, improved acceleration with ...

... extremely early torque converter lock-up in 1st gear

... more intelligent TopoDyn Life control unit with lower shift speeds

... improved efficiency in city traffic

Primary retarder for better deceleration in city traffic; intelligent adaption of brake force to topography and load

Fuel savings of up to 10 % due to start-stop function

### Allison Torqmatic

Higher fuel consumption with ...

... torque converter lock-up first engages in 2nd gear

... conventional control unit with higher engine target speeds

... lower efficiency

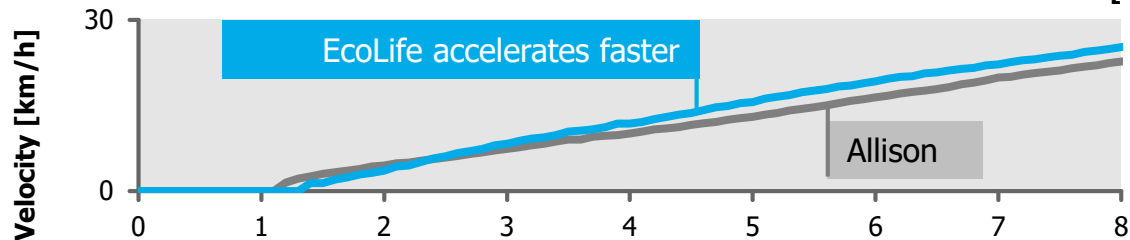
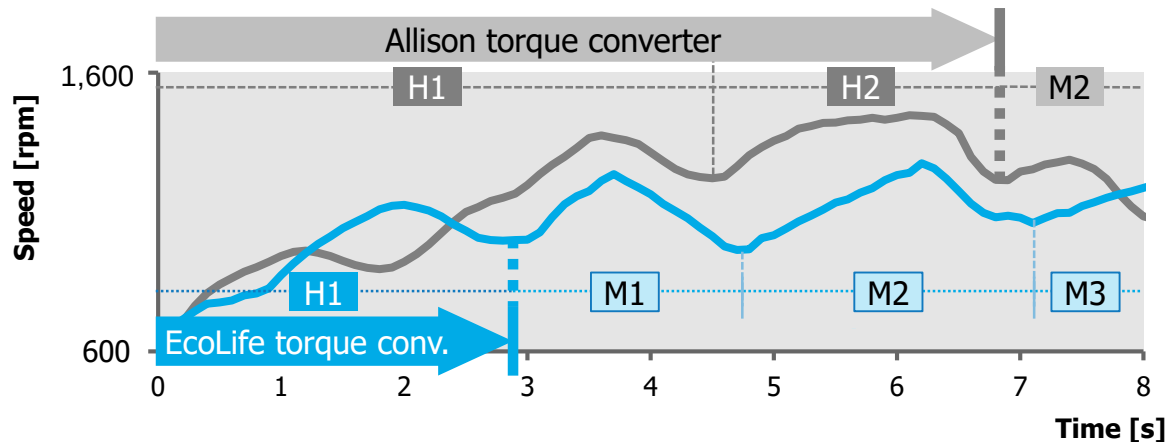
Secondary transmission developed for long-distance haulage trucks; no adjustment of brake force

No start-stop function

# Advantage of EcoLife vs. Allison Torqmatic / Bus Series

## Early Torque Converter Lock-up

### Acceleration procedure, the first 8 seconds



H1, H2: hydromechanical power transmission; M1, M2, M3: mechanical transmission

### EcoLife:

- Disengages torque converter within 3 s in first gear, Allison responds after approx. 7 s and in 2nd gear
- Beneficial, mechanical-only transmission starts far sooner.

**Advantage:**  
less fuel consumption and improved acceleration

### Measurements with:

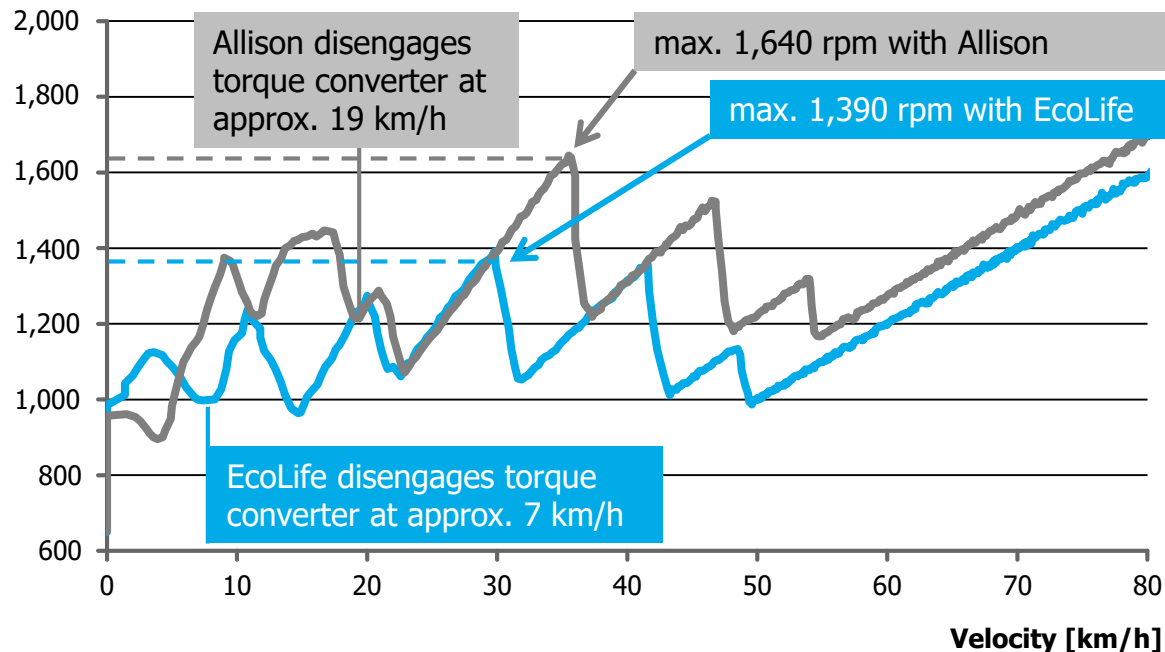
Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; Motor 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; ale ratio 6.2; both feature standard shift program

# Advantage of EcoLife vs. Allison Torqmatic / Bus Series

## Low Speed Curve

### Engine speed at full throttle acceleration

Speed [rpm]



#### EcoLife:

- Lower engine target speeds when shifting resulting in a generally lower speed curve
- Improved acceleration at the same time

**Advantage:**  
reduced fuel consumption and a lower noise level

#### Measurements with:

Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

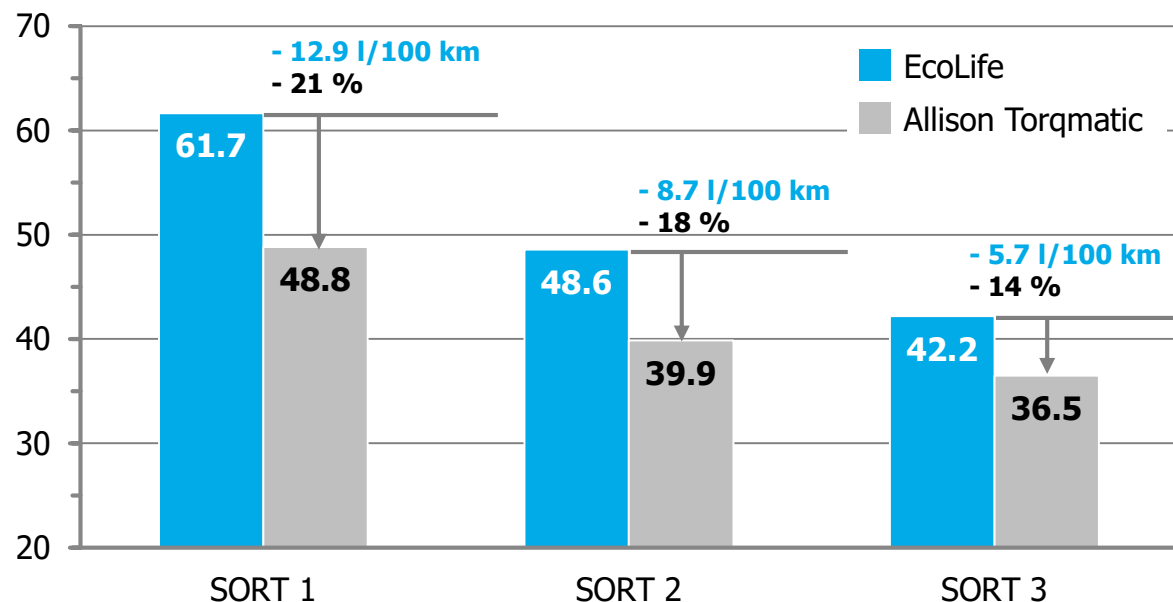
# EcoLife Reduces SORT Consumption: Comparison of Standard Software

## Shift program

Allison: FuelSense **Basic**

EcoLife: Standard TopoDyn Life

Fuel consumption [l/100 km]



## EcoLife:

- SORT consumption reduced by up to 12.9 l/100 km or 21 %
- **Savings:**
  - SORT 1: EUR 10,320 a year
  - SORT 2: EUR 6,960 a year
  - SORT 3: EUR 5,928 a year(at 80,000 km a year, diesel price: EUR 1.30 per l)

## Measurements with:

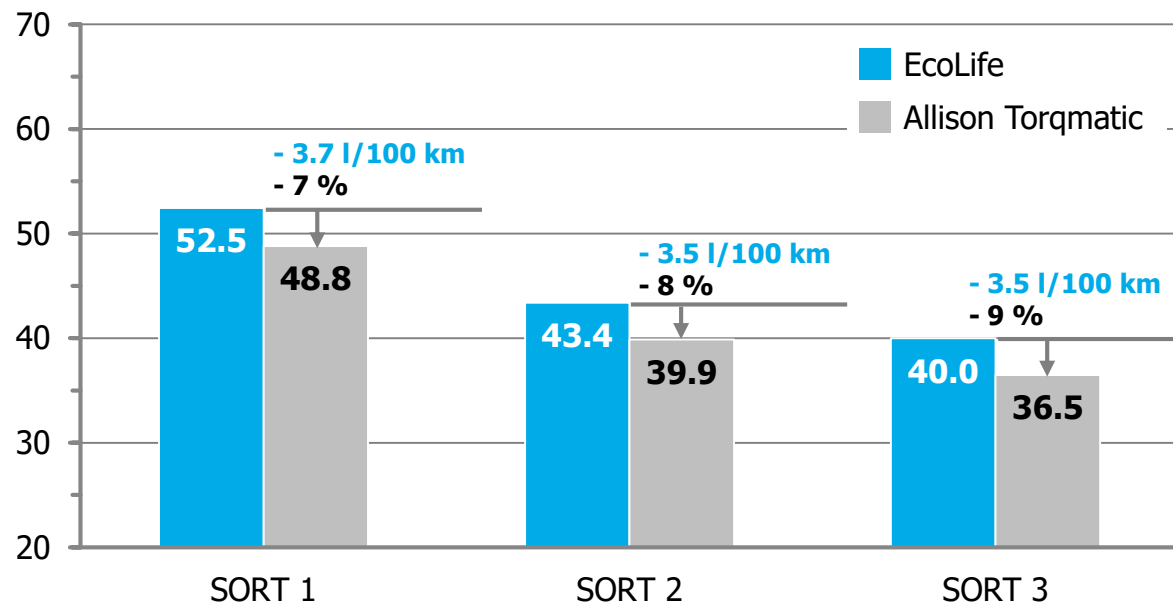
Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R;  
engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

# EcoLife Reduces SORT Consumption: Comparison of Additional Costs of Obligatory Allison Software

## Shift program

Allison: FuelSense **Plus**  
EcoLife: Standard TopoDyn Life

Fuel consumption [l/100 km]



## EcoLife:

- SORT consumption reduced by up to 3.7 l/100 km or 9 %
- **Savings in comparison to FuelSense Plus:**  
SORT 1: EUR 3,848 a year  
SORT 2: EUR 3,640 a year  
SORT 3: EUR 3,640 a year  
(at 80,000 km a year, diesel price: EUR 1.30 per l)

## Measurements with:

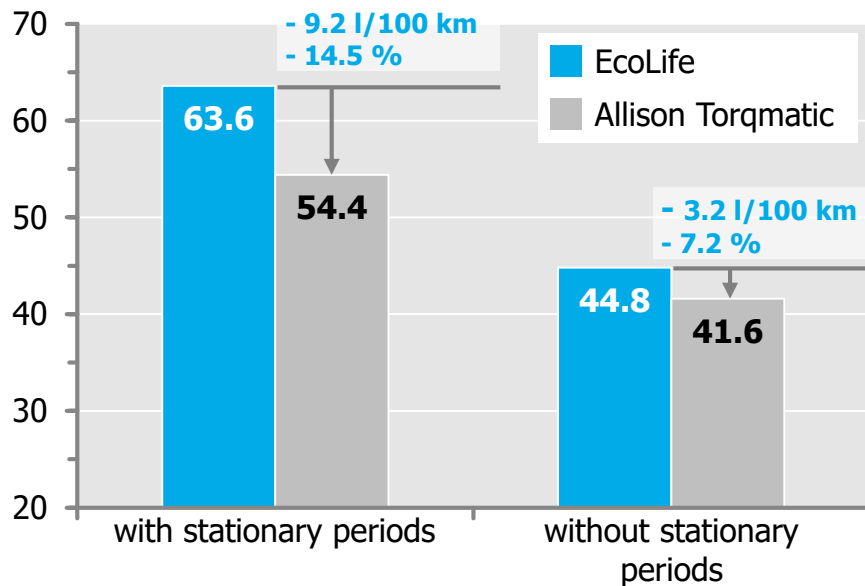
Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R;  
engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2



# EcoLife Reduces Consumption: Field Testing with NYCT

## Measurements on New York City Transit: EcoLife vs. Allison in NovaBus

Fuel consumption [l/100 km]



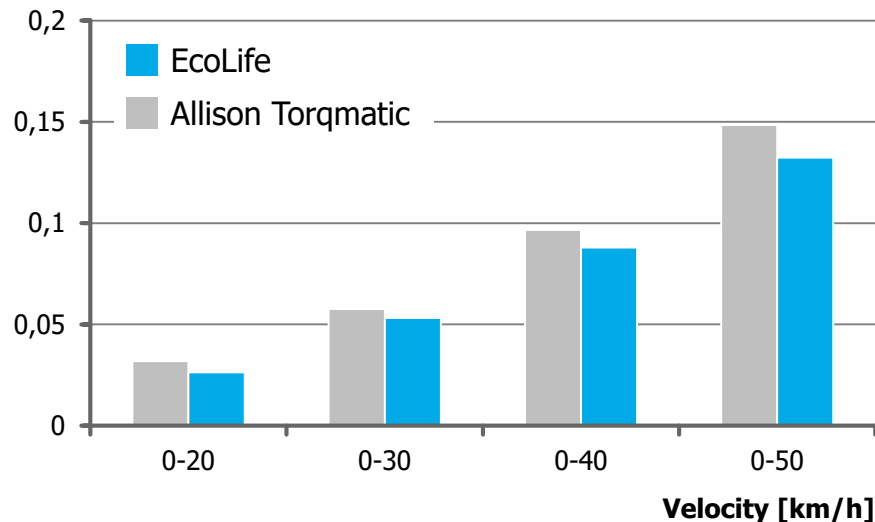
### Field test on North America's largest fleet:

- Each with a NovaBus LFS 40 ft with 6 AP 1400 B and Allison B 400 R
- Cummins engine ISL 280, 900 lb-ft / 1,220 Nm, axle ratio 5.13
- Comparable conditions: average speed, stops per km, percentage at a standstill, etc.

# EcoLife Reduces Consumption Measurements at Full Throttle Acceleration (1/2)

## Absolute consumption up to target speed

### Fuel consumption [l]



**Measurements with:** Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

EcoLife **saves 7 % – 17 %** at acceleration up to 60 km/h.

With 200 accelerations per day to 50 km/h, this translates as:

**EUR 1,150 savings** per bus and per year.  
(275 operating days a year, diesel price EUR 1.30 l)

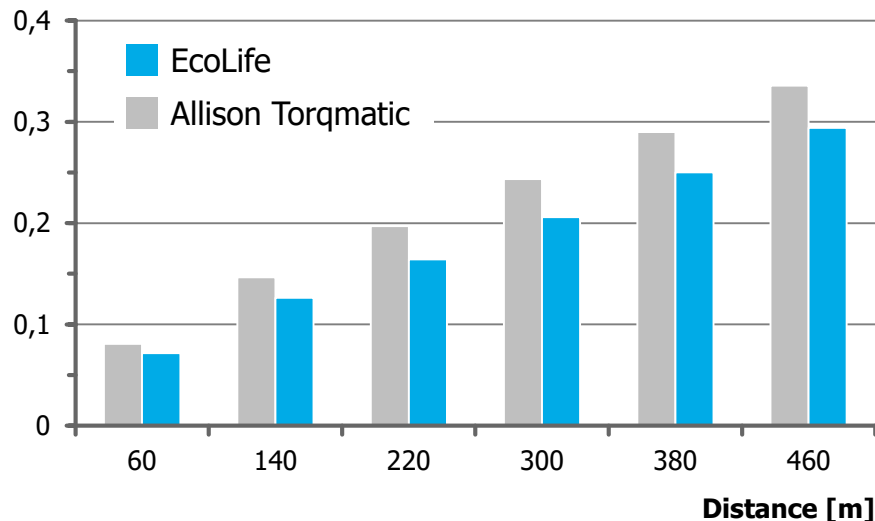
**Advantages from:** early torque converter lock-up and lower shift speeds thanks to TopoDyn Life.

# EcoLife Reduces Consumption

## Measurements at Full Throttle Acceleration (2/2)

### Absolute consumption with distance traveled

Fuel consumption [l]



**Measurements with:** Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

EcoLife **saves 11 – 17 % fuel** at full throttle acceleration.

With 200 accelerations per day to 100 m, this translates as:

**700 l diesel** or **EUR 910 savings** per bus and per year.  
(275 operating days a year, diesel price EUR 1.30 l)

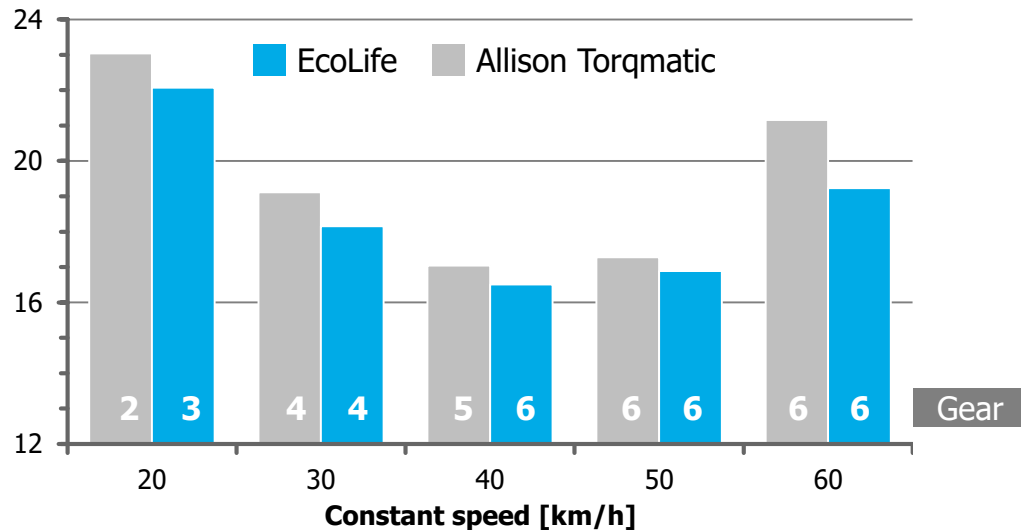
**Advantages from:** early torque converter lock-up and lower shift speeds thanks to TopoDyn Life.

# EcoLife Reduces Consumption

## Measurements at Constant Speed

### Consumption at different speeds

Fuel consumption [l]



**Measurements with:** Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

#### EcoLife:

**Saves 2 – 9 %** or **0.4 – 1.9 l/100 km** fuel at constant speed.

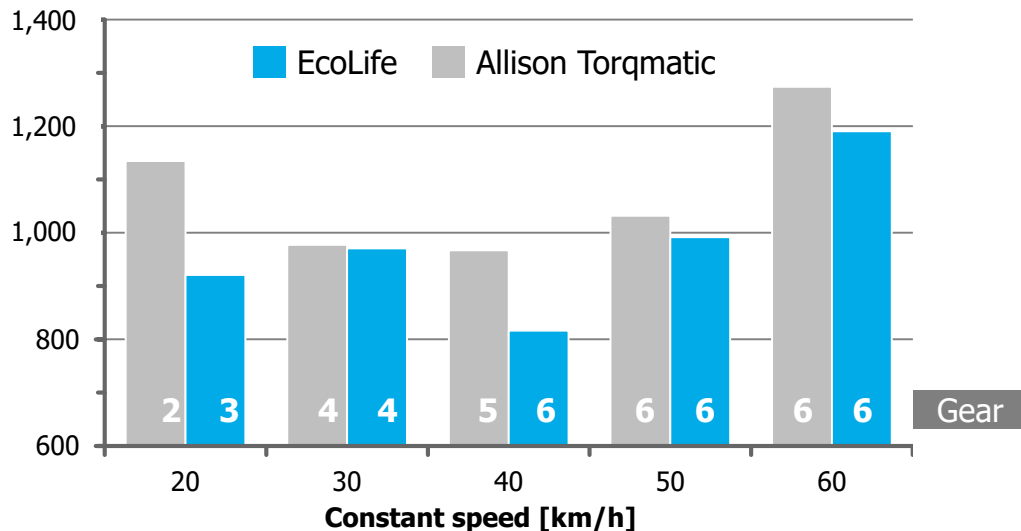
#### Advantages from:

- Improved efficiency
- Lower shift speeds thanks to TopoDyn Life.

# EcoLife Reduces Engine Speed Measurements at Constant Speed

## rpms at different speeds

### Engine speed [rpm]



**Measurements with:** Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

### EcoLife:

- Reduces the engine speeds up to **19 %** or **210 rpm**.
- Reduces the **interior and exterior noises** of the bus as the engine is the main source of noise in city traffic.

### Advantages from:

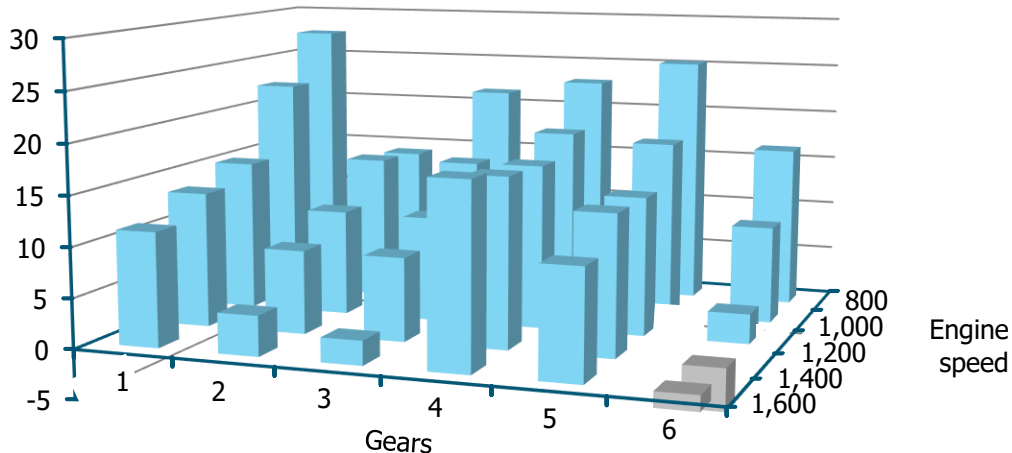
- Lower shift speeds thanks to TopoDyn Life.

# EcoLife has lower inner friction losses and is thus more efficient

**Drag torques = Losses in load-free condition (e.g. in clutches, brakes, bearings)**

Difference between Allison  
and EcoLife [%]

■ Advantage  
of EcoLife    ■ Advantage Allison  
Torqmatic



## EcoLife:

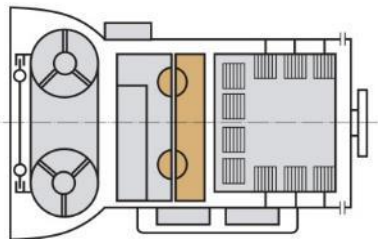
- Lower losses in approximately **95 %** of the main driving range of city buses (gear, speed)
- Up **to 28 %** lower drag torques and thus more efficient

## Advantages thanks to:

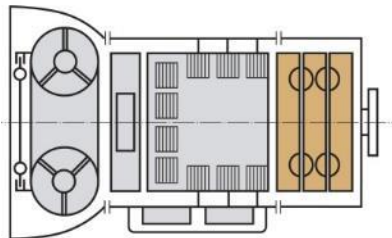
- Lower hydraulic operating pressure

**Measurements on the test bench:** ZF 6 AP 1200 B and Allison T325 R, identical conditions

# Advantage of EcoLife vs. Allison Torqmatic / Bus Series Retarder Principle



1. Primary retarder: performance dependent on engine speed, brake torque is increased by transmission ratio
2. Fully integrated, developed especially for city and intercity buses, simple design



1. Secondary retarder: speed-dependent performance
2. Add-on system, originally designed for trucks, complicated dual-torus design

## Advantages with EcoLife:

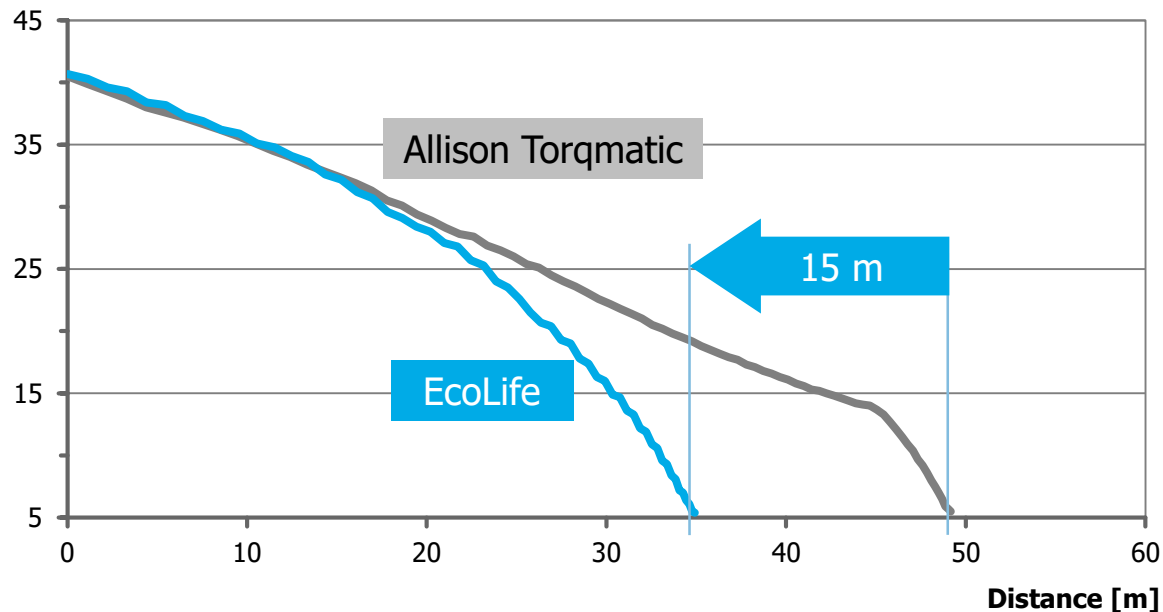
- Highest power in the speed range of city and intercity buses
- Compact design, thus weight savings and reduced total length

# Advantage of EcoLife vs. Allison Torqmatic / Bus Series

## Shorter Stopping Distance with Primary Retarder

Deceleration at inner-city speeds, 100 % retarder

Velocity [km/h]



### EcoLife:

- Stopping distance 15 m shorter
- Advantage of one bus length!

### Measurements with:

Solaris Urbino 12, ZF 6 AP 1200 B, Allison T325 R; engine 6.7 l Euro 6, 1,100 Nm; total weight 14.3 t; axle ratio 6.2

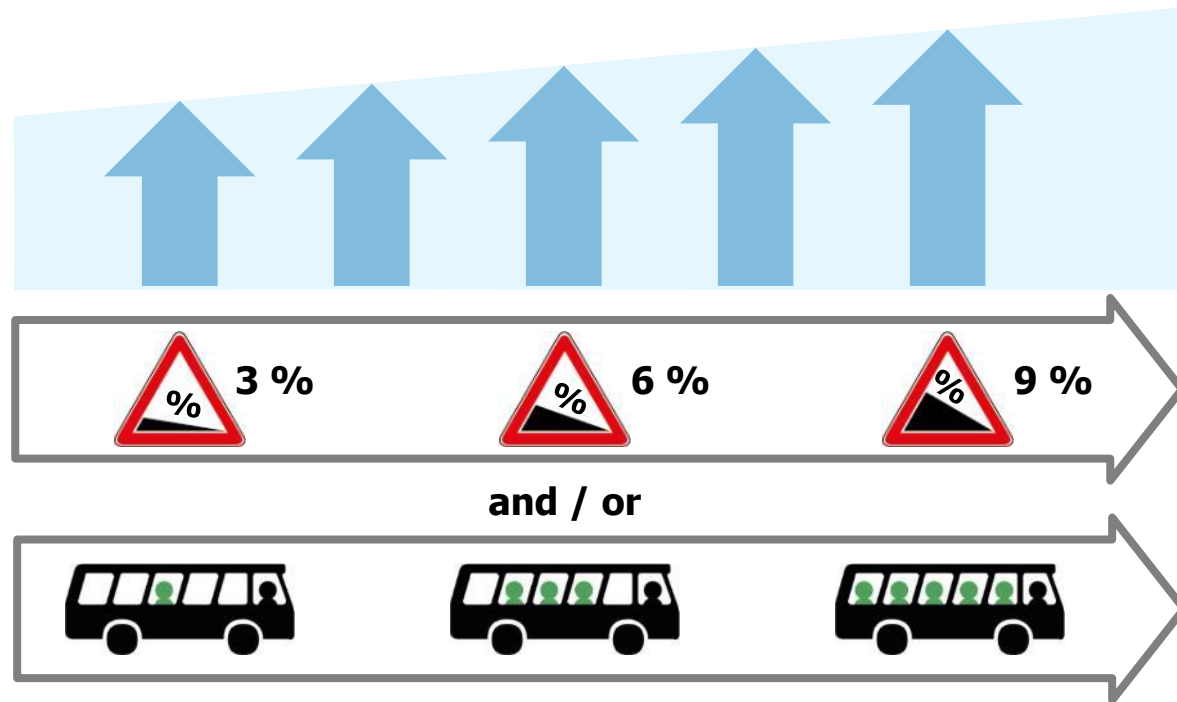
Section of a brake operation only with retarder from 80 km/h to 5 km/h.



# Advantage of EcoLife vs. Allison Torqmatic / Bus Series

## Intelligent Braking with TopoDyn Life

### Retarder brake torque



EcoLife with TopoDyn Life shift program

Adjusts braking torque continuously to topography and loading:

- Smooth on level ground/empty, powerful downhill/full
- Safety, comfort, and cost-effectiveness at the highest level

Allison Torqmatic / Bus Series:  
No such function known