# Reducing $CO_2$ and fuel consumption in fleets

How innovative trailer technologies reduce
fuel consumption and $CO_2$ emissions

we think transport

# Introduction

**Commercial vehicles are the backbone of the economy. The majority of goods reach their destination by road – and the amount continues to rise. Domestic road freight in Germany grew by 75 per cent between 1991 and 2019. The biggest increases during this period were in commercial vehicle traffic, with a gain of almost 103 per cent, which corresponds to a doubling of the transport volume. Rail and ship transport combined made up 24.9 per cent of the modal split in 2020.**[1]

The success of commercial vehicles has consequences for the climate. Commercial vehicles account for more than a quarter of all $CO_2$ emissions from transport and almost five per cent of all greenhouse gas emissions in the EU.[2] The constantly growing volume of goods on the roads has so far outpaced all technological efforts to reduce the fuel consumption of trucks and therefore their climate-damaging $CO_2$ emissions. As such, the transport-related emissions of the greenhouse gas $CO_2$ by trucks have fallen by more than 32 per cent. However, because there are an increasing number of trucks on the roads, direct $CO_2$ emissions in commercial vehicle traffic now stand 17 per cent higher in absolute terms than in 1995.[3] This means that transport fleets have a duty to society to take action to reduce $CO_2$.

This is not the only source of pressure on the industry to renew large swathes of its fleets and move towards particularly sustainable transport solutions. In 2019, the EU responded with the Regulation (EU) 2019/1242 and introduced the first $CO_2$ fleet targets for heavy-duty commercial vehicles in vehicle classes N2 (commercial vehicles from 3.5 to 12 tons permitted total weight) and N3 (commercial vehicles from 12 tons permitted total weight). The regulation stipulates that the average specific $CO_2$ emissions per kilometre from 2025 onwards must be at least 15 per cent lower than in the base year 2019/2020. From 2030 onwards, the target is a reduction of at least 30 per cent compared to 2019/20.[4] The EU uses the VECTO simulation tool (Vehicle Energy Consumption Calculation Tool) to calculate the baseline.

**VECTO (Vehicle Energy Consumption Calculation Tool) is a software application that is publicly available on the internet.[5] It was developed by the European Commission and experts at the Graz University of Technology. It also incorporates input from the vehicle industry and various other institutions.**

**The aim of VECTO is to provide realistic fleet consumption figures for the most common types of commercial vehicle in classes N2 and N3 and to reference these against a standard vehicle stored in the program. VECTO distinguishes between the different driving cycles for urban, regional and long-haul transport and the different payload classes, and evaluates the effectiveness of various fuel-saving measures accordingly.**

**Initially, VECTO was used to calculate the fleet consumption values for the base year 2019/2020 so that the mandatory consumption improvements of 15 or 30 per cent can then be measured against this baseline. All new vehicles must also come with a VECTO certificate, which shows the consumption calculated for that exact type. This should significantly improve transparency when purchasing a vehicle.**

[1] www.umweltbundesamt.de/daten/verkehr/fahrleistungen-verkehrsaufwand-modal-split#guterverkehr

[2] www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12

[3] www.umweltbundesamt.de/daten/verkehr/emissionen-des-verkehrs#pkw-fahren-heute-klima-und-umweltvertraglicher

[4] https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32019R1242

[5] https://ec.europa.eu/clima/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/vehicle-energy-consumption-calculation-tool-vecto_en

# Declaration Results

Note: this presentation of the report does not show all details!

## Vehicle Configuration

Manufacturer: Example Manufacturer
Manufacturer Address: Example Street 1, Example City XY, Example Country
Commercial Name: Example Trailer SuperEco
VIN: ExampleVIN1234567890
Date: 2021-07-28T12:52:07.7148405Z
Legislative Category: O4
Axle Count: 3
Trailer Type: DA
Manufacturer: dry box
Manufacturer: n/a

Masses:
- Mass In Running Order: 7700 kg
- TPMLM Total Trailer: 39000 kg
- TPMLM Axle Assembly: 24000 kg

Vehicle Group Annex I: 131
Vehicle Group Tool Internal: 31101

Dimensions:
- External length of the body: 13.685
- External width of the body: 2.550
- External height of the body: 2.850
- Total height of the trailer: 4.000
- Length from trailer front end to center of first axle: 8.075
- Length between centers of axles: 2.620
- Internal height of the body: 2.600
- Cargo Volume: 91.000

Aero Features:

**Input Data Hash**

Y42OAm72MJK6Zxg8jHUTO/KFgRL0…

**VECTO Version:** 0.8.0.2366-DEV !!NOT FOR CERTIFICATION!!

**Date:** 2021-07-28T12:56:49.9126986Z

Towing Vehicle:Generic group 5 (4x2 tractor), MY2019/20, 325kW

### Long Haul

Loading: 19300 kg
CdxAyawAngle0: 5.630
CdxAyawAngle3: 5.821
CdxAyawAngle6: 6.494
CdxAyawAngle9: 7.340
Average Speed: 78.56 km/h

Fuel Consumption: 31.7 l/100km
Fuel Consumption: 0.0164 l/t-km
Fuel Consumption: 0.00349 l/m³-km
CO2: 829.89 g/km
CO2: 43.00 g/t-km
CO2: 9.12 g/m³-km
Efficiency Ratio: 1.0000 g/km
Efficiency Ratio: 1.0000 g/t-km
Efficiency Ratio: 1.0000 g/m³-km

### Long Haul

Loading: 2600 kg
CdxAyawAngle0: 5.630
CdxAyawAngle3: 5.821
CdxAyawAngle6: 6.494
CdxAyawAngle9: 7.340
Average Speed: 79.68 km/h

Fuel Consumption: 23.7 l/100km
Fuel Consumption: 0.0913 l/t-km
Fuel Consumption: 0.00261 l/m³-km
CO2: 621.17 g/km
CO2: 238.91 g/t-km
CO2: 6.83 g/m³-km
Efficiency Ratio: 1.0000 g/km
Efficiency Ratio: 1.0000 g/t-km
Efficiency Ratio: 1.0000 g/m³-km

### Regional Delivery

Loading: 2600 kg
CdxAyawAngle0: 5.630
CdxAyawAngle3: 5.821
CdxAyawAngle6: 6.494
CdxAyawAngle9: 7.340
Average Speed: 60.57 km/h

Fuel Consumption: 24.3 l/100km
Fuel Consumption: 0.0935 l/t-km
Fuel Consumption: 0.00267 l/m³-km
CO2: 636.35 g/km
CO2: 244.75 g/t-km
CO2: 6.99 g/m³-km
Efficiency Ratio: 0.9700 g/km
Efficiency Ratio: 0.9700 g/t-km
Efficiency Ratio: 0.9700 g/m³-km

### Regional Delivery

Loading: 12900 kg
CdxAyawAngle0: 5.630
CdxAyawAngle3: 5.821
CdxAyawAngle6: 6.494
CdxAyawAngle9: 7.340
Average Speed: 60.10 km/h

Fuel Consumption: 30.7 l/100km
Fuel Consumption: 0.0238 l/t-km
Fuel Consumption: 0.00338 l/m³-km
CO2: 803.86 g/km
CO2: 62.31 g/t-km
CO2: 8.83 g/m³-km
Efficiency Ratio: 0.9700 g/km
Efficiency Ratio: 0.9700 g/t-km
Efficiency Ratio: 0.9700 g/m³-km

**VECTO calculation tests,**
three-axle standard curtainsider with steering axle

The $CO_2$ fleet targets are due to be revised next year, and it is likely that the target values will be tightened given that climate change is proceeding virtually unabated. Meanwhile, it is probable that the entire truck-trailer combination and therefore also the trailer will be included in the VECTO calculations from January 2024 onwards, with a transitional period of six months. Rules to this effect have already been issued in the form of Regulation (EU) 2019/1242 of the European Parliament and of the Council setting $CO_2$ emission performance standards for new heavy-duty vehicles.[6] Vehicle manufacturers that fail to meet the fleet targets can expect to receive fines. These could cause commercial vehicle prices to rise and would add to the financial burden on transport fleets.

However, this is not the sole reason for the major challenges facing operators of commercial vehicle fleets. The transport and logistics industry has already been suffering from enormous cost pressure for years, and the current cost increases are aggravating this further. This is mainly due to the recent dramatic rises in energy and fuel expenses, as well as for staff and materials.

On the one side, high cost pressure, political requirements and a duty to society are providing a strong incentive for fleet renewal. On the other side, the investments in modern carbon-reducing measures also need to pay their way through lower fuel spending, so that commercial vehicles remain efficient and therefore competitive in order to continue to fulfil their key role as the backbone of the economy.

Whereas the various electric solutions and other alternative drives for trucks come with high investment costs, the trailer currently holds particular potential. The present political and economic conditions are making these low-hanging fruits particularly appealing. They offer clear potential for saving $CO_2$ and also promise an attractive cost-benefit ratio, so fleet operators can quickly see a return on their investment. The truck-trailer combination can even recoup the outlay within twelve months in some cases. All fleet operators should therefore spend time becoming familiar with the relevant trailer features so that they are ready to make investments.

**The white paper 'Reducing $CO_2$ and fuel consumption in fleets – How innovative trailer technologies reduce fuel consumption and $CO_2$ emissions' serves an accessible guide to the options available in this regard.**

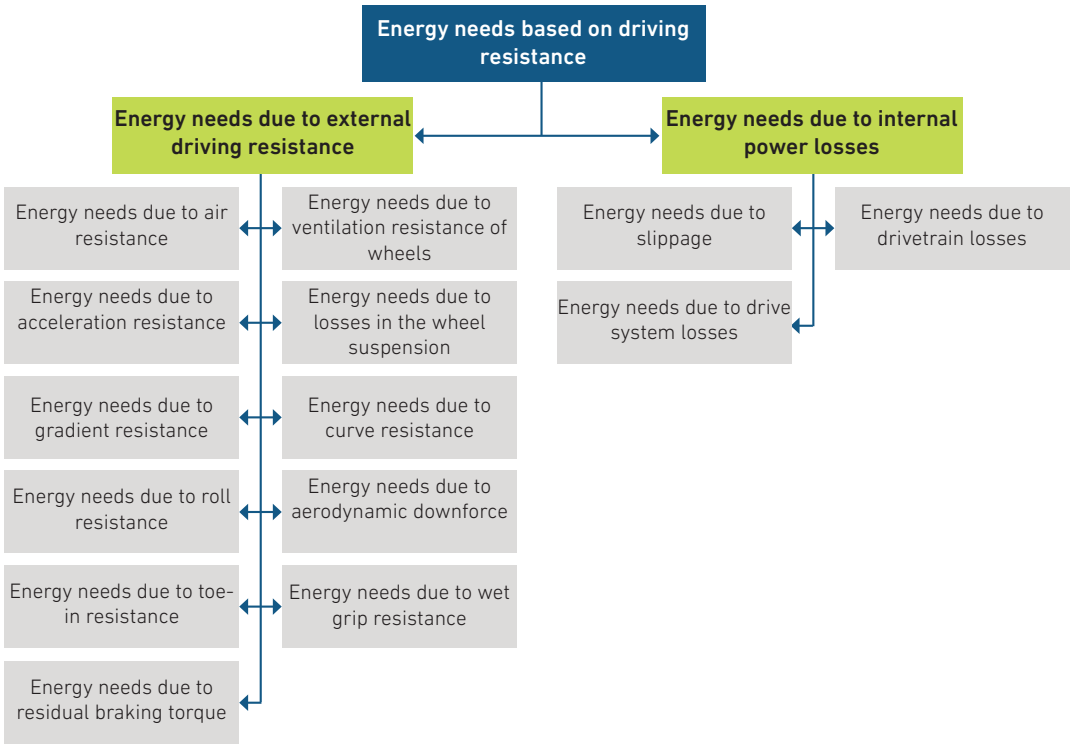
[6] https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32019R1242

# Driving resistance

**The various types of driving resistance counteract the driving force of a vehicle. Air resistance, gradient resistance, roll resistance and some other forms of resistance slow the forward motion of the truck. The truck needs power from a source of energy such as diesel fuel to overcome this resistance. The greater the resistance, the more power the truck's drive system needs to deliver and therefore the more energy it consumes. Power dissipation losses – for example in the drive system, the rest of the drivetrain and the running gear – increase the energy demand.**

The aim of vehicle manufacturers and expert partners such as the supplier industry is therefore to keep the driving resistance and power losses as low as possible. They can achieve this in various ways. VECTO takes into account all relevant technologies here – the latest version includes tractor units and trucks, as well as drawbar trailers and semi-trailers. Aerodynamic devices, tyres optimised for roll resistance, steering axles and lift axles are taken into consideration as special trailer equipment.

Apart from the technologies included in VECTO, it makes sense for all fleet operators to also consider features for drawbar trailers and semi-trailers that are not yet covered by the simulation tool but that do also reduce $CO_2$ and therefore enable fuel savings that translate into financial savings.




**Energy needs of a vehicle**
(Source: FAT Schrift 300 (report by the German Research Association of Automotive Technology), Berlin 2017)

3

# Trailer aerodynamics

The fewer corners and edges there are on a semi-trailer – with the associated reduced potential for air turbulence – the more this helps the tractor unit to consume less fuel. And the faster the vehicle travels, the more of a detrimental impact the air resistance has on fuel consumption. Aerodynamic optimisation therefore makes particular sense for truck-trailer combinations that predominantly travel at high speeds, as is usual for long-haul transport.

A standard semi-trailer uses 36 per cent of the energy to overcome its air resistance on the motorway. At a cW value of 0.6 for a standard trailer, just adding flaps to the rear frame can reduce the wind resistance by nine per cent. Further potential savings to the tune of two to three per cent can be achieved at the gap between the tractor unit's spoiler and the trailer's bulkhead, between the rear end of the tractor unit and the support bases, between the underbody and the trailer axles and at the rear underride guard.[7]

However, numerous factors such as weather and road conditions have a noticeable impact in real-world use. A trailer with full aerodynamic optimisation can deliver fuel savings of 6.5 per cent on average, which is roughly equivalent to two litres of diesel per 100 kilometres. Field tests have demonstrated this potential. For a fleet of ten vehicles with annual mileages of 120,000 kilometres, this could potentially save up to 24,000 litres of diesel or 63.6 tons of CO2 per year. VECTO, in turn, awards standardised bonuses for a vehicle with aerodynamic cladding, according to the particular usage. Provided the relevant cladding manufacturer has certified its individual system, customised bonuses should also be possible.

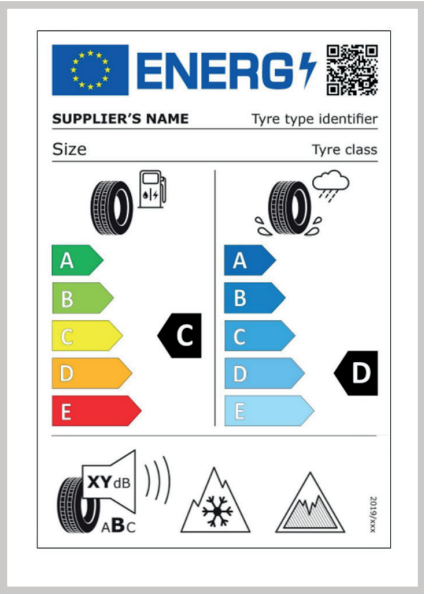

**Improved aerodynamics reduces fuel consumption in semi-trailer trucks. Source: Betterflow.** Source: Betterflow

[7] www.betterflow.com, Betterflow Whitepaper, 2021

# Roll resistance optimisation in trailer running gear

## Air pressure checks

Four per cent of annual road transport emissions can be influenced by roll resistance alone. When this is applied to fleet costs, the figures are even more impressive. The roll resistance of tyres can account for up to 30 per cent of all fleet expenses.[8] Tyres optimised for roll resistance are therefore particularly valuable for long-haul transport with its high annual mileages. They can be identified from the tyre labels and are also classed as consumption-reducing in VECTO.




**A standardised EU label provides information about the tyre performance, for example relating to its roll resistance (left-hand scale on the label)**

But even the best tyres cannot deliver optimum results if the tyre pressure is not set correctly. The rule of thumb is that if the pressure is just one bar too low, this can push fuel consumption up by one per cent – and on top of this, it causes increased tyre wear and therefore reduces its mileage performance. It also increases the amount of tyre wear particles – a major cause of microplastics, which contaminate soils and water.[9] Keeping the tyres in perfect condition and carrying out the extensive pre-departure checks that are prescribed therefore helps to ensure no fuel or mileage is lost unnecessarily and prevents additional harm to the environment from microplastic particles.

**Tyre wear particles are damaging for soils and water**

In practice, however, the pre-departure check is often not carried out, possibly due to time pressure or inadequate rest stops. There are, however, intelligent systems that help to monitor tyre pressure and also automatically maintain the ideal value.

[8] www.continental-reifen.de/bus-und-lkw/flottenloesungen/vecto/kurze-erklaerung

[9] www.bund.net/themen/aktuelles/detail-aktuelles/news/tausende-tonnen-mikroplastik-durch-reifenabrieb-von-der-strasse-in-unsere-lungen/

A tyre pressure refill system (TPRS) such as the **BPW AirSave** ensures that the preset air pressure in the tyres is always maintained. At an annual mileage of 120,000 kilometres per vehicle, which is a standard average for long-haul transport, this can save 2,480 litres of diesel in a fleet with ten vehicles. That is the equivalent of 6,570 kilograms of $CO_2$.[10]

The low-maintenance system is installed directly on the trailer axle ex works. A control box with a booster automatically monitors the tyre pressure during travel and adjusts it to the desired pressure. If there are considerable deviations from the target pressure, a warning light informs the driver to this effect so that they can promptly drive to a service station instead of breaking down on the side of the motorway. It can also connect to the fleet telematics to enable remote monitoring.

**The AirSave tyre pressure refill system from BPW uses the existing trailer pneumatics and automatically ensures that the preset tyre pressure is maintained at all times via a booster pump.**

As of 6 July 2022, the TPRS' little cousin, the **BPW TireMonitor** tyre pressure monitoring system (TPMS), has been mandatory equipment on all new type-tested trailer models and will also be mandatory for all newly registered drawbar trailers and semi-trailers from 7 July 2024.

The BPW TireMonitor also warns of pressure loss – informing the driver via an app and the fleet operator via telematics. Unlike the BPW AirSave, however, it cannot actively regulate the tyre pressure. The potential fuel savings and other benefits are the same, however, provided that the driver manually carries out the checks and tyre maintenance. Fleet operators should therefore start equipping all new vehicles with the BPW AirSave or BPW TireMonitor right away. The BPW TireMonitor can be installed without any tools on all common rim sizes and is available as original equipment or for retrofitting.

**The BPW TireMonitor consists of individual sensors that are attached to the rims and transmit the tyre pressure to a receiving unit with an accuracy of +/- 0.3 bar.**

[10] Michael Hilgers, Kraftstoffverbrauch und Verbrauchsoptimierung (Nutzfahrzeugtechnik lernen), Vieweg Verlag 2016, P. 48

4.2

# Roll resistance optimisation in trailer running gear

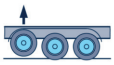
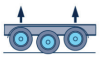
## Trailer running gear

The trailer running gear as an overall system also has an impact on a truck-trailer combination's energy needs. The quality of the running gear system directly affects the roll, toe-in and curve resistance, residual braking torque, tyre slip and losses in the wheel suspension.

Apart from that, the tyre temperature is quite important, as the roll resistance coefficient falls as the temperature increases. In other words, specifically increasing the tyre temperature reduces fuel consumption. This effect can be achieved by using a lift axle in a tri-axle unit.

Lifting the first axle when running with a part load means that the tyres on the second and third axles are used to a greater degree. The temperature of those tyres thus increases and the roll resistance decreases, enabling fuel savings of 0.4 per cent in long-haul transport. The lower the ambient temperature, the greater the reduction in roll resistance. At least this is true when driving on a straight road.

**Advantages (+) in long-distance, regional and urban traffic**

| |  one lift |  two lifts |  |
|---|---|---|---|
| **Tyre wear** | + | ++ | ++ |
| **Reduced fuel consumption/$CO_2$** | + | ++ | ++ |
| **Axle load drive axle** | + | ++ | neutral |

A lift axle has benefits when driving on winding roads as well. Rigid axles are reluctant to be steered, so they fight against changes in direction and thus result in power loss, known as curve resistance. If one of the three axles is lifted on bends, this makes it easier to steer and the energy losses decrease.

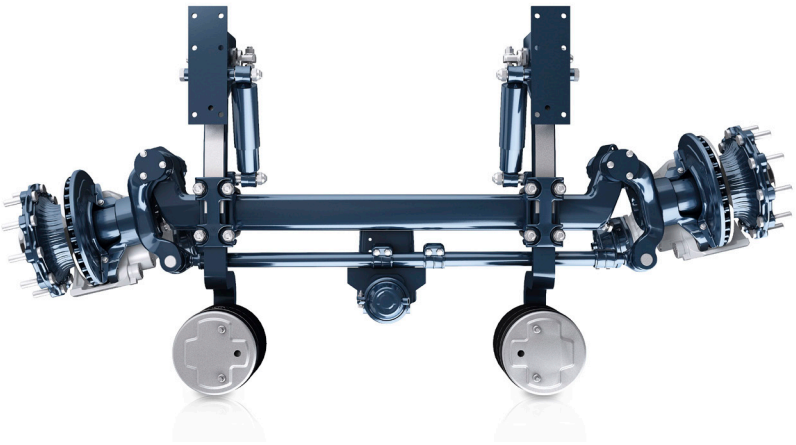
**Axle lifts are activated automatically or manually when running with a part or empty load**

The latest studies by the German Research Association of Automotive Technology (FAT) have shown that the axle lift offers similar benefits to a steering axle on bends and the combination of both types unlocks even greater potential fuel savings, although the axle lift can only reduce fuel consumption when running with empty or part loads, whereas the self-steering axle is always effective.

According to VECTO, this can translate into a reduction in fuel consumption of up to 5.2 per cent. The effect is greatest in the urban driving cycle and is only minimal in long-haul transport, with savings of 0.4 per cent.[11]

Using a self-steering axle such as the BPW LL rather than a rigid axle is another way to increase the benefit. The steering axle reduces transverse forces by up to 30 per cent on bends, meaning that the drive system needs to deliver much less power, particularly on tight corners. According to tests by manufacturers and trade journals, a 40-ton semi-trailer truck can save between three and five per cent fuel in mixed operation on urban streets, inter-urban roads and motorways.[12] This matches the values that VECTO uses in its calculation for the different areas of use. The software application calculates 4.5 per cent savings for vehicles with a steering axle in urban transport and 3 per cent in regional transport. In purely long-haul transport, where bends are more of an exception than the rule, the figure stands at just 0.3 per cent.

At an average consumption of 30 litres per 100 kilometres, the realistic fuel savings in practice are therefore between 0.9 and 1.5 litres per 100 kilometres. Given an annual mileage of 120,000 kilometres, this could save 10,800 to 18,000 litres of fuel in a fleet with ten semi-trailer trucks. This in turn corresponds to a reduction in $CO_2$ emissions of 28.6 to 47.7 tons.



**The BPW LL self-steering axle. The LL indicates that this model has load-dependent steering stabilisation.**

[11] Workshop on VECTO Trailer Tool am 22.5.2022; P. 24-25

[12] FAT Schrift 258 „Sensitivitätsanalyse rollwiderstandsrelevanter Einflussgrößen bei Nutzfahrzeugen" (2013); Running gear systems for towed vehicles, Bibliothek der Technik Band 266, Verlag Moderne Industrie, P. 85 (2013); Measures BPW 2014

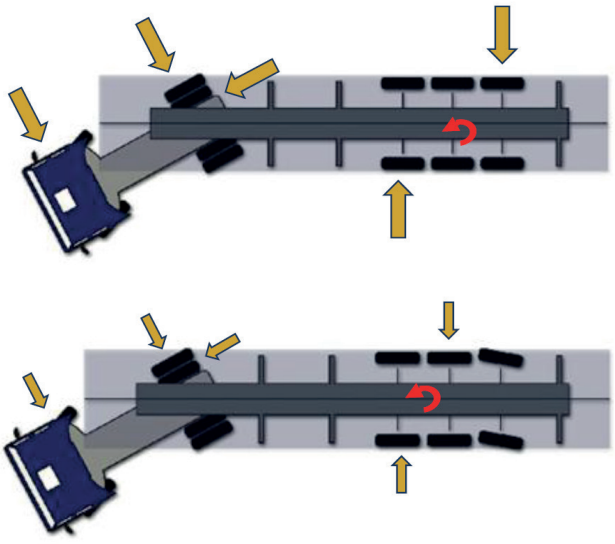
## PRACTICAL TIP

**To unlock the benefits of the LL self-steering axle when driving in reverse, BPW offers the option of an intelligent fully automatic reverse steering system. The Active Reverse Control (ARC) electro-hydraulic auxiliary steering system can be used independently of the EBS system and means that the benefits of the steering axle in terms of manoeuvrability and tyre wear particles also apply when reversing, when the axle would otherwise be locked in place and behave like a rigid axle.**

Aside from this, the vehicle operator benefits not only from better fuel consumption, but also from reduced tyre wear and therefore improved mileage performance. Steering axles also reduce the risk of collisions, increase the resale value of the trailer and therefore lower the operational costs considerably.

The effect of the steering axle is even greater when combined with a lift on the first axle. Long-term studies on semi-trailers in local transport and delivery service have shown that the tyres' life expectancy on the first and third axle of tri-axle suspension can be two to three times greater than in a rigid tri-axle system.[13] VECTO also takes this scenario into account and applies the lift axle bonus factor plus 0.5 times the bonus factor for a steering axle.

Last but not least, the weight of the axle also has an impact on fuel consumption. Lightweight options such as the **BPW aluminium hub** can be used to further reduce the weight of the BPW AIRLIGHT II suspension system, which is already among the lightest in the 9-ton trailer axle segment. This means that a total of 54 kilograms can be saved in the tri-axle suspension. These weight savings have a benefit in terms of the usable load, reducing $CO_2$ emissions per ton-kilometre and providing a cost-efficiency gain for the vehicle operator. At a mileage of 120,000 kilometres, this can save 43 litres of diesel and 114 kilograms of $CO_2$ per year per vehicle, which can equal more than 450 euros in savings depending on the transported goods.[14]



**The steering axle causes the suspension unit to steer better in bends and nearly follow the circular path of the tractor unit. The lateral forces that occur on the tyres are distributed optimally across all axles.**

[13] Running gear systems for towed vehicles, Bibliothek der Technik Band 266, Verlag Moderne Industrie (2014), P. 85

[14] Michael Hilgers, Kraftstoffverbrauch und Verbrauchsoptimierung, Nutzfahrzeugtechnik lernen, Vieweg Verlag 2016, P. 33.
Paul Wittenbrink, Transportmanagement, Springer Gabler, 2014, P. 176

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# Trailer-Telematik

**Trailer telematics** is a particularly powerful tool for reducing fleet consumption. Systems such as those from idem telematics result in fuel savings of up to ten per cent.[15] These systems achieve this by connecting the load, vehicle and driver in an 'Internet of Transport' and thus help to increase how much of the cargo area is used, whilst also reducing the transport distance with the aid of precise location information. Geolocation and load information, as well as track and trace functions can also be used to combine part loads efficiently.

They also reduce the risk of missing binding transport deadlines. The fleet dispatch team has an overview of the fleet's location and status in real time and can therefore intervene promptly and reallocate time-critical cargo to other vehicles if necessary. This can ultimately also avoid contractual penalties.

The cargofleet driver app provides the driver with job and route data, text messages and navigation destinations from the dispatcher, which the driver can then answer or edit directly on the display.

[15] Jacques Léonardi, Michael Baumgartner, Oliver Krusch, Max-Planck-Institut für Meteorologie Hamburg, Report Nr. 353, 2004, Summary P. VI

## Summary

# Many measures – big impact

Both the VECTO simulation tool and measurements in the field prove how effective innovative technologies on trailers can be. All of the systems described here have the potential to noticeably reduce fleet operational costs and efficiently limit $CO_2$ emissions, depending on the particular area of use. And this can be achieved without vast initial investment costs, meaning that a rapid return on investments is possible for most fleets. Overall, significant savings can be achieved when it comes to operational costs and $CO_2$ in any case.

All of the above mentioned options make environmental and financial sense, particularly when operating with a high proportion of regional and urban transport and large payloads. In purely long-haul transport, the use of a self-steering axle may possibly be a borderline case and the use of lightweight elements might not be the first choice for volume-sensitive transport. But professional transport fleet operators are already used to working things out down to the last penny, so calculating the return on investment may well already be a routine exercise. Given the significant rcost pressure in the transport industry, premium running gear components and system expertise – as offered by BPW – can be a key element of a successful business strategy.

| Measure | Diesel savings p.a.* | $CO_2$ savings p. a.* | Cost savings p. a.* | Additional benefits |
|---|---|---|---|---|
| **Aerodynamics** | 2,400 l | 6,360 kg | 4,200 Euro | |
| **BPW AirSave/TireMonitor** | 248 l | 660 kg | 430 Euro | + Security<br>+ Tyre mileage |
| **BPW Lift axle** | 360 l | 950 kg | 630 Euro | + Maneuverability<br>+ Tyre mileage |
| **BPW Self steering axle LL** | 1,080 -1,800 l | 2,860-4,800 kg | 1,890-3,150 Euro | + Tyre mileage<br>+ Maneuverability<br>- Collision damage |
| **BPW Lightweight option aluminum hub** | 43 l | 140 kg | 450 Euro | + 54 kg Payload |
| **Trailer-Telematics** | 3,600 l | 9,540 kg | 6,300 Euro | + Security<br>+ Technical condition |

* based on a road train with 120,000 km mileage p.a., diesel price: 1.75 euros. The relative savings are based on an average consumption of 30 l/100 km.