HVTT15: THE COMMERCIAL VEHICLE OF THE FUTURE: AN INTEGRATED APPROACH FOR SUSTAINABLE TRUCK OPERATIONS

The commercial vehicle of the future: an integrated approach for sustainable truck operations



TIM BREEMERSCH
Senior Researcher at Transport & Mobility Leuven, M.Sc. Applied Economics (Business Engineer), M.Sc. Environmental Science & Technology

LARS AKKERMANS
Senior Researcher at Transport & Mobility Leuven, M.Sc. in Psychology

MARC BILLIET
Senior Adviser - Goods Transport at the International Road Transport Union

Abstract

This paper provides insight in the available options (technological, operational and legislative) to reduce the fuel consumption and CO_2 emissions of heavy duty road freight transport for 2050. We build on earlier work focusing on shorter terms options for 2020, adding results of the work done in the Commercial Vehicle of the Future working group, meetings of which were chaired and hosted by the International Road transport Union. This group of stakeholders, researchers and other experts provided input of a diverse nature to assess the contributions of different measures to meeting the GHG emission targets of the road freight sector in Europe by 2030 and 2050. As such, this paper deals principally with the topic (subtheme) of low emission transport and sets out policies and vision towards the long terms goals, mainly in the long haul operational cycle, but it will also touch on the potential of different options in the regional delivery and urban delivery cycles.

Keywords: Low emission transport, integrated approach, long term vision, emission reduction technologies, logistic organisation.

1. Introduction

This paper provides insight in the available options (technological, operational and legislative) to reduce the fuel consumption and CO_2 emissions of heavy duty road freight transport for 2030 and 2050. We build on earlier publications by Breemersch & Akkermans (2015) and Breemersch & Vanherle (2016) which focused on shorter terms options for 2020, adding results of the work done in the Commercial Vehicle of the Future working group, meetings of which were chaired and hosted by the IRU. This group of stakeholders, researchers and other experts provided input of a diverse nature to assess the contributions of different measures to meeting the GHG emission targets of the road freight sector in Europe by 2030 and 2050. As such, this paper deals principally with the topic of low emission transport and sets out policies and vision towards the long terms goals.

The focus of this paper is on the long haul operational cycle, but it will also touch on the potential of different options in other cycles such the regional delivery and urban delivery. First, we will set the stage by establishing the targets for CO_2 reduction from road freight. Then, we will assess the contributions of measures of these types:

- Propulsion systems and energy carriers
- Other vehicle related measures
- Driving behavior and automation
- Logistics
- Infrastructure

The paper concludes with a tabular overview of the cumulative CO_2 reduction potential, accounting for interactions.

2. Research approach

The information to compile this overview was collected through literature review, input from stakeholders and experts in the road freight transport industry (vehicle manufacturers, suppliers, transport operators, shippers, fuel producers, infrastructure managers, sustainable transport campaigners, policy makers) and the results of discussions between those stakeholders during plenary and small-group meetings. The first step of the work was to compile a list of specific relevant measures. Stakeholders were requested to provide input on those measures in their area of expertise, which were then assessed by the research team and compiled into a general overview. In the next step, validation was sought with independent experts and reductions were assessed accounting for potential interactions with others. As a final step, the timeline for the implementation of each measure was determined in light of the targets for 2050.

3. Results

3.1 Targets

The work was focused on long term CO_2 reduction targets for heavy duty road freight. The first step was thus to look into the targets set by different instances and translate them into meaningful numbers for the sector. Those instances include the Kyoto protocol, the European Transport White Paper (2011) and the European Commission’s Low-Emissions Mobility Strategy (2016), which have set reduction targets of -20% (2030 vs 2008) or -60% (2050 vs

1990). The issue with these however is that they do not set a specific target for road freight transport, but at a more aggregate level.
Converting the target to a usable number for the road freight sector is done by going through reported emission data for road transport published by the European Environmental Agency (EEA).

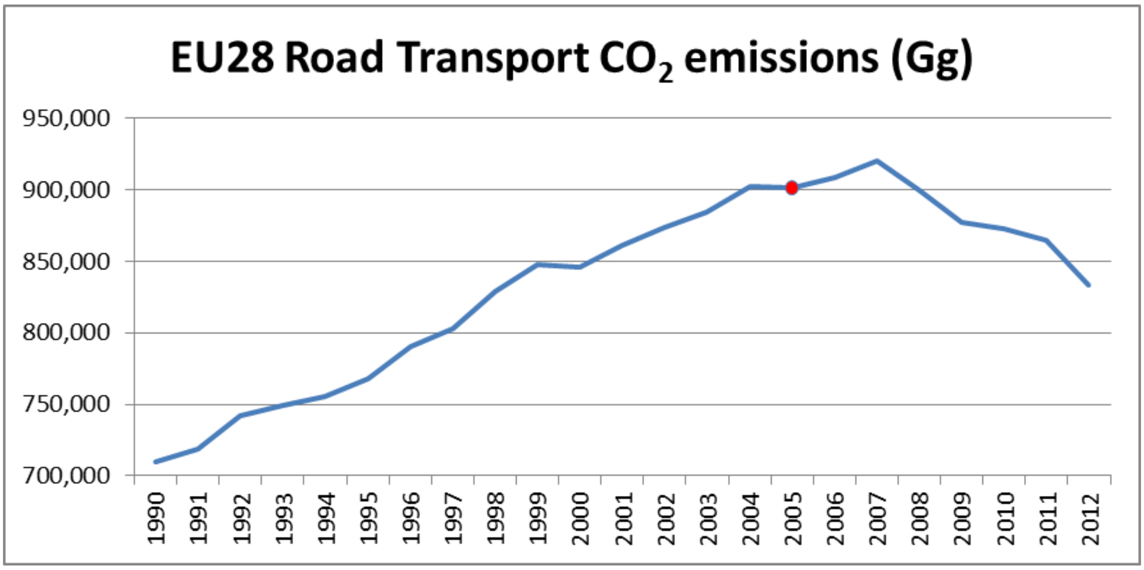

Figure 1: EU28 CO_2 emssions from road transport (source: EEA)

This is then split into passenger transport and freight transport using TREMOVE (v3.5c) output, with the freight sector representing around 30% of the road transport CO_2 emissions. To determine the final target on a per tonne.km basis, we refer to the 2016 EC Transport Reference scenario, which projects a 57% increase in road freight transport demand. Assuming a business-as-usual scenario between 2010 and 2050 (no CO_2 emission improvement), that translates to a 2050 CO_2 emission level for road freight of 411 Mt, whereas the target value is 85 Mt. This puts the real reduction target per tonne.km at just under 80%. Even assuming a lower (40%) growth in demand for road freight transport, the reduction target is still 77%.

3.2 CO_2 reduction measures

This sections discusses the concepts and merits of fuel efficiency improvement measures of different types.

- Propulsion systems and energy carriers
- Other vehicle related measures
- Driving behaviour and automation
- Logistics
- Infrastructure

Propulsion systems and energy carriers
Nearly 100% of the current heavy goods vehicles (HGV) fleet are equipped with a typical internal combustion engine (ICE) and most burn diesel to generate energy for propulsion. Reports by AEA-Ricardo (2011) and TIAX (2011) described extensive research into the options available for increasing diesel engine efficiency. Improving the combustion system

(high pressure fuel injection, reducing engine friction, etc.), waste-heat recovery (turbo-compounding, bottoming cycles, etc.) and other general improvements (friction reduction in other parts of the powertrain, electrification of accessories, etc.) should all help to reduce vehicle CO_2 emissions by at least 15% compared to 2010 levels in the long haul cycle, and around 11% in the regional delivery cycle.

The CO_2 emission of modern natural gas (CH_4) vehicles using High Pressure Diesel Injection (HDPI) can be 10-15% lower than diesel powered vehicles. However, gas powered vehicles are a contentious topic in the discussion of long term CO_2 reduction options due to the fact that their primary fuel is still fossil and it is uncertain whether the renewable alternative (biogas or synthetic gas) can be produced at acceptable costs and at a sufficiently large scale. The Low Emission Mobility strategy nonetheless expects a significant contribution from gas powered vehicles, which will be needed given the significant investement that the refuelling infrastructure to be constructed for gas (CNG & LNG) requires as described by Directive 2014/94/EC on alternative fuels infrastructure.

Another measure in this area that can improve WTW CO_2 emissions is the use of sustainable renewable fuels. Many first generation biofuels (biodiesel in particular) have proven to be unsustainable when land use change effects are included and EU policy on the matter is shifting towards second generation biofuels (produced from non-food crops or waste materials). While these are generally more sustainable than first generation biofuels, they are currently still more expensive than fossil fuels. Nevertheless, the use of hydrotreated vegetable oils from non-food crops is expected to contribute to further CO_2 reduction when fatty-acid methyl esters (FAME, presently the most used alternative to diesel, with a 7% blend wall) can contribute no further. Synthetic fuels (primarily biomass-to-liquid), which are in an earlier phase of technological development (mainly with regard to production cost) should also enter the market before 2030.

As for their long-term contribution, the 2011 International Energy Agency (IEA) roadmap for biofuels projects that by 2050, 27% of global transport fuels should be renewable (at least second generation). Although this covers all transport modes, we assume that the 27% level will be valid specifically for road freight transport in Europe too (though it could be argued that aviation and maritime transport will command a larger share). However, much will depend on the right decisions being taken to allocate the necessary resources to commercial road freight transport. According to the Renewable Energy Directive 2009/28/EC (Annex V), second generation biofuels have a well-to-wheel (WTW) CO_2 reduction potential of over 90%, without accounting for land use changes. Their indirect emissions due to land use changes are considered to be around zero (some negative, some positive, depending on the production pathway and feedstock). If these long-term plans come to fruition, a 24% reduction would thus be achievable. Given the current state of the market (in terms of petrol prices, biofuel prices, availability of feedstock and of fuel production plants), a breakthrough may not happen before 2030–2035. Medium-term (2030) expectations should probably be tempered. In a 2013 study, E4tech estimated the 2030 share of advanced biofuels would be 9%–21% of the total amount of biofuels used as diesel substitutes, which was estimated at 11% of diesel volume (up from 7% in the current B7 blend). These calculations would put the potential reduction by 2030 at just over 2%: a maximum 11% (share of biofuel) multiplied by 21% (advanced biofuel share of biofuel mix) multiplied by 90% (reduction in second generation biofuels).

Sustainable electricity in heavy duty freight operations can be supplied to the vehicle in three manners: from a battery, from a hydrogen fuel cell or directly from the grid. The success of the first option will depend primarily on the evolution of battery technology and the range that can be achieved for vehicles at full load. Hybrid configurations are already on the market (with potential reductions in the range of 3-12% depending on the operational profile), and several manufacturers (including Daimler, Volvo, DAF and notably Tesla) have presented full electric battery powered heavy duty vehicles, albeit with limited range of 100-200 km, ideal for short and medium distance operations (with the exception of Tesla – though their claims about an 800km range are questioned by experts). Full battery-powered electric operation should be possible in urban delivery well before 2050.

An option that is less contested in terms of its usability is the use of Electric Road Systems, where the electric energy is transmitted to the vehicle while on the road, with three main connection systems being tested:

- through overhead catenary wires and a pantograph mounted on the roof of the vehicle;
- a conductive system which transmits energy from the power grid to rails in the ground and then to the vehicle via a slide-in current collector system;
- inductive charging transmits energy from the road to the moving vehicle wirelessly via a magnetic field.

All systems have their advantages and disadvantages in terms of energy efficiency, cost (investment and maintenance of the road and of the vehicle), robustness, safety and visual impact. While it remains to be seen which option(s) will be applied, our consultation of literature and experts suggests that the long term CO_2 reduction potential of electrification is around 37% in the long haul, which is mainly determined by the share of the primary road network that can be electrified.

Electricity can also be deployed indirectly in power-to-gas or power-to-liquid applications, creating a fossil-free fuel when the electricity used in the process is sustainably generated.

Hydrogen fuel cell technology as a means of decarbonisation is also being tested, yet it has considerable pitfalls: hydrogen production is currently mainly based on steam reforming of (fossil) methane, while sustainable production would rather be based on electrolysis of water – a process whose cost effectiveness depends on the price and supply of renewable electricity. The cost of fuel cell technology itself as well is considerably higher than that of ICE or battery electric vehicles. While learning effects and economies of scale could lead to significant cost reductions, the uncertainties regarding the determinants for these effects (including the advances in other electrification technologies and the uptake in the passenger car market) could be prohibitive. Therefore, fuel cell technology is not explicitly considered in the final overview of reduction technologies, as was also done in the T&E (2016) roadmap.

Other vehicle related measures

In addition to measures based on engine efficiency and energy carriers, other modifications can be made to vehicles in order to reduce emissions, such as lowering aerodynamic drag or rolling resistance.

The 2015 amendment to Directive 96/53/EC created derogations to maximum length regulations by allowing for design changes specifically intended to improve vehicles' aerodynamic performance, i.e. by addressing the issue of airflow along the vehicle, starting with the front but also including solutions to allow aerodynamic modifications, such as roof deflectors, side fairings, a boat tail on the (semi-)trailer, or even semitrailers shaped like a teardrop or with adjustable rooftops. An important point to remember about the effectiveness of aerodynamic modifications is their interaction with vehicle speed limits. As speed decreases, so does the savings reduction potential of aerodynamic measures. A 10% reduction in aerodynamic drag at 90 km/h leads to a 3.9% reduction in fuel consumption. At 80 km/h, this results in a 3.4% reduction in fuel consumption (or a 13% "efficiency loss"). Accounting for interactions and market penetration, the fuel use reduction potential of aerodynamic measures is estimated to be 6% by 2030 and 9% by 2050 in long haul, and about half that in regional delivery operation.

Rolling resistance is the second force which road vehicles must overcome, and indeed it is the most important one for speeds up to the maximum limits set for HGVs by national and EU rules. The use of low rolling resistance tyres (LRRT) is expected to provide significant benefits to CO_2 emissions reduction, according to a review study of the Tyre Labelling Regulation (EC) No 1222/2009 by Viegand Maagøe A/S (2016). In 2015, the average C3 tyre (for heavy-duty vehicles, HDVs) had a rolling resistance coefficient (RRC) of 6.1, equivalent to class D. By 2030, this could evolve to class B (RRC = 4.6) or even class A (RRC = 3.5) according to the most optimistic scenario. This is equivalent to CO_2 emission reductions of 7.5% and 12.5%, respectively, which we will use as the reduction values for 2030 and 2050 respectively, assuming full penetration of the applicable tyre class in the given year. Additional (limited) benefits can be provided by single wide tyres and tyre pressure monitoring systems.

The use of lighter materials in the construction of HGVs is a topic of ongoing research for vehicle and trailer manufacturers. Both TIAX and AEA-Ricardo have reported that a CO_2 emission reduction of 2.2% is possible with appropriate lightweighting. However, due to weight increases from other types of measures, the net weight effect of all modifications is probably closer to zero.

Driving behaviour and automation

Advanced driver assistance systems (ADAS) built into new vehicles often serve a dual purpose: improving safety and reducing fuel consumption. A non-exhaustive list of technologies providing better fuel efficiency includes:

- *Predictive Cruise Control* is a system using GPS to determine the vehicle's position and anticipate shifts in power requirements, mainly due to upward and downward sloping roads. Fuel efficiency improvements of 2%–5% are possible, depending on the route.
- *Adaptive Cruise Control* (ACC) is a sensor-based technology to detect the speeds of nearby vehicles. By better anticipating the behaviour of other drivers, excessive braking and accelerations can be avoided. This measure's contribution will be greater in more congested areas. In a way, ACC is a step towards vehicle platooning (see further).
- *A Green Zone Indicator* is a dashboard meter that shows fuel consumption in real-time and suggests modifications to driving behaviour (changing gear, braking, etc.). In itself, this measure does not reduce fuel consumption, but it guides the driver towards a more efficient driving style.
- *Speed limiters* can help engines to run at more efficient levels. A limit of 80 km/h instead of 90 km/h can reduce fuel consumption by almost 4%. This can also be done by drivers voluntarily adopting speed reductions. A majority of European countries already limit the maximum speed of HGVs to 80 km/h (e.g. Germany and Italy, but not France or the UK).

- *Acceleration control* limits the time the engine can perform at peak load, when fuel consumption increases disproportionately. In the long- haul cycle, with relatively little acceleration and braking, its effect is likely to be small.
- *Eco-rolling* is a practice where the engine goes into idle mode when the HGV is coasting down a hill. The effectiveness depends on the route, but average savings of 1% could be realistic.

Many of the effects above can also be achieved by training drivers to adopt a more fuel-efficient and safe driving style - these measures are mostly complementary. According to McKinnon (2008), CO_2 emissions savings of up to 10% per vehicle are possible. At the fleet level in the UK, Faber Maunsell (2008) projected a reduction in fuel consumption of 2%–8%, with an average of around 5%. Effects are, however, likely to diminish as time progresses, meaning that regularly recurring training is recommended. The ECOeffect project carried out limited real-world testing and found that immediate reductions of up to 20% were possible, dropping off to 7%–10% later. In the GHG-TransPoRD study, the potential of eco-driving training for the whole road transport sector was estimated at 10%. The same number was found by AEA-Ricardo (2011) for the UK. Driver training is likely to be more effective in situations where lots of driver action is needed, i.e. in urban areas rather than motorway driving.

As ADAS and driver training mostly follow the same impact pathways, it is best to assess their combined potential. Driver training works for any vehicle but requires frequent refresher sessions to maintain results. As ADAS increase their penetration in vehicle fleets, they will progressively automate many of the actions a well-trained driver would take to reduce fuel consumption. A total potential reduction of around 8% (long haul to 10% (regional delivery), made up of short-term (training) and medium-term (combined training and ADAS) efforts. If operators decide to apply a reduction in maximum speeds to 80 km/h, an additional 2-6% can be saved.

When it comes to automation in the context of intelligent transport systems (ITS) and CO_2 reduction, one of the practices closest to the market is probably vehicle platooning. A platoon of HGVs is essentially an organised, semi-automated vehicle column, each following closely behind the other in a centrally coordinated manner (using ITS-based vehicle-to-vehicle communication). Platooning would be able to significantly reduce the air turbulence between vehicles. Given that aerodynamic drag represents 34%–39% of the force that an HGV needs to overcome at motorway speeds, the resulting reduction in fuel consumption could be significant, around 2-8% for the lead vehicle (which only experience a reduction of air drag at the back of the vehicle), and 8-13% for the following vehicles, according to the SARTRE project, or about 10% on average. Based on assessments about market share from TNO (2015), the expected total reduction in long haul is expected to be 1-4%. ITS measures in regional delivery can also include dynamic routing, avoiding congested roads to reduce consumption. The potential of ITS measures in this type of operation is estimated at 2-5%.

Logistics

An important component of optimising efficiency is avoiding empty runs or sub-optimally loaded vehicles. The load factor/fill rate is not straightforward to define: it refers to the percentage of the maximum payload on a vehicle during a trip, but the payload is often expressed in weight terms. This definition works for high-density goods, but an important part of the goods transported by road are low density, and a vehicle’s loading unit may run out of volume before the maximum payload weight is reached (“cubing out”). For palletised goods, it may also be that floor space runs out before the maximum weight or volume is reached. The incentive to maximise HGV fill rates is very strong: within the requirements for service levels (delivery dates/times), it is in the road freight transport and logistics operators' best interest to have as much payload in their vehicles as possible, provided that revenue is higher than incremental cost - which is basically the extra fuel cost (and the incentive gets stronger as fuel prices rise). The total overall improvement possible from greater logistics efficiency (i.e. covering more than just long-haul) over the entire road freight sector is estimated to be around 20% (GHG-TransPoRD (2011), PBL (2014)). This includes digitalisation, collaboration, load optimisation, avoiding empty running, right-sizing the vehicle (e.g. longer, heavier vehicles or small delivery vans), and a relaxation of certain operational conditions such as driving/resting time regulations and delivery windows. With regard to how effective these tools might be at increasing the load factors of laden road freight transport, few or no separate estimates were to be found in the literature. A study by CfSRF (2015) estimates the CO_2 emissions reduction potential of synchronised load consolidation (for laden vehicles) at 0.8% when supported by an ICT platform. Very rough estimates of the contribution these tools could make to increasing load factors for the 2030 and 2050 horizons are 2% and 10%, respectively.

Using longer heavier vehicles (of 25.25m and 60 tonnes) can bring efficiency gains between 10-25% per trip (TML (2008), Fraunhofer (2008), RWS (2010), VDA (2015)); 17.5% average. The eventual contribution to CO_2 reduction is determined by the market uptake. Based on market studies in different countries (Sweden, Finland, Netherlands, Denmark, Germany) and input from the CVOF working group, a 20% market share in long haul transport is considered realistic by 2030, for a 3.5% overall improvement. By 2050, it is assumed that this increases to 30%, and that even larger vehicles also enter the market. A 7.5% overall reduction was estimated. Longer heavier vehicles can also contribute in regional delivery transport when sufficient volume is available, which should be helped by improved logistic organization. However, we expect the CO_2 reduction potential for the total regional delivery operations to be limited to around 1%.

Infrastructure

Infrastructure in the narrow sense contributes to CO_2 reduction through the road pavement and its rolling resistance coefficient. Several contributions to the MIRIAM project suggest that a 10% improvement in RRC can be achieved (in addition to the improvements in tyre rolling resistance), citing country examples like Denmark and Sweden. As part of a normal road-maintenance cycle (resurfacing roads for the sole purpose of emissions reduction does not happen), this could lead to a 3% decrease in fuel consumption by 2030. Although it is possible that further specialised pavement surfaces (or other modifications) allow for greater reductions by 2050, little to no information is available on this matter.

3.3 Conclusion

The outcome of the study is an overview of the potential CO_2 reduction measures, their expected contribution and main conditions/assumptions for successful implementation for the long haul, regional delivery and urban delivery cycles. The quoted figures apply to the vehicle fleet as a whole.

Table 1: CO_2 reduction potential in long haul road freight transport

Long haul	Potential 2030	Potential 2050	Cumulative 2030	Cumulative 2050
Powertrain efficiency	10%	15%	10.0%	15.0%

Gas powered vehicles	2%	4%	11.8%	18.4%
Renewable fuels	2%	24%	13.6%	38.2%
Ecodriving and driver assistance systems	6%	8%	18.8%	43.2%
Lower max speed	2%	2%	20.4%	44.3%
Platooning	1%	4%	21.2%	46.5%
Aerodynamics	6%	10%	25.9%	51.3%
Tyres	7.5%	12.5%	31.5%	57.4%
Road pavement	3%	3%	33.5%	58.7%
Logistic organisation	2%	10%	34.8%	62.8%
Longer heavier vehicles	3.5%	7.5%	37.1%	65.6%
Hybridisation (2030)/electrification (2050)	3%	37%	39.0%	78.2%

For long haul transport, the largest contribution for the long term is expected from renewable fuels and electrification. However, these will take time and money to develop from a technological and economic perspective (particularly given that the electrification measure for long haul transport assumes the construction of power supply on large parts of the primary road network) and intermediate steps are necessary to start the transition now; more efficient power trains, ecodriving, aerodynamic improvements and low rolling resistance tyres should bring significant improvements by 2030. Continuous improvements in logistic processes are also expected to improve load factors and reduce fuel consumption. The reviewed measures bring the 2050 CO_2 reduction target of -80% within reach.

In the **regional delivery cycle**, certain measures are less efficient (aerodynamics, tyres, powertrain efficiency, electrification – which in this cycle will come from more battery operation or advanced hybridization) and others are more efficient (ecodriving, ITS, logistic optimization), but overall, the 80% reduction target will be more difficult (costly) to realise than for long haul. The proposed measures would deliver a reduction of around 68%.

Urban freight transport, which could also stand to benefit from many measures in terms of energy efficiency, should be able to achieve near zero CO_2 emissions through full electrification well before 2050. The EC Transport White Paper (2011) indeed mentions “essentially CO_2 free city logistics in major urban centres by 2030” as a goal, while several European countries have already presented their plans to ban the sale of combustion engine vehicles in the upcoming decades.

4. Conclusions and discussion

Road transport is one of the most challenging sectors to decarbonize in the fight against climate change, but certainly is not without weapons. Certain actions will be needed that require significant investment from both the private sector and society as a whole. The economic production of sustainable biofuels with a high blend wall is an important challenge, as is the development of innovative ways to electrify road freight transport, especially in the heavier operational cycles. These will be the main contributors to lower CO_2 emissions in road freight – and likely in all of transport. Other recent roadmap studies like T&E (2017) and IEA (2017) come to similar conclusions, though T&E is less optimistic about the contribution of biofuels. The availability of sustainable electricity to power vehicles directly or to generate fuel with (power-to-liquid or power-to-gas) will be critical.

However, there is still lots of low hanging fruit ripe for the picking: low rolling resistance tyres and ecodriving can bring significant benefits at negligible costs, while small adjustments to legislation for vehicle weights and dimensions (LHVs, aerodynamics) and operational conditions (driving and resting times, automation) can also unlock important benefits.

5. Acknowledgements

The report “Commercial Vehicle of the Future: A roadmap towards fully sustainable truck operations” that this paper is based on, was sponsored by the IRU.

6. References

- AEA-Ricardo (2011), Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy
- Breemersch, T. & Akkermans, L. (2015), GHG reduction measures for the Road Freight Transport sector up to 2020
- Breemersch, T. & Vanherle, K. (2016), An integrated approach to road freight transport CO2 reduction in Europe,
- Centre for Sustainable Road Freight (2015), An assessment of the potential for demand-side fuel savings in the Heavy Goods Vehicle (HGV) sector.
- E4Tech (2013), A harmonised Auto-Fuel biofuel roadmap for the EU to 2030.
- ECOeffect project, http://ecoeffect.org/
- Ecofys, IIASA & E4Tech (2015), The land use change impact of biofuels consumed in the EU
- European Commission (2011), Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system (White Paper), Brussels 2011
- European Commission (2016), A European Strategy for Low-Emission Mobility
- European Commission (2016), EU Reference Scenario 2016. Energy, transport and GHG emissions. Trends to 2050
- European Environmental Agency, Greenhouse gas emissions from transport
- Faber Maunsell, (2008), Fuel Efficiency Trials Research, conducted for Freight Best Practice
- Fraunhofer (2008), Long-Term Climate Impacts of the Introduction of Mega-Trucks
- International Energy Agency (2011), Technology Roadmap. Biofuels for Transport.
- International Energy Agency (2017), The Future of Trucks
- McKinnon, A.C., (2008), Advice on CO2 emissions from the UK Freight Transport Sector” Committee on Climate Change, London
- MIRIAM project, http://miriam-co2.net/
- PBL (2014), Options for the Road Freight Sector to Meet Long-Term Climate Targets
- Renewable Energy Directive 2009/28/EC
- Rijkswaterstaat (2010), Langere en Zwaardere Vrachtauto’s in Nederland
- SARTRE project (2013), Report on Fuel Consumption
- Sripad, S. & Viswanathen, V. (2017), Performance Metrics Required of Next-Generation Batteries to Make a Practical Electric Semi Truck.
- Tesla Tuck: Fact or Fiction (2017), http://www.dieselnews.com.au/tesla-truck-fact-or-fiction/
- TIAX (2011), European Union Greenhouse Gas Reduction Potential for Heavy-Duty

Vehicles

- TNO (2015): Truck Platooning: Driving the Future of Transportation
- Transport & Environment (2016), Globiom: the basis for biofuel policy post-2020.
- Transport & Environment (2017), Roadmap to climate-friendly land freight and buses in Europe
- Transport & Mobility Leuven (2008), Effects of adapting the rules on weights and dimensions of heavy commercial vehicles as established within Directive 96/53/EC
- Transport & Mobility Leuven (2010), Ranking of measures to reduce GHG emissions of transport: reduction potentials and feasibility qualification" (GHG-TransPoRD D2.1)
- Transport & Mobility Leuven (2012), TREMOVE 3.5c
- Transport & Mobility Leuven (2017), Commercial Vehicle of the Future: A roadmap towards fully sustainable truck operations
- UNFCCC (1997), Kyoto protocol
- VDA (2015), 13 Mythen und die Fakten zum Einsatz von Lang-Lkw in Deutschland
- Viegand Maagøe A/S (2016), Review study on the Regulation (EC) No 1222/2009 on the labelling of tyres