Market Barriers to Increased Efficiency in the European On-road Freight Sector

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Preface

This report has been written for the International Council on Clean Transportation (ICCT). The surveys of transport companies were the basis of many of our conclusions, and the response rate of these surveys was enhanced greatly with the help of Marc Billiet of the International Road Transport Union (IRU). The surveys of Italian stakeholders were carried out by TRT, and the surveys of Polish stakeholders by Agnieszka Markowska. We thank Sten Forseke (Greater Than), Christophe Pavret de La Rochefordiere and Ian Hodgson (European Commission, DG CLIMA, Transport and Ozone Unit), Fanta Kamakaté, Ben Sharpe and Peter Mock (ICCT) for their input and valuable comments on earlier drafts. Errors and omissions are, of course, only attributable to us. Finally, a workshop has been organised to discuss this report with relevant stakeholders, we would like to thank all participants for their feedback.

Jasper Faber

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Summary

Transport is responsible for around a quarter of EU greenhouse gas (GHG) emissions, and the road freight sector for almost 6%. While GHG emissions from other sectors have decreased by almost a quarter between 1990 and 2009, those from transport have increased by almost a third in the same period. Also, in the future, significant increases in total GHG emissions from transport – and in particular of HDVs – are expected if no additional policies are implemented.

In the Transport White Paper, the European Commission presents its vision for the future EU transport system and defines a policy agenda for the next decade in order to start moving towards 60% reduction in CO_2 emissions in 2050 compared to 1990 levels (EC, 2011). Improving the energy performance of vehicles and developing and deploying sustainable fuels and propulsion systems are identified as routes that should be followed to reach this objective.

There are several technical and operational measures available to improve the fuel efficiency of truck fleets, but many of these measures are currently not universally implemented. Even cost-effective measures are often not adopted, i.e. measures which can be implemented at a net profit because the fuel savings outweigh the technology costs.

This report aims to better understand the reasons for the limited adoption of cost-effective fuel-saving technologies and to inform the policy making process in the EU and abroad, and specifically to provide input to the European Commission's strategy for reducing GHG emissions from HDVs. The primary goal of the study is to identify the barriers to the implementation of technologies that improve fuel efficiency in the European road freight transport sector. The study is based on a survey and in-depth interviews with stakeholders, guided by an extensive literature review.

This study first reviews the costs and benefits of existing technologies that improve HGV fuel-efficiency. The review serves as a basis for a survey amongst stakeholders. We have analysed 18 technologies of which seven can be implemented at a net profit over a range of plausible fuel prices, discount rates and write-down periods. Together, these technologies have the potential to increase the fuel-efficiency of trucks by 10 to 32.5%, depending on the type of truck and its operational profile. Ten technologies are often, but not always cost-effective.

Hereafter, we have analysed the existence and importance of barriers through a survey of transport companies, original equipment manufacturers (OEMs), shippers and logistics service providers. In addition, a number of in-depth interviews were held to analyse some of the issues in more detail.

We find that an important barrier is the lack of information on the fuel savings of individual technical measures for trucks and especially on trailers. While many transport companies and all OEMs are aware that certain technologies exist, few respondents believed that these technologies are cost-effective. The survey results suggest that the transport freight industry is more focused on operational improvements for fuel savings than on new technologies; it is a widely held belief in the road freight sector that operational measures – especially those measures which do not require investments – lead to savings, and that technical measures are more costly.

Perhaps as a result of this belief, the supply of fuel-saving technologies from OEMs is limited. Most truck OEMs offer packages of certain technologies as options to prospective truck purchasers. Certain technologies are often not offered on new vehicles, but rather, sold as aftermarket devices for in-use trucks. For trailers, the situation is worse; body builders do not appear to offer fuel-saving equipment unless their client specifically asks for it. The limited supply of trailer-based technologies gives rise to higher search and information costs for transport companies. Moreover, while transport companies are generally allowed to test-drive a truck to evaluate its fuel efficiency, these trucks mostly come with the fuel-saving technology package that OEMs promote (i.e. only with the set of technologies chosen by OEMs), or as a standard truck without any fuel-saving technologies.

Other barriers are also evident in specific situations. For example, in some countries limited access to financial instruments makes it hard to finance fleet modernisation. While the split incentive is not a major barrier in general, it is in some cases. One such split-incentive example is when shippers own trailers and hence decide on its technology (including fuel saving options like low-resistance tires and aerodynamic improvements), but transport companies operate them and hence benefit from fuel savings. Another split-incentive example is when transport companies operate under an open-book contract, under which they can bill the shipper for the actual fuel consumption. Both cases occur but are not universal.

1 Introduction

Transport is responsible for around a quarter of EU greenhouse gas (GHG) emissions. From the various transport sectors road transport is the biggest contributor to the GHG emissions from transport: about two-third of EU transport-related GHG emissions are emitted by road transport (AEA, 2012). Passenger cars are responsible for the main part of these emissions, but Heavy Duty Vehicles (HDVs) account for a significant part of the transport-related GHG emissions in Europe as well. According to AEA (2011), around 26% of all carbon dioxide (CO_2) emissions from road transport in the EU are from HDVs, most of which (85%) are from trucks. The remainder is due to buses and coaches.

While GHG emissions from other sectors have decreased by 24% between 1990 and 2009, those from transport have increased by 29% during this same period. Also, significant increases in total transport GHG emissions – and, in particular, of HDVs – are expected if no additional policies are implemented (AEA, 2010).

In the Transport White Paper, the European Commission presents its vision for the future EU transport system and defines a policy agenda for the next decade in order to start moving towards 60% reduction in CO_2 emissions in 2050 compared to 1990 levels (EC, 2011). Improving the energy performance of vehicles and developing and deploying sustainable fuels and propulsion systems are identified as routes that should be followed to reach this objective.

Several technical and operational measures are available to improve the fuel efficiency of HDVs (AEA, 2011; TIAX, 2011). Many of these measures are currently not universally implemented.

The uptake of fuel-saving technologies in the road freight transport market depends on many factors. However, technologies that have no cost-saving advantage will generally not be applied, unless they have other benefits (e.g. improving vehicle safety, reducing times for loading and unloading, etc.).

In practice, it turns out that even technologies that can save fuel are not always implemented, suggesting that there are barriers, such as:

- split incentives (also called principal-agent problems);
- limited options for funding of investments (related to risk aversion within banks and other financers);
- risk aversion to new technologies within the transport sector;
- information asymmetries (e.g. lack of standardised information).

This report aims to better understand the reasons for the limited adoption of fuel-saving technologies and to inform the policy making process in the EU and abroad, and specifically to provide input to the European Commission's strategy for reducing GHG emissions from HDVs. The primary goal of the study is:

To identify the barriers to the implementation of fuel efficiency improving technologies in the European road freight transport sector.

The scope of the work is:
- EU wide;
- focuses on freight transport in three segments:
  - urban delivery (Gross Vehicle Weight (GVW) ranging from 3.500 kg to 14.000 kg);
  - regional delivery (GVW ranging from 7.500 kg to over 16.000 kg);
  - long haul (GVW ranging from 16.000 kg to over 40.000 kg);
- includes manufacturers (OEMs), shippers, transport companies and logistics service providers;
- limited to technical measures that reduce vehicle fuel consumption but does not include optimisation of the logistics process.

1.1 Outline

The remainder of this report is organised in four chapters. Chapter 2 analyses the cost-effectiveness of measures to improve the fuel-efficiency of heavy goods vehicles (HGVs) for three categories: long haul transport, regional transport and urban delivery. In each of these categories, there are a number of technologies available that appear to be cost-effective under a wide range of fuel prices and other factors.

Chapter 3 presents a review of the literature on barriers to the adoption of fuel-saving technologies with a special emphasis on the road freight sector. It classifies the barriers in three categories: technology-specific, institutional and financial.

The importance of these barriers is analysed in Chapter 4 and is based on a survey of transport companies, equipment manufacturers and other relevant stakeholders.

Chapter 5 presents our conclusions.

2 Fuel-saving technologies in the on-road freight sector

2.1 Introduction

The on-road freight sector contributes to global warming as heavy goods vehicles (HGVs) emit a significant part of the total road transport GHG emissions (AEA, 2011). Improving the efficiency of these vehicles would therefore assist the transport sector in meeting its long term climate target of a 60% GHG emission reduction in 2050 compared to 1990 levels. According to the IPCC (2007), energy-efficiency improving measures are very important in order to reach these targets. A recent study by TIAX (2011) has found that there are multiple measures already available, or becoming available between 2015-2020, that can improve the energy-efficiency of HDVs. The AEA-Ricardo and TIAX studies both report that these near-term technologies can reduce per-vehicle CO_2 emissions by 30 to 50%. However, many of these fuel-saving technologies and approaches have had slow uptake into the market, which has been confirmed by the results of this study (Section 4.3.5).

A recent project by CE Delft (2012) has calculated the cost-effectiveness of these technologies and Marginal Abatement Cost Curves (MACCs) for different market segments, including the urban, regional and long haul segments of on-road freight transport that are the focus of this study. This model (called the *MACH model*) indicates that several fuel-saving technologies have higher benefits than costs in at least some scenarios, although the exact figure depends on underlying assumptions, such as fuel prices or the discount rate.

This chapter will summarise some of the technologies transport companies can employ to reduce fuel consumption and CO_2 emissions and how these technologies compare in terms of cost-effectiveness. A technology is considered cost-effective when the Net-Present Value (NPV) of the benefits – in terms of fuel savings – outweigh the NPV of the investment and possible operational costs.

The choice of technologies, their investment costs, operational costs and fuel savings have been taken from the TIAX study (2011). Using the MACH model of CE Delft (version of May, 2012), we have estimated the cost-effectiveness of these technologies using different assumptions on key parameters such as discount rates, fuel price and write down period. Various values for these assumptions have been used to test the robustness of the cost-effectiveness estimates. To bound the estimates, one set of scenarios uses low fuel prices in combination with high discount rates, as this degrades the cost-effectiveness of technologies. At the other end of the spectrum, high fuel prices and low discount rates are combined for the scenarios in which technologies are the most attractive in terms of cost savings over time.

We have varied three parameters in the model of CE Delft (2012). The input parameters should not be considered as forecasts or projections, but rather as assumptions needed to test the likelihood of different technologies being cost-effective under a wide range of different circumstances. It is important to take such variations into account, as earlier studies (e.g. CE, 2009a) have found that the inputs chosen have a large influence on the benefits of energy-efficient technologies. The input parameters chosen are:

- Discount rate[1]; It was particularly hard to find information about discount rates used in the on-road transport sector, hence we have assumed two discount rates that reflect medium (10%) and high (16%) risk premiums. These coincide with weighted average cost of capital in other transport sectors (see e.g. IMO, 2010).
- The fuel price; € 1/litre (low), € 1,50/litre (moderate) and € 2/litre (high). Currently, the average diesel price in Europe is € 1,39. Obviously, different countries have different diesel prices, which ranges from € 1,18 in Luxembourg to € 1,72 in the United Kingdom at the moment (Europe's Energy portal, 2012).
- The vehicle lifetime: the lifetime of vehicles varies between the different market segments. Thereby, the actual lifetime of a vehicle can be much longer than the number of years that the company *owns* the vehicle, as companies often sell their vehicles before the end of their lifetime. In this case, companies are likely to use the number of years they *own* the vehicle in their calculations rather than the actual lifetime. Obviously, this can have an impact on the estimated benefits resulting from the investment, and hence on its cost-effectiveness. Therefore, it is important whether the transport company expects to receive a higher resale value for a more fuel-efficient trucks as compared to a less fuel-efficient one. The resale value that is estimated will also have an impact on the cost-effectiveness of a technology. We have set the lifetime that TIAX (2011) has estimated as the high value (which is the estimated actual lifetime of a vehicle), while dividing this high value by 2 to obtain a estimate of the low value (which can be considered as a shortened lifetime in case the vehicle is sold before the end of its lifetime):
  - Long Haul; low (4 years) and high (8 years).
  - Regional; low (6 years) and high (12 years).
  - Urban; low (9 years) and high (19 years).

The next section will describe the fuel-saving technologies that are included in the MACH model (CE, 2012). Hereafter, Sections 2.3, 2.4, and 2.5 will examine the cost-effectiveness of these technologies in more detail for urban delivery, regional delivery, and long haul, respectively.

It should be mentioned that although marginal abatement cost figures similar to the ones presented in this chapter are often used by governments to design policies, most likely this is not the case for transport companies. In other words, companies will probably use other indicators (e.g. NPV or payback time) to determine whether or not to invest in a technology (see Section 4.3.4). Despite this, the cost-effectiveness analysis is relevant as it still provides an indication of which technologies have higher benefits than costs in different scenarios (which is closely related to the NPV and payback period of a technology). In addition to potentially providing useful information to the industry, the cost-effectiveness metric facilitates estimates of the costs of GHG abatement, which is relevant from a societal perspective.

2.2 Fuel saving measures

Owners of trucks and trailers can implement a variety of measures to improve the energy-efficiency of their vehicles. TIAX (2011) has identified 24 different measures in seven different categories of HDVs. These technologies were also

[1] The discount rate is a factor used to determine the present value of future cash flows, as the value of a future cash flow is worth less than if the same cash flow occurs in the present time (due to missed interest earnings). The higher the discount rate, the lower the value of a future cash flow.

included in the MACH model of CE Delft (2012). Not every one of these technologies is already available to transport companies today, as TIAX (2011) also included technical measures that will become available between 2015 and 2020.

Also, not every technology is appropriate for every market segment; a predictive cruise control system, for example, is useful for vehicles traveling long distances at a time. Hence, adopting this technology in the urban segment would not deliver many fuel-saving benefits (AEA, 2011). Therefore, even if a technology would be able to reduce fuel consumption in multiple market segments, the exact amount of fuel savings would still differ between these segments due to the different types of vehicles used, different driving cycles, and so on (AEA, 2011).

Table 1 provides an overview of the technologies identified by TIAX (2011) that can reduce fuel consumption in the urban, regional and/or long haul market segment. For each technology an indication is given as to whether the technology needs to be installed on the truck or on the trailer. This is an important difference to acknowledge as transport companies buy their trucks and trailers from different parties, and there may be differences in ownership patterns of trucks versus trailers (i.e. although many truck companies may own their trucks, this is not necessarily the case for the trailers they operate).

Table 1 Overview of possible measures to increase energy efficiency

Category	Technology	Applicable to:	
		Truck	Trailer
Aerodynamics	Trailer rear end taper (in MACH model called an 'aft box taper')		√
	Boat tail		√
	Trailer skirts (in MACH model called 'box skirts')		√
	Cab side extension or gap fairings	√	
	Full gap fairing	√	
	Full skirts		√
	Roof deflector	√	
Light-weighting	Material substitution	√	√
Tires	Automatic tire inflation on vehicle	√	
	Automatic tire inflation on trailer		√
	Low rolling resistance wide-base single tires	√	√
Transmission and driveline	Transmission friction reduction	√	
Engine efficiency	Improved diesel engine	√	
Hybridisation	Dual-mode hybrid	√	
	Parallel hybrid	√	
Management	Predictive cruise control	√	
	Route management	√	
	Training and feedback	√	

Source: TIAX, 2011, edited by CE Delft.

The technologies that are shown in Table 1 above are described in more detail below.

Aerodynamics

After accounting for the energy that is lost to heat during the combustion process, aerodynamic resistance typically represents the largest drag force for vehicles operating at highway speeds (i.e. at 80 kph). Therefore, reducing the aerodynamic drag of trucks improves fuel efficiency. These benefits are largest for vehicles that travel long distances at high speeds (AEA, 2011). Several technologies can be implemented to reduce aerodynamic drag (illustrating pictures can be found in Figure 1):

– *Trailer rear end taper*: a trailer rear end taper is a tapered extension of the back end of a trailer which reduces wake and drag resistance (TMA, 2007).
– *Boat tail:* a boat tail is a tapered extension of the trailer (longer than a trailer rear end taper) to reduce the wind resistance from the trailer (TW, 2009).
– *Trailer skirts:* These are vertical plates that are placed in the longitudinal direction of the truck covering the open spaces. This can reduce wind resistance as it prevents wind flow from going under the truck where the flow would run into many disturbances (e.g. storage boxes, axles and the wheels) (TU Delft, 2008).
– *Cab side extensions or gap fairings*: Cab side extenders bridge the gap between the cab and the body of the truck; they are located at the sides of the rear cab edges (AEA, 2011).
– *Full gap fairing:* are additional add-ons bridging the gap between the cab and the body of the truck (ibid.).
– *Roof deflector*: this is a three-dimensional moulding on the cab roof that allows the wind flow a smooth transition from the cab roof to the trailer (ibid.).

Figure 1 Aerodynamic technologies


Trailer rear end taper


Boat tail


Trailer skirts


Cab side extenders


Full gap fairing


Roof deflector

Light-weighting

Reducing the weight of vehicles can reduce their energy consumption and therefore reduces the amount of CO_2 that is emitted (IFEU, 2003). For the on-road freight sector, weight reduction is typically achieved by substituting relatively heavy materials for lighter aluminium alloys (AEA, 2011).

Tires

Technologies in this category are mainly aimed at reducing the rolling resistance of tires (AEA, 2011):

– *Low rolling resistance tires;* these are tires that are optimised to provide the lowest possible level of rolling resistance (ibid.).
– *Automatic tire inflation:* low tire pressure results in larger rolling resistance, which increases fuel consumption (ECLA, 2010). An automatic tire inflation system, which can either be placed on the vehicle itself or on the trailer, automatically inflates tires when pressure is low (AEA, 2011; TIAX, 2011). It should be mentioned that this is relatively expensive in contrast to a tire pressure monitoring system (TPMS), which also measures the pressure of the tires and provides this information to the driver, but cannot inflate the tires automatically. This information system was included in the questionnaires as well, as it is argued by some parties to be very cost effective (Doran Manufacturing, 2011).

Transmission and driveline

Friction in the transmission and other driveline components reduce vehicle efficiency. By reducing this friction, less fuel is consumed, and less carbon is emitted. This can be accomplished by using low friction plastics for the key components for example.

Engine efficiency

Technical developments constantly improve engines' efficiency. Adopting measures to increase the efficiency of engines improve the overall fuel efficiency of the vehicle. Two types of engines have been distinguished, one for the regional and urban segment and one for the long haul segment. The former is an advanced 6-9 l engine with 220-230 bar cylinder pressure, 3.000 bar fuel injection and a peak thermal efficiency of 46 to 49%, whereas the latter comprises of an advanced 11-15 l engine with 240 bar cylinder pressure, 4.000 bar supercritical atomisation fuel injection and a peak thermal efficiency of 51 to 53%[2].

Hybridisation

Hybrid systems for HGVs aim to reduce unnecessary engine idling when the vehicle is stationary (by means of a start/stop hybrid) and/or to recover energy from braking, which is stored and then used to help accelerate the vehicle (AEA, 2011). Hybrid technologies will have largest benefits for vehicles operating in urban areas as these vehicles typically have transient driving patterns (ibid.). Two hybrids are distinguished by TIAX (2011) for the market segments that are the focus of this study:

[2] Further technical specifications of both engines can be found in TIAX (2011).

- *(Generation II) Dual-mode hybrid (long haul and regional haul):* The dual mode hybrid automatically switches the engine off at idle. When accelerating from stop, the diesel engine and electric motor blend their power until the truck has reached highway speed, from there the diesel engine takes over, although the electric motor can still assist when going up a steep hill for example. In addition, the electric motor is used to power all accessories that would normally run with the diesel engine, such as the power steering or air compressor. Its batteries can be loaded either from storing energy that is released when breaking or the diesel engine can work as a generator (ArvinMeritor, 2008).
- *Parallel hybrid:* A parallel hybrid turns the engine off at idle and uses the electric motor to drive when starting. Thereafter, the diesel engine is started as well; both power sources can work in parallel. The electric motor also works as a generator to deliver energy that is recovered from braking to the battery pack (Volvo trucks global, 2012). As vehicles driving in urban areas need to brake often, the parallel hybrid is typically advantageous for this group of vehicles (TIAX, 2011).

Management

In addition to improvements in vehicle technologies, there are other measures that can be taken to reduce CO_2 emissions, mostly by focusing on driver behaviour and the management of the fleet (AEA, 2011; TIAX, 2011).

- *Predictive cruise control:* a system that combines GPS data with cruise control to optimise gearing and speeds to reduce the fuel consumption of vehicles (AEA, 2011).
- *Route management:* logistics-related improvements such as utilising dynamic route management software to streamline operations can reduce fuel consumption.
- *Training and feedback:* driver training and evaluation programmes as well as real-time vehicle performance displays have been shown to reduce fuel consumption. A well-known example is the Ecodriving program, which is offered by different parties (ECLA, 2010).

2.3 Urban delivery

In order to estimate the extent to which the technologies described in the previous sector are likely to be cost effective, the MACH model of CE Delft (2012, model version of May 2012) was used. This was done by simulating their cost-effectiveness in different scenarios - varying the discount rate, vehicle lifetime, and fuel price (described in Chapter 1) -. This results in a total of 9 different scenarios in which each technology has different marginal abatement costs (MACs)[3]. The MACs of the different technologies in this wide range of scenarios can be found in Annex A.1 for the urban segment. These results are summarised in Table 2 below.

[3] The marginal abatement costs reflect the costs of abating one additional unit of CO_2

Table 2 **Cost-effectiveness of urban vehicle technologies in different scenarios**

Technology	Cost effective in *all* of our scenarios	Cost effective in *some* of our scenarios	Cost effective in *none* of our scenarios
Low resistance wheels	X		
Trailer rear end taper	X		
Roof deflector	X		
Trailer skirts	X		
Advanced 6-9 l engine		X	
Parallel hybrid		X	
Cab side extension		X	
Material substitution			X

As can be seen in Table 3, within the urban market segment, four technologies were cost-effective in every of our assumed scenarios; these are:

- **Low rolling resistance tyres** (cost-effectiveness ranging from -140 to -420 €/tonCO_2).
- **Trailer rear end taper** (Cost-effectiveness ranging from -70 to -390 €/tonCO_2).
- **Roof deflector** (Cost-effectiveness ranging from -70 to -370 €/tonCO_2).
- **Trailer skirts** (Cost-effectiveness ranging from -60 to -360 €/tonCO_2).

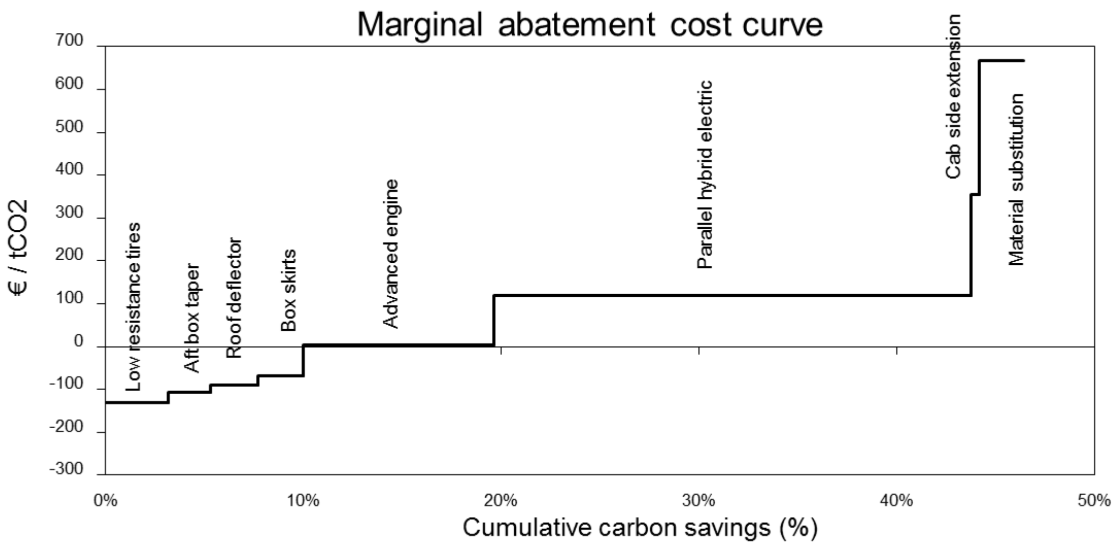
The negative cost-effectiveness of these technologies indicates that with the assumed parameters, reducing one ton of CO_2 actually delivers enough cost savings to completely offset the investment and even generate profits as a result of reduced fuel use. However, it should be emphasised that these are simulated scenarios; in practice, cost effectiveness will differ significantly between companies as they will use different information sources of costs and benefits, and will choose different underlying parameters in their calculations.

Additionally, the advanced 6-9 l engine, parallel hybrid and cab side extensions were cost effective in some of our scenarios. Finally, material substitution was not cost-effective in any of the modelled scenarios.

The results of the model simulations (Annex A) confirm the findings of CE Delft (2009a). The assumptions made with respect to fuel prices, discount rates and vehicle lifetime had a significant influence on the cost-effectiveness of a technology. For example, increasing the fuel price by 1 Euro (everything else remaining equal) increases the cost-effectiveness of some technologies by 100 or sometimes even 200%. The same applies to the assumed discount rate, although this mechanism works the other way around; the lower the discount rate, the higher the benefits.

The MACH model (CE, 2012) further shows that if the four technologies that were cost effective in all of our scenarios would be adopted by companies operating in the urban market segment, CO_2 would be reduced by **10%**. Moreover, a CO_2 reduction of approximately 44% could be achieved in the urban market segment if all technologies except for material substitution (as this technology is not cost-effective in any of our scenarios) are adopted. This reduction potential and relative costs/benefits of the different technologies are shown graphically for our worst-case scenario (i.e. with a high discount rate, low fuel price, and low vehicle lifetime) in Figure 2 below.

Figure 2 **Reduction potential and relative costs of technologies in the urban market segment in the worst case scenario**



Source: MACH model (CE, 2012).

2.4 Regional delivery

In addition to the urban segment, the cost-effectiveness of different technologies in the regional segment has been estimated with several model runs. The results of the model runs can be found in Annex A.2 and are summarised in Table 3 below.

Table 3 **Cost-effectiveness of regional vehicle technologies in different scenarios**

Technology	Cost effective in *all* of our scenarios	Cost effective in *some* of our scenarios	Cost effective in *none* of our scenarios
Low resistance tires	X		
Predictive cruise control	X		
Transmission friction reduction	X		
Advanced 6-9 l engine	X		
Boat tail		X	
Auto. tire inflation trailer		X	
Full skirts		X	
Material substitution		X	
(Generation II) Dual hybrid			X
Auto. tire inflation vehicle			X
Full gap fairing	-	-	-

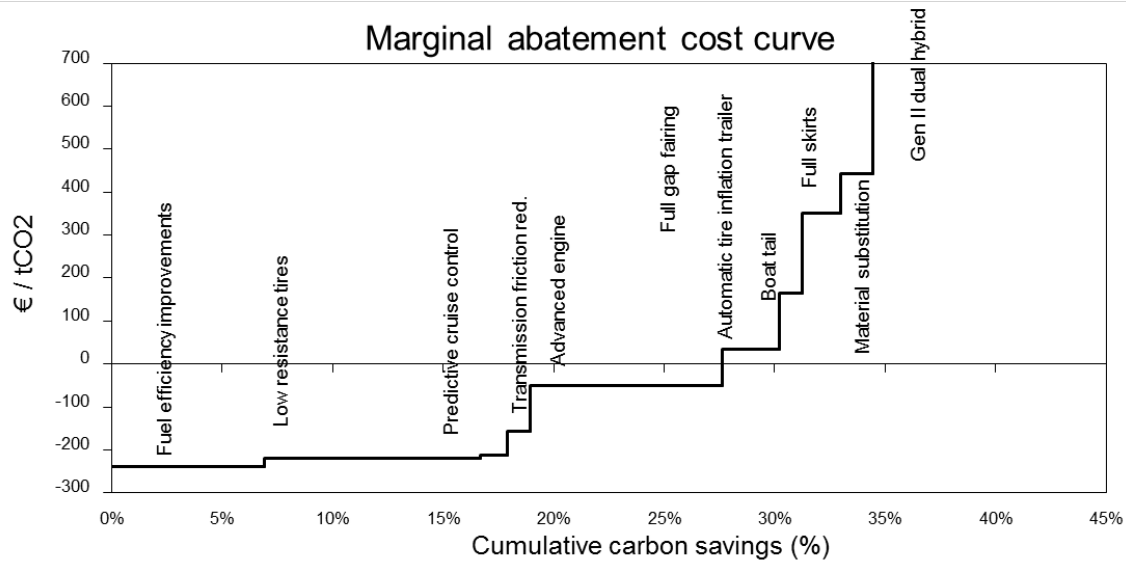
As indicated in Table 4 above, four technologies in the regional vehicle segment resulted in higher benefits than costs in every model run. These technologies are:

- **Low resistance tyres** (Cost-effectiveness ranging from -150 to -530 €/tonCO_2).
- **Predictive cruise control** (Cost-effectiveness ranging from -150 to -520 €/tonCO_2).
- **Transmission friction reduction** (Cost-effectiveness ranging from -120 to -470 €/tonCO_2.).
- **Advanced 6-9 l engine** (Cost-effectiveness ranging from -50 to -370 €/tonCO_2).

It was already explained in the previous section that the negative cost-effectiveness means that the benefits of reducing one ton of CO_2 are larger than its costs. The boat tail, automatic tire inflation on the trailer, full skirts, and material substitution were cost-effective in some of the model runs. Finally, the automatic tire inflation system on the vehicle and the dual hybrid system were not cost-effective in any of our scenarios.

The reduction potential in the regional segment is substantial; the MACH model (CE, 2012) estimated that if the four technologies that were cost effective in all of our assumed scenarios (technologies in bold above) are implemented, CO_2 would be reduced by **28%.** Moreover, if the technologies that were cost-effective in some of our scenarios would also be adopted, CO_2 emissions would be reduced with 35%. These cumulative carbon savings do include the CO_2 reduction benefits from *improved efficiency of fuels* (i.e. reduced carbon content) that is expected from 2010-2014 though. Hence, the actual savings that would merely result from implementing these fuel-saving technologies will be approximately 7% lower. The estimated reduction potential and relative/benefits/costs of abatement in the worst-case scenario (i.e. high discount rate, low vehicle lifetime and lowest fuel price) are shown in Figure 3 below.

Figure 3 **Reduction potential and relative costs of technologies in the regional market segment in the worst case scenario**



Source: MACH model (CE, 2012).

2.5 Long haul

Nine model runs were conducted to estimate the cost-effectiveness of the different fuel-saving technologies in the long haul vehicle segment as well. The marginal abatement costs of these different technologies in the different scenarios can be found in Annex A.3 and are summarised in Table 4 below.

Table 4 Cost-effectiveness of long haul vehicle technologies in different scenarios

Technology	Cost effective in *all* of our scenarios	Cost effective in *some* of our scenarios	Cost effective in *none* of our scenarios
Low resistance tires	X		
Predictive cruise control	X		
Transmission friction reduction	X		
Training & Feedback	X		
Boat tail	X		
Auto. tire inflation trailer	X		
Full gap fairing	X		
Advanced 11-15 l engine	X		
Route man.		X	
Full skirts		X	
Material substitution		X	
(Generation II) Dual hybrid		X	
Auto. tire inflation vehicle			X

As can be seen in Table 5, many of the long haul energy-efficient technologies were cost-effective in all of our assumed scenarios. These eight technologies comprise of:

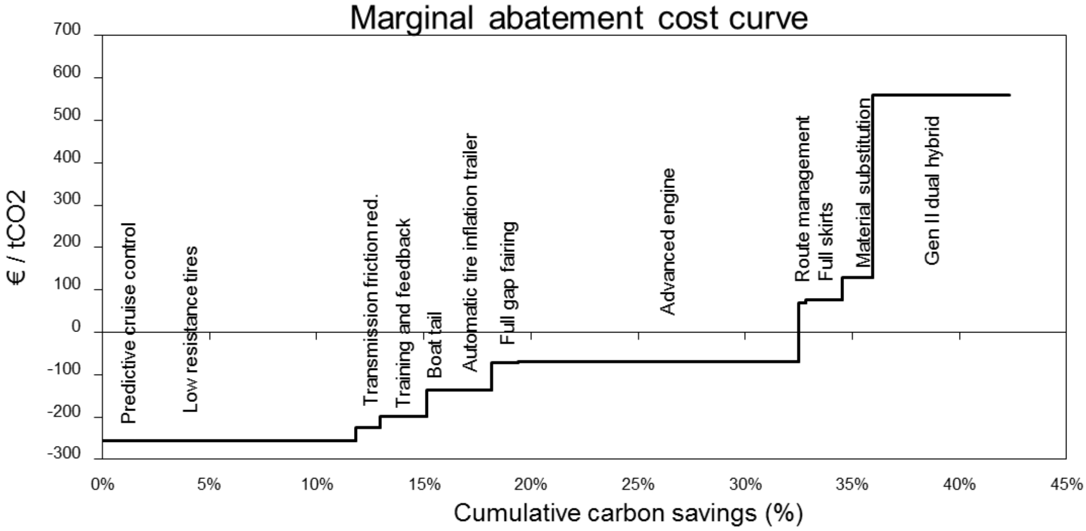
- **Low resistance tires** (Cost-effectiveness ranging from -200 to -590 €/tonCO_2).
- **Predictive cruise control** (Cost-effectiveness ranging from -200 to -580 €/tonCO_2).
- **Transmission friction reduction** (Cost-effectiveness ranging from -180 to -550 €/tonCO_2).
- **Training and feedback** (Cost-effectiveness ranging from -170 to -530 €/tonCO_2).
- **Boat tail** (Cost-effectiveness ranging from -140 to -470 €/tonCO_2).
- **Automatic tire inflation trailer** (Cost-effectiveness ranging from -140 to -470 €/tonCO_2).
- **Full gap fairing** (Cost-effectiveness ranging from -80 to -410 €/tonCO_2).
- **Advanced 11-15 l engine** (Cost-effectiveness ranging from -70 to -410 €/tonCO_2).

These technologies are most likely to be beneficial when implemented in the long haul vehicle segment as the benefits of reducing CO_2 outweigh its costs. Route management, full skirts, material substitution and the (generation II) dual hybrid were also cost effective in some of our scenarios. The automatic tire inflation on the vehicle on the other hand was not cost-effective in any of these scenarios.

The MACH model (CE, 2012) further indicated that when implementing the eight technologies in the long haul segment that are cost effective in all of the assumed scenarios, a CO_2 reduction of **32.5**% would be achieved. When route management, full skirts, material substitution and the dual hybrid engine would be adopted as well, a CO_2 reduction of 42,2% could be obtained.

Figure 4 shows the abatement potential and costs/benefits of the different technologies when implemented in the long haul segment under unfavourable assumptions (i.e. a high discount rate, low fuel price, and short lifetime).

Figure 4 Reduction potential and relative costs of technologies in the long haul market segment in the worst case scenario



Source: MACH model (CE, 2012).

2.6 Conclusion

This chapter has shown that in each market segment (i.e. urban, regional, and long haul segments) there are several technologies that are potentially cost-effective to implement, even when the underlying parameters of fuel price, discount rate and vehicle lifetime vary substantially. Put differently, in our scenarios, each market segment has several technologies for which the benefits resulting from reduced fuel consumption (and hence reduced CO_2 emissions) are larger than their implementation costs. It should be emphasised that this was the case for the scenarios that were designed for this analysis and is based on information of other studies, which in turn have estimated European averages. In practice, some companies may perceive higher benefits than our estimations, whereas others may face worse outcomes than the results presented in this chapter. Either way, the CO_2 reduction that could be obtained by implementing the most cost-effective technologies is 10% for urban, 27.6% for regional and 32.5% for long haul vehicles.

Additionally, the results of the model runs have shown the significant influence of fuel price, discount rate and vehicle lifetime on the cost-effectiveness of the different technologies.

3 Overview of barriers to the implementation of cost-effective technologies

3.1 Introduction

The previous chapter has shown that there are several fuel-efficient technologies in the on-road freight sector that are cost-effective to implement and would reduce CO_2 significantly. However, the adoption rate of these technologies appears to be low, which was also the case in our sample of transport companies (see Section 4.3.5). This may indicate that an *efficiency gap* is present in the on-road freight sector.

Some economists argue that this gap indicates that there are calculation artefacts in estimating the cost-effectiveness of the technologies. This may be the case if fuel prices are overestimated or if not all real cost components are included (e.g. Nickell, 1978, cited in CE, 2009b). Costs for searching and evaluating technologies may be overlooked, for example. The logic behind this argument is that companies that aim to maximise profits would have implemented a fuel-saving technology if its benefits had truly outweighed its costs. Although the previous chapter indeed showed the sensitivity of cost-effectiveness to changes in the underlying parameters, this view is widely debated.

Another explanation of the existence of an efficiency gap is the presence of (market) barriers that impede the adoption of energy-efficient measures. *Market barriers* have been defined as 'any obstacles that contribute to a slow diffusion and adoption of energy-efficient technologies' (Ecofys, 2007). An extensive literature review has been carried out in order to identify these possible barriers to fuel-saving technologies in the on-road freight sector. However, while there is a substantive body of literature on market barriers in general, the available literature dealing with the road freight sector is limited. This chapter describes the results of the literature review; the remaining sections will explain several categories of barriers in more detail. While doing so, we have followed the categorisation of IMO (2010):
- Technological barriers (Section 3.2).
- Institutional barriers (Section 3.3).
- Financial barriers (Section 3.4).

This chapter will end with some conclusions about possible market barriers in the on-road freight sector.

3.2 Technological barriers

It is often mentioned that there are several technical barriers to energy efficiency improving measures. For example, certain technologies may not be commercially available (Ecofys et al., 2007). This is unlikely to be the case for the on-road freight sector though, as Chapter 2 already indicated that there are several technologies available to improve the energy efficiency of HDVs (TIAX, 2011; AEA, 2011; CE, 2012).

Still, if (new) energy-efficient technologies are available, these technologies may have several uncertainties, which is a well-known barrier to the adoption of new technologies (Geroski, 2000, cited in KSK, 2001). Two main sources of uncertainty are often mentioned (CE, 2009b);

- *Uncertainty that is inherent to the technology itself*. New technologies entail several risks, as users will not know for sure if the technology will truly deliver the promised benefits and how it may affect the existing operations.
- *Uncertainty about market developments*. To estimate the benefits of an energy-efficient technology it is important to have knowledge about the general market developments that can be expected, especially with respect to the fuel price development. This source of uncertainty will be described in Section 3.4.2.

In the on-road freight sector, the performance of a fuel-saving technology is very difficult to estimate, as this does not only depend on the fuel price (see Section 3.4.2), but also on other aspects like the vehicle lifetime, discount rate (see Chapter 2), weather conditions or the routes that are driven (e.g. flat roads vs. steep hills). Consequently, it may well be the case that the expected benefits are subject to significant uncertainty. On top of that, the new technology may have additional risks if it can have significant consequences for the company's operations. If the malfunctioning of a technology would result in repairs that would require the truck to be in the workshop several days, or would result in breaching of contract agreements, the loss of revenues could offset fuel savings. Obviously, this would have a significant impact on the company's operations and may impede the adoption of a technology. Especially those transport companies that give a higher priority to the reliability of their fleet than to its fuel efficiency may perceive uncertainties like these as an unacceptable risk.

3.3 Institutional barriers

3.3.1 Split incentives

Split incentives occur when the investor in a technology is different from the person who benefits from it. This can be considered as a principal-agent problem (Ecofys et al., 2007). If split incentives are present, this can act as a significant barrier to energy-efficient technologies, as the person who has to make the investment has little incentive to do so (ibid.).

There are some studies that indicate that split incentives indeed impede the adoption of fuel-saving technologies in the transport sector (e.g. Greater Than, 2011; IMO, 2010;). Split incentives can either be caused by the contract structures and/or by the ownership patterns that are present. Both aspects are described in more detail below.

Contract structures

One of the ways that split incentives often manifest in the on-road freight sector is when transport companies can pass their fuel costs directly to the shipper (e.g. the retailer). This reduces incentives for the transport companies and third party logistics providers (logistics service providers) to improve the fuel efficiency of their own trucks, and/or demand fuel-efficient trucks from the companies they rent their vehicles from. According to Greater Than (2011), common contract types in Europe are:

- *Open book contracts:* Buyers and transport providers agree on a fixed operational margin. In this case, hauliers are entirely shielded from fuel prices, and will not have an incentive to reduce their fuel consumption.
- *Fixed price contracts.* Rather than agreeing on an operational margin, the parties agree on a fixed price per freight unit. This price is protected with so-called 'fuel escalators clauses' through which hauliers can pass on any fuel cost increases to the buyers.
- *Commission.* Logistics service providers generally add a commission on top of the transport costs. Consequently, the higher the transport costs, the higher the commission, which may result in reduced incentive to minimise fuel costs. In addition, logistics service providers often work with fuel surcharges to pass on fuel cost increases to the buyers, again eliminating incentives to utilise energy-efficient vehicles.

Open book contracts remove the incentive for a transport company to improve the fuel efficiency of trucks, unless this is a specific criterion for selecting a transport company.

Fuel surcharges and rebates do not remove the incentive for fuel efficiency improvements, as more efficient trucks could still operate with a higher margin than less efficient ones. However, when companies are shielded from fuel price fluctuations, fuel efficiency improvements may move down the priority list of the management.

Greater Than (2011) conducted questionnaires amongst 1.100 haulers and logistics service providers in Europe. They have found that energy-efficiency is given a low priority during operations by most companies (further described in the next section), which they consider (at least partially) results from the fact that transport companies and logistics service providers do not have to pay for (part of) the fuel costs. These types of fuel contract arrangements are likely to impede the adoption of energy-efficient technologies.

There is no literature available that indicated the relative amount of companies using open book contracts or fixed price contracts. However, the ING (2011) has estimated that 70% of the transport companies in Belgium have fuel clauses to pass on fuel price increases to the shippers. Despite this, the study does point out that many transport companies calculate the fuel price increases only once a month or once every three months. Consequently, not every fuel price development is passed on to the shippers, which can be an advantage to transport companies when the fuel price decreases. However, when considering the overall upward fuel price trend it may mostly be a disadvantage. In addition, some companies can only pass on fuel price increases when it has reached a certain minimum level. These two effects may, at least partially, expose some transport companies to fuel price fluctuations.

Ownership patterns

Split incentives may also result from the ownership patterns of the vehicles. This is especially relevant for logistics service providers, as these companies generally do not own vehicles themselves. Third party logistics providers do not typically make the investments in energy-efficient technologies themselves, and it may also be difficult for 3PL firms to persuade the companies from which they lease the vehicles to invest in such technologies. Consequently, ownership patterns may impede the adoption of fuel-saving technologies. This may also be a relevant barrier to some transport companies who lease their trucks rather than purchasing them themselves.

Another form of split incentive related to ownership patterns results from the fact that OEMs and body builders would have to design and invest in new fuel-saving technologies, while the transport companies benefit from the reduced fuel consumption. It is well-known that R&D is a highly expensive and risky activity; OEMs and body builders may be reluctant to do so, especially if they do not expect to be able to earn back their investments from charging a premium price or from increased sales.

3.3.2 Priority order

Whether or not a fuel-efficient technology will be adopted is likely to be influenced by the priority that a firm gives to energy efficiency. A company that gives low priority to energy efficiency is more likely to invest its limited resources in technologies resulting in other benefits. According to Ecofys et al. (2007) energy efficiency is generally given low priority when energy costs are only a small share of a company's total costs.

In the European on-road transport sector, fuel costs are approximately 22,2% of the total operation costs (in contrast, wages are 30,6%, depreciation 11,1%, financing costs 3,8% and other costs the remaining 32,3% of the total costs) (ING, 2011); therefore, it can be expected that energy efficiency is given a high priority, especially when taking into account the trend of increasing fuel prices. However, there is some empirical evidence pointing in the opposite direction. Greater Than (2011) has conducted 1.100 questionnaires amongst transport companies and logistics service providers in Europe. They have found that 92% of the interviewed companies did not prioritise fuel savings and had not set any fuel saving targets as a result. It should be emphasised that this is the case *during operations*; when investing in new vehicles, fuel efficiency was one of the top priorities. According to Greater Than (2011), 'traditions' (i.e. culture or shared beliefs e.g. the transport sector perceives fuel as a necessity that is hard to influence) and/or the contract structures shielding companies from fuel price fluctuations (described in the previous section), are the likely causes of this low priority.

3.3.3 Time lag for retrofits

Several of the cost-effective technologies that were pointed out in the previous chapter will require that the vehicle is temporarily suspended from operation while the particular technology is being installed. Transport companies may be reluctant to do so. This may not be the case when the technology is being installed during scheduled down-time. Also, once a company has decided to adopt a technology it may still take time before it is actually acquired and installed, especially when the existing technology has not been fully depreciated (i.e. diminished in value) yet. In other words, there can be a time lag between the point at which a measure becomes available and the point at which it is actually implemented (CE, 2009b)

There is no literature that indicates whether time lags are relevant in the on-road freight sector.

3.3.4 Lack of information and high transaction costs

According to KSG (2001) one of the main forces behind the slow diffusion of a technology is the fact that adoption is very risky to the investor. Consequently, the investor requires a substantial amount of information about the attributes of the technology and about its expected performance prior to making the investment. However, in many markets, the developers of a technology have a better, or more complete view about the possible outcomes of a technology adoption than the adopters themselves (Thollander et al., 2010). Therefore, transport companies may only know about the technologies that equipment developers or manufacturers tell them exist. Consequently, it may well be the case that transport companies are not aware of all cost-effective technologies that were mentioned in Chapter 2. Firms that are not aware about possible energy-efficient measures will obviously not invest in them.

In addition, there is no commonly agreed metric for expressing the fuel efficiency of a truck or trailer; as a result, it may be hard to convey the benefits of technologies. Actively searching and synthesising information about (new) technologies can be very costly (Jaffe and Stavins, 1994); this contributes to the overall transaction costs of a technology. In most cases, the diffusion of such information will take time (KSG, 2001). For these reasons, a lack of information can act as a barrier, especially as companies are unlikely to make poorly informed investments.

According to Thollander et al. (2010), this barrier will be most significant for technologies that are not purchased frequently. It seems likely that this applies to at least some of the technologies that were described in Chapter 2, such as the hybrid vehicle[4]. Also, the extent of this barrier may vary between large and small companies, as larger companies are likely to have more trucks, and therefore would need to buy trucks more often as compared to smaller ones.

Once a decision has been made to invest in a technology, additional transaction costs will result, such as the negotiation, implementation and monitoring of contracts. These aspects can be very costly as well (CE, 2009b). Moreover, there may also be hidden transaction costs, such as the time that is taken to arrange and supervise work (ibid.). Transaction costs increase the overall costs of making an investment, and may therefore act as a barrier, particularly when these costs cause that the overall costs of the investment offset the benefits. If transaction costs for fuel-saving technologies in the on-road freight sector are indeed high, this may be particularly troublesome to smaller actors; these companies generally have fewer resources (e.g. time, money) available and have to spread these costs over fewer trucks.

3.4 Financial barriers

3.4.1 Financial constraints

Capital-intensive investments will often require sources of external funding. This will especially be the case for smaller companies that typically have fewer resources available. Consequently, banks and/or other financers have to be willing to provide this capital. When an actor fails to arrange funding - for example, due to risk aversion of the financers - this will impede the adoption of the proposed measure (Jaffe and Stavins, 1994).

It has been argued that fuel-saving technologies in the transport sector have relatively high upfront capital costs as compared to other sectors (McKinsey & Company, 2009), which would imply that these technologies would add a significant amount of additional costs to the trucks, as compared to trucks without these features (i.e. incremental costs of fuel-saving technologies may be high)[5]. Consequently, obtaining funding for the investment may become more difficult when several fuel-saving technologies are added to the truck. If

4 Thereby, this technology is still relatively nascent within the HDV sector.

5 Even though the average incremental costs of fuel saving technologies may be higher in the transport sector as *compared* to other sectors, the incremental costs of different technologies *within* the transport sector vary significantly. Low rolling resistance tires for example, have low incremental costs, hence, obtaining funding will be less of an issue for this technology.

a company fails to arrange funding as a result, it may decide to buy a relatively cheaper truck. Consequently, obtaining enough funding may well be a precondition for the adoption of at least some of the fuel-saving technologies, and hence, a lack of access to capital may act as a barrier to their adoption.

A study by Goodyear Dunlop (2012) in which 400 fleet managers were surveyed has indeed found evidence that for 40% of the transport companies in their sample a lack of funds to replace older trucks is a barrier to increasing their energy efficiency.

Additionally, OEMs and body builders have limited resources available for R&D; consequently, they will not be able to invest in every possible fuel-saving option. Obviously, this in turn will influence the fuel-saving technologies that are/become available to transport companies. Although relevant, this research mainly focussed on transport companies; capital constraints from an OEMs' or body builders' point of view has not been investigated.

3.4.2 Fuel price trends and volatility

Fuel prices have an important influence on the adoption of fuel-saving technologies for two main reasons:

- The value of resource-saving technologies depends on the price development of the underlying resource (KSG, 2001). In other words, the market changes in fuel prices have an important influence on the benefits that can be obtained with fuel-saving technologies. Logically, the higher the fuel price, the larger the benefits that will result from fuel-saving technologies.
- Fuel costs make up a significant part of the total operation costs of hauliers (approximately 22,2%) (ING, 2011). It seems logical therefore that if fuel prices increase, the number of fuel-saving technologies that is being adopted increases as well (and the other way around).

It is well known that fuel prices are subject to large fluctuations in the short-term. Over the last decade, crude oil prices have been higher than 100 dollar, but also lower than 30 per barrel (WTRG, 2011). Diesel prices have shown similar movements, although fluctuations have been somewhat moderated by excise duties and taxes. Since fuel prices are of such significant influence on the cost-effectiveness of different fuel-saving technologies, uncertainties about diesel prices may act as a significant barrier to their adoption, as it is difficult to estimate the exact benefits that will result from the investment. Consequently, investors may require a higher risk premium, which will reduce the net present value of fuel-saving technologies, and hence their likelihood of being adopted.

Although fuel prices have shown fluctuations, an overall upward trend has occurred (WTRG, 2011). As fuel costs are over a fifth of hauliers' total costs - their second highest cost factor after wages - (ING, 2011), it can be expected that these companies are highly sensitive to this upward trend and aim to reduce their fuel use.

3.4.3 Investment criteria

Several criteria have to be met before a company decides to invest in a fuel-saving technology, such as a minimal net present value or maximal payback period.

In at least some segments of the transport sector, such as shipping, the payback period of an investment is used to determine whether to invest rather than a net present value approach. Thereby, very short payback periods are required (IMO, 2010), which may result in the rejection of measures with positive net present values, but with longer payback periods.

In the on-road freight sector the payback period is highly dependent on two factors:

- *Annual mileage*. The mileage per year differs significantly between trucks. The higher the mileage, the shorter the payback period is likely to be, as a truck with a higher mileage saves relatively more fuel per year than a truck with a low mileage.
- *Fuel prices*. The higher the fuel prices, the shorter the payback period will be, as the benefits of a fuel saving technology increase when the price of the underlying resource, fuel, increases. However, as mentioned earlier, fuel prices fluctuate significantly between countries and over time.

These two factors are of significant influence on the benefits retrieved from an investment, and hence on both the net present value and the payback period. The fact that these aspects are highly variable and uncertain may lead to a higher risk premium in the calculations (i.e. a higher discount rate is used) (Jaffe and Stavins, 1994). A higher discount rate will increase the payback period and reduce the net present value of technologies, which may be problematic if transport companies indeed use strict investment criteria (short payback periods).

Another aspect that may reduce the needed pay back period of technologies is the fact that many truck owners do not own a vehicle for its entire lifetime. In this case, the vehicle owner would use a shorter time-horizon to evaluate investments than would have been the case otherwise (i.e. use a lower lifetime). Using a shorter lifetime would result in fewer benefits from fuel savings. The investor may only use a shorter lifetime in his calculations if it is expected that no premium will be paid for a more fuel-efficient vehicle in the second hand market. Otherwise, the investor may include the expected premium in the calculations. However, there is no literature available that indicates whether fuel-efficient devices sell for premium prices in the second hand market.

3.5 Summary

This chapter has described several barriers to measures that can improve energy-efficiency, and has indicated to what extent these are likely to be relevant in the on-road freight sector. Although the literature on this topic is scarce, several barriers seem relevant to take into account. Especially, the possibility of *split incentives* and the applied *investment criteria* were mentioned quite often in the literature and therefore seem important. However, due to the lack of literature it is important to take every possible barrier into account and to be open to sector specific barriers that did not result from the general literature search on barriers to energy efficiency.

4 Empirical evidence of barriers

4.1 Introduction

In order to assess whether the barriers that were identified in the literature review of Chapter 3 inhibit the adoption of cost-effective measures in practice, we have interviewed representatives of European transport companies, shippers, logistics service providers and OEMs. The aim was to gather empirical evidence for conducting a qualitative analysis of the results. We did not aim for a representative sample, and a formal statistical analysis was beyond the scope of this report. The methodology that was used is described in more detail in Section 4.2.

Each barrier that was identified in Chapter 3 is analysed in Section 4.3. Section 4.4 analyses whether barriers are different for different market segments, while Section 4.5 does so for differently sized companies. Section 4.6 analyses the relevance of the barriers in different countries. Finally, the main conclusions of these analyses are presented in Section 4.7.

4.2 Methodology for collecting primary data

As mentioned in the previous section, interviews were conducted to investigate whether the barriers that were identified in literature indeed impede the adoption of fuel-saving technologies in practice. To that end, several questions were formulated, which is described in more detail below.

4.2.1 Design of the questionnaires

The findings of the literature review were used as guidance to formulate the interview questions. Four different questionnaires were designed; one for transport companies, one for shippers, one for logistic service providers and one for OEMs.

The questionnaires for shippers and logistic service providers were relatively short (four and six questions, respectively), as these were intended to provide background information about whether there are likely to be any market incentives for transport companies to invest in fuel efficiency or not. Likewise, the questionnaires for OEMs were used as a source of background information about the availability of fuel-saving technologies in the market and consisted of seven questions. The questionnaire for transport companies consisted of sixteen questions, which all directly or indirectly related to the possible barriers that were identified in Chapter 3. The four questionnaires can be found in Annex B. In this annex, the possible barrier each question investigates is also indicated.

4.2.2 Distribution of the questionnaires

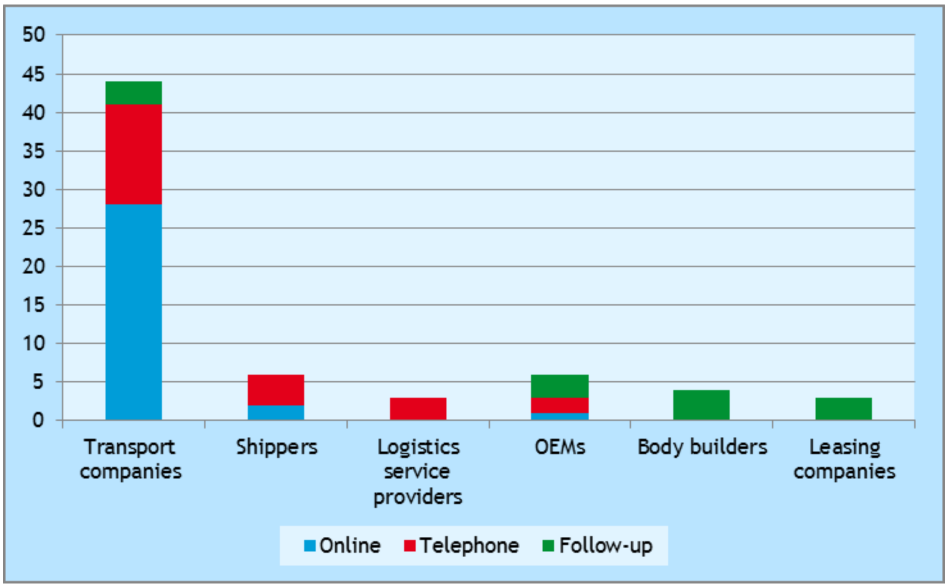
The questionnaire was distributed in two main ways. On the one hand, an online survey was developed. The International Road Transport Union (IRU) placed a link to this online survey on their website to increase the likelihood of getting a sufficient number of responses. In addition to this online survey, several telephone interviews were held in order to further ensure a sufficient number of responses. There was not much difference between both distribution channels in terms of the questions that were asked. There is one exception though; in the telephone interviews respondents were asked to rank different criteria (from 1 to x), while in the online survey respondents were asked to divide a 100 points between criteria. This latter method allowed for an assessment of the relative differences in importance between a criterion being given most points (i.e. comparable to being ranked 1) and second most points (i.e. comparable to being ranked 2); however, for the figures presented in this chapter, the points have been translated into a ranking as well. Additionally, the responses from the online survey were relatively short, while the results from the telephone interviews often entailed more detailed and in-depth information, as the interviewee could ask follow-up questions or explanations for unclear statements.

The choices for the distribution of the questionnaire may have biased the results towards more environmentally focused companies, as a significant share of the respondents either are in the IRU's network, or in CE Delft's and TRT's own network. These companies have already overcome at least some of the barriers to fuel-saving technologies. This implies that while the barriers that are found in this research are also likely to be applicable to other companies, those aspects that were not found to be impeding fuel-saving technologies are not necessarily absent as a barrier to others. In addition, the priority that is given to fuel-efficiency and the awareness and implementation rates may actually be somewhat lower in the overall market than is the case in this sample.

4.2.3 Responses to the questionnaires

In total, we have received 53 responses; 41 from transport companies, 6 from shippers, 3 from logistic service providers and 3 from OEMs. The contribution of the two distribution channels for each category is shown in Figure 5 below. Figure 5 also shows the number of follow-up interviews, which will be described in more detail in Section 4.2.4.

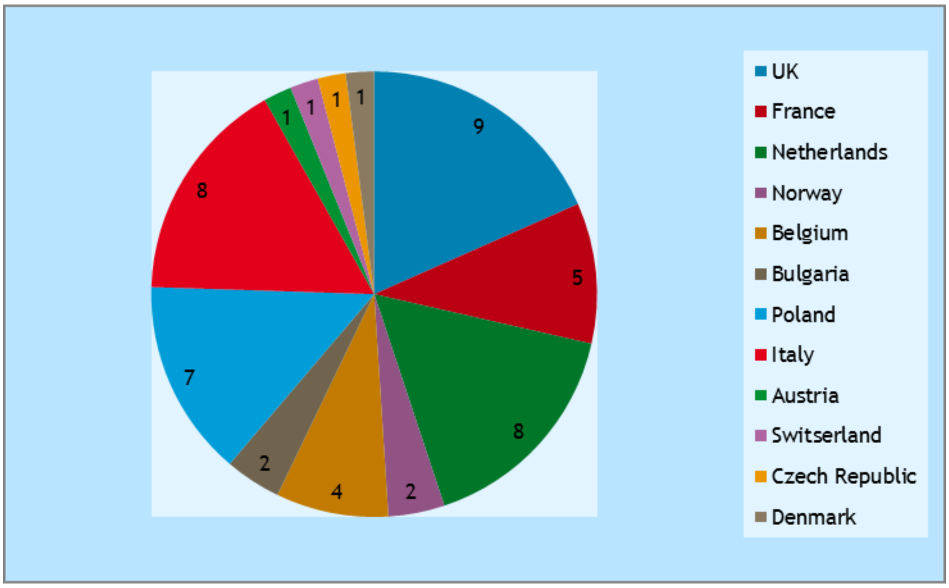
Figure 5 Respondents to the online and telephone interviews



As mentioned earlier, this sample was not intended to be representative of the entire industry. Rather, the sample was used to conduct a qualitative analysis of the likelihood of different barriers and incentives to be present in the market. In this light, especially the conclusions about incentives that resulted from surveys of shippers, logistic service providers and OEMs should be approached carefully, as these are based on very few responses.

Respondents were not obligated to indicate their company's country of origin. However, 89% of the companies did answer this question; these companies originated from 12 different European countries, as is shown in Figure 6.

Figure 6 Geographical distribution of the total sample



As can be seen in Figure 6, the sample does have a wide geographical spread, although companies in North-western Europe are represented relatively better than those in Eastern and Southern Europe.

The sample of transport companies

In addition to a general analysis of the transport companies' sample, three in-depth analyses have been conducted:

- barriers in different countries;
- barriers in different market segments;
- barriers for differently sized companies.

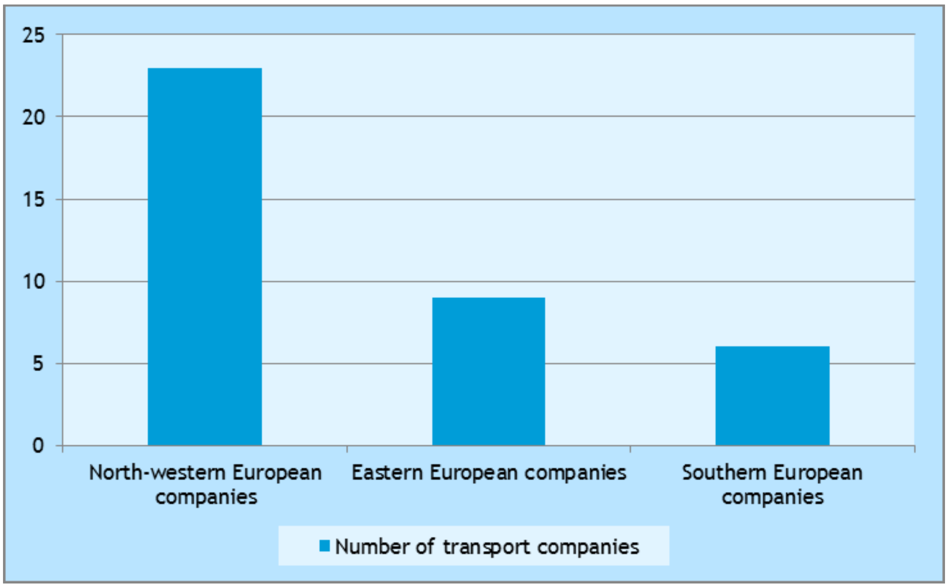
The samples that were used for these analyses are described in more detail below.

The geographical analysis of transport companies was focused on three segments:

- North-western Europe (UK, France, Netherlands, Norway, Denmark and Belgium);
- Southern Europe (Italy);
- Central and Eastern Europe (Bulgaria, Poland, Austria and Czech Republic).

Figure 7 shows the number of transport companies in the sample originating from each of these geographical segments.

Figure 7 Number of transport companies in the different geographic segments



As can be seen in Figure 7, the sample of transport companies is slightly biased towards companies from North-western Europe as well. Figure 7 also shows that a total of 38 transport companies have indicated their country of origin; hence, 93% of the total sample of transport companies can be used for the analysis of barriers in different geographical segments.

The analysis of differently sized transport companies made a distinction between very small (<20 trucks) and larger (>20 trucks) transport companies in the sample. A total of 26 companies has indicated their size and could therefore be included in this analysis (63% of the total sample of transport companies). The number of companies in each of these categories is shown in Figure 8.

Figure 8 Number of companies in different company size segments

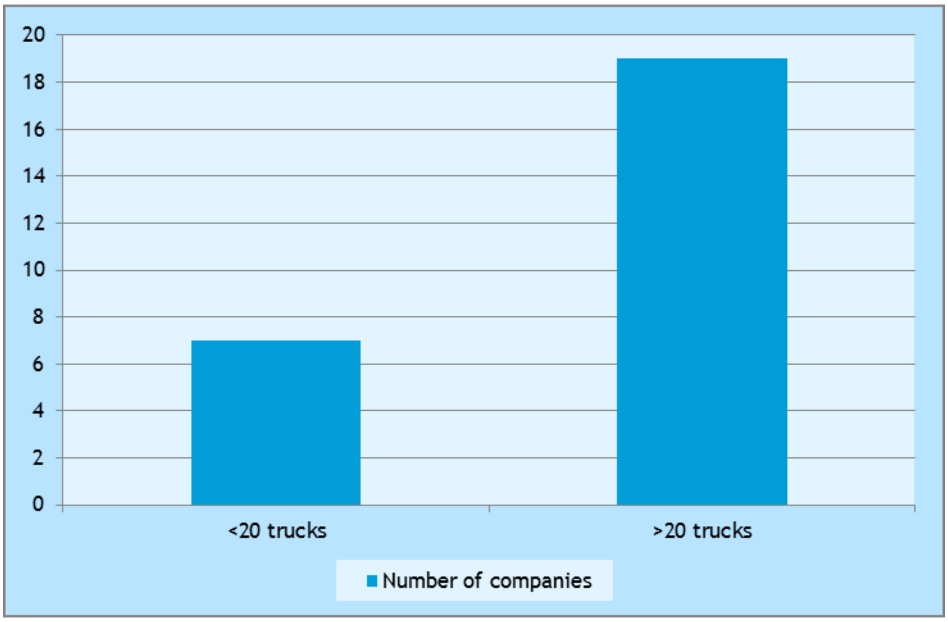


Figure 8 indicates that the sample is biased towards larger companies. This distinction is quite rough though; the number of trucks of 'larger companies' ranges from 20 to several hundred trucks. The fact that many smaller sized companies did not completely fill out the questionnaire further increased this gap between large and small companies. Therefore, it may be the case that the barriers that have been identified in this study do not apply to small companies, and in addition, these smaller companies may face additional barriers that are not an issue to the larger companies that dominated the sample of this study.

Finally, a separate analysis was conducted for the different market segments (i.e. long haul, regional, and urban). However, a significant share (39%) of the transport companies are active in more than one, or in all three segments. This complicates the analysis of the barriers in different market segments. Figure 9 shows the sample that could be used for this analysis (i.e. when only including the companies that are active in one segment).

Figure 9 **Number of companies in different market segments**

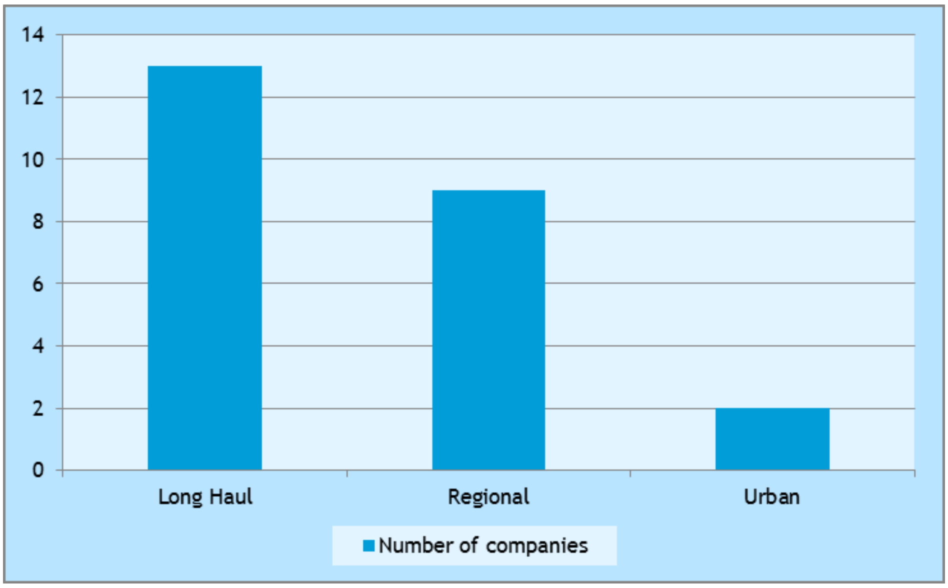


Figure 9 shows that only two companies in the sample are active merely in the urban market segment, which is insufficient to draw any meaningful conclusions. Therefore, the analysis of barriers in different market segments will focus on differences between the long haul and regional segment, which implies that the responses of 22 companies could be used (54% of the total transport companies sample). Excluding the urban market segment is an important limitation to keep in mind, considering that the long haul and regional segment are relatively similar; the operating patterns in the urban market segment are very different. Therefore, barriers are likely to be different for the urban segment as well.

4.2.4 Follow-up interviews

After the analyses had been conducted of the reponses from online surveys and telephone interviews, several factors resulted that are likely to be signficantly impeding the adoption of fuel-saving technologies. To increase the validity of these results, several follow-up interviews (Figure 5) were planned to verify these barriers and investigate them in more detail. Additionally, these interviews were used to clarify uncertainties that were still present after the first analysis. To that end, 13 additional interviews were conducted;

3 with transport companies, 3 with OEMs, 3 with body builders of trailers, and 3 with leasing companies. Also one additional interview was conducted with a manufacturer of aerodynamic technologies for trailers. The questions that were asked in these follow-up interviews and the responses that were given can be found in Annex C.

4.3 General analysis of the results

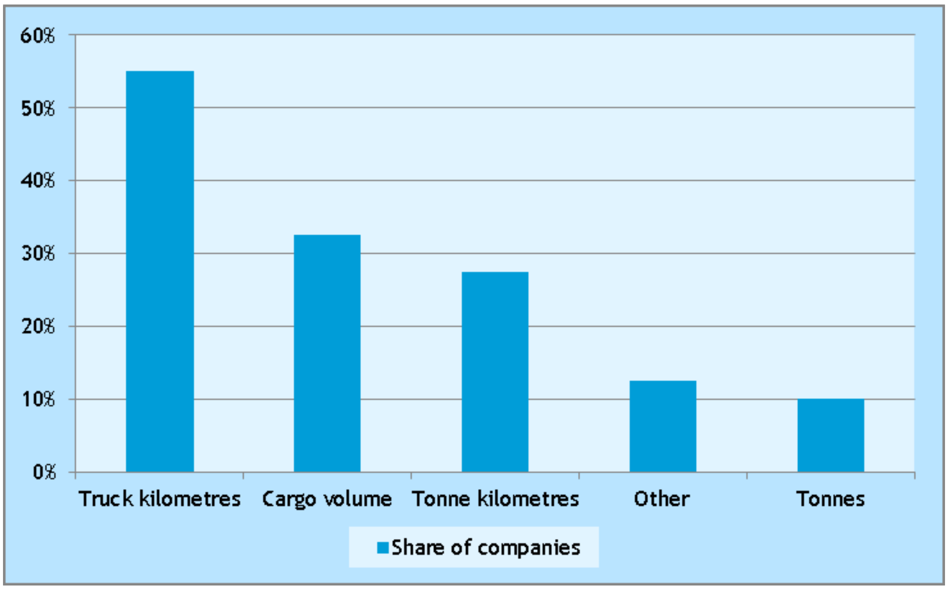
4.3.1 Split incentive

As was explained in Chapter 3, split incentives may either result from contract structures or truck ownership patterns. Both forms of split incentives have been investigated and are described below.

Contract structure - transport companies' point of view

The fee system that is used in contracts differs significantly between transport companies. Moreover, it was indicated by some respondents that the payment metric will differ within the same company according to the demands of the shippers as well. Irrespective of these differences, the majority of transport companies (55%[6]) use truck-kilometres in at least some cases, as is shown in Figure 10.

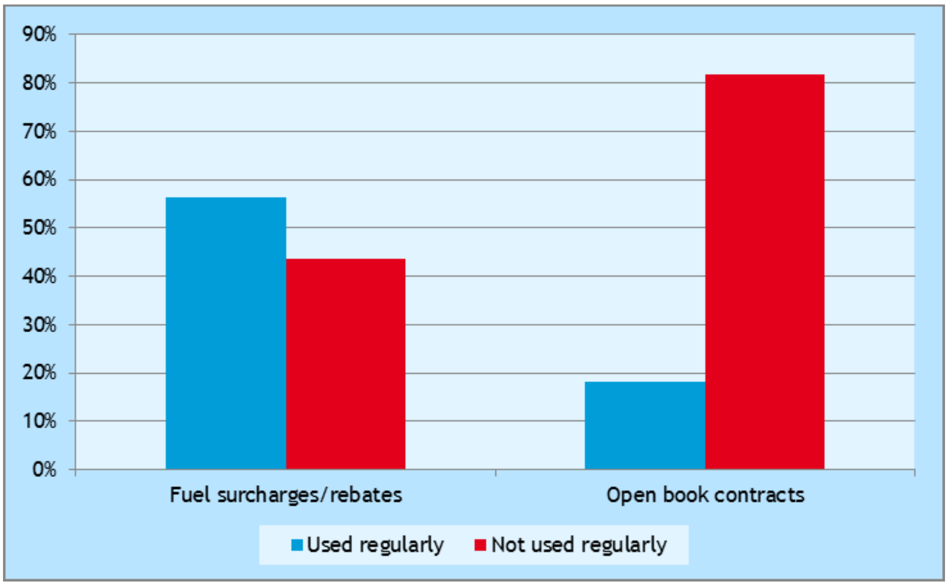
Figure 10 Payment metric transport companies use in their contracts



More importantly, arrangements with respect to fuel costs differ significantly between companies as well, as is shown in Figure 11.

[6] Respondents were not obligated to answer any of the question; consequently, all percentages mentioned in this chapter reflect the share of companies that gave a particular answer as compared to the *total number of companies that gave an answer to the question.*

Figure 11 Contract structures used by transport companies



As can be seen in Figure 11, the number of transport companies using fuel surcharges and/or rebates is split almost evenly amongst the companies in the sample (i.e. 56% with fuel surcharges and 44% without). Those companies that do include fuel surcharges in their contracts use a wide range of underlying parameters to calculate the surcharge. Whereas some incorporate the national diesel price on a monthly basis, others use a minimum invoice value. Either way, these companies are at least partially shielded from the fuel price fluctuations, which may reduce their incentive to invest in fuel-saving technologies. Consequently, for approximately half of the sample, shielding may impede the adoption of fuel-saving technologies. However, a split incentive in the original sense, in which the transport company is completely shielded from all fuel price changes, is not applicable to these companies. Those transport companies that do not use fuel surcharges or rebates mostly indicate that contracts and corresponding prices are agreed upfront, or that shippers are not willing to pay for these costs. These companies are fully exposed to fuel prices; consequently, for the other half of the sample, shielding is not a likely barrier to fuel-saving technologies.

Figure 11 further indicates that most transport companies never operate under open book contracts (82%). The remaining 18% of the companies in the sample indicated that they use open book contracts in some cases. It was discussed in Chapter 3 that open book contracts do cause split incentives in most cases, as these companies will be entirely shielded from changes in fuel prices. When looking at the criteria taken into account when buying a new truck, four of the five companies with open book contracts have not ranked fuel efficiency as an important criteria, which indicates that open book contracts indeed cause a split incentive. However, as mentioned earlier, the number of transport companies in the sample with such contracts is low.

In one of the follow-up interviews, the manufacturer of trailer aerodynamic technologies stated that the number of transport companies with open book contracts is actually very high, at least in the Netherlands. This is contradictory to the sample of transport companies that was collected for this research.

Contract structures - Shippers' and logistics service providers' point of view

Although the results from this study suggest that transport companies rarely use open book contracts, the situation may be very different for logistics service providers. Although our sample of logistics service providers is too small to draw conclusions, a number of logistics service providers work on a commission basis. Under such a contract, they do not have an incentive to reduce transport costs, including fuel costs. However, others operate for a fixed fee per tonne-mile. These companies do have an incentive to reduce transport costs, including fuel costs.

The fact that transport companies do not often operate under open book contracts aligns well with the responses of shippers and logistics service providers; when asking them about the contract structures they use when contracting transport companies, every shipper and logistics service provider in our sample indicated that they use fuel surcharges and rebates in their contacts with transport companies rather than open book contracts. One shipper did indicate that these fuel surcharges were calculated only three times a year, which still significantly exposes transport companies to fuel price fluctuations during the intervals. Put differently, the frequency of adapting fuel prices in the surcharges influences the level of shielding (i.e. assessing fuel prices only few times a year increases the exposure of the company to fuel price developments, even if surcharges are in place).

Truck ownership patterns

Another form of split incentives may result from the ownership patterns of trucks. However, at least in this sample, this barrier seems irrelevant; every company in the sample (100%) owns (at least part of) its vehicle fleet. Considering that transport companies mostly own their trucks unlikely causes a split incentive in the market.

However, in one of the follow-up interviews it was indicated that a significant share of transport companies lease their trucks. Although it is difficult to determine the exact share, this can range from 0% (in countries where truck leases are forbidden by law, such as Greece) to far over 50% (in countries where truck leases are allowed, such as Germany). However, even if this share is indeed high, our results indicate that it does not seem to cause a split incentive. Both the leasing company of trucks and the association of leasing companies have stated that transport companies decide about which fuel-saving technologies they want to install on their truck. The leasing company can advise in this matter, but essentially the truck is chosen first, and acquired afterwards.

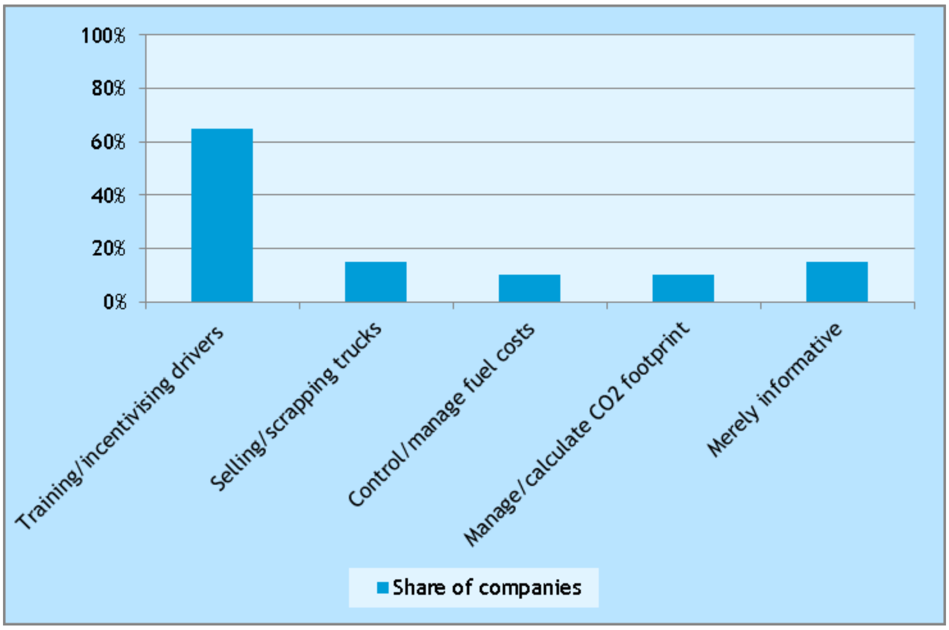
However, truck ownership patterns may differ from those of trailers. Initially, no questions were asked about transport companies' trailer ownership. The three transport companies in the follow-up sample all owned their trailers, but obviously this follow-up sample is too small to draw any meaningful conclusions about trailer ownership patterns in Europe. According to the association of trailer leasing companies, the share of trailer leasing is roughly equal to the share of leased trucks. The manufacturer of trailer technologies confirmed that in many cases, trailers are leased rather than owned. He argues that this does cause a split incentive between the trailer leasing company and the transport company, as the leasing company purchases the trailers, while the transport company would benefit from the reduced fuel consumption of a more efficient trailer. Therefore, the leasing company may not have an incentive to purchase a more efficient trailer or aftermarket devices, which would add to the investment costs. The leasing company of trailers confirmed that trailers are rarely altered for transport companies, and that transport companies could choose trailers from their fleet. It seems that for trailers, transport companies have less to say in the fuel-saving technologies that they want. Trailer ownership patterns can therefore impede the fuel-efficient technologies that can be installed on trailers in the case where they are leased.

4.3.2 Priority order

Chapter 3 has described that fuel efficiency is likely to receive a high priority when fuel costs make up a large share of the total costs, which is the case for the transport sector. The previous section indicated that approximately half of the companies operate without fuel surcharges, and that only a very small share operates with open book contacts. Consequently, it would be expected that fuel efficiency is given a high priority by transport companies.

The empirical data indeed indicates that transport companies are well aware of the fuel efficiency of their trucks and drivers; every transport company in the sample (100%) measures the fuel efficiency of their operation. This is done for different reasons, summarised in Figure 12 below. In practice, this rate may be somewhat lower, as there is likely to be some bias towards environmentally aware companies in this sample. Nonetheless, similar results were reported by Goodyear Dunlop (2012); they found that 92% of the transport companies they sampled measured fuel consumption to some extent.

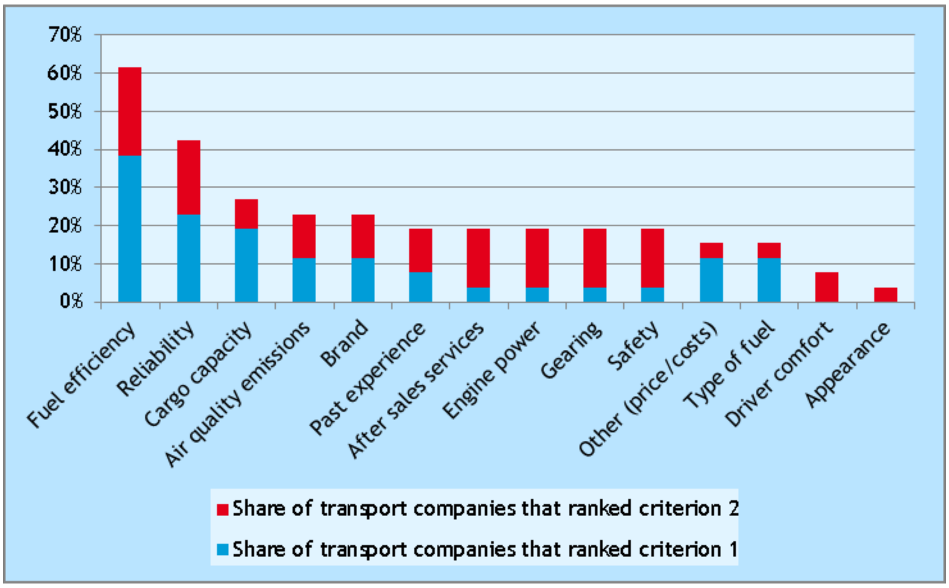
Figure 12 **Transport companies' motivations for collecting data on fuel efficiency**



As can be seen in Figure 12, the majority of transport companies (65%) use information about fuel-efficiency for operational ends, mainly to train and incentivise drivers. Only a few companies (15%) measure fuel consumption to determine the technical fuel efficiency of a truck. Consequently, the share of transport companies using fuel efficiency data for technical ends (i.e. as an indication of whether they want to sell/scrap trucks or not) is low as well.

When buying new trucks, roughly every transport company in the sample (96%) claims to take fuel efficiency into account. When asked to rank their most important criteria, 62% of the companies ranked fuel efficiency very high (i.e. as the most or second-most important criterion). In addition, a wide variety of other criteria are considered while acquiring a new truck. Figure 13 shows the relative importance of different criteria.

Figure 13 **Criteria transport companies ranked as most or second-most important when acquiring a new truck**



As can be seen in Figure 13, reliability and cargo capacity are important criteria in addition to fuel efficiency; these criteria are ranked most or second-most important by 42 and 27% of the transport companies in the sample, respectively. Although transport companies were asked to rank their criteria when buying *new trucks*, cargo capacity is also highly related to the acquisition of trailers. Driver comfort and appearance score lowest and are considered very important by roughly 8 and 4% of the companies in the sample, respectively. Although fuel efficiency is ranked as very important by 60% of the companies, two of those companies pointed out the difficulty in assessing the true fuel efficiency of a new truck. This issue will be further analysed in Section 4.3.7. Despite this uncertainty, OEMs did indeed indicate that the majority of companies pay a lot of attention to fuel efficiency nowadays, whereas in the past companies would look at the engine power for example.

The findings described above are in-line with the study performed by Greater Than (2011), which concluded that fuel efficiency is a top priority when *buying new trucks*. In contrast to that study, however, transport companies in our sample are also interested in operational fuel efficiency. In fact, the main reason why they monitor the fuel efficiency of their trucks is to inform and train drivers to improve their fuel efficiency, not to evaluate the performance of different trucks or technologies.

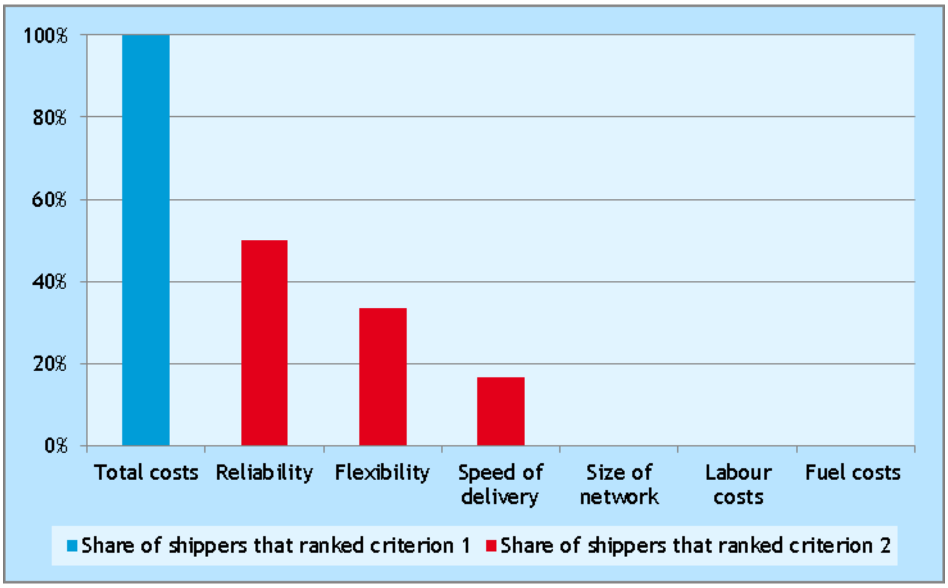
Initially, companies were not asked for their most important acquisition criteria when buying *trailers*. However, the three body builders in the follow-up sample unanimously answered that transport companies do not take into account the fuel efficiency of different trailers during the acquisition. The leasing company of trailers shares this point of view and indicated that transport companies do not pay attention to the fuel efficiency when choosing which trailer they want to lease. Consequently, the leasing company did not report that they look to acquire more fuel-efficient trailers either.

In conclusion, the high priority that is given to fuel efficiency when buying new trucks does not seem to apply to the acquisition of trailers. This may be caused by a difference in ownership patterns (described in the previous section), or by fact that it is even more difficult to determine the benefits from fuel savings of trailer-specific technologies for example (Section 4.3.7.)

Shippers' and logistics service providers' criteria for selecting transport companies

The criteria of shippers and logistics service providers for selecting transport companies may also have an influence on the acquisition criteria of transport companies. The most important criteria for shippers when selecting transport companies (i.e. ranked as most or second most important) are shown in Figure 14 below.

Figure 14 Share of shippers that ranked a criterion as most, or second most important, when selecting a transport company



As becomes clear from Figure 14, every shipper in the sample (100%) ranked the total costs of the contract as the most important criterion when selecting a transport company. Reliability and flexibility followed as the second and third most important criteria, respectively. As fuel costs account for more than 20% of the total costs of transport companies' operations (ING, 2011), it would make sense if shippers paid attention to fuel costs and/or would choose the transport company that is most fuel-efficient. This does not appear to be the case though. None of the shippers looks specifically at the fuel costs under different contracts and focus on total costs instead. Although 40% of the shippers claim to evaluate the fuel efficiency of transport companies' fleet, half of this 40% indicated that this is more of a theory rather than something that is truly evaluated in practice. The reason for this has been mentioned earlier in this section from a transport company's point of view; it can be difficult to evaluate the fuel efficiency of individual trucks or for the entire fleet. This may also partially explain why none of the shippers (0%) sets a minimum fuel efficiency target that transport companies should meet. Likewise, none of the shippers (0%) have defined a minimal CO_2 performance level when selecting transport companies. As was discussed in Section 4.2, the shippers sample consisted of only 6 companies, which is clearly very small. However, these results indicate that although fuel consumption is indirectly taken into account by selecting transport companies on total costs, it can very well be the case that market incentives to stimulate transport companies to invest in fuel efficiency are mostly absent.

When logistics service providers select transport companies, they use roughly the same decision criteria as shippers. Their criteria are shown in Figure 15 below.

Figure 15 Share of logistics service providers that ranked a criterion as most, or second most important, when selecting a transport company

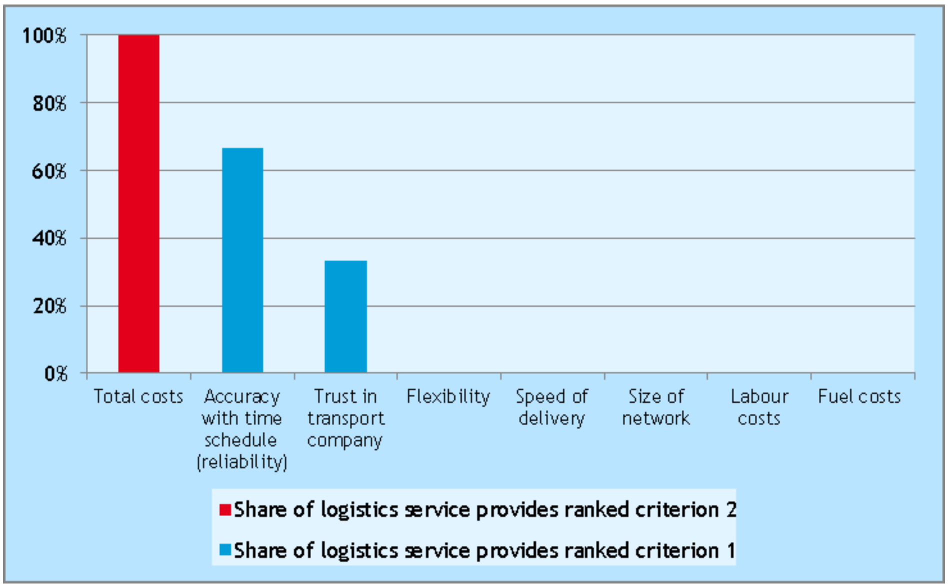


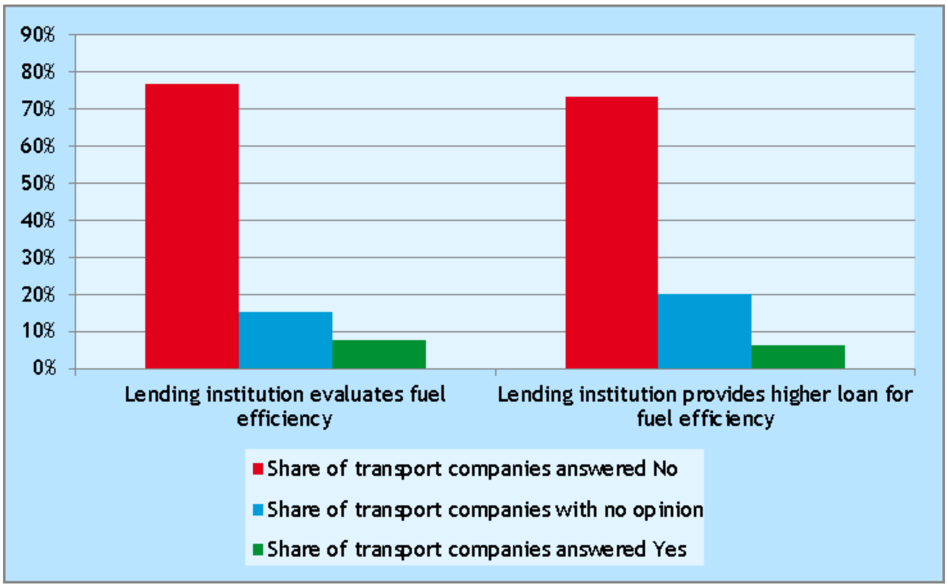
Figure 15 shows that most logistics service providers (67%) ranked the accuracy of the transport company in keeping with time schedules as the most important criteria, followed by the level of trust in the transport company (33%). The total costs of the contract was ranked second most important by every of the logistics service providers (100%). Despite the fact that costs are still very important, none of the logistics service providers (0%) claim to evaluate the fuel efficiency of the transport companies nor do they require transport companies to meet a certain minimum fuel efficiency target. As was indicated previously, a possible explanation for this is the fact that the fuel efficiency of a transport company is very difficult to evaluate. Finally, one logistics service provider (33%) claimed to evaluate a company's CO_2 footprint and to choose the company with the lowest CO_2 emissions, *if* the total costs are comparable. If not, the company with the lowest contract price is chosen. As was the case for shippers, the sample of logistics service providers is small, and therefore it is difficult to conclude with certainty about a lack of market incentives to stimulate transport companies to invest in fuel efficiency.

4.3.3 Financial constraints

Financial constraints may act as a barrier to the adoption of fuel-saving technologies if the investor relies on a third party for financing the project. Approximately 73% of the companies in the sample have indicated that they use a financial company when investing in new trucks. The remaining 27% of the companies use their own resources (18%) or use both options regularly (9%). Put differently, a high share of transport companies are dependent on leasing companies to enable the acquisition of a new truck. This was confirmed during the follow-up interview with the association of leasing companies. This has a negative impact on the adoption of fuel-saving technologies, as the leasing of trucks is not permitted in every European country. Legislation from the European commission leaves the decision to allow or forbid truck leases at the member state level. As a result, the share of truck leases is very low in some Southern and Eastern European countries, which in turn results in very high lifetimes of the vehicle fleets of these countries (as companies may not be able afford new trucks and also have less alternatives in obtaining funding). An older fleet also means less clean and efficient vehicles. Consequently, financial constraints are very likely to be impeding the acquisition of new trucks – and, hence, fuel-saving technologies - in those countries that have restrictions on truck/trailer leases in place.

Interestingly, transport companies are quite equal-minded about the relevance of fuel efficiency in case they can arrange funding, which is summarised in Figure 16 below.

Figure 16 Transport companies' point of view on the relevance of fuel efficiency for lending institutions



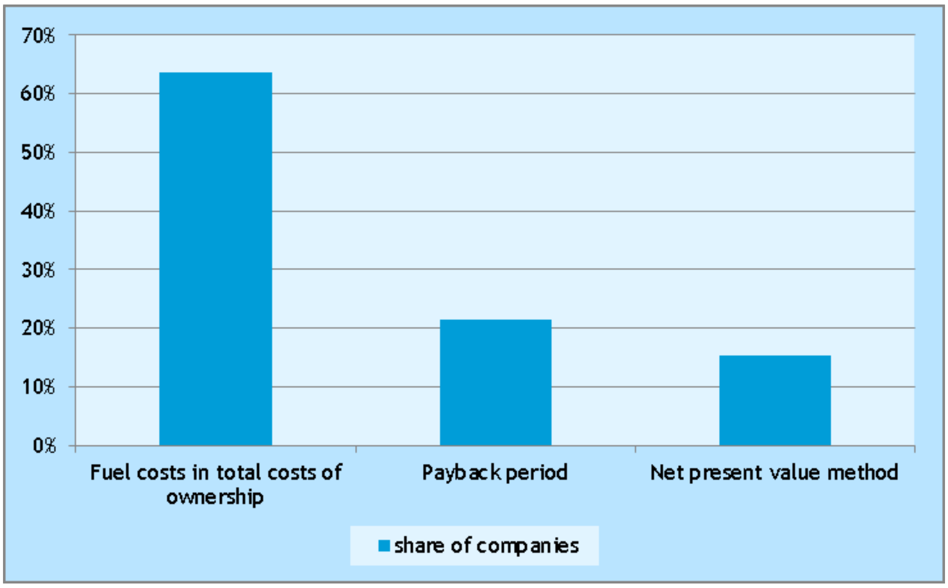
As can be seen in Figure 16, there is only one transport company (8%) who believes that the lending institution evaluates the fuel efficiency of the proposed truck. The majority of transport companies in the sample (92%) argues that lending institutions do not evaluate fuel efficiency. Consequently, the share of transport companies that believe that the lending institution would provide a higher loan for fuel-efficient trucks is low as well (6%). The OEMs share this point of view.

The leasing companies in the follow-up interviews confirmed that the amount of the loan/lease is not dependent on the fuel efficiency of the truck or trailer. They only look at the financial health of the company and base their decision on that factor. From this point of view, it can be the case that financial constraints impede some fuel-saving technologies when trucks/ trailers are leased, most likely those with relatively high incremental costs. However, when looking from another perspective, leasing may actually positively impact the adoption of fuel-saving technologies; the association of leasing companies explained that whereas companies financing the truck themselves may mostly look at the catalogue values and buy the cheapest truck, this may not be the case when they lease a vehicle (the payments to leasing companies are on a monthly basis). Also, leasing companies may have more experience and better data on the monthly operating costs of different fuel-saving technologies, and may therefore play an advisory role.

4.3.4 Investment criteria

Companies differ significantly in the methods they use to evaluate investments, as is shown in Figure 17.

Figure 17 **Methods used by transport companies to evaluate fuel-saving technologies**



The majority of transport companies (64%) indicated that they evaluate the fuel costs in the total costs of ownership when deciding on an investment, followed by the net present value method (21%) and the payback period of an investment (15%), respectively. Companies did not provide detailed information about the input parameters and their specific rejection criteria though. Consequently, no conclusions can be drawn about whether this causes cost-effective technologies to be rejected.

Several other aspects are included in the investment criteria and therefore have an impact on the decision to acquire a fuel-saving technology or not, and these are described in more detail below.

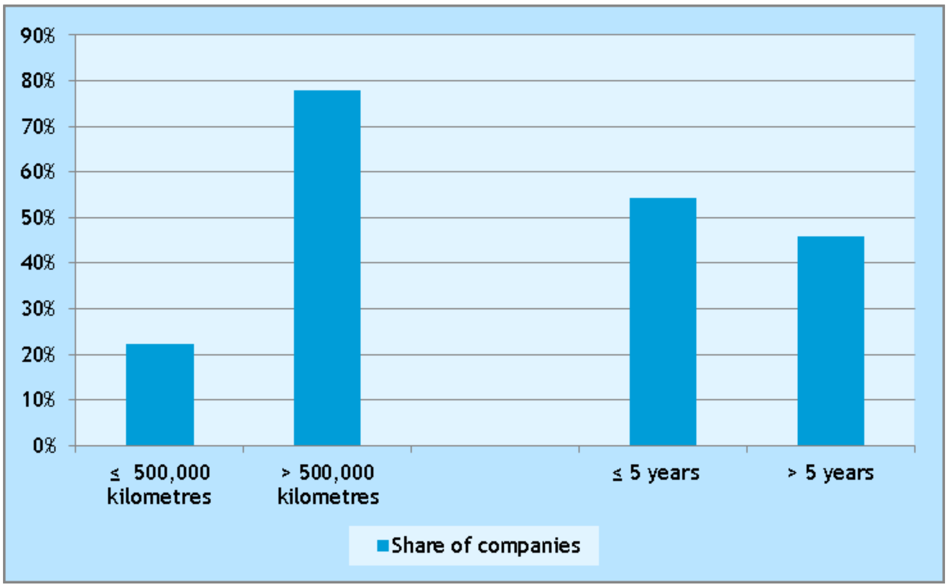
Fuel prices

Companies use representative fuel prices in their calculations. Most often cited are the national/European average fuel price or fuel prices that have been determined by the Freight Transport Association (FTA). As these fuel prices are *actual* fuel prices, and therefore not unreasonably low, this seems unlikely to negatively affect the outcome of the investment calculations. Therefore, this is not a relevant barrier.

Lifetime of vehicles within the company

The number of years and/or number of vehicle kilometres that transport companies hold on to their vehicles differs significantly between companies, which is summarised in Figure 18. These ownership patterns will also be dependent on other factors, such as whether a truck is leased or not, and on the market segment in which a transport company is active (further explored in Section 4.4).

Figure 18 **Average lifetime of transport companies' trucks within the company**



With respect to truck kilometres, the majority of transport companies (78%) hold their truck for more than 500,000 kilometres (up to 1,300,000 kilometres). The number of years companies that companies hold on to their trucks varies more significantly; whereas some transport companies replace trucks after three years, others wait 10 years before taking the truck out of their fleet. Around 54% of the companies in the sample use a relatively low maximum of years (< 5 years), while the remaining 46% retain their trucks for a relatively long period of time (6-10 years). Two interviewees did point out that new regulations can be of important influence on the lifetime of trucks as well. When the German MAUT regulation came into force for example, these companies decided to replace part of their fleet earlier then they normally would, as the toll rate became partially dependent on the emission category of the vehicle as a consequence of this law. In addition to legislation, financial constraints/arrangements will also influence how long a company will own a truck. For example, for leased trucks, the lifetime of a truck within a company is relatively short (mostly 5 years or less).

Also of influence on the lifetime that is used in calculations is whether fuel-efficient trucks can be sold at premium prices in the resale market. The share of companies that believes fuel-efficient trucks can be sold for higher prices (57%) is slightly higher than those arguing the opposite to be true (43%). With respect to the latter group, some companies explained that they sell their trucks when they are relatively old (6-7 years or older), which cannot be sold in European markets anymore. Consequently, the trucks are exported to developing countries like Africa, where buyers in the second hand market do not typically pay attention to fuel efficiency. Despite the fact that this argument sounds like a reasonable explanation, it could not be confirmed by the data from the whole sample, as some companies selling relatively old trucks (10 years) believe that they can obtain a premium price for it, and vice versa. The association of leasing companies that was interviewed after the initial set of surveys did argue the same to be true; leasing companies would receive a higher value for trucks sold to European countries than in case the truck has to be sold to non-European countries.

No relationship could be found between those believing they can obtain a premium price for fuel-efficient trucks and those companies that ranked fuel efficiency as very important when acquiring a new truck. This suggests that other factors are of influence on the priority given to fuel efficiency when acquiring a new truck.

The findings presented above indicate that companies differ in their investment criteria, and therefore the cost effectiveness of different technologies will vary between companies as well. The fact that at least some companies do not believe to obtain premium prices when selling fuel-efficient trucks implies that these companies need to earn back their investment in a relatively short timeframe, which may impede the adoption of at least some technologies.

4.3.5 Technology-specific barriers

The literature review revealed that information asymmetry between the OEMs and transport companies may result in a low awareness of a technology, which is examined in the sub-section below.

Transport companies' level of awareness and level of implementation.

Table 5 provides an overview of the technological options to improve fuel efficiency, and indicates whether the majority (>50% of the sample) is aware (coloured green) or not (coloured red) of a particular technology. In addition, it is summarised whether the majority (>50% of the sample) has planned or implemented a technology (coloured green) or not (coloured red). As was the case for the priority given to fuel efficiency, it should be emphasised that the sample is biased towards more environmentally focused companies; the awareness and implementation rates presented in this section may therefore be somewhat higher than is the case for the whole market. Additionally, the 'improved diesel engine' has not been specified in the questionnaires, and therefore, cannot be compared to the advanced diesel engines that were included in the analysis of Chapter 2.

Table 5 Overview of transport companies' awareness and implementation of different technologies

Technology	Not aware	Aware	Planned/ Implemented
Aerodynamics			
Trailer rear end taper	18%	82%	27%
Boat tail	56%	44%	11%
Box skirts	33%	67%	11%
Cab side extension or gap fairings	27%	73%	55%
Full gap fairing	25%	75%	33%
Full skirts	30%	70%	10%
Roof deflector	17%	83%	67%
Material substitution			
Light-weighting	18%	82%	45%
Tires and Wheels			
Tire Pressure Monitoring System (TPMS)	8%	92%	42%
Automatic tire inflation on truck or trailer	45%	55%	9%
Low rolling resistance tires	9%	91%	55%
Tire management	11%	89%	56%
Engine efficiency			
Improved diesel engine	8%	92%	83%
Hybridisation			
Dual-mode hybrid	56%	44%	0%
Parallel hybrid	67%	33%	0%
Other			
Speed limiters	9%	91%	64%

As shown in Table 6, the majority of companies are aware of most technologies, except for both technologies in the category 'hybridisation' and the boat tail in the category 'aerodynamics'. This indicates that the barrier of a lack of information about the *existence* of technologies is of little importance. With respect to hybridisation, low awareness may be due to the fact that only few OEMs are offering this product currently. Thereby, this technology was not often cost effective in our modelled scenarios (Annex A). If this is the case in reality, it seems logical that OEMs do not offer/promote these hybrid technologies, knowing that rational transport companies will not invest in technologies with higher costs than benefits. The level of awareness for the trailer-specific boat tail was low as well, although this technology was often cost effective in our simulations (Annex A). In the follow-up interviews, it became clear that none of the body builders offers this technology at the moment, which explains the low level of awareness. Two interviewees explained that restrictions on the length of trailers are the main reason for not offering boat tails at the moment; in Europe, these length restrictions *include* the additional length resulting from the aerodynamic device, consequently, a company would have to give up load capacity in order to install it, which does not make sense from a transport company's point of view.

Table 5 also indicates that of the thirteen technologies for which awareness was relatively high (>50% of the companies), only six have relatively high implementation rates (shown between brackets) as well:
1. **Improved diesel engine** (83%).
2. **Roof deflector** (67%).
3. Speed limiters (64%).
4. Tire management (56%).
5. Cab side extensions (55%).
6. **Low rolling resistance tires** (55%).

The technologies shown in bold also were estimated to be cost effective technologies in every of the scenarios in the MAC analysis presented in Chapter 2. As mentioned before, the 'improved diesel engine' is a very broad term, and cannot be compared to the advanced diesel engine that was included in the MACH model (CE, 2012). Besides, speed limiters and tire management were not included in this model. Irrespectively of their cost effectiveness, speed limiters have been obligated by law (92/6/EEC) for trucks with a GVW of over 10 ton, which most likely explains the high implementation rate, especially for companies in the regional and long haul segment, which operate larger trucks than those in the urban market. The cost-effectiveness of tire management was not evaluated with the MACH model, however, considering that it is more operational in nature it may well be a relatively cheap measure to implement.

None of the shippers or logistics service providers demand from transport companies that they implement certain fuel-saving technologies. Therefore, it seems that the implementation of the above technologies above has not been forced upon transport companies by their clients. To what extent other parties (mainly OEMs and body builders) have had an influence on the high level of implementation of the technologies summarised above will be described in the next sub-section.

Technologies with high awareness but low implementation rates (shown between the brackets) are the following:
1. **Automatic tire inflation (9%).**
2. Full skirts (10%).
3. **Trailer skirts (11%).**
4. Trailer rear end taper (27%).
5. **Full gap fairing (33%).**
6. Tire pressure monitoring system (42%).
7. Light weighting (45%).

Again, the technologies in bold are those that are cost effective in every of the assumed scenarios in Chapter 2. The most often mentioned reasons for not implementing these technologies are their high costs, low expected benefits as compared to the costs, and that the technology does not fit with existing operations (e.g. one company did not adopt full gap fairing as the company has differently sized trailers). With respect to the high costs and low expected benefits, it may either be the case that this is indeed true in reality or that these are *perceived* problems rather than *real* ones. It is difficult to make conclusions about this aspect, however. As will be described in detail in Section 4.3.7, the fact that it is very difficult to estimate the fuel efficiency benefits of a new technology may result in an under- (or over) estimation of its benefits, and therefore influence the adoption decision. This is especially relevant to those technologies that are *trailer-specific* (further elaborated on in *Section* 4.3.7). Yet another explanation for the low implementation rates of trailer-specific technologies may be due to the fact that many trailers are leased; the trailer leasing company that was interviewed stated that companies could choose from a range of trailers in their fleet. Consequently, the transport company has no say in the fuel-saving technologies installed on these trailers, as the trailers are rarely adapted for individual transport companies. Those companies that lease trucks from OEMs do not seem to experience this issue, as they can customise the truck they lease. It is not clear whether this is also the case when the truck is leased from a company that is not an OEM (i.e. if a company has to choose a truck from the leasing company's own fleet or whether the transport company can fully customise the truck it leases).

In addition to these possible explanations, the implementation rates of both truck- and trailer-specific technologies are influenced by what technologies are offered and best promoted by OEMs and body builders. This has been investigated in depth with the follow-up interviews, and is described in the next sub-section.

OEMs' and body builders' offer of fuel-saving technologies

When initially asking OEMs about the technologies that they offer, no clear list of technologies resulted. Therefore, more detailed questions about the specific list of technologies included in Chapter 1 (Table 1) were asked during the follow-up interviews with OEMs and body builders. OEMs and body builders were hereby asked to indicate whether they sold an energy-efficient technology as an option, whether it was standard to every truck, or whether they did not offer that particular technology to transport companies. The results are shown in Table 6.

Table 6 The offer of fuel-saving technologies by OEMs and body builders

	Not offered	Optional	Standard
Aerodynamics			
Trailer rear end taper	67%	33%	0%
Boat tail	100%	0%	0%
Box skirts	0%	100%	0%
Cab side extension or gap fairings	0%	100%	0%
Full gap fairing	33%	67%	0%
Full skirts	0%	100%	0%
Roof deflector	0%	100%	0%
Material substitution			
Light-weighting (truck)	0%	100%	0%
Light-weighting (trailer)	0%	100%	0%
Tires and Wheels			
Automatic tire inflation (truck)	33%	67%	0%
Automatic tire inflation (trailer)	0%	100%	0%
Low rolling resistance tires (truck)	0%	33%	67%
Low rolling resistance tires (trailer)	0%	67%	33%
Transmission and driveline			
Transmission friction reduction	100%	0%	0%
Engine efficiency			
Improved diesel engine	0%	0%	100%
Hybridisation			
Hybrid engine	33%	67%	0%
Management			
Training and feedback	0%	67%	33%
Predictive cruise control	0%	100%	0%

Table 6 indicates that most fuel-saving technologies are optional. There are a few exceptions though. As mentioned earlier in this section, the boat tail is not offered by any of the body builders, which explains both the low level of awareness and implementation. The same applies to transmission friction reduction, which - as was the case for the diesel engine – is a very vague and broad term that was not specified in the questionnaires. Therefore, it is not possible to draw any further conclusions of this technology.

The trailer rear end taper, full gap fairing, automatic tire inflation on the truck and the hybrid engine are offered as an option by some, but not all body builders or OEMs. Every of these four technologies also had low implementation rates. An improved diesel engine is standard on every truck within this sample of OEMs, which is in line with the high implementation rate within the transport company sample. Two of the three OEMs and one body builder in the follow-up sample also installed low rolling resistance tires on every truck or trailer, which is again in-line with high implementation rates for this technology. These results suggest that the offer of technologies by OEMs and body builders, and whether a technology is offered standard or as an option, influences the adoption levels of transport companies. In this light, it also seems relevant to what extent transport companies can customise their truck or trailer; this is described in the next sub-section.

Level of customisation when acquiring a truck or trailer

In addition to the technologies that are offered, the extent to which transport companies can add or eliminate individual fuel-saving technologies to a truck or trailer will also be of influence on the implementation rates of different technologies.

Every transport company in the follow-up sample does perceive that both OEMs and body builders suggest adding at least some fuel-saving features when purchasing trucks or trailers. However, there was one highly innovative, environmentally conscious transport company in the follow-up sample that confirmed that most technologies can be delivered upon request (i.e. are optional). However, this company emphasised that these options are not promoted well by OEMs nor by body builders. Put differently, if a transport company is knowledgeable about different fuel-saving options, these can be added, but companies that are not well aware of the range of possible fuel-saving options will end up with a more ‘standard’ truck or trailer. This may indicate that transport companies that have less access to knowledge of fuel-saving technologies may not necessarily be offered the *whole* range of possibilities during the purchase decision.

OEMs confirmed that it is indeed possible to add each fuel-saving technology separately. However, more often OEMs based their interview responses on packages that they offered, such as an eco package or fuel efficiency package. Such packages include technologies such as a speed limiter (set at a lower speed than required by law), a tire pressure monitoring system, driver training, the elimination of the external sun visor, light weighting, low rolling resistance tires and aerodynamic chassis panelling. It is these packages that OEMs advertise and try to sell to transport companies, and, OEMs often have demonstration trucks that are equipped with these packages. This, in turn, indicates that, especially for companies that are less informed in this area, the implementation of fuel-saving technologies is highly influenced by what the OEMs decide to include in their fuel-saving or eco package.

With respect to body builders, customised trailers are a possibility but are rarely sold. As mentioned earlier, body builders perceive that transport companies do not demand trailer-specific fuel-saving technologies, and as a consequence, there is no need to add such features to trailers. The manufacturer of side skirts confirms that body builders face a low demand for fuel-saving technologies from transport companies.

Operational measures

When looking at the operational measures, it appears that except for predictive cruise control, the majority of transport companies are aware of the listed operational measures shown in Table 7.

Table 7 Overview of awareness and implementation rates of different operational measures

Operational Measures	Not Aware	Aware	Planned/ implemented
Predictive cruise control	56%	44%	22%
Route management	17%	83%	83%
Training and feedback	8%	92%	92%
Manual tire pressure monitoring	11%	89%	78%
Front wheel alignment	11%	89%	78%
Axle alignment	11%	89%	78%
Driver fuel efficiency control	22%	78%	78%
Registration of fuel consumption	10%	90%	80%

Moreover, not only were companies largely aware of operational measures to improve fuel efficiency, most companies have actually implemented them. Therefore, these implementation rates are substantially higher (ranging from 78% to 92%) than is the case for most technical options (ranging from 55% to 67%). This seems congruent with the fact that most companies reported that they collect fuel consumption data for training and feedback, which is also an operational measure.

Predictive cruise control was found to be often cost-effective across a range of various assumptions in Chapter 2. As was the case for the boat tail technology, the low awareness level is puzzling, especially when considering that this technology is offered as an option by every OEM in the follow-up sample. Training and feedback was indeed found to have high cost-effectiveness in the analysis, but route management did not. Despite this, the majority of companies (83%) have implemented route management as an operational measure, which may be explained by other benefits than fuel efficiency (e.g. increased speed of delivery).

In the follow-up interviews one thing became very clear: transport companies, body builders, leasing companies and OEMs are convinced that not only do operational measures result in more fuel savings than technical measures, but these are also far less costly and difficult to implement. Some typical statements were:

- Transport company: “The largest fuel savings result from drivers that use their right foot correctly”.
- OEM: “Either the company can invest a lot of money in technical measures that only deliver fuel savings of a few percent points, or the company can invest a little bit in driver training and other driver monitoring system and save a lot more fuel”.

– Body builder: “You can save a lot more with operational measures. Thereby this is far less radical and expensive. All fuel saving options for trailers are very expensive and the exact fuel savings unsure”.

Though there seems to be a widely held belief that operational measures are best to implement at the moment, several OEMs, body builders and transport companies did indicate that a focus on technical measures is necessary in addition to operational ones. However, the survey results for this project suggest that operational measures are preferred over most fuel-saving technologies.

4.3.6 Time lag

It is quite difficult to conclude whether there exists a time lag between the point at which a new technology becomes available and when it is bought. The previous section did indicate that companies are aware of most technologies.

Companies indicated whether they are considering making aerodynamic retrofits to their existing fleet or not. Whereas 30% of the transport companies claimed to consider this, 70% answered they are not. Two transport companies indicated that they do consider aerodynamic aspects when they acquire a new truck and that it would be troublesome to do so with existing trucks as this would require to temporarily shut down operations. This may indicate that at least in some cases a time lag is present. The fact that most companies focus on operational fuel efficiency (which can be implemented while continuing operations) rather than technical efficiency may also be an indication of companies’ reluctance to take their trucks out of operations.

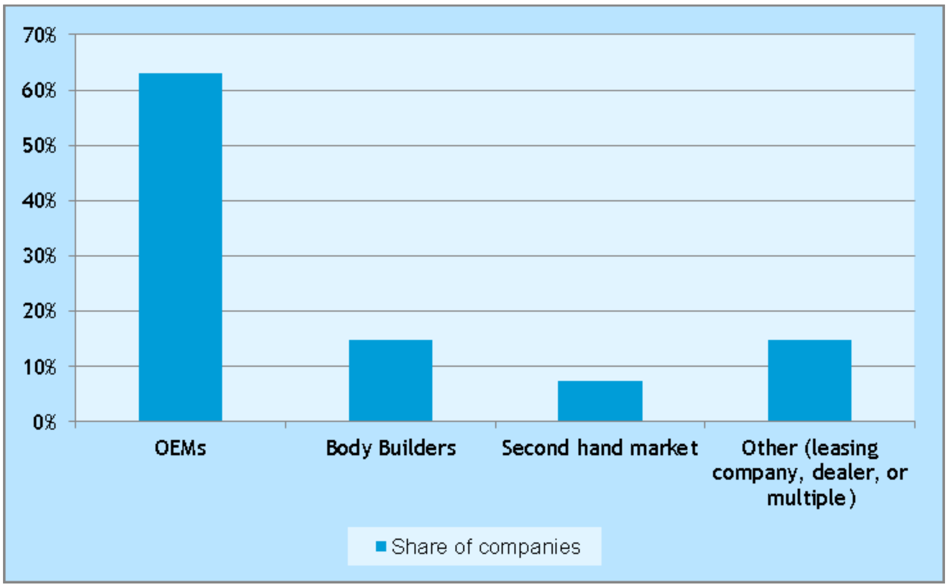
In the follow-up interviews there were indications that retrofits to trucks and/or trailers are very expensive and, hence, often not considered. Rather, companies will wait until they acquire a new truck. It is clear therefore that time lags are present in at least some cases, but the scale of the problem cannot be determined with our results.

4.3.7 Lack of information and high transaction costs

As pointed out in the previous chapter, there often exists an information asymmetry in the market, which occurs when manufacturers (OEM) have better information about technologies than the parties investing in it. This asymmetry can result in a complete lack of awareness of the existence of a technology, or in uncertainties about its performance. Section 4.3.5. discussed that the former seems less relevant, as the majority of companies are well aware of most technologies.

However, it may still be costly to find information about the performance of new technologies. When looking at Figure 19 below, it becomes clear that most transport companies surveyed (63%) acquire their new trucks from OEMs; hence, the data provided by this party is likely to be an important source of information for transport companies.

Figure 19 **Parties from which transport companies acquire trucks**



As aforementioned, it may be difficult to obtain information about the fuel efficiency of the trucks OEMs are offering, or as one interviewee has put it: 'every OEM will claim that his truck is the most fuel-efficient in its category'. When looking at the responses of the OEMs, they indeed all claim that their trucks belong to the most fuel-efficient in the market.

The methods used by the different parties to obtain an indication of the fuel-efficiency of new trucks has been investigated during the follow-up interviews.

OEMs measure the fuel efficiency of their trucks in a similar fashion; every OEM stated that they test drive their trucks with on board computers that measure fuel consumption and other determinants of influence on the truck's fuel consumption. They share this data with transport companies.

All of the OEMs in the follow-up interviews further indicated that transport companies can evaluate the fuel efficiency of a new truck with two methods:
- First, every OEM reported that they offer a demonstration truck that the transport company can drive. During this test drive, fuel consumption data is registered and can be discussed hereafter. The demo trucks are efficient trucks and most are equipped with a *fuel-saving* package. Consequently, a transport company can use a test drive as an indication of the overall efficiency of a truck with a package of fuel-saving technologies. However, this method cannot be used to determine the fuel efficiency of individual fuel-saving technologies, as these demo trucks cannot be customised to exactly what the transport company is considering to buy.
- Second, OEMs indicate that there are several parties that compare and test the trucks of different brands. These results are then published in expert journals for example, and therefore are available to transport companies. One OEM did indicate that it is often not a truck with a fuel saving package that is being tested, rather it are the 'standard' trucks that different OEMs offer. This would limit the usefulness of this data source for transport companies deciding on different fuel-saving technologies.

Only one of the three transport companies in the follow-up interviews has indicated that they use demo trucks when acquiring a new truck. However, despite this, the company explained that this is still only an estimation of actual fuel consumption and therefore, the acquired truck will most often serve as a practice example, which will influence next acquisitions. None of these transport companies indicated that they rely on expert journals/tests when deciding on a truck acquisition. Rather, two of the three transport companies stated that they rely on the data that is provided by OEMs. The third transport company does not believe there is much difference in the fuel efficiency of different brands nowadays.

Body builders of trailers are experiencing even more difficulties when assessing the fuel efficiency of their trailers; none of the body builders that were interviewed stated that they are able to measure, and hence know, the fuel efficiency of their own trailers. As a result, body builders cannot provide this information to transport companies. They do not seem to perceive this as a problem though, as every of the body builders indicated that transport companies do not, or rarely, ask questions about the fuel efficiency of different trailers.

In sum, these results suggest that there is a significant lack of information about the performance of both fuel-saving truck and trailer technologies in the market, which impedes the adoption of at least some fuel-saving technologies.

4.4 Barriers for different market segments

As mentioned in Section 4.2., it is quite difficult to determine whether different barriers are present in different market segments (long haul, regional, and urban), as most companies interviewed are active in multiple market segments. Urban delivery has to be excluded as there were only two companies only active in this market.

Few significant differences could be found between the regional and long haul segments, which was expected since these two segments are relatively similar. Our sample does indicate that the number of companies with fuel surcharges is somewhat higher in the long haul (85%) than in the regional market (50%), as is shown in Figure 20.

Figure 20 Contract structures used in the different market segments

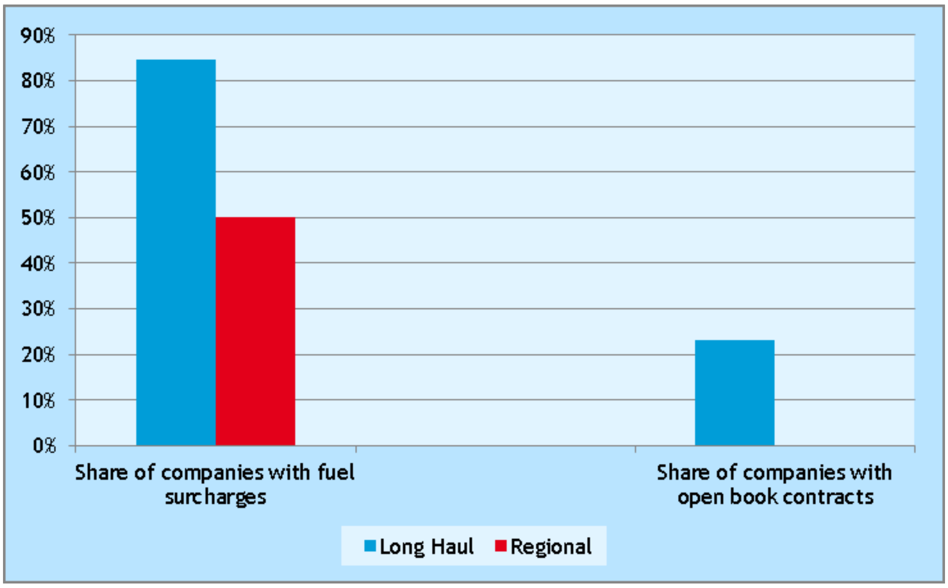


Figure 20 also shows that the share of companies sometimes operating with open book contracts are active in the long haul segment (23%) rather than in the regional segment (0%). The higher share of fuel surcharges and open book contracts in the long haul segment may also be explained by the fact that fuel costs are a relatively higher share of the total costs; therefore, fuel price fluctuations can potentially have a larger impact. For these companies it may therefore be more of a necessity to negotiate such clauses. Either way, when looking only at contract structures, it can be expected that fuel efficiency is relatively more important in the regional segment, considering that in this segment companies are less shielded from fuel price fluctuations.

Some difference could be detected when looking at the ranking of fuel efficiency in the criteria for investing in new trucks, as is shown in Figure 21 below.

Figure 21 **The importance of fuel efficiency when acquiring a new truck in different market segments**

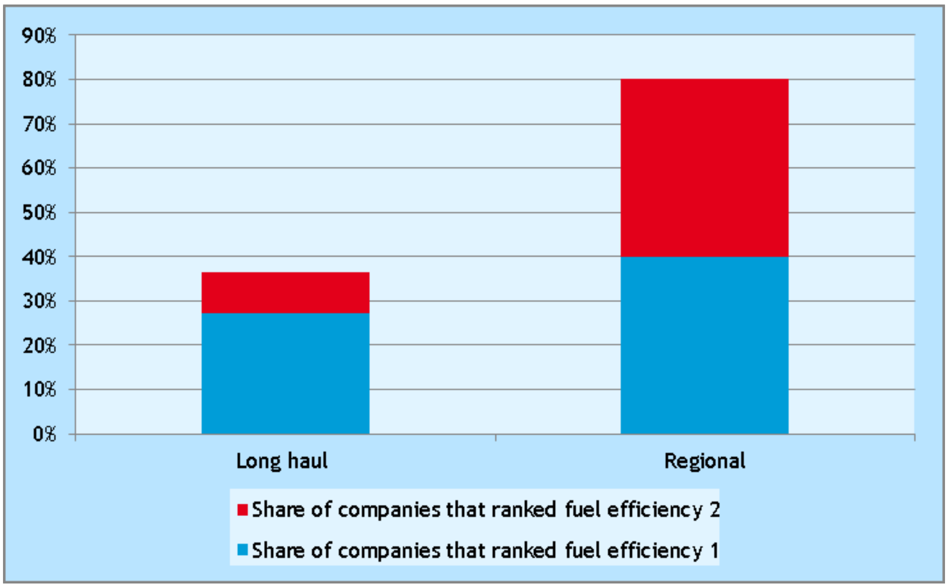


Figure 21 shows that fuel efficiency is considered to be most important by a relatively larger share of companies in the regional (40%) than in the long haul segment (27%). When also taking into account the share of companies ranking fuel efficiency second most important, the difference between market segments becomes even larger (Figure 21). In the long haul segment, cargo capacity is considered most important more often than fuel efficiency (36 vs. 27%).

Unfortunately, it could not be analysed whether the companies in the regional segment did indeed implement more fuel-saving technologies, as the sample has become too small at this point (only 3 companies in each market segment answered this question).

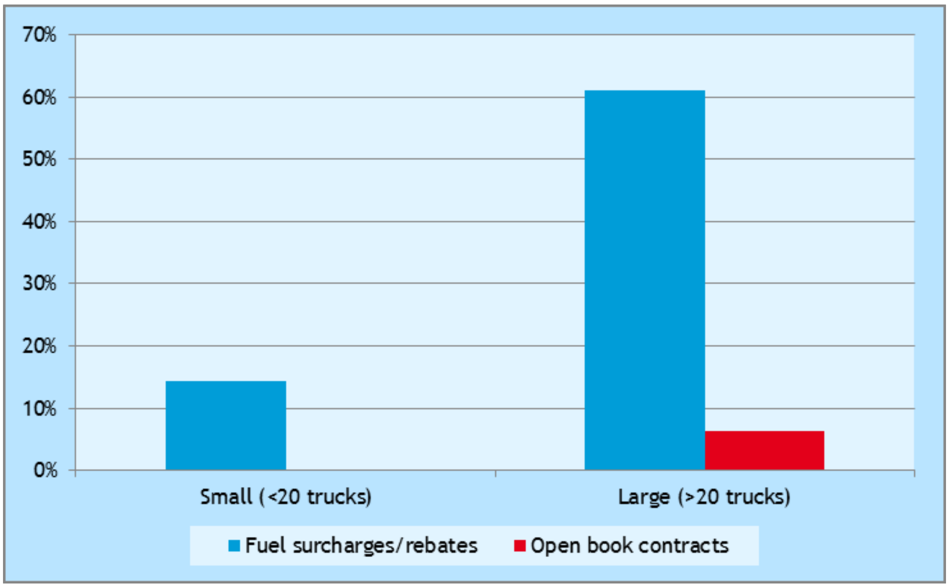
When looking at the underlying investment criteria no significant differences could be detected, except with respect to lifetime. The majority of companies in the long haul segment (78%) holds on to their trucks for less than 6 years, whereas in the regional segment companies mostly indicated to hold on to their trucks for 6 years or more (75%). This matches expectations, as long haul trucks typically run more kilometres a year than those used for regional transport.

4.5 Barriers for differently sized companies

As mentioned in the literature review, company size may have an influence on the significance of barriers as well. Unfortunately, the number of very small companies that completely filled out the questionnaire is very low in our sample. Consequently, it cannot be concluded whether very small companies face additional barriers, such as problems with obtaining funding when acquiring new trucks.

The contract structures used by small and large companies in our sample did significantly differ though, which is shown in Figure 22.

Figure 22 The use of fuel surcharges and open book contracts for differently sized companies



As becomes clear from Figure 22, small companies are significantly more exposed to fuel prices, as only 14% operate with fuel surcharges in their contracts. In contrast, within the sample of larger companies, 61% of the companies use fuel surcharges and are therefore at least partially shielded from fuel price fluctuations. Only one (larger) company in this sub-sample indicated that they also operate with open book contracts, which likely causes a split incentive.

It cannot be concluded whether smaller companies pay more attention to fuel efficiency when acquiring new trucks and/or implement more fuel-saving technologies as compared to the partially shielded larger companies, as only three small-sized companies filled out the related questions.

One of the OEMs stated that smaller companies are actually less willing to evaluate their fleet in terms of fuel efficiency and to invest a little bit extra in fuel-efficient technologies than larger ones. According to this interviewee, larger companies can make use of economies of scale, which makes such evaluations easier and less costly to accomplish.

4.6 Barriers in different countries

The geographical coverage of the sample is quite high. When looking at the differences between countries a few interesting trends can be detected, these are described below.

The most significant difference that could be detected concerns how companies in different countries deal with fuel price fluctuations in their contracts, as is shown in Figure 23.

Figure 23 Differences in the use of fuel surcharges and open book contracts in different parts of Europe

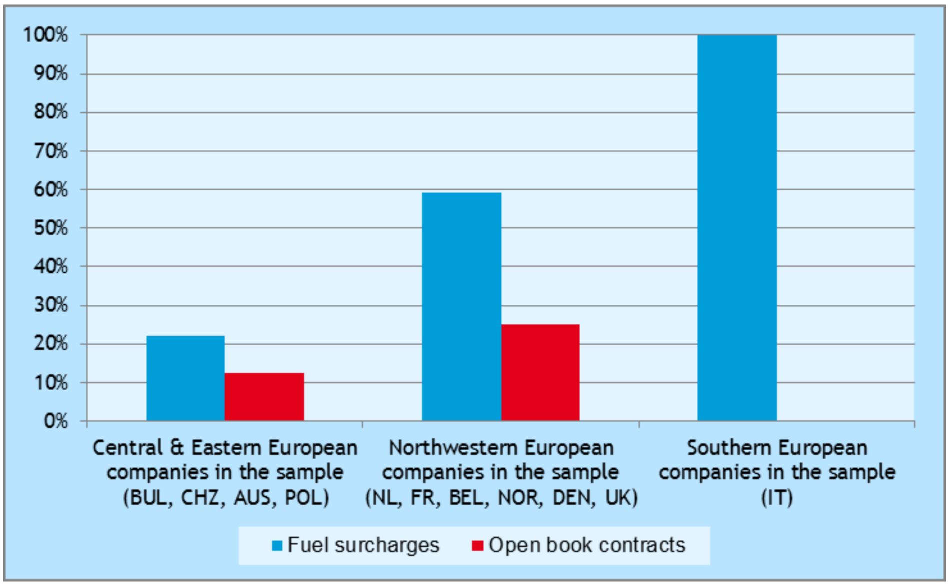
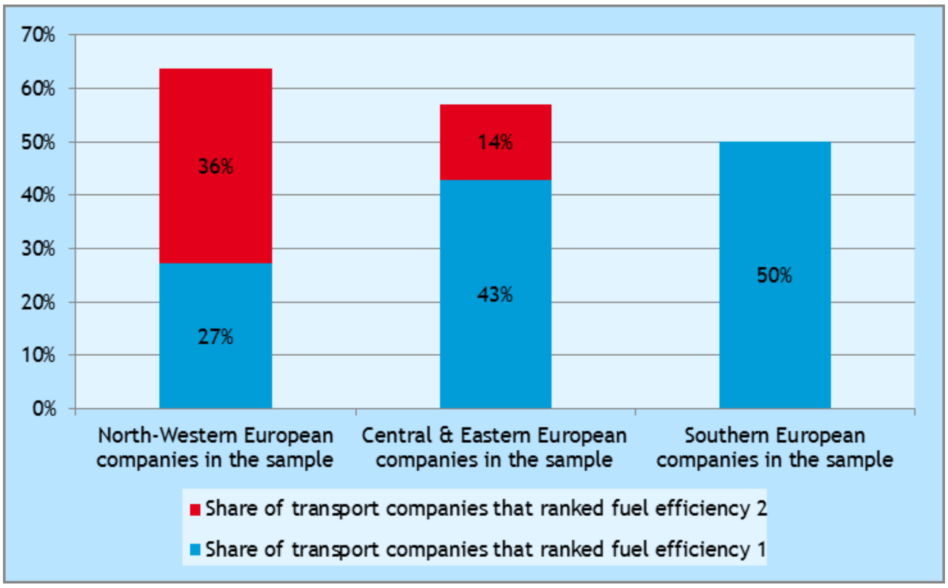


Figure 23 shows that especially in the Eastern European countries (i.e. Bulgaria, Czech Republic, Austria and Poland) fuel surcharges are mostly absent. Although 22% do include fuel surcharges in their contracts, the remaining 78% does not. The reasons for not using fuel surcharges mostly relate to the unwillingness of shippers to pay for such clauses. In Northwest Europe (Netherlands, France, Belgium, UK, Denmark and Norway) and Southern Europe (Italy) the shares of companies with fuel surcharges are significantly higher with 59 and 100%, respectively. However, it should be noted that almost every Italian company as well as some companies in Northwest Europe indicated that the fuel prices in their surcharges were only updated a few times a year. As mentioned earlier this is likely to reduce the shielding from fuel price developments, as companies would still be exposed to fuel price fluctuations during the interval periods. Also, Italian companies indicated that they could not apply this surcharge very often in practice due to the pressure of shippers.

Figure 23 also shows that with respect to open book contracts, a similar picture emerges. In Eastern Europe only 12,5% occasionally operates with such a contract, whereas in Northwest Europe this is 25%. According to this sample, a quarter of the companies in North-western European countries may have a split incentive and therefore not willing to invest in fuel efficiency. In Southern Europe none of the companies in the sample operates under open book contracts (although this is based on a sample of only five companies).

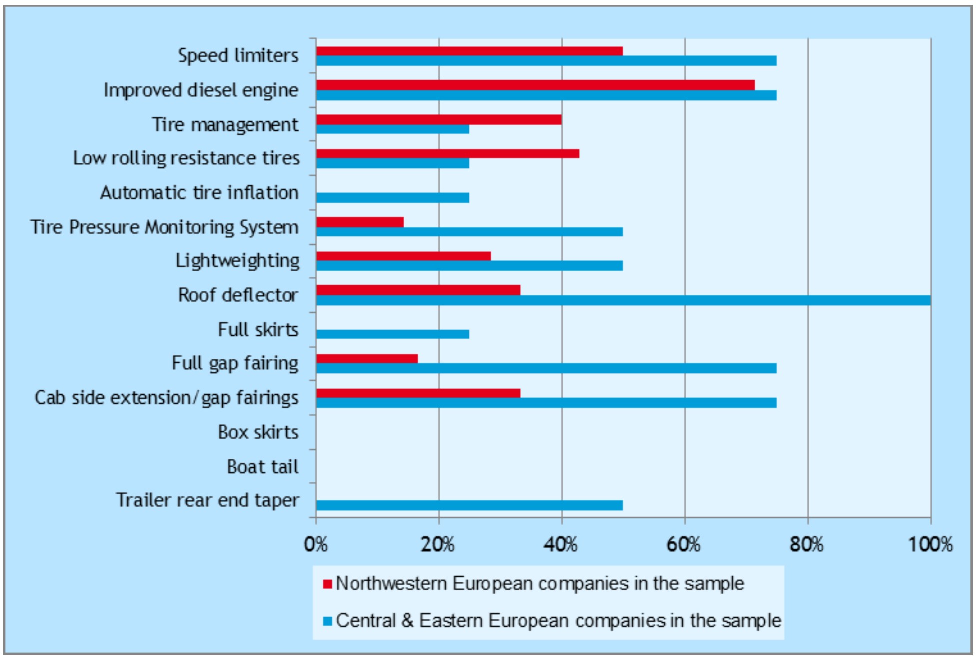
When looking merely at contract structures, it could be expected that companies operating in Eastern European countries would pay relatively more attention to fuel-saving technologies. The relative importance of fuel efficiency in the different segments is shown in Figure 24.

Figure 24 **The importance of fuel efficiency in acquiring a new truck for different geographical segments**



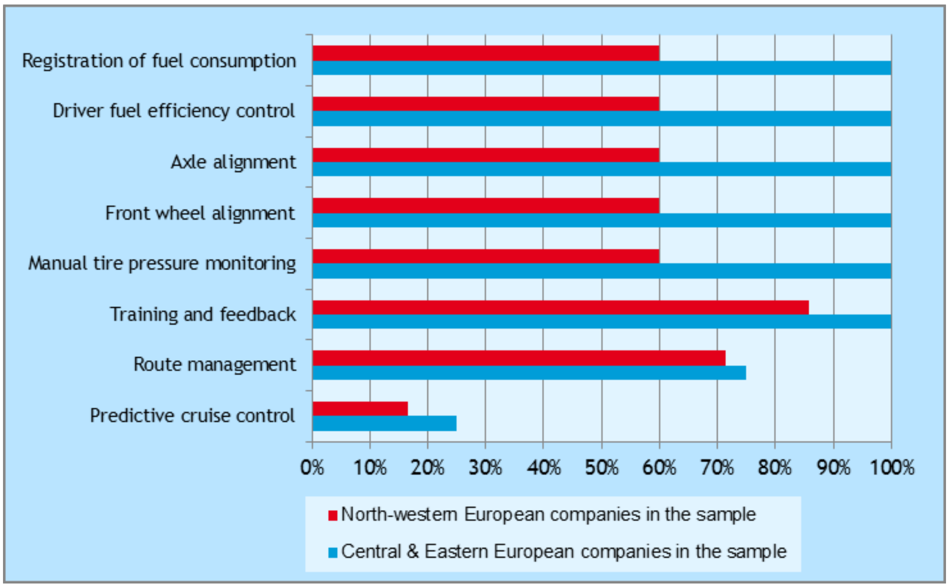
Eastern European companies are quite diverse in the criteria they take into account when buying new trucks. However, it is indeed the case that fuel efficiency is considered as most or second most important by 57% the Eastern European companies, which is followed by the brand of the vehicle (43% of the companies ranked this criterion most or second most important). In North-western Europe, fuel efficiency is also the criterion ranked 1 or 2 most often, although relatively more companies ranked it second most important as compared to companies in Eastern Europe. In North-western Europe cargo capacity is the second most important criteria (36% of the companies ranked it either most or second most important). Although 50% of the companies in Southern European ranked fuel efficiency as most important, it is not the most important criterion in segment; reliability was ranked 1 by 50% of the companies, and in addition, it was ranked second most important by 33% of the companies (in contrast, fuel efficiency was not ranked second most important once by the remainder of the companies).
Additionally, Figure 25 below shows the share of companies in both Eastern and Western European companies that have implemented technical options to save fuel (Southern Europe is excluded as these companies did not answer this question).

Figure 25 Implementation rates of fuel-saving technologies in different geographical segments



As can be seen in Figure 25, the implementation rates are significantly higher in Eastern European countries for most technologies. However, the sample size is relatively small (4 Eastern European companies and 7 companies in North-west Europe answered this question). With respect to the operational measures, a similar distribution results, which is shown in Figure 26 below.

Figure 26 Implementation rates of operational measures in different geographical segments



As can be seen in Figure 26, companies in Eastern Europe have implemented relatively more operational measures than those in North-western Europe. The fact that companies in North-western European countries have lower implementation rates for both technical and operational measures may indicate that fuel surcharges indeed reduce the priority given to fuel efficiency, and hence their investment in fuel-saving measures.

When looking at the underlying investment criteria, no significant differences could be detected between the different parts of Europe. Most likely this results from the fact that even companies within the same geographical category differ significantly in the investment criteria that they use.

Finally, the differences that have been found between companies in different geographical segments with respect to fuel costs in contracts and the implementation of fuel-saving measures may also be a result of the different fuel prices that are present in these regions. However, it is beyond the scope of this paper to investigate how this has influenced the results described in this section.

4.7 Conclusion

The results from the survey and follow-up interviews indicate that the main barriers impeding the adoption of fuel-saving technologies are technical and financial factors.

Many transport companies are partially shielded from fuel price fluctuations by fuel surcharges and rebates. While this could move fuel efficiency down the management priority list in theory, most companies in our sample still actively monitored fuel consumption of trucks and used this information to inform and train drivers. Hence, they recognise that operational fuel-efficiency is important. However, hardly any company uses the data to evaluate technologies or compare trucks. In other words, they do not appear to be as active in improving the technical fuel-efficiency as they are in improving the operational fuel-efficiency. It has become clear from the follow-up interviews that this results from the fact that operational measures entail larger fuel saving benefits, and are less costly and difficult to implement. It is not certain whether this is a *belief* or whether this is *true* in reality. However, the fact that it is extremely difficult for transport companies to estimate the fuel-savings from different trucks and trailers at the point of acquisition (i.e. there is a lack of information) will not have a positive influence on their view of these technical measures. At present, transport companies mostly rely on the information that is provided by OEMs and body builders. However, while the fuel efficiency of trucks is typically measured during test drives by OEMs and can be estimated by end-users using demonstration vehicles, body builders do not measure the drag characteristics (i.e. rolling resistance and aerodynamic) of their trailers. So although a lack of information can impede both truck- and trailer fuel-saving technologies, it is especially troublesome for trailer-specific technologies.

In addition, OEMs and body builders have an important influence on the implementation rates of technical measures through their decisions on which technologies to offer and promote. OEMs are able to deliver most technologies that were included in this research as an option. However, OEMs are mainly focussed on promoting the fuel-efficiency packages in their entirety and therefore do not promote individual technical options well. Although body builders can deliver most technologies as well, they do not promote them at all, as transport companies do not demand additional technologies.

Financial constraints are likely to be an important barrier in some cases. Many transport companies need to use financial institutions when acquiring a new truck; this may negatively impact the adoption of fuel-saving measures in two main ways. On the one hand, transport companies indicated that lending institutions are not willing to supply higher loans for more fuel-efficient trucks, which was confirmed by leasing companies. These lending entities merely look at the financial health of the company. On the other hand, there are restrictions on truck leases in several European countries. For companies operating in these countries it will therefore be very difficult to arrange funding; this will result in less truck acquisitions and hence less fuel-saving technology adoption. In this case, financial constraints indirectly result from legislation. Legislation is also resulting in some technology-specific barriers, such as the restrictions on trailer length, which is impeding the adoption of boat tails.

It was also found that transport companies vary with regards to the time they hold on to their vehicles and with regards to their expectation of being able to sell their more fuel-efficient trucks at a premium in the second hand market. As a result, the criteria for evaluating investments in fuel-efficient technologies varies considerably between companies. However, due to a lack of information, it cannot be concluded whether this is impeding fuel-saving technologies.

Finally, this survey has not found evidence that a split incentive resulting from contract structures is a major barrier for improvements of the fuel-efficiency of trucks in the on-road transport sector. While the survey results suggest that a split incentive is apparent in an open book contract, these are rare, and most companies that have them also operate under different contract types.

The results of the survey that have been presented above are somewhat biased towards relatively larger companies (>20 trucks), as it was very difficult to get representative and comprehensive feedback from small (<20 trucks) transport companies. Consequently, the results of this study not necessarily apply to very small transport companies; these companies may face a different set of barriers and incentives than larger transport companies. The results from the survey were not sufficient to draw any meaningful conclusions on this matter though. The survey did provide some indication that very small companies use fuel surcharges and open book contracts significantly less often than larger companies, but more research is needed on this topic. The role of leasing companies with respect to the adoption of fuel-saving technologies also requires more in-depth research, considering that they are involved with a large share of the new truck and trailer acquisitions.

5 Conclusions

In the on-road freight sector, many cost-effective measures to reduce the fuel consumption of trucks and truck-trailer combinations are not universally implemented. Hence, there are barriers that prevent their uptake.

Based on a survey of transport companies, shippers, third party logistics providers and original equipment manufacturers as well as a number of in-depth interviews, we find that there are four types of barriers which prevent the uptake of these measures.

Because our survey and interview sample may be biased towards companies that are more environmentally aware than the average company, the answers could be biased towards companies that:
- are probably more aware of the fuel saving options;
- have probably implemented a larger share of fuel-saving options;
- are less affected by the barriers.

The presumed bias in our sample means that the barriers we have identified are likely to be relevant for the whole road freight sector (including transport companies, OEMs, trailer body builders, shippers and logistics service providers). Conversely, barriers that we did not identify in our study may still be relevant for a different segment of the road freight sector, although the more environmentally aware companies have found ways to overcome them. . In addition, our sample does not cover SMEs well, while these companies may have a different view on fuel efficiency than larger companies. Future research is needed to investigate their perspectives.

An important barrier is the lack of information on the fuel saving potential of individual technologies for trucks and especially on trailers. While many transport companies and all OEMs are aware that certain technologies exist, very few think they are cost-effective. It is a widely held belief in the road freight sector that operational measures, and especially those measures which do not require investments, lead to savings and that technical measures are too costly.

Perhaps as a result of this belief, the supply of fuel saving technologies from OEMs is limited. Most OEMs of trucks offer packages of certain technologies as options when buying a new truck. The package of one of the interviewed OEMs includes technologies such as a speed limiter (set at a lower speed than required by law), a tire pressure monitoring system, driver training, the elimination of the external sun visor, light weighting, low rolling resistance tires and aerodynamic chassis panelling. Other technologies are often not offered; many are retrofits on existing trucks. For trailers, the situation is worse; body builders appear not to offer fuel-saving equipment unless their client specifically asks for it. The limited supply gives rise to higher search and information costs for transport companies. Moreover, while transport companies are generally allowed to test drive a truck to evaluate its fuel efficiency, these trucks are equipped with the fuel-saving package offered by the OEM, and therefore are of limited use for transport companies deciding which individual technologies to buy.

The limited offer of technologies on new trucks is odd, since many transport companies are very interested in the fuel efficiency of trucks when they buy a new one. At that point, they face limited information on the efficiency improvements of individual measures, however, and have no means to evaluate them prior to acquiring a truck or adding a specific technology. In contrast, once they have acquired a truck, transport companies generally focus on operational measures such as driver training to improve fuel efficiency.

Other barriers are less important or apply only in specific situations. A split incentive occurs in trailers, where shippers sometimes order and own the trailers, and hence have to make an investment in fuel saving technologies, while transport companies are likely to benefit from it. A split incentive also occurs when transport companies operate under an open book contract, under which they can bill the shipper for the actual fuel consumption, but very few companies operate exclusively with open book contracts. Many have fuel surcharge clauses, which still allows them to increase their margin if they improve the fuel efficiency of their trucks. The attention that transport companies give to operational fuel efficiency also disproves the existence of a split incentive.

Financial constraints are not a barrier in general, although in some countries a limited access to financial instruments makes it hard to finance fleet renewal. Moreover, transport companies seem to be disinclined to invest in fuel saving technologies, but this is probably not because of lack of access to capital, but because the lack of information about the benefits of certain measures and the belief that efficiency improvements are to be made by operational measures.

These findings point toward several recommendations for industry and policy decision-makers. It is evident that there are a number of heavy-duty truck efficiency technologies that exist with the potential for fuel savings that overcome the initial technology costs. Policies, including vehicle labelling and regulatory approaches with appropriate lead-time, can provide improved investment certainty for technology development among truck manufacturers and suppliers. Such policies can also help ensure market growth in technologies that are emerging, cost-effective, but are sold only in low volumes today.

However, it appears that improved information is needed to help facilitate this market for known, available, and cost-effective efficiency technologies. Consistent and transparent technical information on fuel-saving technology options from joint government/industry-developed test procedures would help at many levels to reduce the prevailing market barriers. For example, such information would help truck and trailer purchasers better understand fuel-saving technology availability and these technologies' potential attractiveness to their own fleet's truck classes and operations. With consistent data sources, OEMs would be able to better market fuel-saving options to prospective buyers. In addition, transport companies could better publicise their average fleet efficiency characteristics to potential shippers, and shippers could better understand the truck efficiency technologies available to them. To get this point of high-quality technical information, a standardised test procedure with transparent results by engine and/or truck model is a necessary step. In addition, public-private partnerships could be explored to demonstrate and validate fuel-saving benefits from leading new vehicle technologies (e.g., engine and transmission), as well as aftermarket technologies (e.g., aerodynamic features, and low-rolling resistance tires).

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Annex A Results of the MACH model runs

A.1 Results of the MACH model runs for urban delivery

In order to estimate the likelihood of different fuel-saving technologies being cost effective to implement, the MACH model of CE Delft (2012, model version of May) was used. With this model it was possible to vary different underlying parameters to obtain a range of marginal abatement costs (i.e. cost effectiveness) in different scenarios. Through varying the discount rate, life time, and fuel price, nine different scenarios resulted. Table 8 shows the Marginal abatement costs of different technologies in the different scenarios for the urban market segment.

Table 8 Cost-effectiveness of urban vehicle technologies in different scenarios in €/tonCO_2[7]

Technology	Scenario (Discount rate in % =DR, vehicle lifetime in years = VL, Fuel price €/l = FP) +++											- - -
DR	10%	10%	16%	16%	10%	10%	16%	16%	10%	10%	16%	16%
VL	19	9	19	9	19	9	19	9	19	9	19	9
FP	€ 2	€ 2	€ 2	€ 2	€ 1.5	€ 1.5	€ 1.5	€ 1.5	€ 1	€ 1	€ 1	€ 1
Low resistance wheels	-300	-420	-210	-330	-220	-300	-150	-230	-140	-190	-90	-140
Trailer rear end (i.e. aft box) taper	-290	-390	-190	-300	-210	-270	-130	-200	-120	-150	-70	-100
Roof deflector	-280	-370	-180	-280	-200	-250	-120	-180	-120	-130	-70	-90
Trailer (i.e. Box) skirts	-270	-360	-170	-260	-190	-240	-120	-160	-110	-120	-60	-70
Advanced 6-9 l engine	-240	-290	-140	-190	-160	-170	-80	-100	-70	-50	-20	0
Parallel hybrid	-190	-180	-90	-80	-110	-60	-30	10	-20	60	30	110
Cab side extension	-80	40	10	140	0	160	70	230	80	280	130	330
Material substitution	60	330	150	430	140	450	210	530	220	570	270	620

Source: CE, 2012, model version of May.

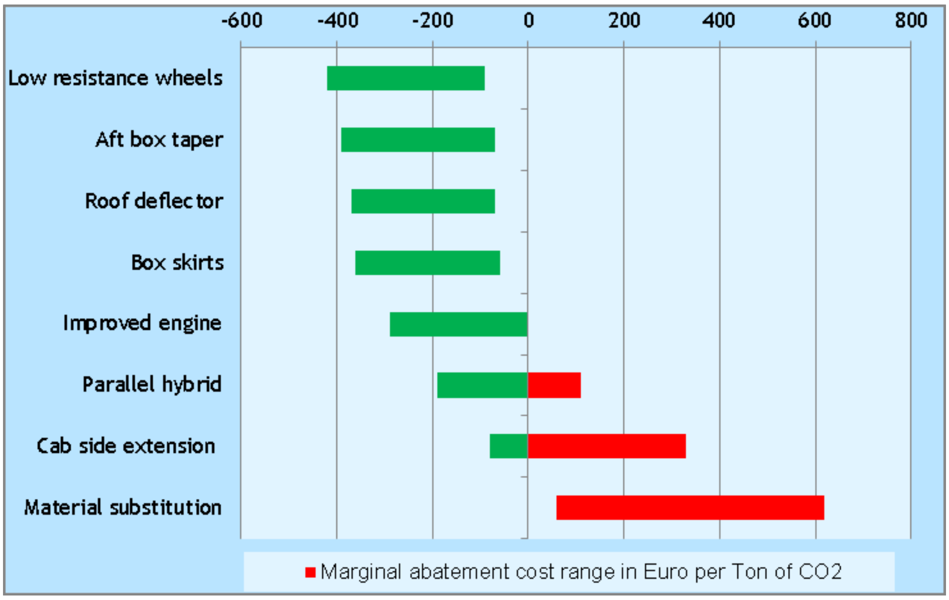
As can be seen in Table 8, within the urban market segment, four technologies were cost-effective in every of the assumed scenarios, even when the underlying parameters were varied significantly. These are: low rolling resistance tyres, a trailer rear end taper, the roof deflector, and trailer skirts.

7 In some of the modelled scenarios the average benefits from reducing one ton of CO_2 become *larger* when *reducing* the lifetime of the vehicle, which may seem odd in first instance. The explanation for this effect can be found in the use of the discount rate, which causes that future cash flows are worth less then similar cash flows that occur in a shorter timeframe. The NPV does decrease when the lifetime is shortened. When looking at the trailer rear end taper for example, the benefits from reducing one ton of CO_2 increase from € -290 per ton when the lifetime is 19 years to € -390 when the lifetime is 9 years. However, the NPV of the overall investment actually decreases from € 2,857.00 (19 years) to € 1,740.00 (9 years).

Additionally, the advanced 6-9 l engine is cost-effective in most scenarios as well, except when both the vehicle lifetime and fuel prices are low and a high discount rate is applied. In this worst case scenario, the technology breaks even. The cost-effectiveness of a parallel hybrid and cab side extensions vary significantly between simulations; these are riskier to invest as the benefits to be obtained are less certain and subject to fuel price fluctuations. Finally, material substitution was not cost-effective in any of the modelled scenarios.

Figure 27 shows the range of marginal abatement costs that resulted from the different model runs graphically.

Figure 27 The marginal abatement cost range of urban vehicle technologies in different scenarios



A.2 Results of the MACH model runs for regional delivery

The same analysis as outlined in the previous section has been conducted for the regional market segment. Table 9 shows the MAC of different technologies for the regional segment in different scenarios.

Table 9 Cost-effectiveness of regional vehicle technologies in different scenarios €/tonCO_2

Technology	Scenario (Discount rate =DR, vehicle lifetime in years = VL, Fuel price €/l = FP)											
	+++											- - -
DR	10%	10%	16%	16%	10%	10%	16%	16%	10%	10%	16%	16%
VL	12	6	12	6	12	6	12	6	12	6	12	6
FP	€ 2	€ 2	€ 2	€ 2	€ 1.5	€ 1.5	€ 1.5	€ 1.5	€ 1	€ 1	€ 1	€ 1
Low resistance tires	-420	-530	-320	-450	-310	-390	-240	-330	-210	-260	-150	-220
Predictive cruise control	-410	-520	-310	-430	-310	-380	-230	-320	-200	-250	-150	-200
Transmission friction reduction	-390	-470	-290	-380	-280	-330	-200	-270	-170	-190	-120	-150
Advanced 6-9 l engine	-340	-370	-240	-280	-230	-230	-150	-170	-120	-100	-70	-50
Boat tail	-300	-290	-200	-200	-190	-150	-120	-90	-80	-20	-30	30
Auto. tire inflation trailer	-300	-290	-200	-210	-190	-150	-120	-90	-90	-20	-30	20
Full skirts	-60	180	40	260	40	320	120	380	150	450	200	490
Material substitution	-10	290	90	380	100	430	170	490	210	560	260	610
Generation II dual hybrid	310	930	410	1010	420	1060	490	1130	520	1200	570	1240
Auto. tire inflation vehicle	2210	4730	2310	4810	2320	4870	2390	4930	2420	5000	2470	5040
Full gap fairing	-	-	-	-	-	-	-	-	-	-	-	-

Source: CE, 2012, model version of May.

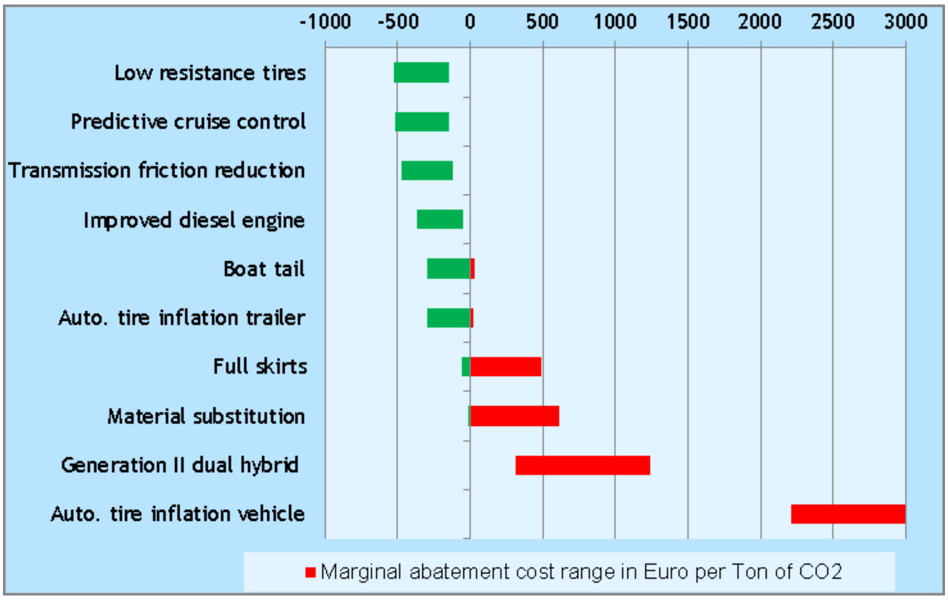
Table 9 shows that four technologies are cost effective in every of the modelled scenarios; these comprise of low resistance tires, predictive cruise control, transmission friction reduction, and the advanced 6-9 l engine.

The boat tail technology and an automatic tire inflation system on the trailer are cost-effective in almost every of the included scenarios as well, except in the worst case scenario. Full skirts and material substitution on the other hand, are only cost-effective in the defined best case scenario. Finally, the generation II dual mode hybrid and automatic tire inflation system on the vehicle were not cost-effective in any of the modelled scenarios.

No marginal abatement costs resulted from the model for full gap fairing, which means that this technology cannot be adopted simultaneously with some other technologies. The fact that no marginal abatement costs resulted in any model run implies that these other technologies are more cost-effective.

The range of marginal abatement costs of each technology in the regional segment is shown graphically in Figure 28.

Figure 28 The marginal abatement cost range of regional vehicle technologies in different scenarios



A.3 Results of the MACH model runs for long haul delivery

Finally, 9 simulations were conducted for technologies that can reduce fuel consumption in the long haul market segment. The marginal abatement costs that resulted can be found in Table 10.

Table 10 Cost-effectiveness of long haul vehicle technologies in different scenarios in €/tonCO_2

Technology	Scenario (Discount rate =DR, vehicle lifetime in years = VL, Fuel price €/L = FP) +++											- - -
DR	10%	10%	16%	16%	10%	10%	16%	16%	10%	10%	16%	16%
VL	8	4	8	4	8	4	8	4	8	4	8	4
FP	€ 2	€ 2	€ 2	€ 2	€ 1.5	€ 1.5	€ 1.5	€ 1.5	€ 1	€ 1	€ 1	€ 1
Low resistance tires	-500	-590	-400	-520	-370	-440	-300	-380	-250	-290	-200	-250
Predictive cruise control	-490	-580	-400	-510	-370	-430	-300	-380	-240	-280	-200	-250
Transmission friction reduction	-480	-550	-390	-480	-350	-400	-280	-350	-230	-260	-180	-220
Training & Feedback	-470	-530	-370	-460	-340	-380	-270	-330	-220	-230	-170	-200
Boat tail	-440	-470	-340	-400	-310	-320	-240	-270	-190	-170	-140	-140
Auto. tire inflation trailer	-440	-470	-340	-400	-310	-320	-240	-270	-190	-170	-140	-140
Full gap fairing	-410	-410	-310	-340	-280	-260	-210	-210	-160	-110	-110	-80
Advanced 11-15 l engine	-410	-410	-310	-340	-280	-260	-210	-210	-160	-110	-110	-70
Route man.	-340	-280	-250	-210	-220	-130	-150	-70	-90	20	-40	60
Full skirts	-340	-270	-240	-200	-210	-120	-140	-70	-90	30	-40	60
Material substitution	-310	-220	-220	-150	-190	-70	-120	-20	-60	80	-20	110
Dual hybrid	-110	180	-20	250	10	330	80	380	140	480	180	510
Auto. tire inflation vehicle	-	-	-	-	-	-	-	-	-	-	-	-

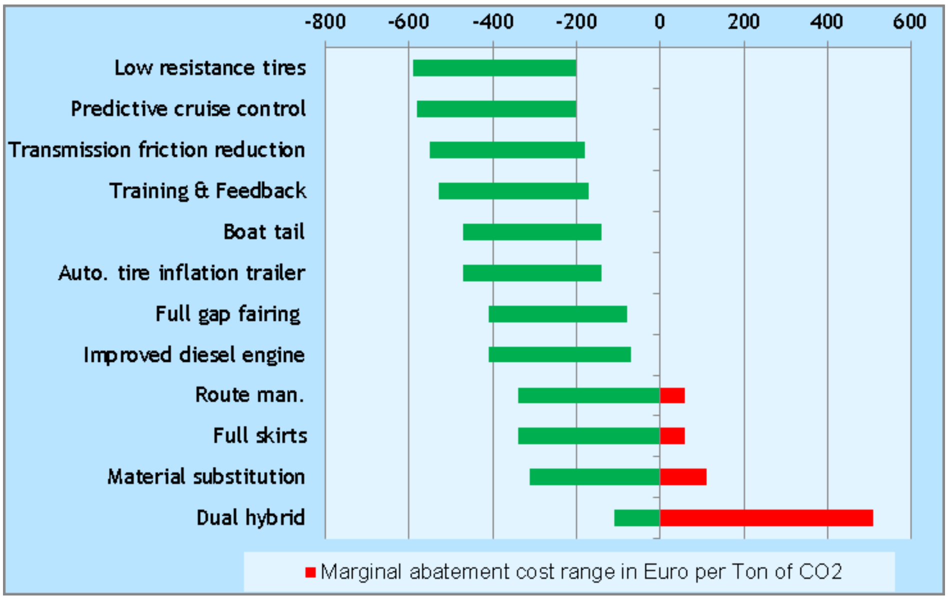
Source: CE, 2012, model version of May.

As can be seen in Table 10, eight technologies have negative marginal abatement costs in every scenario. These comprise of: low resistance tires, predictive cruise control, transmission friction reduction, training and feedback, boat tail, automatic tire inflation trailer, full gap fairing, and an advanced 11-15 l engine.

Route management, full skirts, and material substitution are often cost-effective as well, except when both the fuel price and vehicle lifetime are low. The dual hybrid only has negative cost-effectiveness when both fuel price and vehicle lifetime are high. Finally, automatic tire inflation is less cost-effective than the technologies with which it cannot be adopted simultaneously.

The overall range in marginal abatement costs is shown graphically in Figure 29 for the different technologies in the long haul market segment.

Figure 29 The marginal abatement cost range of long haul vehicle technologies in different scenarios



Annex B Questionnaires

Four questionnaires have been designed in order to investigate the likelihood of different barriers impeding fuel-saving technologies in the on-road freight sector. In every questionnaire, each question directly, or indirectly, relates to one of the barriers that have been identified in literature. The following sub-sections each entail one of these questionnaires, starting with transport companies. Annex B.2 shows the questionnaire of logistics service providers, whereas B.3 does so for OEMs. Finally, Annex B.4. entails the questionnaire that was used for shippers.

In each questionnaire, an indication is given (between brackets) as to which barrier the question relates. Obviously, this indication was not provided in the online questionnaire, and is therefore merely background information for this report.

B.1 Transport companies

Questionnaire for transport companies

The 2011 EU Transport Policy aims at reducing CO_2 emissions from transport by 60% by 2050, which means that also road freight transport will have to undertake additional efforts to reduce its emissions One of the ways to achieve such a reduction is to improve the fuel-efficiency of trucks. Several technologies and operational measures are available and reports show that they often generate a net benefit or can be implemented at low cost. Still, the uptake of these technologies and operational measures appears to be slow.

The International Council on Clean Transportation (ICCT) has commissioned CE Delft to analyse whether there are barriers to the implementation of cost-effective technologies and operational measures in the road freight sector. To that end, we hold an online survey and conduct interviews with transport companies and relevant stakeholders.

Interview date	
Interview conducted by	
Approved by interviewee	Yes/No

1. Company information

Name of your company (not required)	
Contact person and contact details (not required)	
In which country is your company based?	
In which countries is your company active?	
What fleet does your company operate (number of vehicles above 3.5 tonnes GVW, above 12 tonnes GVW, size)	
(Split incentives - ownership structure) Is your company part of or owned by a shipper or a third party logistics provider?	No/Shipper/third party logistics provider
In which market segment(s) does your company operate?	Long haul/regional/urban delivery

General barriers to the implementation of energy saving measures
The costs of fuel are a major and volatile component in the operating costs of HGVs. As a result, contracts may transfer some of the fuel price risk from the transport company to the shipper. This may reduce the incentive to improve the fuel efficiency of trucks.

(Split incentives - contract structures)
1. In general, what is your rate structure based upon (tonne kilometres, tonnes, cargo volume, truck kilometres, other)?
2. Does your company apply fuel surcharges and/or rebates in its contracts?
   a. If so, please specify the basis on which the surcharge and rebate are calculated.
   b. If not, why not?
3. Does your company operate under open book contracts (in which the transport company has a fixed operational margin)?

Companies differ in the attention they pay to fuel efficiency.

(Transaction costs)
4. Does your company generally acquire new trucks or second hand trucks?
5. Does your company generally acquire trucks from:
   - OEMs;
   - body builders;
   - other.

(Investment criteria)
6. How long do you hold onto your trucks in general (years or kilometres)?
   ______ years ___________________________________ kilometres

(Priority order)
7. What are the most important characteristics of trucks you are taking into account when deciding on an acquisition? Please rank from 1 (most important) to 9 (least important).
   a. Cargo capacity.
   b. Engine power.
   c. Gearing.
   d. Reliability.
   e. Past experience.
   f. Brand.
   g. Driver comfort.
   h. Appearance.
   i. Type of propulsion.
   j. Type of fuel.
   k. Air quality emissions.
   l. Fuel efficiency.
   m. After sales services.
   n. Safety.
   o. Other?

(Investment criteria)

8. (If applicable) When buying new trucks, does your company evaluate their fuel efficiency?
   a. Does your company include fuel costs in the total costs of ownership?
   b. Does your company calculate the net present value of the fuel costs and compare it to additional costs of more efficient trucks? If so, which discount rate do you use?
   c. Does your company require a certain payback time for additional costs of more efficient vehicles? If so, which?
   d. Does your company use another method?
   e. Which fuel prices does your company use for such calculations?

(Investment criteria)

9. (If applicable) When buying second hand trucks, does your company evaluate their fuel efficiency?
   a. If so, how?

(Investment criteria)

10. When selling trucks, do trucks with more fuel-efficient features sell at a premium?

(Priority order)

11. Does your company collect data on the fuel efficiency of the trucks you operate?
    a. If so, what is this information used for (e.g. training drivers, incentivising drivers, deciding on selling, buying or scrapping trucks)

(Time lag)

12. Does your company consider making aerodynamic retrofits to trucks in order to improve their efficiency?

    (Investment criteria)
    a. If so, which evaluation methods does your company employ (net present value, payback time, internal rate of return, other)?

Ownership patterns and financial constructions may affect the influence a company has over the fuel efficiency of its fleet.

(Split incentives – truck ownership patterns)

13. Does your company own the trucks it operates?

(Financial constraints)

14. If your company uses a financial company to lease trucks and or provide a loan for truck finance, does the leasing company or bank evaluate the fuel efficiency of your trucks?
    a. If so, would your lending institution be willing to provide a larger loan for a more fuel-efficient truck?

2. Energy Efficiency Measures: State of the Art/Plans for the Future

We would like to know which fuel-saving technologies transport companies are aware of, and if aware, why it is chosen for to implement the technology or not. Please indicate whether you are not aware of a technology, aware of a technology, or if you have already planned/implemented the technology.

(Technology specific barriers)
15. Technical measures

Technology	Not aware	Aware	Planned/ implemented	If aware, but not implemented: why not?
Aerodynamics: Trailer rear end taper				
Aerodynamics: Boat tail				
Aerodynamics: Trailer (box) skirts				
Aerodynamics: Cab side extension or gap fairings				
Aerodynamics: Full gap fairing				
Aerodynamics: Full skirts				
Aerodynamics: Roof deflector				
Material substitution – weight reduction				
Tires: Tire Pressure Monitoring System (TPMS)				
Tires: Automatic tire inflation on truck or trailer				
Tires: Low rolling resistance wide-base single tires				
Tires: Tire management				
Transmission friction reduction				
Improved diesel engine				
Hybridisation: Dual-mode hybrid				
Hybridisation: Parallel hybrid				
Others: Speed limiters				

(Technology specific barriers)
16. Operational measures

Measure	Not aware	Aware	Planned/ implemented	If aware, but not implemented: why not?
Predictive cruise control				
Route management				
Training and feedback				
Manual tire pressure monitoring				
Front wheel alignment				
Axle alignment				
Driver fuel efficiency control				
Registration of fuel consumption				

B.2 Logistics service providers

Questionnaire for logistics service providers

The 2011 EU Transport Policy aims at reducing CO_2 emissions from transport by 60% by 2050, which means that also road freight transport will have to undertake additional efforts to reduce its emissions One of the ways to achieve such a reduction is to improve the fuel-efficiency of trucks. Several technologies and operational measures are available and reports show that they often generate a net benefit or can be implemented at low cost. Still, the uptake of these technologies and operational measures appears to be slow.

The International Council on Clean Transportation (ICCT) has commissioned CE Delft to analyse whether there are barriers to the implementation of cost-effective technologies and operational measures in the road freight sector. To that end, we hold an online survey and conduct interviews with transport companies and relevant stakeholders.

Interview date	
Interview conducted by	
Approved by interviewee	Yes/No

1. Company information

Name of your company (not required)	
Contact person and contact details (not required)	
In which country is your company based?	
In which countries is your company active?	
Can you give an impression of the amount of road transport your company contracts? (e.g. annual tonne kilometres, number of truck deliveries, other)	

2. Importance of fuel efficiency

(Priority order)

1. Which are in your view the most important criteria for your clients to select a third party logistics service provider? Please rank from 1 (most important) to 9 (least important).
   - Size.
   - Geographical coverage.
   - Accuracy in keeping with time schedules.
   - Speed of delivery.
   - Flexibility.
   - Costs.
   - Fuel costs.
   - Other, please specify:

(Priority order)

2. When contracting a transport company, which criteria does your company have? Please rank from 1 (most important) to 9 (least important).
   - Size.
   - Geographical coverage.
   - Accuracy in keeping with time schedules.
   - Speed of delivery.
   - Flexibility.
   - Costs.
   - Fuel costs.
   - Other, please specify:

Several initiatives exist to include information on emissions and efficiency in contracts. Such initiatives often aim to incentivise contract parties to reduce emissions. These questions deal with evaluation criteria and information flows between your company and your transport service provider(s).

(Priority order)

3. When contracting a transport company, does your company evaluate:
   a. The fuel efficiency of its fleet?
   b. Its carbon footprint?
   c. Total fuel costs for services under the contract?
   d. How is this included in the evaluation criteria?

(Priority order)

4. Does your company require the transport companies that work for you:
   a. To report their carbon footprint? If so, why?
   b. To meet a certain fuel efficiency target? If so, why?
   c. (***Technology-specific – implementation rates)***
      To implement certain technologies? If so, why?
   d. Other?

Contract structures can either enforce or reduce incentives to improve fuel efficiency from fuel prices. This question deals with how this works in the contracts that your company has with its transport service provider(s).

(Split incentives – contract structures)

5. In general, how do you deal with fluctuating fuel prices in contracts with transport companies?
   - Through open book contracts (in which the transport company has a fixed operational margin)?
   - Through fuel surcharges and rebates?
   - Other, please specify

(Split incentives – contract structures)

6. How are third party logistics providers usually paid?
   - A flat fee.
   - On the basis of tonnes/volume of cargo.
   - On the basis of tonne kilometres.
   - A mark-up on freight rates.
   - Other, please specify:

B.3 Shippers

Questionnaire for shippers

The 2011 EU Transport Policy aims at reducing CO_2 emissions from transport by 60% by 2050, which means that also road freight transport will have to undertake additional efforts to reduce its emissions One of the ways to achieve such a reduction is to improve the fuel-efficiency of trucks. Several technologies and operational measures are available and reports show that they often generate a net benefit or can be implemented at low cost. Still, the uptake of these technologies and operational measures appears to be slow.

The International Council on Clean Transportation (ICCT) has commissioned CE Delft to analyse whether there are barriers to the implementation of cost-effective technologies and operational measures in the road freight sector. To that end, we hold an online survey and conduct interviews with transport companies and relevant stakeholders.

Interview date	
Interview conducted by	
Approved by interviewee	Yes/No

1. Company information

Name of your company (not required)	
Contact person and contact details (not required)	
In which country is your company based?	
In which countries is your company active?	
Can you give an impression of the amount of road transport your company contracts? (e.g. annual tonne kilometres, number of truck deliveries, other)	
How has your company addressed its transport demand?	□ Outsourced to a third party logistics provider □ Contract with one transport company □ Contracts with several transport companies □ Other (specify)

2. Importance of fuel efficiency of transport service providers

Several initiatives exist to include information on emissions and efficiency in contracts. Such initiatives often aim to incentivise contract parties to reduce emissions. These questions deal with evaluation criteria and information flows between your company and your transport service provider(s).

(Priority order)

1. When contracting a transport company or a third party logistics provider, which criteria are important? Please rank from 1 (most important) to 9 (least important).
   - Total costs.
   - Flexibility.
   - Speed of delivery.
   - Size of network.
   - Labour costs.
   - Fuel costs.
   - Reliability.
   - Other, please specify.

(Priority order)

2. When contracting a transport company or a third party logistics provider, does your company evaluate:
   a. The fuel efficiency of its fleet?
   b. Its carbon footprint?
   c. How is this included in the evaluation criteria?

(Priority order)

3. Does your company require the transport companies that work for you:
   a. To report their carbon footprint?
   b. To meet a certain fuel efficiency target?
   c. ***(Technology-specific – implementation rates)*** To implement certain technologies (if so, which)?
   d. Other, please specify.

Contract structures can either enforce or reduce incentives to improve fuel efficiency from fuel prices. This question deals with how this works in the contracts that your company has with its transport service provider(s).

(Split incentives – contract structures)

4. In general, how do you deal with fluctuating fuel prices in contracts with transport companies or third party logistics providers?
   - Through open book contracts (in which the transport company has a fixed operational margin)?
   - Through fuel surcharges and rebates?
   - Other, please specify.

B.4 OEMs

Questionnaire for equipment manufacturers

The 2011 EU Transport Policy aims at reducing CO_2 emissions from transport by 60% by 2050, which means that also road freight transport will have to undertake additional efforts to reduce its emissions One of the ways to achieve such a reduction is to improve the fuel-efficiency of trucks. Several technologies and operational measures are available and reports show that they often generate a net benefit or can be implemented at low cost. Still, the uptake of these technologies and operational measures appears to be slow.

The International Council on Clean Transportation (ICCT) has commissioned CE Delft to analyse whether there are barriers to the implementation of cost-effective technologies and operational measures in the road freight sector. To that end, we hold an online survey and conduct interviews with transport companies and relevant stakeholders.

Interview date	
Interview conducted by	
Approved by interviewee	Yes/No

1. Company information

Name of your company (not required)	
Contact person and contact details (not required)	
In which country is your company based?	
In which countries is your company active?	
(Technology specific - OEMs offer) Which fuel-efficiency improving products does your company manufacture	
In which market segment(s) does your company operate?	Long haul/regional/urban delivery

2. General barriers to the implementation of energy saving measures

Several studies show that transport companies differ in the attention they pay to fuel efficiency.

(Priority order)

1. Is this also your experience?
   a. If so, do you experience an increase or decrease in the share of companies paying attention to fuel efficiency in the past five years?

(Investment criteria)

2. When buying new trucks, how do transport companies generally evaluate fuel efficiency?
   - By including fuel costs in the total costs of ownership?
   - By calculating the net present value of the fuel costs and compare it to additional costs of more efficient trucks?
   - On the basis of payback time for additional costs of more efficient vehicles?
   - On the basis of the internal rate of return on investment?
   - Or using another method, please specify?

(Technology-specific – OEMs offer)

3. Have fuel efficiency evaluation criteria of transport companies influenced your offer of technologies (e.g. have you decided not to offer technologies with a long payback period?
   a. Which technologies have you not decided to offer and why?

(Technology-specific – Implementation rates)

4. How would you describe the attitude of transport companies towards new technologies? (more than one answer possible)
   - They are not aware of new technologies
   - They are conservative
   - They are eager to implement technologies that save costs
   - They evaluate new technologies seriously
   - other

   a. How does this vary across companies? (e.g. are large companies different from small ones, are leasing companies different from transport companies, etc.).

(Technology-specific – OEMs offer)

5. In your opinion, which aspects of trucks will see technological change the coming five years? please indicate the relative amount of resources you expect to invest in these options by dividing 100 points.
   - Engine power.
   - Engine air pollutant emissions.
   - Engine fuel efficiency.
   - Aerodynamics.
   - Gearing.
   - Reliability.
   - Driver comfort.
   - Other.

New technologies may have uncertain benefits and thus create a risk for the company that implements them. This may inhibit the adoption of new technologies in the transport sector.

(Transaction costs/Lack of information)

6. How does your company address this barrier
   - Have technologies tested by independent institutes
   - Develop technology jointly with transport companies
   - Guarantee results
   - Co-financing
   - Other, please specify?

Transport companies often lease trucks or finance them with bank loans.

(Financial constraints)

7. Does this affect their interest in fuel-efficiency improving technologies? (e.g. are leasing companies more risk averse or do they employ other criteria to investment appraisal?)

Annex C Results of the follow-up interviews

C.1 Transport companies

Question	Transport company 1	Transport company 2 (Highly innovative/experimental with respect to fuel-saving technologies)	Transport company 3
How do you evaluate the fuel efficiency of the different trucks/technologies that you can buy?	We do take fuel efficiency into account when buying a new truck. However, there is not much difference between the fuel efficiency of the trucks of different OEMs .	This is difficult, you cannot know this prior to buying the truck, as a lot of factors are of influence on actual fuel consumption. At first you rely on the fuel efficiency data provided by the OEM and you can use a demo to estimate fuel efficiency. However, most often what it comes down to is that you buy a truck and you use that as a practice example; you can then start measuring fuel efficiency, which will affect the next trucks that you will buy.	Yes, we look at the total costs of ownership, fuel efficiency is part hereof (although it is not necessarily the case that the most fuel-efficient truck is also the cheapest with respect to total costs). We evaluate fuel efficiency by using the data of different OEMs, and in case it concerns a brand that we are unfamiliar with we might check it with our colleagues.
When you buy trucks, are you offered fuel-efficiency improving options, such as low resistance tyres, cab side extensions, a roof deflector, low weight materials, etc.?	Yes definitely. We mainly look at the roof deflector, the weight of the truck and at choosing the right options such as a tire pressure system.	Full gap fairing, transmission friction reduction, and predictive cruise control are not offered. None of the technologies are on standard trucks, although low rolling resistance tires are increasingly offered.	Yes, they advice you on additional features, they always want to sell as much as possible
When you buy a trailer, are you offered fuel-efficiency improving options, such as a boat tail, side skirts, low resistance tyres, et cetera?	Yes, but this is more difficult as we have container transport.	The trailer rear end taper, boat tail, and automatic tire inflation are not offered by body builders. The remainder of technologies is optional. We add skirts to all our trailers for example.	Yes, they advice you on additional features, they always want to sell as much as possible
When buying trucks, do you generally buy a standard truck/package (with fuel efficiency technologies already chosen by the OEM) that is offered, or do you add several fuel efficiency improving technologies to the trucks yourself?	Every OEM will advise you to buy several fuel-saving technologies, as a good fuel effiency record will increase his chances that the customer will return for the next truck acquisition. As a buyer you can influence this, however there are limits; if the truck manufacturer cannot deliver a certain	Yes, OEMs can add a lot of fuel-saving technologies to their standard trucks, however they do not promote this well. You have to know exactly which fuel saving features you want to add to your truck yourself, and if you ask for those they will often be able to add it to the offer. However, they do not explicitly promote,	Buying a truck is like buying a car; the salesman always wants to sell more than you need. We determine our requirements prior to going to an OEM. With those requirements we compare prices of different OEMs and we choose the cheapest.

Question	Transport company 1	Transport company 2 (Highly innovative/experimental with respect to fuel-saving technologies)	Transport company 3
	technology, then you simply cannot adopt it. Retrofits are often expensive and not the right quality, so generally transport companies will not opt for such.	nor stimulate, these fuel saving options. So most companies that do not know much about fuel saving measures will end up buying a more ‘standard’ truck. The same applies to the acquisition of trailers.	
In general, are gains from operational improvements larger than gains from technical improvements?	The largest fuel savings result from drivers that use their right foot correctly. Consequently, all our drivers are trained regularly to achieve maximum fuel savings.	If you are active in saving fuel you will need both options. However, whereas in the past the focus was mostly on technical aspects, nowadays the focus is shifting more towards operational measures. OEMs respond to that by focussing a lot on driving courses and on-board computers to establish driver styles as well.	Yes very. We employ speed limiters and driver training. These are cheap options that deliver much cost savings. Thereby, you can implement them on your current fleet rather than the need to buy a new truck. Transport companies are very careful with buying trucks these days, so we rather focus on our existing fleet.

C.2 OEMs

Question	OEM 1	OEM 2	OEM 3
When you sell trucks, which fuel-saving technologies do you sell standard, which do you offer as optional, and which technologies do you not sell?	Standard: – Low rolling resistance tires Not: – Transmission friction reduction – Hybrid engines Optional: – The remainder of truck fuel-saving technologies from **Fout! Verwijzingsbron niet gevonden.** in Chapter 1)	Standard: – Training and feedback Not: – Transmission friction reduction – Automatic tire inflation truck Optional: – The remainder of truck fuel-saving technologies from **Fout! Verwijzingsbron niet gevonden.** in Chapter 1)	Standard: – Low rolling resistance tires Not: – Transmission friction reduction – Full gap fairing Optional: – The remainder of truck fuel-saving technologies from **Fout! Verwijzingsbron niet gevonden.** in Chapter 1)
To what extent can transport companies customise (i.e. add separate fuel-saving technologies to 'standard' trucks) the trucks they buy?	We try to advise companies to buy fuel-efficient trucks. Companies can order a Fuel efficiency package in addition to our standard trucks to save fuel. This package is sold quite often and has different fuel saving features. It would also be possible to buy a standard truck with only 1 or 2 fuel saving features	OEMs have an advisory role. We compete to deliver the most efficient vehicle with an Euro 5 or 6 engine. These are our standard trucks. However, we do try to sell an Eco package to each truck, which is a package with several fuel saving options companies can choose from at a surcharge.	Companies can add every of these options separately if they want. In addition we offer several packages of fuel-efficient measures. Especially, side skirts and the roof deflector are sold often. Hybrid engine is still in its infancy. Driver training is our most sold option, at some of our dealers this is even standard option.
How do transport companies evaluate the fuel efficiency of the different trucks/technologies that you offer?	They can mainly use two methods: – We have demonstration projects (of a standard truck with the fuel saving package). These demo trucks have registration systems so we can see how the driver has behaved, and discuss fuel savings. – There are several magazines that offer test results of different trucks/brands (which are often not trucks with the fuel-efficient package) to compare fuel efficiency.	We offer a test drive. These are only trucks with the Eco package that we use as demo. There are also quite some expert journals that compare different trucks of different companies that companies can use to evaluate fuel efficiency.	We have calculated the performance of our trucks, so we can advise companies on which trucks are best fitted to their driving cycles. Also companies can drive a demo truck for e few days which has on board computers from which we can read fuel consumption and driver behaviour. This demo is a standard, but efficient truck. Finally, there are always journalists and research institutes which compare trucks.
How do you determine the fuel efficiency of your trucks?	We have test drives with our trucks during which fuel consumption is registered.	We measure our own fuel efficiency. We can install a software in the truck that can measure the fuel consumption (and other parameters that are of influence on consumption) very precisely.	We have calculated the performance of our trucks with several on board computer technologies.
Is it possible to notice fuel efficiency improvements of only a few percent points?	Yes	Yes	Yes, definitely. This is very precise

Question	OEM 1	OEM 2	OEM 3
When you sell trucks, do you also suggest specific trailers/trailer technologies to transport companies to further improve fuel efficiency?	If companies ask us about this we would make suggestions, however this is rarely the case. Often the companies have already had contact with trailer builders, or they already know what kind of trailer they want.	No, we only focus on trucks	If companies ask us about this we provide advice. Mostly with respect to trailer alignment. Also we have had contact with a trailer technology supplier about their side skirts, we have provided this information to our dealers, as we want our dealers to be up to date.
In general, are gains from operational improvements larger than gains from technical improvements?	Yes, you can add several technical features to save fuel, however, in the end it is the driver that has the largest influence on the actual fuel consumption. Thereby these measures are easier for companies. Technical measures are available, and they will reduce fuel, but these are mostly more expensive and less seizable/visible.	Yes definitely. Operational fuel efficiency (especially driver efficiency) is very important and entails the largest possible fuel savings. Approximately 80/90% of the fuel consumption is influenced by the driver style. So basically what it comes down to: either the company can invest a lot of money in technical measures that only deliver fuel savings of a few percent points, or the company can invest a little bit in driver training and other driver monitoring systems and save a lot more fuel.	Yes, it is proven that drivers have a large influence on fuel consumption; if you would let two drivers drive the same circle, they would have very different fuel consumptions most likely. The focus on drivers training is also in legislation nowadays; 'het nieuwe rijden' is an obligated program, so we focus on that as well. Thereby, operational measures with respect to the driver have additional benefits for safety and image. However, when this is taken care of, technical measures on both the truck and trailer are necessary as well. The focus may also be more on operational as this can be taken care of at any point. Technical measures are mostly bought when buying a new truck, as it is very expensive to do so as a retrofit to a truck.

C.3 Body builders

Question	Body builder 1 (One of the largest in Europe)	Body builder 2	Body builder 3
When you sell trailers, which fuel-saving technologies do you sell standard, which do you offer as optional, and which technologies do you not sell?	Standard: – None Not offered: – Trailer rear end taper (not much fuel savings, but allowed by law) – Boat tail (significant fuel savings, but not allowed by law) Optional: – The remainder of fuel-saving technologies for trailers from **Fout! Verwijzingsbron niet gevonden.**Chapter 1.	Standard: – Low rolling resistance tires Not offered: – Trailer rear end taper – Boat tail Optional: – The remainder of fuel-saving technologies for trailers from **Fout! Verwijzingsbron niet gevonden.** Chapter 1.	Standard: – None Not offered: – Boat tail Optional: – The remainder of fuel-saving technologies for trailers from **Fout! Verwijzingsbron niet gevonden.** Chapter 1.
To what extent do transport companies customise (i.e. add separate fuel-saving technologies to 'standard' trailers) the trailers they buy?	They mostly buy standard trailers (none of the fuel saving measures mentioned above). There are some exceptions (e.g. Peter Appel transport, TNT, AH), but mostly companies do not buy any fuel saving features.	We normally sell our standard trailers without fuel saving add ons. The fuel saving options for trailers are limited, also because everything is very costly to make (differently sized trailers, so no standardised fuel saving options possible mostly). I do notice some increase in demand, but this is still quite rare	We sell 'standard' trailers without any additional fuel saving measures. We would be able to deliver fuel saving features if a company asks/demands this, but this rarely is the case. Some attention is given to box skirts lately, but still this is demanded by very few companies.
Do transport companies evaluate the fuel efficiency of the different trailers/technologies that you offer? If so, how?	No, transport companies rarely ask questions about the fuel efficiency of trailers. We are involved in designing fuel-efficient trailers, however, transport companies are not yet	Companies do not evaluate the fuel efficiency of trailers. Trailers do not have an engine, that's where they focus on mostly.	Companies that buy trailers seem not to evaluate the fuel efficiency of the different trailers that we offer.
Do you measure the fuel efficiency of your trailers? If so, how	It is very difficult for us to measure the fuel efficiency of our trailers ourselves. However, we closely operate with a technology supplier of aerodynamic features; all the fuel-saving technologies that we deliver, we buy from them. This company has done a lot of tests to measure fuel savings from their technologies, so we can use their numbers as an indication.	No, we cannot measure this.	We don't.
When you sell trailers, do you also suggest specific trucks/truck technologies to transport companies to	No, this is the business of truck manufacturers.	No.	No, this is the business of truck manufacturers.

Question	Body builder 1 (One of the largest in Europe)	Body builder 2	Body builder 3
further improve fuel efficiency?			
In general, are gains from operational improvements larger than gains from technical improvements?	Yes. Companies mostly seem to focus on operational measures; driver training in particular. They can obtain more fuel savings from that at the moment than is the case for technical measures. However, they should focus on technical measures as well. Once drivers are already driving fuel-efficient they should look at other methods to improve fuel efficiency, as this is where they can make money. They could save several percentages by buying a fuel-efficient trailer.	Yes, you can save a lot more with operational measures. Thereby, this is far less radical and expensive. All fuel saving options for trailers are very expensive and the exact fuel savings unsure.	No opinion. The technical improvements also depend on the type of truck; an open truck has limited possibilities, a closed truck has some. If all possible fuel saving measures would be implemented, 10-15% of fuel could potentially be saved.
Background follow-up interview	**Technology developer/supplier trailer skirts**		
To what extent do companies evaluate the fuel efficiency of trailers?	A lot of transport companies are not aware at all about the technologies available to reduce fuel efficiency of trailers. Especially, aerodynamics is a very new area, although awareness is increasing it is needed to make a large step here in providing information to transport companies. This is especially necessary when considering that the market is structured in such a way that it reduces the incentives of transport companies to invest in fuel efficiency: – The market is very conservative; especially with the newness in aerodynamics, transport companies that invest in side skirts have a higher risk; the damage reports are not known yet. Thereby, we cannot produce cheaply as a consequence of a lack of economies of scale. – The trailer is often leased as trailers are very expensive and the investment needs to be spread (especially cooled ones, and aerodynamic features); consequently, the company using the trailer and the company that needs to invest in the trailer are different from each other. – A lot of open book contracts are used in the Netherlands. Consequently, a company that would invest in fuel efficiency would receive a lower rate. So although the transport company is the one reducing its fuel consumption, it does not benefit from doing so.		
To what extent do body builders ask for your products?	The body builder does not have much interest for selling side skirts, as transport companies do generally not ask for this. Consequently, demand is low. We try to cooperate with body builders, as it is very expensive to make retrofits to trailers, therefore, it is better to sell side skirts when the transport company buys a trailer from the body builder. We try to promote our products as an added value; the body builder can sell a larger product range, and prevents sustainable transport companies to switch to producers that do offer skirts.		
In addition to the low incentives of transport companies, do you perceive other barriers are impeding the wide-scale adoption of aerodynamic technologies for trailers?	Legislation. The largest fuel efficiency improvements with respect to trailers can be obtained from reducing the aerodynamic drag from the end of the trailer. We have had experiments with boat tails that can reduce fuel consumption with 1,5 l over 100 km on highways, which is huge. However, boat tails are not allowed, as there applies a maximum trailer length. Consequently, companies would now have to cut their load capacity, which makes no sense. In the US, companies are allowed a maximum length, but in addition can apply extensions to reduce aerodynamic drag. In Europe, new legislation will most likely be implemented from September onwards, allowing a 50 cm boat tail. However, this is too short, to have a real impact on fuel consumption, and hence to trigger companies to invest in the technology, you should install a boat tail of approximately 1 to 1.5 metre.		

C.4 Leasing companies

	Leasing company 1 **(offers truck leases; also an OEM)**	**Leasing company 2** **(offers trailer leases, owns one of the largest trailer fleets in Europe)**	**Leasing company 3** **(An association of leasing companies)**
How does a truck lease work? To what extent do transport companies decide about the characteristics of the truck/trailer they lease and you place that offer at the OEM/body builder? Or did your company already buy a fleet, from which companies can choose to lease vehicles from?	If a transport company needs a new truck we can offer the finance for that truck, the transport company decides.	We own a very large fleet of trailers, including many different types; companies can choose their trailer from this fleet.	Normally, a transport companies decides what truck it wants and with which characteristics. With these requirements the transport company contacts the leasing company, which will make several propositions.
To what extent can transport companies customise the trucks/trailers (i.e. to what extent can they add fuel saving features)	The transport company decides about the truck it wants to lease. This does not necessarily have to be a standard truck; companies can add specific technologies to the truck, hereafter we will manufacture it. So the company decides first, then we will manufacture it.	Sometimes we make adaptions to a trailer for a customer, but this rarely happens.	The transport company decides; however, leasing companies can have an advisory role as they know well which technologies will impact fuel-efficiency (and hence the monthly costs.
To what extent do transport companies pay attention to the fuel saving options on their trucks/trailers?	They do pay attention to the fuel efficiency of trucks/trailers. We try to stimulate that, as we are one of the most fuel-efficient manufacturers.	They do not, they mainly look at the fuel efficiency of trucks, with respect to trailers not much can be done for that aspect.	Yes, transport companies do take fuel efficiency into account when they decide on which truck they want to lease; the lease amount is determined by the purchase value and operational costs. These operational costs can be lowered by fuel saving technologies and other environmentally friendly technologies, especially now that taxation is often linked to this aspect.
Would you be willing to provide a bigger loan/lease for more fuel-efficient trucks?	No. If a company would want to buy an extremely inefficient truck that would influence his profits, so then we may not want to offer credit. However, in general it is not the case that we provide larger credit if a company offers to buy a more efficient truck	No.	Not necessarily. Leasing company will mainly look at the monthly available budget and at the residential value of the truck. These aspects are more important than the purchase price.

	Leasing company 1 (offers truck leases; also an OEM)	Leasing company 2 (offers trailer leases, owns one of the largest trailer fleets in Europe)	Leasing company 3 (An association of leasing companies)
How do transport companies evaluate the fuel efficiency of new trucks/trailers do you think? E.g. by test driving a truck for a certain period, by evaluating documentation, etc.?	It is difficult for them. They have to rely on the numbers of different producers. Of course they can make a test drive, with our most efficient vehicles, to evaluate fuel efficiency themselves, but they won't exactly know the fuel efficiency of a truck until the truck is in its own operations.	N/a	Normally, transport companies will choose the cheapest truck; each fuel saving feature will add to the costs. However, the leasing company has wide experience and data on different technologies and their monthly operational costs. Consequently, when a truck is leased, the transport company evaluates monthly costs.
Which fuel-efficiency improving options can be delivered on a lease truck/trailer?	▫ Cab side extensions Yes ▫ Roof deflector Yes ▫ Full gap faring Yes ▫ Lightweight material Yes ▫ Automatic tire inflation Not sure ▫ Low rolling resistance tires Yes ▫ Transmission friction reduction No ▫ Hybrid engines On some truck models ▫ Predictive cruise control Yes ▫ Training and feedback Yes	As far as I know, we are not active with respect to buying fuel-efficient technologies for our trailer fleet. I do not know that precisely, you should talk to the person who buys the trailers. (not willing to cooperate)	N/a
Do transport companies often add these features to their truck/trailer?	Differs highly between companies.	No	N/a
In general, are gains from operational improvements larger than gains from technical improvements?	Yes, the driver has the largest influence on the actual fuel consumption of the truck. We can add as many technical features on trucks, but the driver has a larger influence.	Yes with respect to trailers, not much can be done to save fuel.	We do not know this, operational efficiency is the experience of transport companies.
Additional barriers from a lease perspective (from background interview with association of lease companies)			
The largest barrier that we run into is that we cannot lease/rent trucks in very country; there is a law of the European commission which states that member states can decide to allow, restrict, or forbid leasing and/or renting trucks without a driver. There is a relation between whether or not there are such restrictions and the average age of the fleet in a country. In Greece for example, it is not allowed to lease or rent trucks; the average age of this country's fleet is over 18 years. Obviously, this has significant consequences for fuel efficiency as well. In countries without such restrictions, such as Germany, the average age of the fleet is 5-6 years. This relationship results from the fact that acquiring a truck with trailer is very expensive, especially the Euro 6 engine will increase the overall purchase and maintenance costs. There are many companies which cannot finance this themselves. Consequently, lease/rental arrangements would provide a solution to this problem and would enable companies to buy new(er) trucks. Many companies use this option; in western countries (were leasing is not restricted) this percentage is very high. It is difficult to estimate the exact share, but it can well be over 50%. In Eastern/Southern European countries this share is much lower, as there are often restrictions here. The same percentages are likely to apply to trailers as companies mostly lease a truck and trailer at once.			

<table>
<tr><th></th><th>Leasing company 1
(offers truck leases; also an OEM)</th><th>Leasing company 2
(offers trailer leases, owns one of the largest trailer fleets in Europe)</th><th>Leasing company 3
(An association of leasing companies)</th></tr>
<tr><td colspan="4">There are several other legal aspects that make the lease market more difficult, such as
– Registration regimes making it difficult to lease or rent trucks across borders
– Complicated an lengthy administrative procedures when importing or exporting a truck, which makes it difficult for leasing companies to re-allocate and utilise trucks

Leased trucks are owned for approximately 5-6 years, hereafter they are used as replacement vehicle for 1 or 2 years. Finally, when they are 8 years or so they are sold to countries such as Hungary, Russia or North-Africa. Whether the leasing company will receive a premium for the vehicle depends on to which country it is shipped to; if it is shipped within Europe, buyers definitely look at environmental characteristics, however, if it is shipped to non-European countries, buyers do not care.</td></tr>
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Annex D Summary of a workshop with relevant stakeholders

This Annex provides an account of the workshop that was conducted in order to solicit comments and feedback on this report when it was in its drafting stages.

The following lists the timeline for the outreach workshop to solicit feedback:
- October 4, 2012: Workshop participants from manufacturing, shipping, environmental, research, and government organisations invited to October 15 workshop.
  - Invitation letter (Annex D.1).
- October 10. 2012: Draft CE Delft study distributed to workshop.
- October 15, 2012: Workshop was hosted at the European Commission – Climate Action (DG CLIMA) in association with the International Council on Clean Transportation (ICCT) in Brussels, Belgium.
- October 17: Notes from the workshop are generated from the workshop.
  - Workshop notes are summarized below.

This Annex reproduces the invitation background letter, the workshop agenda, and the workshop notes. The presentation and final posting of the report is posted in two places:
- CE Delft website: www.cedelft.eu.
- ICCT website: http://theicct.org/market-barriers-increased-efficiency-european-onroad-freight-sector.

D.1 Invitation letter

The invitation letter that has been sent to several relevant stakeholders can be found below.

Workshop

Onroad Freight Efficiency Technology Market Barriers

European Commission – Climate Action
The International Council on Clean Transportation (ICCT)

October 15, 2012, 10:00 - 13:30

Avenue de Beaulieu 24 (room 2/10), Brussels, Belgium

Please join us to have an open discussion concerning the preliminary results of a recent study conducted by CE Delft entitled *Market Barriers to Increased Efficiency in the European Onroad Freight Sector*. Advance copies of the draft report will be supplied to workshop participants prior to the workshop.

Agenda

10:00 Welcome and workshop introductions (Peter Mock, ICCT)

10:15 Introductory comments (DG CLIMA)

10:30 Presentation: Main findings of EU Market Barriers study (Jasper Faber, CE Delft)

11:00 One-slide presentations from interested participants (responses to the report which will be distributed prior to the workshop), and discussion

12:00 Moderated discussion

13:30 Meeting adjourns

We are looking forward to welcome you at the meeting and ask you to **please confirm your participation by email with Peter Mock (peter@theicct.org) by October 10.** Please note that space is limited to a maximum of 20 participants. We therefore can only accommodate one representative per organisation.

(page 1 or 2)

Background

There are several technical and operational measures available to improve the fuel efficiency of truck fleets, but many of these measures are currently not universally implemented. Even cost-effective measures, i.e. measures which can be implemented with net fuel savings that outweigh the initial technology costs and potentially at a net profit, are often not adopted.

The CE Delft report aims to better understand the reasons for the limited adoption of cost-effective fuel-saving technologies and to inform the policy making process in the EU and abroad, and specifically to provide input to the European Commission's strategy for reducing GHG emissions from HDVs. The primary goal of the study is to identify the barriers to the implementation of technologies that improve fuel efficiency in the European road freight transport sector.

For this report, the existence and importance of barriers were analyzed through surveys and interviews of transport companies, original equipment manufacturers (OEMs), shippers and logistics service providers. Some main findings of this study are that there is a lack of demand for retrofit fuel saving technologies, as well as a lack of offer of OEM fuel saving technologies in OEM packages. Furthermore, according to the study results, there is a lack of information on the precise benefits of fuel saving technologies. Also, it was found that the so-called *split incentive* in HDV operations does not appear to be as important as originally anticipated.

What is the purpose of this Workshop?
The purpose of this workshop is to gain valuable information and feedback from those with first hand knowledge on market barriers for technologies in the freight sector. Getting peer feedback from workshop participants prior to dissemination of the CE Delft report will increase the usefulness of the report to policy makers and others who will utilize the report for decision-making purposes.

Who should attend?
Members of industry in Europe who feel that they have valuable real-world knowledge to contribute on the topic of Market Barriers to Efficiency Technologies in the Onroad Freight Sector. Specifically, OEMs, leasing companies, body builders, suppliers, and entities who work with these companies.

(page 2 or 2)

D.2 Summary Notes from the Workshop

This section provides a summary of the discussion from the October 15th workshop. Along with the authors of the report, the workshop participants included individuals from the European Commission and the International Council on Clean Transportation, as well as representatives from leading manufacturing, shipping, environmental, research, government, and transportation organisations. Each of these individuals was invited to give the diverse opinions of different stakeholders as represented by their organisations different roles in technology development within the freight industry. The names of the companies and individuals are not listed because the informal nature of the workshop was intended specifically to encourage a frank exchange of views on the topic of technology deployment, truck purchasing behavior, etc. As a result, these notes are heavily paraphrased without specific attribution in order to convey the major points. The notes are categorized in four main areas: general reflections, potential roles for manufacturing industry, potential roles for transport and logistics groups, and roles for policymakers.

General context and reflections on the study

The issue of market barriers has come up at a number of European Commission meetings in the past. The International Council on Clean Transportation sought to commission a study with CE Delft to systematically investigate and identify any such market barriers in the European heavy-duty vehicle market. Two notable previous projects were discussed in the workshop (1) a Goodyear Dunlop study of over 400 European fleet managers and (2) a GreaterThan study of over 1,000 hauliers and third-party logistics providers. The participants nearly unanimously acknowledged that CE Delft has provided a very strong and timely contribution with strong methods and meaningful findings to further the public understanding of this very challenging issue.

Overall, based on the present CE Delft findings and the participant feedback, information about fuel saving technologies appears to be generally available to customers, but a critical problem seems to be in transferring this general knowledge to the specific trucks and specific routes of particular customers. This in turn limits the ability of a truck operator to understand how precisely a specific fuel-saving technology would impact its vehicle operations and overall profitability. This uncertainty, to some degree, prevents technologies from being applied as widely as one would expect from a rational economic perspective. As reflected below, the participants had several ideas on where future study could build on the results from the CE Delft work.

Role of the manufacturing industry

The role of the vehicle manufacturer (and its interaction with suppliers) is among the most critical to the fundamental development of technologies that will enter the marketplace. There is a critical question, though not the focus of the CE Delft market barriers study, about the technology potential for new efficiency technologies. For example, studies by TIAX and AEA-Ricardo are useful, indicative numbers that will be cited until updated data are developed. Some of the technologies that are investigated in the CE Delft report are already being utilised in trucks, to varying degrees, and are therefore part of the current vehicle baseline. The regulations on vehicle masse and dimensions were noted as a market barrier for introducing additional aerodynamic measures. The lack of LNG fueling infrastructure is a clear and obvious market barrier for LNG vehicles. This indicates a very important type of market barrier – regarding the barrier to the development of new technology. However, the scope of the study was to focus on barriers to the implementation of existing technologies. It is indicated that there are limited financial capabilities on the side of the vehicle manufacturing companies, especially due to relatively small sales volumes in the truck segment, leading to high development costs per unit sold. This is a barrier for OEMs to invest into the development of fuel saving technologies. Having improved information about the effectiveness of fuel-saving technologies, and in particular having objective and standardised information, will help customers to overcome potentially existing hurdles to purchase fuel saving technologies for trucks.

Role of financing and leasing companies
The participants disagreed on the exact extent to which financing and leasing companies already do factor in fuel efficiency technologies and their savings into truck purchasing decisions. Some participants suggest that leasing companies have a genuine interest in operating costs, as they can charge higher lease fees for more fuel-efficient trucks, and are therefore very aware of fuel saving technologies. In addition, lease companies aim to lower transport companies' operating costs, to increase the likelihood of customer loyalty and repeat customers. This seems to be the case in particular in the US, where large leasing companies know more about the fuel consumption of their trucks than the OEMs themselves. Other participants disagree with the statement, and say lease companies do not care about operating costs and are only interested in leasing trucks, no matter what their fuel consumption. It is also noted that in Europe, the OEMs often act as leasing companies themselves, in some instances not only leasing their own trucks, but also trucks of their competitors. It is concluded by the group that there are probably varying leasing company business models, for example, (1) Where a company has already decided which truck it wants and uses the lease company merely for financing and (2) Where the lease company acquires trucks and thereafter leases these trucks to transport companies. Therefore the different experiences of participants suggest different potential roles by financing and leasing companies today and in the future for addressing any market barriers to the adoption of fuel-saving technologies.

Role of truck purchasers, transport and logistics organisations
The specific roles that truck purchasers and transport and logistic companies might play in reducing the prevailing market barriers were unclear. Two major topics came up related to payback periods and contracts. CE Delft emphasised that truck purchasers would not or could not give a clear or direct indication about what was a tolerable payback period for the incremental cost of any efficiency technology. This, in turn, pointed to other questions about the residual value of trucks with given technologies. It is suggested that manufacturers should know details about the residual values of the trucks historically, but that these past experiences may not be fully relevant for the future. One reason for this is that Euro VI trucks using SCR and DPF after treatment technology cannot be operated in typical second-hand markets due to the lack of high-quality low-sulfur fuel needed to run there technologies. In such circumstances, changes to the engine of the truck would be necessary before re-selling to a second-hand market, which will drastically reduce residual values of trucks, and most likely will result in much shorter payback periods assumed when buying new trucks.

The types of contracts can be quite different from what is stated by CE Delft in the report. Sometimes operators (a) have no contracts in place with their shippers, therefore shippers may make immediate short-term purchases, which is cheaper but without any operational profile or knowledge of efficiency of the truck; or (b) have very long-term contracts in place, with a 10-20 years contract period that includes logistical support to the shippers. It is also noted that usually sub-contractors do not have nearly the same level of knowledge about fuel saving technologies and operational measures as the companies they are working for. Many small sub-contractors (with just one or a few vehicles) might operate only on a daily basis, be very unaware of fuel saving technologies, unwilling to invest in these technologies, and uncertain about the potential business impacts. On additional aspect relates to the vehicle sales, whereby older technologies are given away at lower prices because a new technology is introduced (for example sales of Euro IV trucks when Euro V was introduced). This can lead to a situation where companies purchase trucks that are not the most efficient ones in the long run, but are available relatively cheap at the moment. A final point on retrofit technologies; some truck operators tend to not like retrofit devices because devices typically perform less well when they are retrofitted than when they are installed on new vehicles. This could be considered an additional market barrier.

Several other distinctions were drawn. First, the perspective of the dealers is important. The vehicle manufacturers generally do not sell their trucks directly to customers, but instead it is the dealers who buy trucks and re-sell them to end customers. Therefore, the manufacturers do not know exactly what the truck will be used for, and in some cases the dealers themselves do not know, because the customer purchases only the truck, and then approaches a body builder separately to purchase a trailer for the truck. This is a critical barrier in some cases between the direct exchange of information about truck technologies from manufacturers who develop the technologies and end users who purchase the technologies. Finally, it was emphasized that trailers live much longer than trucks and are therefore not replaced as often. This adds to the complexity of the market barrier issues when it comes to the trailers, and trailer technologies that increase vehicle fuel efficiency.

Critical to each of the issues is relevant data about the technologies under consideration – the level of detail, clarity, and objectivity of that data is important. It is generally agreed that there is some amount of information to aid in decision-making, but there is confusion about what data on particular available technologies is directly relevant to each truck fleet’s individual vehicles and overall operations. There are also clear questions about the credibility of many forms of data that are being provided by technology providers, due to lack of standardization. One participant noted that operating measures and fuel saving technologies cannot be separated from each other; drivers need to know how to apply and best utilise the new technologies to actually get the fuel savings that are projected. Simple monitoring the performance of drivers does not reflect the fraction of fuel consumption that drivers can really influence. It is suggested that there could be some level of disconnect between what companies say when asked in surveys, and what actions they take in reality. There was agreement among the participants that, while there is a general awareness of the existence of technologies, there is a lack of a clear understanding of what each of these technologies cost and what fuel savings they can achieve.

Potential future steps
The participant feedback points to a number of future follow-on steps to better understand and respond to the question of market barriers to the adoption of available efficiency technology in the heavy-duty vehicle market. One area for further work includes investigating the different business models and contracts applied among the transport companies, considering the differing experiences identified by participants. In addition, investigating the role of dealers – standing between manufacturers technology-related data and ultimate truck purchaser and end user decisions – appeared to be of interest. Another area for future work is to study very small fleets of one (or a few) trucks, to identify if their decision-making process differed at all from that of the larger companies that were focused upon more heavily by CE Delft.

A separate question about potential market barriers to the development of new technologies was raised. This type of market barrier, at the manufacturer and supplier level, is especially important in investigating emerging technologies that might be of increasing importance in the 2020-2025 timeframe.

There was agreement that standardized, credible data on efficiency technologies and their benefits could be improved upon. Without a standardized data source and method, many individuals with information can cite numbers that do not necessarily reflect many real-world operations for diverse fleets. In addition, companies and organisations with strong data do generally want to publicly circulate such information due to the problem of being held reliable. Ways to work toward better, more transparent information could include systematic collection of available data that might already exist at the member state level. For example, there are several voluntary fuel saving programs at the EU Member State level that have resulted in lots of good data on CO_2 and fuel consumption, and this could be quite useful. Developing better data collection and dissemination tools could also play a role. As a reality check and data generator on real-world efficiency characteristics of heavy-duty vehicles, a monitoring system similar to what has been done in the light-duty sector (e.g., sprintmonitor.de) could be pursued.

It is noted that there are several studies that are likely to build further upon the CE Delft work. The ongoing Low Carbon Vehicle Partnership (LowCVP), carried out by AEA, that will focus specifically on the UK HDV market, and that has started in September 2012. This report is expected to further build upon the CE Delft findings. Also, several US-based projects on heavy-duty vehicle market barriers are underway. The US Environmental Protection Agency and the International Council on Clean Transportation are each conducting separate studies to investigate these market barrier issues in the heavy-duty vehicle market in the US.