CO2 TARGETS

Report to:
Greenpeace

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Executive summary

Preventing climate change is one of today's main challenges and will also be faced by future generations. Several agreements, objectives and measures to reduce greenhouse gas (GHG) emissions are on the political table at world-wide and European level. Recently, the EU has set a target of reducing GHG emissions by 30% (compared to 1990) by 2020, as part of an international agreement, or at least 20% unilaterally. In this report we analyse what the 30% objective means for the European transport sector[1]. We translate the objective into a clear GHG emission target level for the transport sector in 2020. We quantify the effort that is needed to reach this target. We study to what extent currently proposed policy measures help to reach this target level.

BAU scenario

Before we can quantify the effort needed to reach the EU 30% objective, we need a clear view on the transport sector GHG emissions if no further policy measures would be taken. In other words, we need to identify the 2020 transport sector GHG emissions in a business-as-usual (BAU) scenario. In research and impact assessments at European level, several BAU scenarios have been used. We analysed the BAU scenarios used by the European Commission Directorate-General Environment (TREMOVE), the European Commission Directorate-General Transport & Energy (PRIMES), the European Environmental Agency and Öko-Institut.

Estimates for 2020 BAU transport sector CO_2 tank-to-wheel emissions roughly range from 975 to 1100 mega-tonnes. Differences between these estimates mainly stem from different assumptions on the future transport activities and on the future evolution of car fuel efficiency. Scenarios assuming no further fuel efficiency improvements lead to forecasts close to 1100 mega-tonnes (EEA, TREMOVE 2.7b). Scenarios assuming further fuel efficiency improvements result in estimates close to 1000 mega-tonnes (PRIMES, TREMOVE 2.7).

For this study we have set up a more realistic BAU scenario. In this scenario we expect further fuel-efficiency improvements for all road vehicle types, even without new policy measures. 2020 CO_2 tank-to-wheel emissions in this scenario equal 987 mega-tonnes. Adding also well-to-tank emissions, CH_4 and N_2O and correcting for the use of biofuels leads to an estimate for transport well-to-wheel GHG emissions in 2020 of 1168 mega-tonne CO_2-equivalents.

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[1] The definition of transport in this report is based on the European Commission's definition of EU domestic transport, excluding those parts that are covered under the EU Emission Trading Scheme (EU-ETS). This means that road, rail and inland shipping are included, but aviation and maritime transport are excluded.

2020 target

The EU has a target of reducing GHG emissions by 30% by 2020, as part of an international agreement, or at least 20% unilaterally (both relative to 1990 GHG emissions). To reach the 20% objective, it is envisaged to reduce emissions in the ETS sectors by 21% compared to 2005 and to reduce in the non-ETS sectors by 10% compared to 2005. Under the assumption that the reductions are spread evenly over the non-ETS sectors, this means that for transport a 10% reduction (compared to 2005) is needed to reach the 20% target (compared to 1990) [4].

In this report we focus on the 30% overall target, which would correspond with a 15% reduction in the non-ETS sectors. Thus, if the reductions are spread evenly over the non-ETS sectors, a 15% reduction compared to 2005 is needed for the transport sector. To include all transport-related emissions in the analysis we set this target relative to the 2005 well-to-wheel emissions of the main transport sector greenhouse gases (CO_2, CH_4 and N_2O). The 2005 level is 1130 mega-tonnes, thus the 2020 target is 961 (1130 * (1-0.15) mega-tonnes CO_2-equivalents in 2020. As 2020 emissions in our realistic BAU scenario are 1168 mega-tonnes, the required emission reduction in 2020 is thus 207 (1168 – 961) mega-tonnes CO_2-equivalents.

The GHG reduction potential of policy measures that are currently on the table has been estimated. Three types of policy measure, and combinations of them, are studied in this report:

- Fuel economy increases for new passenger cars on the type approval test-cycle;
- Additional measures on new passenger cars: low rolling resistance tyres, tyre pressure monitoring systems, low viscosity lubricants, gear shift indicators and measures on mobile air conditioners;
- Fuel quality and biofuel measures.

New car fuel economy increases on the test-cycle

Voluntary agreements exist between the European Commission and the car manufacturers in which the latter commit themselves to reduce average test-cycle CO_2 emission of new sold cars to 140 g./km by 2008/2009[2]. Currently, the European Commission is studying options to further reduce new car CO_2 emissions by setting binding manufacturer targets.

Numerous alternative proposals have been put on the table by various policy makers and stakeholders. In the communication from the Commission to the Council and the

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[2] There are three agreements with European (ACEA), Japanese (JAMA) and Korean (KAMA) manufacturers. The full texts can be found in the Official Journal of the European Communities: L350, 28.12.1998, p.58; L 100, 20.4.2000, p.55 and L 100, 20.4.2000, p.57.

European Parliament of 07.02.2007 [8], the Commission proposes a 130 g./km limit value for 2012. Also objective values of 120 g., 125 g. and 135 g. have been mentioned. Delaying the objective from 2012 to 2015 has been suggested by ACEA, for example in their Press Release of 8 June 2007[3]. The European Parliament Member Chris Davies put forward a combination of a 120 g. objective in 2015 and a 95 g. objective in 2020 [1]. The German Bundestag Fraction Bündnis 90/Die Grünen and the European Greens/European Free Alliance came up with objectives of 120 g. in 2012 and 80 g. in 2020. After the Ninth Franco-German Council of Ministers ranges of 120-130 g. in 2015 and 95-110 g. in 2020 were suggested by these countries [24].

Given the variety in proposed reduction objectives and target years, we studied a wide range of possible limit values and years:

- 135 g., 130 g. 125 g., 120 g. in 2012 with no further targets;
- 135 g., 130 g. 125 g., 120 g. in 2015 with no further targets;
- 135 g., 130 g. 125 g., 120 g. in 2012 with targets of 70 g., 75 g., 80 g., 85 g., 90 g., 95 g., 100 g. in 2020;
- 135 g., 130 g. 125 g., 120 g. in 2015 with targets of 70 g., 75 g., 80 g., 85 g., 90 g., 95 g., 100 g. in 2020;
- 130 g. in 2015 with a further target of 110 g. in 2020 (upper end of ranges in Franco-German proposal).

A 120 g./km limit value for average new car test-cycle CO_2 emissions in 2012 would reduce GHG emissions by 78 mega-tonnes CO_2-equivalents in 2020. Shifting the objective year from 2012 to 2015 would reduce this reduction potential to 64 mega-tonnes. Having a 130 g. objective in 2012, as proposed by the European Commission [7], would lead to a 43 mega-tonne reduction in 2020. If the objective year for this 130 g. limit is postponed to 2015, the reduction potential lowers to 32 mega-tonnes.

Also combinations of 2012/2015 test-cycle limits and more stringent limits in 2020 have been studied. A 130 g. limit in 2015 combined with a 110 g. limit in 2020, which is the upper end of the ranges indicated after the Ninth France-German Council of Ministers [24], can lead to a 59 mega-tonne reduction. The European Parliament Member Chris Davies put forward a combination of a 120 g. limit in 2015 and a 95 g. limit in 2020 [2]. This could lead to a 103 mega-tonne saving. The ideas of the German Bundestag Fraction Bündnis 90/Die Grünen and the European Greens/European Free Alliance, i.e. a 120 g. limit in 2012 and a 80 g. limit in 2020 would result in a 130 mega-tonne reduction. Finally, the most stringent test-cycle policy scenario studied, a 120 g. limit in 2012 combined with a 70 g. limit in 2020, would lead to a 149 mega-tonne reduction.

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[3] "*The European manufacturers operate in a fiercely competitive environment. Their investiment and innovation capacity should not be crippled. The first feasible data for implementation of new legal requirements is 2015.*"

Additional measures on new passenger cars

In its communication from 07.02.2007 [8], the Commission proposes a combination of fuel efficiency improvements on the test-cycle and additional measures for cars[4]. Following additional measures have been put on the table by the Commission:

- Low rolling resistance tyres (LRRT);
- Low viscosity lubricants (LVL);
- Tyre pressure monitoring systems (TPMS);
- Gear shift indicators (GSI);
- Fuel-efficiency improvements for mobile air conditioners (MAC).

LRRT, LVL and TPMS are three types of car equipment that reduce real-world fuel consumption (and CO_2 emissions) by reducing vehicle and engine resistance factors. We already expect a limited penetration of these technologies in a no-policy (BAU) 2020 scenario. The policy measure we consider in this report is a compulsory introduction of LRRT, LVL and TMPS for all new cars by 2012 through legislative measures.

GSI equipment can reduce real-world fuel consumption by influencing drivers gear-changing behaviour. The GSI policy we consider in this report is similar to that for LRRT, LVL and TMPS.

The MAC measure studied in this report is a scenario in which policy makers aim to accelerate the introduction of more fuel efficient mobile air conditioning systems.

A very wide range of policy packages is possible, combining various objectives for fuel economy increases on the test-cycle with one or more of the additional measures. In this report 20 of such policy packages have been studied.

Combining all additional measures with the Commissions 130 g. target in 2012 would lead to an overall 2020 GHG reduction of 72 mega-tonnes CO_2-equivalents. Combining the additional measures with the stricter 120 g. (2012) and 80 g. (2020) targets can reduce the 2020 emissions by 168 mega-tonnes. This would bring the 2020 GHG emissions down to 1000 (1168-168) mega-tonnes. The gap between the reduction achieved by this policy package and the targeted overall reduction is 39 (207-168) mega-tonnes CO_2-equivalent.

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[4] Note that the Commission proposal also proposes measures on N1 vehicles, thus on light commercial vehicles.

Fuel quality and biofuel measures

The third policy measure studied in this report is article 7a/2 of the new proposal for a revision of the current Fuel Quality Directive [7]. This article aims at, for all fuels brought to the market, reducing the well-to-wheel GHG emissions per unit of energy by 10% in 2020.

We studied different ways to achieve this objective, assuming different penetration rates for biofuels. But, the emission reduction of the measure is not dependent on the way it is achieved.

Combining a 130 g. in 2012 test-cycle policy, with all additional measures and the revised Fuel Quality Directive would reduce 2020 well-to-wheel GHG emissions to 990 mega-tonnes CO_2-equivalents. This is a reduction of 178 (1168-990) mega-tonnes compared to our realistic BAU scenario. Combining the Fuel Quality Directive revision and all additional measures with a 120 g. test-cycle limit in 2012 would result in a 178 mega-tonne reduction in 2020. Combining them with a 130 g. limit in 2012 and a 95 g. limit in 2020 would lead to a 190 mega-tonne reduction.

Note that we did not make calculations for all possible policy combinations, as the list of possible packages is endless. From the calculations we did however, it is clear that there are policy packages that would achieve the 207 mega-tonne reduction target. These packages include:

- 120 g. in 2012 (test-cycle), 70 g. in 2020 (test-cycle), Fuel Quality Directive Revision, all additional measures;
- 120 g. in 2012 (test-cycle), 70 g. in 2020 (test-cycle), Fuel Quality Directive Revision, no additional measures;
- 120 g. in 2012 (test-cycle), 80 g. in 2020 (test-cycle), Fuel Quality Directive Revision, all additional measures;
- 130 g. in 2012 (test-cycle), 70 g. in 2020 (test-cycle), Fuel Quality Directive Revision, all additional measures.

It is important to note that we only studied three policy measures. Our analysis indicates that these selected measures would enable to reach the 2020 reduction target only if extremely strict limits on car emissions would be set. Though, other policy measures are on the table, e.g. kilometre charging, revisions of the regulations on weight and dimensions of road trucks and measures on non-road transport modes. Such policies might also contribute to achieve the GHG reduction target. From our analysis it is clear that the GHG reduction target can only be reached by an integrated policy approach combining the three measures studied in this report with other measures influencing transport demand and technologies of vehicles other than cars.

This report is restricted to the estimation of the GHG emission reduction potential of specific policy measures in the transport sector. Costs or benefits of these measures and cost-effectiveness compared to other possible greenhouse gas abatement measures are not covered by this study.

Also, effects on vehicle fleet composition and on transport demand resulting from such costs or benefits are not fully accounted for. More specifically, changes in fleet composition and transport demand resulting from costs or benefits of setting limits on test-cycle emissions in 2012 or 2015 are accounted for, but similar effects of setting further limits in 2020 are not accounted for. E.g. very strict emission limits (e.g. 70 g./km on the test-cycle in 2020) could lead to a strong increase in the cost of car use (through increases of technology costs). This might lead to reductions in demand for transport, thus in further reductions of the emissions. Such second-order effects have not been quantified in this report..

Estimates for the costs of the less ambitious (not going beyond a 120g. test-cycle target in 2020) policy packages in the transport sector can be found in other Transport & Mobility Leuven (TML) reports, see for example reference [17].

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Introduction

Preventing climate change is one of the main challenges faced today and by future generations. Several agreements, objectives and measures to reduce greenhouse gas (GHG) emissions are on the political table at world-wide and European level. Recently, the EU has set a target of reducing GHG emissions by 30% (compared to 1990) by 2020, as part of an international agreement, or at least 20% unilaterally. In this report we analyse what the 30% objective means for the European transport sector[5]. We translate the objective in a clear GHG emission target level for the transport sector in 2020. We quantify the effort that is needed to reach this target. We study to what extent currently proposed policy measures help to reach this target level.

Before we can quantify the effort needed to reach the EU 30% objective, we need a clear view on the transport sector GHG emissions if no further policy measures are taken. In other words, we need to identify the 2020 transport sector GHG emissions in a business-as-usual (BAU) scenario. In research and impact assessments at European level, several BAU scenarios have been used. In chapter 1 we discuss the BAU scenarios used by the European Commission Directorate-General Environment, the European Commission Directorate-General Transport & Energy, the European Environmental Agency and Öko-Institut. In chapter 2 we construct a new 2020 BAU scenario that we consider to be the most realistic one.

In chapter 3 the 30% EU objective is translated in a clear 2020 GHG emission target level for the transport sector. By comparing our realistic BAU scenario with this target level, we quantify the emission reduction that is needed to reach the target.

Chapter 4 discusses the emission reduction potential of policy measures that are currently on the table. We consider following policy measures:

- Fuel economy increases for new passenger cars on the type approval test-cycle (section 4.1);
- Additional measures on new passenger cars: low rolling resistance tyres, tyre pressure monitoring systems, low viscosity lubricants, gear shift indicators and measures on mobile air conditioners (section 4.2);
- Fuel quality and biofuel measures (section 4.3).

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[5] The definition of transport in this report, is based on the European Commission's definition of EU domestic transport, excluding those parts that are covered under the EU Emission Trading Scheme (EU-ETS). This means that road rail and inland shipping are included, but aviation and maritime transport are excluded.

The two first policy measures tackle car emissions, the third policy affects the emissions of all transport modes.

We focus mainly on cars for several reasons. First of all, cars are responsible for a major share of the transport GHG emissions. Figure 1 shows the 2005 GHG emissions by transport mode in our realistic scenario (more details on this scenario can be found in chapter 2). 62.5% of the transport sector GHG emissions are caused by cars. Only 22.5% are caused by heavy duty trucks, and the share of other transport modes is much smaller. Thus, to reduce transport GHG emissions significantly, measures for cars are essential. Secondly, although there are policy measures on the table for other transport modes, these measures do have not as unique objective to reduce GHG emissions. For example, the heavy duty truck road charging / eurovignette policy and adaptations of the regulation on weight and dimensions of trucks will have effects on GHG emissions, but these measures are not specifically dedicated to reduce GHG emissions. Thirdly, for some transport modes, there are ambiguities in the available data, which make quantification of measures difficult. This is especially the case for light duty trucks and vans (vehicles of the N1 class, below 3.5 tonnes). The allocation of vehicles to the car (M1) and van/light duty truck (N1) categories in published statistics tends to differ by country. Depending on the country, users might register the latter vehicles as cars and vice versa for e.g. fiscal reasons. This causes uncertainties about the actual number of N1 vehicles in the EU fleet and their usage, and makes estimations of effects of related policy measures very unsure.

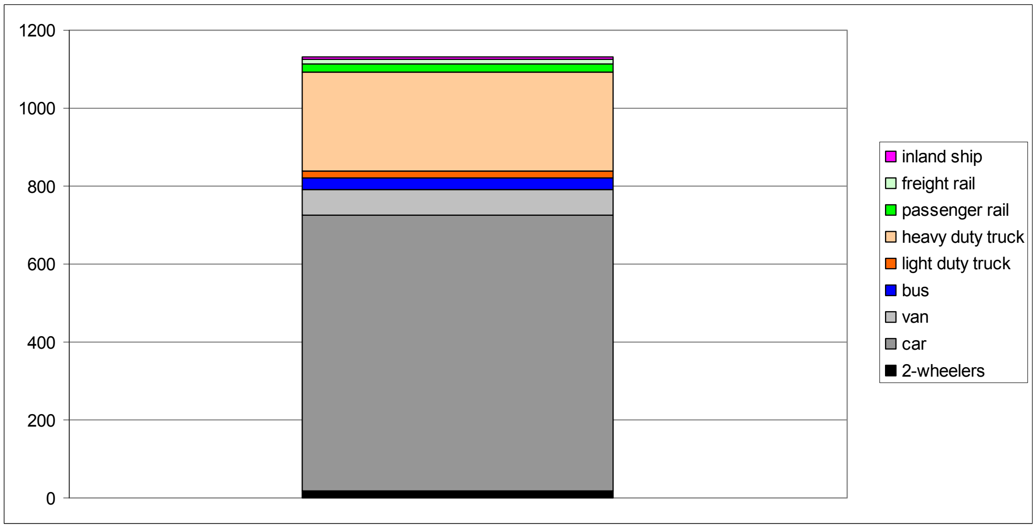


Figure 1: 2005 Transport tank-to-wheel GHG emissions in EU-27 – by mode – Mega-Tonne CO_2

Once the reduction potential of the policy measures, and possible combinations of them, is quantified, their contribution to reach the 2020 target level is known. In chapter 5 we conclude by discussing which policy measures (and packages of them) would reach the target level.

The authors would like to stress that this report is restricted to the estimation of the GHG emission reduction potential of specific policy measures in the transport sector. Costs of these measures and cost-effectiveness compared to other possible greenhouse gas abatement measures are not covered by this study. Estimates for the costs of measures in the transport sector can be found in other Transport & Mobility Leuven (TML) reports, see for example reference [17].

Note that all calculations in this report are approximate. The report does not account for monetary costs or benefits of the studied policy measures and packages. Also effects on vehicle fleet composition and on transport demand resulting from such costs or benefits are not fully accounted for. E.g. very strict emission limits (e.g. 70 g./km on the test-cycle) could lead to an increase in the cost of car use (through increases of technology costs). This might lead to reductions in demand for transport, thus in further reductions of the emissions. Such second-order effects have not been quantified in this report.

1 Existing BAU scenarios for 2020 transport CO2

In this chapter we compare existing BAU 2020 scenarios on transport CO_2 emissions and identify the similarities and the main reasons for differences.

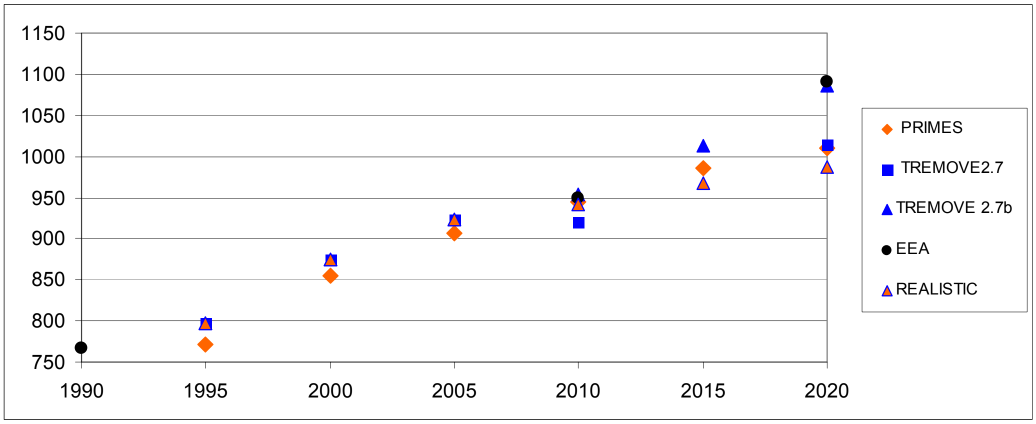
The scenarios studied are those used by:

- European Commission, Directorate-General Environment – based on the TREMOVE model;
- European Commission, Directorate-General Environment – based on the PRIMES model;
- European Environmental Agency

We also discuss shortly the BAU scenario assumptions taken in the note of Öko-Institut to the German Bundestag Fraction Bündnis 90/Die Grünen [23].

The comparison is mainly restricted to the tank-to-wheel (exhaust) emissions of CO_2. Well-to-tank emissions and non-CO_2 greenhouse gas emissions are recognised as important, though the short timeframe of this study did not allow an in-depth an analysis of these emissions in the PRIMES and EEA baselines. In the next chapters of the report, presenting a more realistic BAU scenario and potential effects of proposed policies, we will rather look from a well-to-wheel perspective.

Figure 2 shows a comparison of the exhaust greenhouse gas emissions in the studied BAU scenarios. In the next paragraphs, we will go into more detail on the underlying assumptions and reasons for differences.



**PRIMES: CO_2 emissions; Reference: [5]*
**TREMOVE 2.7 and 2.7b: CO_2 emissions*
**EEA: EU-27 all greenhouse gas emissions, converted to CO_2-equivalents; Reference: [4]*
**REALISTIC: EU-27 CO_2 emissions*

Figure 2: Transport tank-to-wheel greenhouse gas emissions in EU-27 - Mega-Tonne CO_2

1.1 DG ENV projections with TREMOVE

For the analysis of the reduction potential and cost-effectiveness of measures to reduce transport CO_2 emissions, Directorate-General Environment has made use of the TREMOVE model extensively.

TREMOVE is a transport and emission simulation model developed to study the effects of different transport and environment policies on the emissions of the transport sector. The model estimates transport demand, modal split, vehicle fleets, emissions of air pollutants and welfare level under different policy scenarios. All relevant transport modes are covered. The first versions of the model (TREMOVE 1) date 1997-1998 and have been developed by the Catholic University of Leuven (KUL) and Standard and Poor's DRI. Since 2001 TML and KUL have been developing new (TREMOVE 2) versions of the model, mainly funded by Directorate-General Environment. An extensive description of the TREMOVE model can be found in [11]. The model itself as well as documentation and simulation results can be found on TML's dedicated website: www.tremove.org.

As the TREMOVE model is continuously updated and developed by TML and KUL, several model versions have been used for the simulation of greenhouse gas policy measures. In this paragraph we discuss following versions:

- The Commission's February 2007 impact assessment [8] made use of simulations performed with TREMOVE v2.43b. This model version covered the 1995-2020 period and 21 countries (EU-15, Switzerland, Norway, Czech. Rep., Hungary, Slovenia and Poland). Most of the policy simulations with v2.43b have been performed by TML and are reported in [17]. In addition to this, a number of simulations has also been performed by the Commission itself;
- The last model version delivered by TML to the European Commission is v2.7. Compared to v2.43b this version runs up to 2030 and includes 31 countries (EU-27, Switzerland, Norway, Croatia and Turkey);
- For the December 2007 impact assessment [9], Directorate-General Environment adapted slightly the v2.7 model version. This resulted in a different BAU scenario for CO_2 emissions. In the remainder of this report, we refer to the BAU scenario of this version[6] as "v2.7b".

Figure 3, Figure 4, Figure 5, and Figure 6 illustrate the total pkm and tkm evolutions in v2.7 and v2.7b and the evolutions in the car/motorcycle and heavy duty truck segments in the BAU scenarios. Figures of v2.43b are not shown in the graph as this version of the model does not include all EU-27 countries.

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[6] In the Commission's Impact Assessment, this scenario is referred to as v2.53.

TREMOVE calculates emissions for all transport modes. For road transport, the model makes use of the COPERT emission calculation methodology [16]. The TREMOVE BAU scenarios are in line with the assumptions used by TNO, IEEP and LAT in their 2006 research for Directorate-General Entreprise [14]. These assumptions include:

- An improvement of average new car test-cycle CO_2 emissions towards 140g./km in 2008/2009[7], assuming that this objective in the current voluntary agreement with the car industry is met. TREMOVE assumes fuel efficiency and CO_2 improvements up to 2009 also for other road modes (trucks, buses, motorcycles, vans). After 2009 there is no further decrease of the CO_2 emissions of new vehicles;
- A 19.5% ratio between test-cycle and real-world emissions;
- A penetration of low rolling resistance tyres (LRRT), low viscosity lubricants (LVL), tyre pressure monitoring systems (TPMS) and gear-shift-indicators (GSI) in the car fleet.

TREMOVE assumes an introduction of 5.75% of biofuels in road transport by 2010. This share remains stable until 2020.

The TREMOVE v2.7b BAU scenario is equal to v2.7, except for the evolution of new car CO_2 emissions. In v2.7 it is assumed that the 140 g./km test-cycle is met in 2008/2009. In v2.7b. the most recent monitoring result is used, which is about 160 g./km in 2006, and no further improvements are assumed beyond 2006. This assumption is in line with the assumptions in the 2007 report on regulatory approaches to reduce CO_2 emissions from cars by IEEP, CE and TNO [13]. This latter report served, together with TREMOVE simulations, as input to the December 2007 impact assessment [9].

Figure 2 shows the evolution of exhaust CO_2 emissions for all road, rail and inland waterway vehicles in the TREMOVE BAU scenario's v2.7 and v2.7b. Overall and on the long term CO_2 emissions increase significantly, as the improvements in vehicle fuel efficiency do not compensate the increases in transport demand. Note however that in the v2.7 BAU scenario there is a slight decrease in the 2005-2010 period. This is the result of the assumption that the 140 g./km target for cars in 2008/2009 will be met. In other words, if the 140 g./km target would be met, this efficiency improvement would compensate the transport growth in the 2005-2010 period and lead to a temporary stabilisation of the CO_2 emissions. In the v2.7b baseline however, were no improvements are assumed beyond 160 g./km in 2006, there is a continuous growth in transport CO_2 emissions, also in the 2005-2010 period.

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[7] The target year is 2008 for European manufacturers (ACEA) and 2009 for the Japanese (JAMA) and Korean (KAMA) manufacturers.

In 2020 total transport tank-to-wheel CO_2 emissions in EU-27 are 1014 mega-tonne in v2.7 and 1086 mega-tonne in v2.7b.

1.2 DG TREN projection with PRIMES

The most recent greenhouse gas emission projection by the European Commission, Directorate-General Transport and Energy is reported in the '2030 European Energy and Transport, Update 2007' report [5]. The projection is derived from the PRIMES model by a consortium led by the National Technical University of Athens, supported by some more specialised models.

The transport activity projections from PRIMES are reported in Figure 3, Figure 4, Figure 5 and Figure 6. Comparison of PRIMES with TREMOVE 2.7 indicates that PRIMES has a lower passenger transport growth rate. In 2020 PRIMES has 7037 billion passenger kilometres, while TREMOVE has 7592 billion passenger kilometres. Overall freight transport growth in PRIMES and TREMOVE 2.7 is similar, though the growth rate is lower for trucks which is compensated by a higher growth rate for rail and inland shipping. In total, PRIMES reports 3322 billion tonne-kilometres in 2020 and TREMOVE reports 3384 billion tonne-kilometres.

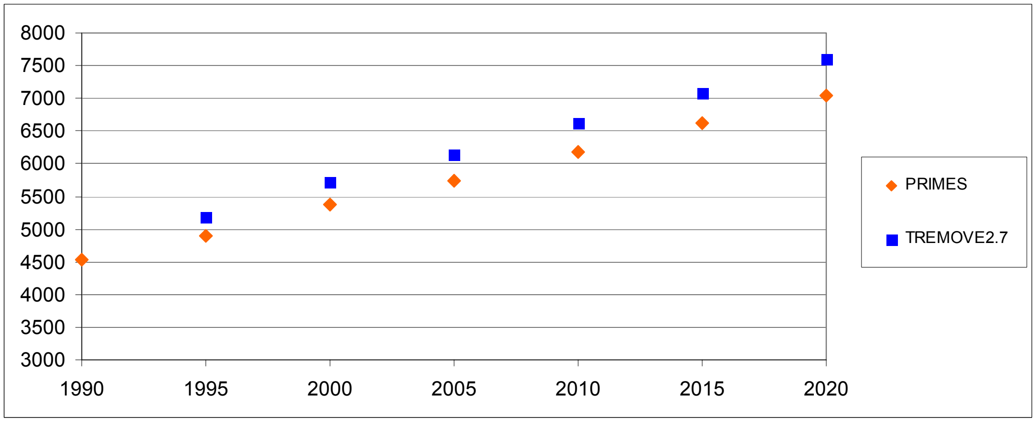

Figure 3: Total passenger transport demand in EU-27 – Billion passenger-kilometres

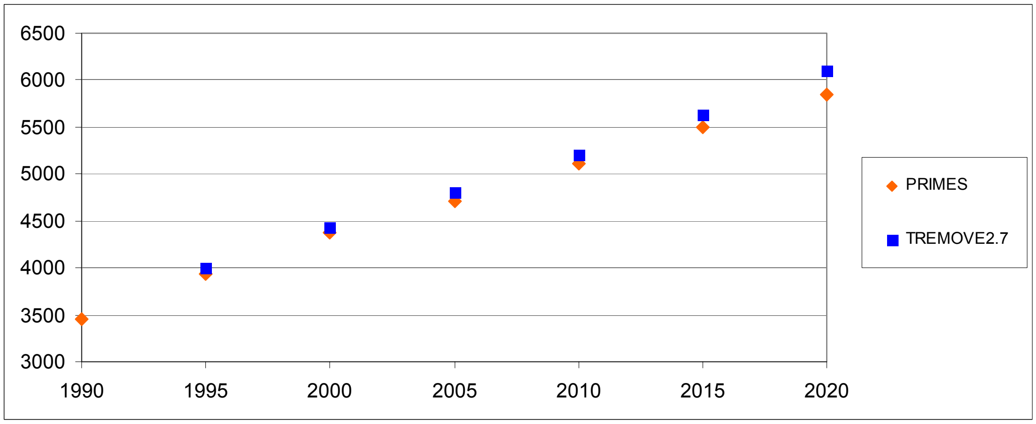

Figure 4: Car and motorcycle transport demand in EU-27 – Billion passenger-kilometres

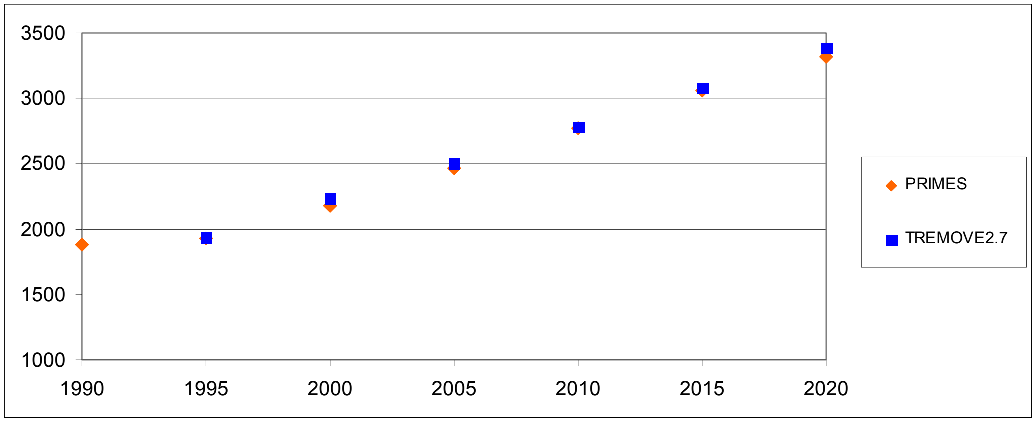

Figure 5: Total freight transport demand in EU-27 – Billion tonne-kilometres

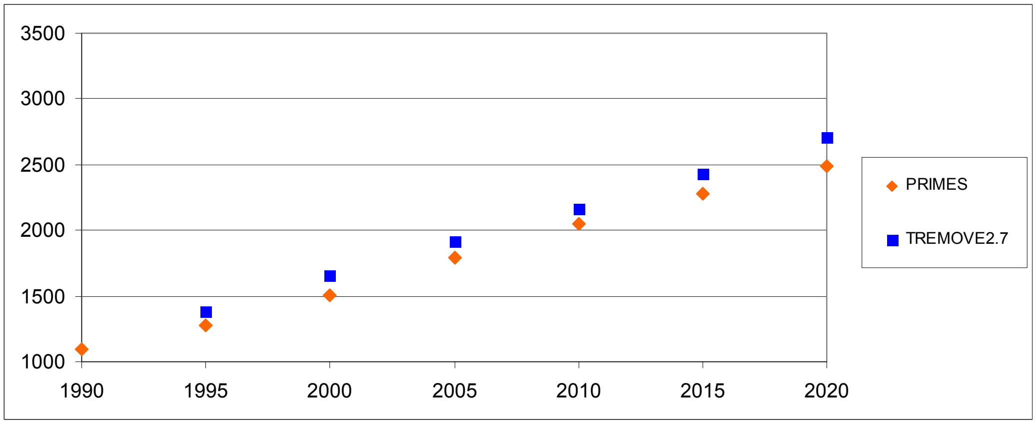

Figure 6: Heavy duty trucks transport demand in EU-27 – Billion tonne-kilometres

Also for a number of other underlying parameters that are of importance to the CO_2 projections significant differences exist between PRIMES and TREMOVE. For instance, the average occupancy rate for cars in PRIMES is 2.41 persons per vehicle in the year 2005, while for TREMOVE this is only 1.6.

Assumptions on the implementation of policies are different in PRIMES compared to TREMOVE. PRIMES assumes that the voluntary 140 g/km objective for cars is not met in 2008/2009 and that in the period 2005-2020 the fuel efficiency of cars will increase by 1.25% annualy. Also, PRIMES predicts only 4% of biofuel by 2010 while TREMOVE includes the 5.75% policy objective for 2010.

Figure 2 shows the exhaust CO_2 emissions predicted by PRIMES.

Note that the DG TREN report [5], does not include the CO_2 emissions of road, rail, inland navigation and air transport separately. Therefore we have estimated the share of air in the reported total emissions, to exclude these emissions from the graph. The plotted PRIMES figures for road, rail and inland navigation are thus estimates.

Despite all the aforementioned differences in underlying parameters and assumptions between TREMOVE and PRIMES they have similar results. The 2020 BAU projection for overall transport exhaust CO_2 emissions in PRIMES (1010 mega-tonnes) is nearly equal to that in TREMOVE 2.7 (1014 mega-tonnes).

1.3 EEA projection

The EEA's TERM 2007 report [4] includes emissions reported in 1990, as well as 2010 and 2020 projections for EU-27 greenhouse gas emissions from transport (excl. air and maritime transport).

The 2010 projections are based on predictions made by the individual Member States, taking into account the effect of existing and additional policy measures. Some more details on these scenarios can be found in the EEA's 'Greenhouse gas emission trends and projections' report of 2007 [1]. The exact underlying trends of drivers as GDP, population, freight flows and passenger flows for the national projections are not documented in the EEA reports. However, it can be summised that every country has used different forecasting approaches and different assumptions to prepare its projections. Additionally, the extent to which new policy measures are included differs amongst the national projections. This means that the 2010 projection reported by EEA should not be seen as an EU-27 wide harmonised BAU scenario. Rather, it is the sum of 27 national projections, each having different assumptions on drivers of transport emissions and policy.

The EEA's 2020 projection is based on the rough assumption that overall transport will grow by 15% and that there will be no further reduction measures. Based on these assumptions EEA expects 2020 emissions to be 15% higher than 2010 emissions. This obviously is a crude approach, that does not account for several relevant trends that will occur even without policy measures. For example it does not account for the fact that old vehicles will disappear from the fleet, which will lead to a significant decrease of the fleet-average CO_2 emission per kilometre.

Surprisingly, despite the simple 2010-2020 forecasting approach of EEA, Figure 2 shows that the 2020 CO_2 forecast of EEA (1091 mega-tonnes) is very close to that of TREMOVE v2.7b (1086 mega-tonnes). Remember that TREMOVE v2.7b assumes no further improvements for new cars beyond 2006 – which is similar to the EEA's assumption of no further reduction measures.

Although not explicitly specified in the EEA report, we presume that for most countries the EEA projections refer to tank-to-wheel emissions of CO_2, CH_4 and N_2O converted to CO_2-equivalents and that these exhaust emissions are further corrected for the use of biofuels.

1.4 Öko-Institut projection

In [23] Dr. Wiebke Zimmer (Öko-Institut) estimates the CO_2 reduction potential of different proposed policy scenarios on the further reduction of CO_2 limit values for new passenger cars in the EU 15.

The note makes use of two 2020 BAU scenarios:

1. A simplified estimation of 2020 EU-15 car CO_2 emissions, used as basis to estimate reduction potentials of the various proposed policies;
2. The PRIMES model forecast on EU-15 transport sector CO_2 emissions for all transport modes, to compare the estimated reduction potentials to the overall transport emissions. See section 1.2.

Both scenarios only include CO_2 emissions, not CH_4 and N_2O.

The simplified estimation of 2020 EU-15 car CO_2 emissions makes use of TREMOVE model data. 2020 car-kilometers by car vintage are taken from TREMOVE and are combined with assumed CO_2 emission factors for average cars of each vintage. The latter factors are different from those applied in TREMOVE 2.7 in 2 ways:

a. From 2004 to 2020 an annual reduction of 1.5% is assumed for the test-cycle CO_2 emission of the average sold cars in EU-15. This leads to an emission factor of approx 129 gram per km in 2020 – whereas TREMOVE 2.7 assumes an evolution towards a 140 gram test-cycle value in 2009 and no further reductions afterwards;
b. Test-cycle emission factors are used as they are – whereas TREMOVE converts these in 'real-world' emission factors accounting for the differences between real-world driving behaviour and the driving cycle specified for the tests.

For these reasons, the BAU 2020 EU-15 car CO_2 emissions in [23] are significantly lower than those in the TREMOVE BAU scenarios.

It is interesting to note that the 1.5% annual reduction is also applied and cited by other researchers, experts and industry representatives. For example, also the German TREMOD model assumes an annual 1.5% improvement. TREMOD is the transport emission model of the German government developed by IFEU [15]. Remember that PRIMES assumes an annual 1.25% improvement.

2 Realistic BAU scenarios for 2020 transport GHG

In this section we present a BAU scenario, that we consider more realistic than the scenarios discussed in the previous section.

In the previous section we discussed and compared BAU scenarios for transport CO_2 emissions developed and used by the European Commission Directorate-General Environment, Directorate-General Transport and Energy, European Environmental Agency and Öko-Institut.

The TREMOVE model, used by DG Environment, is the most detailed and extensive available model for transport emissions covering all EU countries. Therefore for our more realistic scenario we also use the TREMOVE model results as a basis. I.e. we start from the TREMOVE 2.7 baselines and make a number of adaptations to generate a scenario we consider more realistic.

The TREMOVE 2.7 baseline assumes that the 140 g CO_2./km target for new cars is met in 2008/2009 and that there will be no further improvements. The TREMOVE 2.7b baseline assumes that car emissions stabilise at their current level (160 g./km on the test-cycle for new sold cars in 2006). Both assumptions are not fully realistic. On one hand, it is almost certain that the 140 g./km target will not be met by 2008/2009. On the other hand, it is expected that, even without policy measures, emission reductions will continue up to 2020.

Based on our best knowledge and of views of other experts, we make the following assumptions in our realistic scenario:

- From 2006 to 2020 there will be an annual improvement of new car CO_2 emissions of 1.5%. I.e. we assume a similar annual reduction as in the 1995-2004 period[8]. This assumption has also been used by Öko-Institut [23] and by the German federal government in their most recent version of the TREMOD model [15].
- From 2006 to 2020 there will be similar improvements for other road vehicles (2-wheelers, vans, buses, trucks) of 1% per year. Such endogenous efficiency improvements have also been used in the Auto Oil II study [10]. They are often mentioned by industry representatives;
- There will be 5.75% biofuels blended in road transport fuels by 2010 and this percentage will remain stable up to 2020. More specifically 5.75% biodiesel is blended into diesel and 5.75% ethanol is blended into petrol. The average well-

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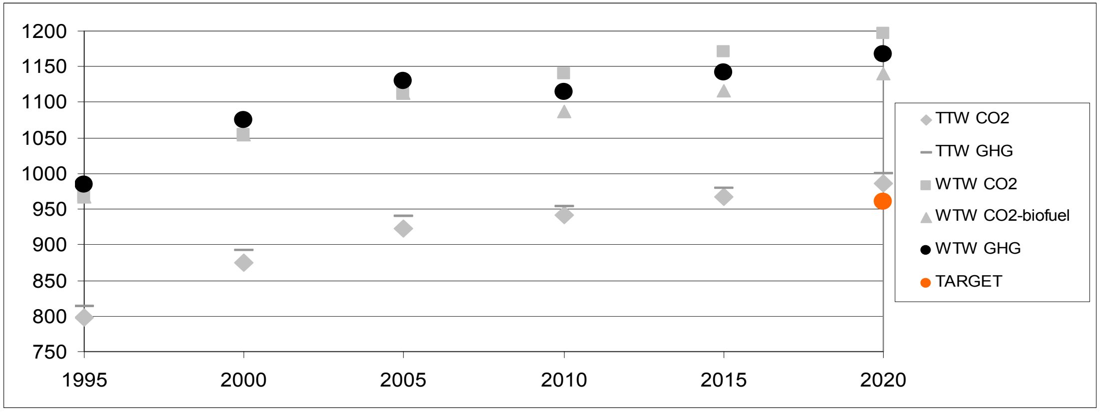
[8] The European Commission [8] reports for the EU-15 average new car test-cycle CO_2 emissions: 1995: 186 g./km; 2004: 163 g./km. The average annual reduction in this period is 1.5%

to-wheel CO_2 saving obtained by using these fuels is 57% (for the calculation of this percentage, see 4.3.2);

- None of the above assumptions have an impact on future transport demand or vehicle fleet composition. I.e. transport demand and fleet composition remains equal to that in TREMOVE 2.7.

Figure 7 shows the emissions we calculate for the realistic scenario, starting from the TREMOVE scenarios and taking into account the aforementioned additional assumptions. The graph shows tank-to-wheel (exhaust) CO_2 emissions, as well as well-to-wheel CO_2 emissions (sum of exhaust emissions and emissions related to fuel production and delivery). As CO_2 emissions generated by the combustion of biofuels is considered not to contribute to the greenhouse effect, the graph shows also emissions excluding those from biofuels[9]. Next, we added also CH_4 and N_2O emissions to the analysis to have total greenhouse gas (GHG) emissions



		1995	2000	2005	2010	2015	2020
TTW CO2	Mton	797	874	923	942	967	987
TTW GHG	Mton CO2-eq	814	892	939	954	979	999
WTW CO2	Mton	967	1055	1113	1141	1170	1196
WTW CO2-biofuel	Mton	967	1055	1113	1088	1116	1141
WTW GHG	Mton CO2-eq	984	1074	1130	1114	1142	1168
TARGET	Mton CO2-eq						961

**TTW CO2: Tank-to-Wheel CO_2 emissions – MTon*

**TTW GHG: Tank-to-Wheel CO_2, CH_4, N_2O emissions – Mton CO_2-eq*

**WTW CO2: Well-to-Wheel CO_2 emissions, including emissions from biofuel combustion - Mton*

**WTW CO2-biofuel: Well-to-Wheel CO_2 emissions, excluding emissions from biofuel combustion - Mton*

**WTW GHG: Well-to-Wheel CO_2, CH_4, N_2O emissions, excl. CO_2 emission from biofuel combustion – Mton CO_2-eq*

Figure 7: Realistic scenario greenhouse gas emissions - Mega-Tonne CO_2-equivalents

In our more realistic scenario total 2020 tank-to-wheel CO_2 emissions in EU-27 are 987 mega-tonnes. This is about 2.5% lower than those in the TREMOVE v2.7 (1014 mega-tonnes) and PRIMES (1010 mega-tonnes) baselines. The higher figure for PRIMES is due to the fact that PRIMES assumes a 1.25% annual efficiency improvement for new cars, while our realistic scenario assumes 1.5% annually and also improvements for other

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[9] Only exhaust emissions related to biofuels are excluded, well-to-tank emissions of biofuels are included.

vehicles than cars. TREMOVE v2.7 assumes stronger improvements for cars up to 2009 than our scenario, but no improvements afterwards. As our scenario assumes slower, but continued improvements up to 2020 it results in a slightly lower overall emission figure than v2.7.

As the EEA and TREMOVE v2.7b scenarios assume no further improvements from now on, they result in 10% higher 2020 tank-to-wheel emissions than our realistic scenario (EEA: 1091 mega-tonnes; TREMOVE v2.7b: 1086 mega-tonnes).

In order to assess the overall global warming impact of the transport sector one should not restrict to the tank-to-wheel (exhaust) emissions of CO_2. Also emissions of other pollutants (most relevant are CH_4 and N_2O) and well-to-tank emissions related to the production of fossil and biofuels should be accounted for. Furthermore CO_2 emissions generated by combusting biofuels in engines should be excluded from the analysis (as they are considered not to contribute to the greenhouse effect). I.e. we suggest to focus on the total well-to-wheel CO_2, CH_4 and N_2O emissions, excluding CO2 emissions from biofuel combustion. In our realistic scenario, these total 2020 well-to-wheel greenhouse gas emissions of the EU-27 transport sector are 1168 mega-tonnes CO_2-equivalents. The evolution of these emissions is indicated by the black dots in Figure 7.

3 Target for 2020 transport CO_2 and GHG

The EU has a target of reducing GHG emissions by 30% by 2020, as part of an international agreement, or at least 20% unilaterally (both relative to 1990 GHG emissions). To reach the 20% objective, it is envisaged to reduce emissions in the ETS sectors by 21% compared to 2005 and to reduce in the non-ETS sectors by 10% compared to 2005. Under the assumption that the reductions are spread evenly over the non-ETS sectors, this means that for transport a 10% reduction (compared to 2005) is needed to reach the 20% target (compared to 1990) [4].

In this report we focus on the 30% overall target, which would correspond to a 15% reduction in the non-ETS sectors. Thus, if the reductions are spread evenly over the non-ETS sectors, a 15% reduction compared to 2005 is needed for the transport sector. To include all transport-related emissions in the analysis we set this target relative to the 2005 well-to-wheel emissions of the main transport sector greenhouse gases (CO_2, CH_4 and N_2O).

The 2005 emission level and the target are graphically represented in Figure 7. The 2005 level is 1130 mega-tonnes and the 2020 target is 961 mega-tonnes CO_2-equivalents by 2020. As 2020 emissions in our realistic BAU scenario are 1168 mega-tonnes, the needed emission reduction in 2020 is thus 207 mega-tonnes CO_2-equivalents.

4 GHG reduction from proposed measures

In this chapter we estimate the GHG reduction potential of policy measures that are currently on the table, relative to our realistic BAU scenario. We will evaluate to what extent these policy measures contribute to reaching the target presented in chapter 3. We quantify the gap between the reduction potential of these proposed measures and the reduction needed to reach the target.

Three types of policy measure, and combinations of them, are studied in this chapter:

- Fuel economy increases for new passenger cars on the type approval test-cycle (section 4.1);
- Additional measures on new passenger cars: low rolling resistance tyres, tyre pressure monitoring systems, low viscosity lubricants, gear shift indicators and measures on mobile air conditioners (section 4.2);
- Fuel quality and biofuel measures (section 4.3).

The two first policy measures tackle car emissions, the third policy affects emissions of all transport modes.

We focus mainly on cars for several reasons. First of all, cars are responsible for a major share of the transport GHG emissions. Figure 1 shows the 2005 GHG emissions by transport mode in our realistic BAU scenario. 62.5% of the transport sector GHG emissions are caused by cars. Only 22.5% is caused by heavy duty trucks, and the share of other transport modes is much smaller. Thus, to reduce transport GHG emissions significantly, measures for cars are essential. Secondly, although there are policy measures on the table for other transport modes, these measures do not have the reduction of GHG emissions as a unique objective. For example, the heavy duty truck road charging / eurovignette policy and adaptations of the regulation on weight and dimensions of trucks will have effects on GHG emissions, but these measures are not specifically dedicated to reduce GHG emissions. Thirdly, for some transport modes, there are ambiguities in the available data, which make quantification of measures difficult. This is especially the case for light duty trucks and vans (vehicles of the N1 class, below 3.5 tonnes). The allocation of vehicles to the car (M1) and van/light duty truck (N1) categories in published statistics tends to differ by country. Depending on the country, users might register the latter vehicles as cars and vice versa for e.g. fiscal reasons. This causes uncertainties about the actual number of N1 vehicles in the EU fleet and their usage. These uncertainties make estimations of effects of related policy measures very unsure.

4.1 New car fuel economy increases on the test-cycle

4.1.1 Proposed and studied measures

Voluntary agreements exist between the European Commission and the car manufacturers in which the latter commit themselves to reduce average test-cycle CO_2 emission of new sold cars to 140 g./km in 2008/2009[10]. Currently, the European Commission is studying options to further reduce new car CO_2 emissions by setting binding manufacturer targets. In its communication from the Commission to the Council and the European Parliament of 07.02.2007 [8], the Commission proposes to mandate a combination of fuel economy improvements on the test-cycle and additional measures. For the fuel-economy improvements on the test-cycle the Commission envisaged a Regulation to make manufacturers reduce average test-cycle CO_2 emissions of new cars cars sold towards 130 g./km in 2012. This Regulation would be combined with additional measures (low rolling resistance tyres, low viscosity lubricants, tyre pressure monitoring systems, measures w.r.t. aircon equipment) that will not necessarily[11] affect test-cycle emissions, though will lead to a decrease of emissions in real-world driving. In this section we focus on the reductions on the test-cycle. The additional measures are studied in section 4.2.

As the European Parliament and Council have not taken a final decision on the test-cycle targets yet, debates and analyses are ongoing. Numerous alternative proposals have been put on the table by various policy makers and stakeholders. Next to 130 g./km, alternative objective values of 120 g., 125 g. and 135 g. have also been mentioned. Delaying the objective from 2012 to 2015 has been suggested by ACEA, for example in their Press Release of 8 June 2007[12]. The European Parliament Member Chris Davies has put forward a combination of a 120 g. objective in 2015 and a 95 g. objective in 2020 [1]. The German Bundestag Fraction Bündnis 90/Die Grünen and the European Greens/European Free Alliance came up with objectives of 120 g. in 2012 and 80 g. in 2020. After the Ninth Franco-German Council of Ministers ranges of 120-130 g. in 2015 and 95-110 g. in 2020 were suggested by these countries [24].

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[10] There are three agreements: European (ACEA), Japanese (JAMA) and Korean (KAMA) manufacturers. The full texts can be found in the Official Journal of the European Communities: L350, 28.12.1998, p.58; L 100, 20.4.2000, p.55 and L 100, 20.4.2000, p.57.

[11] It is not certain that the tyres and lubricants used during the test-cycle measurements are fitted on the sold cars. Reduction potentials of GSI, TPMS and MAC depend on driver behaviour that is not monitored in the test-cycle measurements.

[12] "*The European manufacturers operate in a fiercely competitive environment. Their investment and innovation capacity should not be crippled. The first feasible data for implementation of new legal requirements is 2015.*"

Given the variety in proposed reduction objectives and target years, we studied a wide range of possible objective values and years:

- 135 g., 130 g. 125 g., 120 g. in 2012 with no further targets;
- 135 g., 130 g. 125 g., 120 g. in 2015 with no further targets;
- 135 g., 130 g. 125 g., 120 g. in 2012 with targets of 70 g., 75 g., 80 g., 85 g., 90 g., 95 g., 100 g. in 2020;
- 135 g., 130 g. 125 g., 120 g. in 2015 with targets of 70 g., 75 g., 80 g., 85 g., 90 g., 95 g., 100 g. in 2020;
- 130 g. in 2015 with a further target of 110 g. in 2020 (upper end of ranges in Franco-German proposal).

4.1.2 Methodology

a. 135 g., 130 g., 125 g., 120 g. in 2012 with no further targets

Simulations of the 135 g., 130 g., 125 g. and 120 g. targets in 2012 have been performed earlier by TML with the TREMOVE model for the European Commission, Directorate-General Environment. Assumptions and results of these policy simulations are reported in [17] and [19].

These simulations were performed only for EU-15, Czech Republic, Hungary, Poland and Slovenia. Therefore, for this report, the earlier model results have been extrapolated to the EU-27 by using the TREMOVE data for all these countries. Also, the BAU baseline used for the earlier simulations (TREMOVE v2.43b) included an average new car test-cycle CO_2 emission factor of 140 g./km in 2008/2009 and no fuel further fuel efficiency improvements beyond 2009. This baseline has a lower 2020 emission level than the more realistic BAU scenario that we use in this report. Therefore the reduction potentials of the measures compared to our realistic BAU scenario are higher than compared to the earlier v2.43b baseline (as reported in [17] and [19]). As a consequence, we have also adapted the earlier model results to account for this difference. The resulting reduction potentials reported in this report thus refer to our realistic BAU scenario as discussed in chapter 2.

It is important to note that the TREMOVE simulations do not only account for the change in emission factors, but also for the related changes in costs and taxes. I.e. the increase in fuel economy entails increased vehicle (technology) costs and reduced fuel costs and taxes. These changes lead to changes in transport demand (car kilometres) and purchasing behaviour (car fleet composition) which are also accounted for in the calculated GHG reduction potentials. The changes in vehicle (technology) costs related to the fuel efficiency improvements have been taken from dedicated research for Directorate-General Entreprise [14].

TREMOVE takes also into account that emissions in the real-world are higher than on the test-cycle, as real-world driving patterns differ from the pattern of the test-cycle. Roughly, a 1 g CO_2./km improvement of test-cycle emissions leads to a 1.1 to 1.2 g./km improvement under real-world driving conditions.

As TREMOVE also calculates CH_4 and N_2O exhaust emissions, as well as well-to-tank emissions of CO_2, CH_4 and N_2O, we can report the reduction in total well-to-wheel emissions for all these greenhouse gases.

All details on the TREMOVE simulations are reported in [17] and [19] and the simulation input and output files are publicly available on www.tremove.org.

b. 135 g., 130 g., 125 g., 120 g. in 2015 with no further targets

For the measures 135 g., 130 g., 125 g., 120 g. in 2015 with no further targets, we also started from the TREMOVE simulations for 2012 objectives (referred to in section **a.** above). Further calculations have then been made outside TREMOVE, adapting the fuel efficiency factors of new sold vehicles between 2009 and 2015 to reflect the shift of the objective from 2012 to 2015. The transport demand and car fleet composition in 2020 has been kept equal to those in the TREMOVE simulations. *As a proxy, we assume that these effects on transport demand and fleet composition in the year 2020 are similar for objectives set for 2012 or 2015.*

c. Combination with further targets in 2020: 70 g., 75 g., 80 g., 85 g., 90 g., 95 g., 100 g., 110g.

For the scenarios with further targets in 2020, we started our calculations from the results for the 2012/2015 objectives as calculated in **a.** and **b.**. For the cars sold in the years 2012/2015 up to 2020 fuel consumption factors then have been adapted downwards towards the objective value in 2020. No further changes to 2020 transport demand and fleet composition have been made. *We did not include changes in transport demand or fleet composition that would be caused by the introduction of more fuel efficient cars beyond the 2012/2015 objectives. Or, in other words, we did not account for consumers reactions to vehicle (technology) price increases and fuel savings related to these fuel efficiency improvements. Note that the related technology research [14] did not study costs of technologies beyond 120 g./km objectives. Currently there is no firm basis to estimate long-term technology costs of such reductions.*

4.1.3 Estimated reduction potentials and gaps with the target

Figure 8 and Figure 9 show the greenhouse gas reductions calculated for the studied fuel economy increases for new passenger cars. Figure 8 includes the outcomes for measures having 2012 as first target year. Figure 9 shows the outcomes for measures having 2015 as first target year.

On the horizontal axis one sees the achieved greenhouse gas emission reduction. These figures are reductions in total well-to-wheel emissions of the main transport sector greenhouse gases (CO_2, CH_4 and N_2O), expressed in mega-tonnes CO_2-equivalents. The red line represents the reduction target discussed in chapter 3. The vertical axis shows the CO_2 emission objective set by the policy maker for new sold cars in 2012/2015.

The graphs show in black the policy cases of 135 g. (diamond), 130 g. (square), 125 g. (triangle) and 120 g. (circle) in 2012/2015 with no further objectives.

The graph shows also the reduction potential of:

- Combinations of a 135 g. objective in 2012/2015 with further objectives in 2020 (ranging from 100 g. to 70 g.): coloured diamonds;
- Combinations of a 130 g. objective in 2012/2015 with further objectives in 2020 (ranging from 100 g. to 70 g.): coloured squares;
- Combinations of a 125 g. objective in 2012/2015 with further objectives in 2020 (ranging from 100 g. to 70 g.): coloured triangles;
- Combinations of a 120 g. objective in 2012/15 with further objectives in 2020 (ranging from 100 g. to 70 g.): coloured circles;
- Combination of a 130 g. objective in 2015 with a further objective of 110 g. in 2020 (upper end of ranges in Franco-German proposal): red square with asterisk in Figure 9.

The table in the annex includes the numbers shown in the graphs and the calculated gap with the target set in chapter 3. None of policy scenarios studied in this section achieves the reduction target set in chapter 3 (207 mega-tonne reduction).

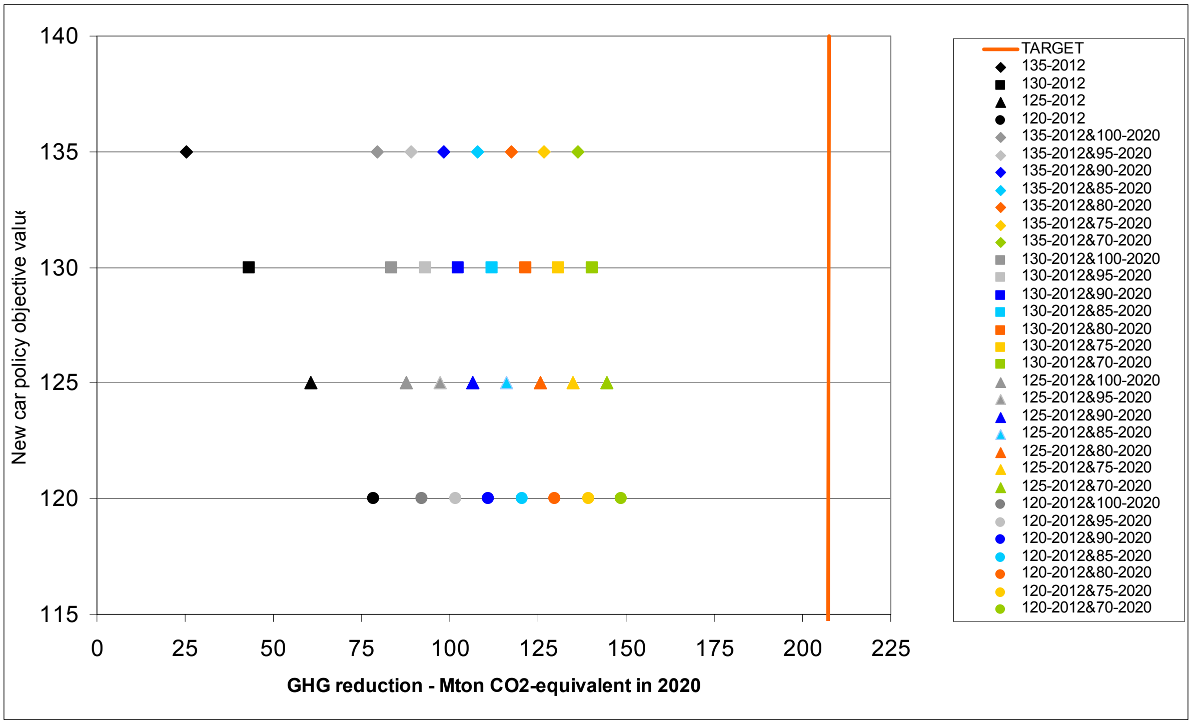

Figure 8: Estimated reduction potential of test-cycle fuel economy measures – Mega-tonnes CO_2-equivalent in EU27 – First objective year 2012

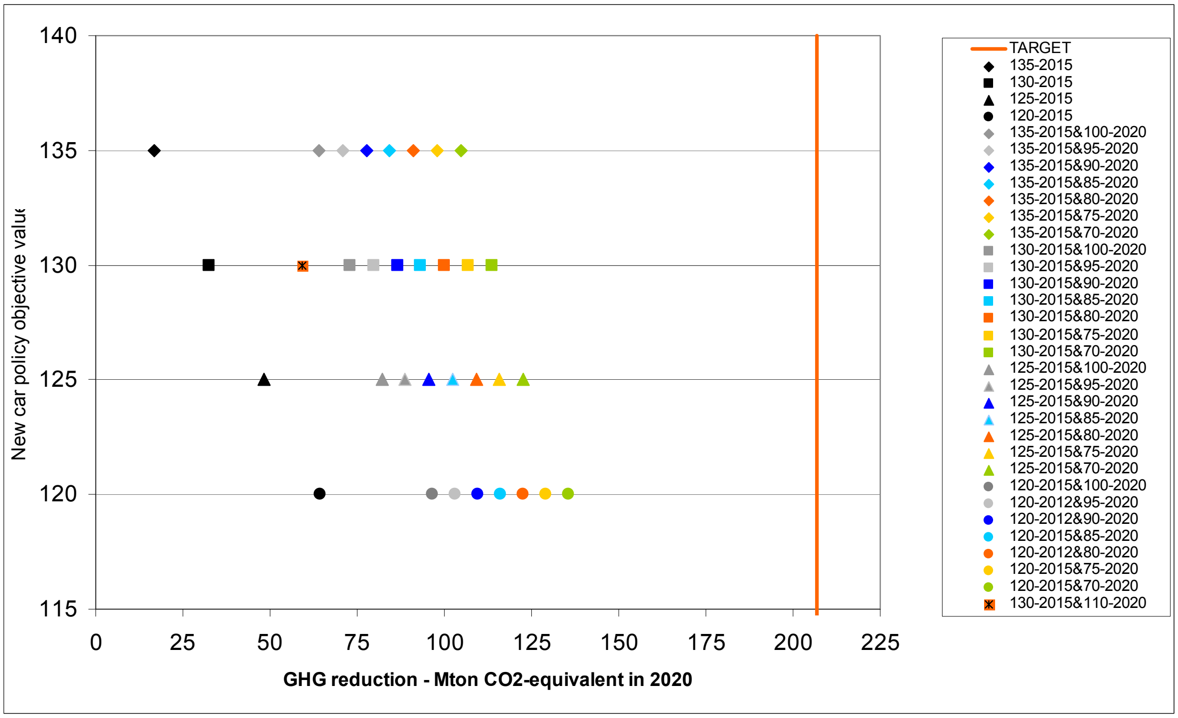

Figure 9: Estimated reduction potential of test-cycle fuel economy measures – Mega-tonnes CO_2-equivalent in EU27 – First objective year 2015

4.1.4 Comparison with EEA estimate

In its TERM 2007 report [3] EEA mentions 125 mega-tonne CO_2-equivalent as estimate for the EU-27 exhaust emission reduction in 2020 that would result from a 130 g./km limit value in 2012. From section 1.3 we remember that EEA used a BAU scenario assuming no further fuel-efficiency improvements beyond 2006. This BAU scenario resulted in 1091 mega-tonne CO_2-equivalent in 2020. I.e. for the 130 g. limit in 2020, EEA estimates the exhaust emission level in 2020 at 966 (1091-125) mega-tonne CO_2-equivalent. All these figures refer to the aggregate of CO_2, CH_4 and N_2O tank-to-wheel emissions.

In our realistic BAU scenario 2020 exhaust tank-to-wheel emissions of CO_2, CH_4 and N_2O are 999 mega-tonne CO_2-equivalent (see Figure 7). We estimate the reduction for a 130 g. limit value in 2012 at 43 mega-tonne CO_2-equivalent for the total well-to-wheel emissions (Figure 8). For only the tank-to-wheel emissions the reduction we calculated is 37 mega-tonnes CO_2-equivalent. Thus, for the 130 g. limit in 2020, we estimated the emission levels in 2020 at 962 (999-37) mega-tonne CO_2-equivalent. This estimate is almost equal to that from EEA (966), the difference is less than 0.5%.

In other words, for a scenario with a 130 g. limit in 2012, we estimate equal GHG emissions as EEA in 2020. EEA however reports a higher reduction potential for this policy as they use a BAU scenario with higher emissions in 2020 than ours.
Note that comparisons with the reduction potential values reported in the European Commissions impact assessments [8] and [9] were not feasible in the scope of our research. The Commission reports the emissions savings cumulated over the 2010-2020 period, while our study focuses on effects in the year 2020.

4.1.5 Comparison with Öko-Institut estimates

Table 1 compares our estimates with the earlier estimates by Öko-Institut [23].

	Öko (low)	Öko (central)	Öko (high)	TML
130 g. 2012	16	35	60	43
130 g. 2015	9	18	22	32
120 g. 2015 & 95 g. 2020	-	57	-	103
120 g. 2012 & 80 g. 2020	-	95	-	130

Table 1: Estimated reduction potential of test-cycle fuel economy measures by Öko (EU-15, Mega-tonnes CO_2, and TML (EU-27, Mega-tonnes CO_2-equivalent)

The reduction potentials we calculated are higher than the central estimates of Öko-Institut. The first reason for this is the scope of the study. We calculated reduction potentials for well-to-wheel emissions of CO_2, CH_4 and N_2O in EU-27, while Öko-Institut restricted calculations to CO_2 exhaust emissions in EU-15. Secondly, Öko-Institut did not account for the difference between real-world and test-cycle emission factors. As indicated earlier, the policy is expected to deliver larger reductions (expressed in grammes CO_2) in the real-world than on the test-cycle. Thirdly, Öko-Institut did not account for changes in travel patterns (car kilometres) and car fleet composition. We accounted for such changes up to 2012/2015. In other words, compared to Öko-Institut's calculations, our calculations have a much broader scope (countries, pollutants, real-world) and a more elaborate methodology (changes in travel patterns).

Furthermore, for policy measures with a limit value only for 2012 or 2015 and none for 2020, we assumed no further fuel efficiency improvements beyond 2012 or 2015. Öko-Institut calculated three estimates for each scenario: low estimates are based on the same assumption as our calculations, central estimates assume a further fuel-efficiency improvement of 1.5% per year (as in the BAU scenario) and Öko-Institut's high estimates assume a fuel-efficiency reduction higher than 1.5% after 2012 or 2015.

Figure 10 shows the test-cycle CO_2 emission factors for cars (by vintage) that are used in the different calculations. The figure represents the 130 g. in 2012 limit scenario. In this scenario we assume no further efforts beyond the 130 g. limit. Of course, we have calculated the potential of such efforts in the scenario that combine 2012 limits with 2020 limits. In their 'central' and 'high' estimations, Öko did assume further improvements beyond the 2012 limits.

Note also that Öko-institut assumes that the policy already leads to reductions in 2008, while we kept emission factors equal to the BAU scenario up to 2009.

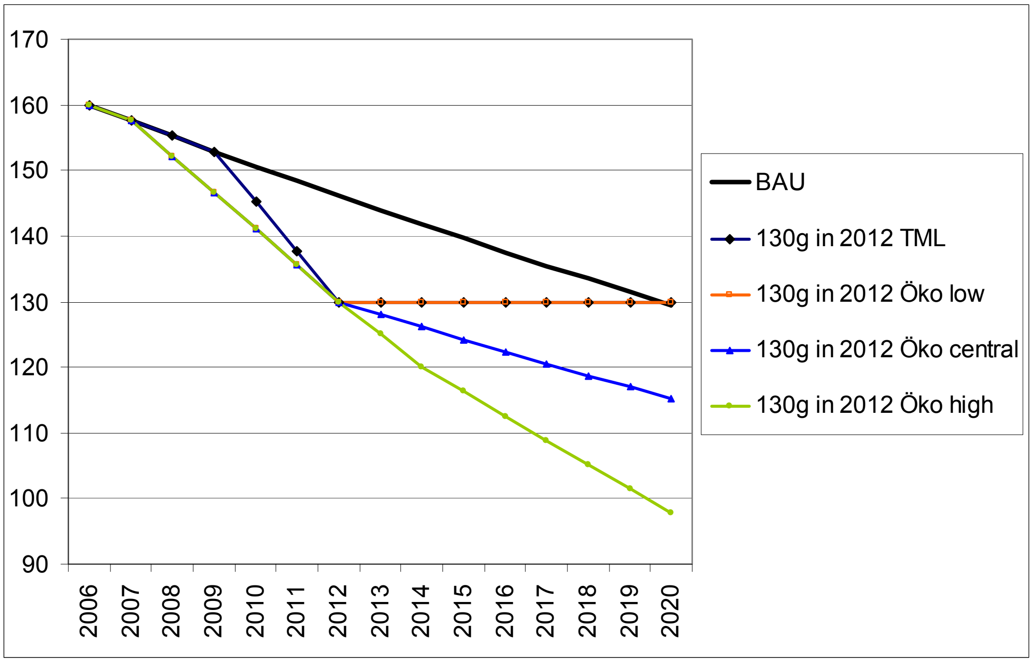

Figure 10: Test-cycle CO_2 emission factors for cars by vintage – 130 g. in 2012 limit – g./km

In conclusion, the assumptions, scope and methodology of our calculations and those of Öko-Institut differ very significantly and consequently results are not directly comparable.

A consequence of these differences is that the impact of a shift of the 130 g. limit from 2012 to 2015 has a larger influence on the reduction potential in the calculations of Öko-Institut, than in our calculations (see Table 1). Figure 11 shows the test-cycle CO_2 emission factors for cars (by vintage) for the 130 g. in 2015 limit scenario. This figure can be easily compared with Figure 10.

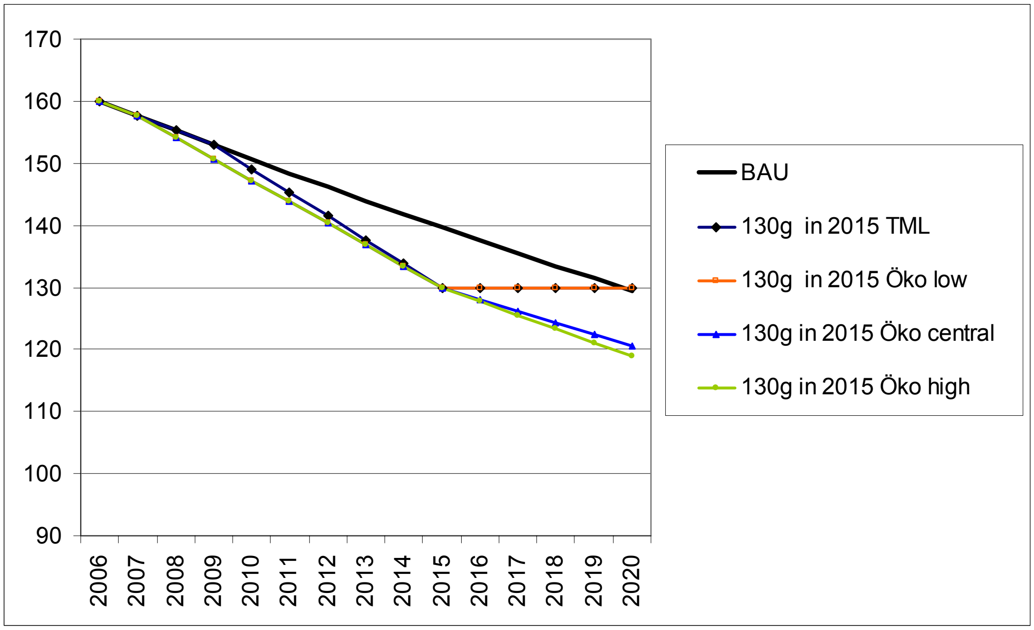

Figure 11: Test-cycle CO_2 emission factors for cars by vintage – 130 g. in 2015 limit – g./km

Our estimate for 130 g. in 2015 (32) is 25% below that for 130 g. in 2012 (43). That this difference is limited to 25% can be explained by having a closer look at Figure 12. This figure shows the share of cars of different vintages (years of sale) in the total car kilometres of the year 2020. About 20% of the kilometres driven in 2020 are performed by cars sold in 2009 or before. We assume that none of the policy measures studied will have an impact on cars sold in 2009 or earlier. Thus these cars do not contribute to the reduction potential of the policy measures. About 53% of these kilometres are performed by cars sold in 2015 or thereafter. Irrespective of the limit year (2012 or 2015) these cars will, on average, comply with the fleet average of 130 g. on the test-cycle. Thus, whether the limit year is 2012 or 2015 does not affect the contribution of these cars to the policies emission reduction potential. Concluding, only for the cars sold from 2010 to 2014 that the shift of the limit year from 2012 to 2015 has an impact on the reduction potential of the policy. These cars perform about only 27% (100% - 53% - 20%) of the kilometres driven in 2020. Shifting the 130 g. limit year from 2012 to 2015 leads to an increase in the emission factor for these cars that is not larger than 11 g. (compare the TML values in Figure 12 and Figure 11, the difference is 11 g. in 2012). Together this results in a decrease of the reduction potential by 25% if shifted the 130 g. target is postponed from 2012 to 2015.

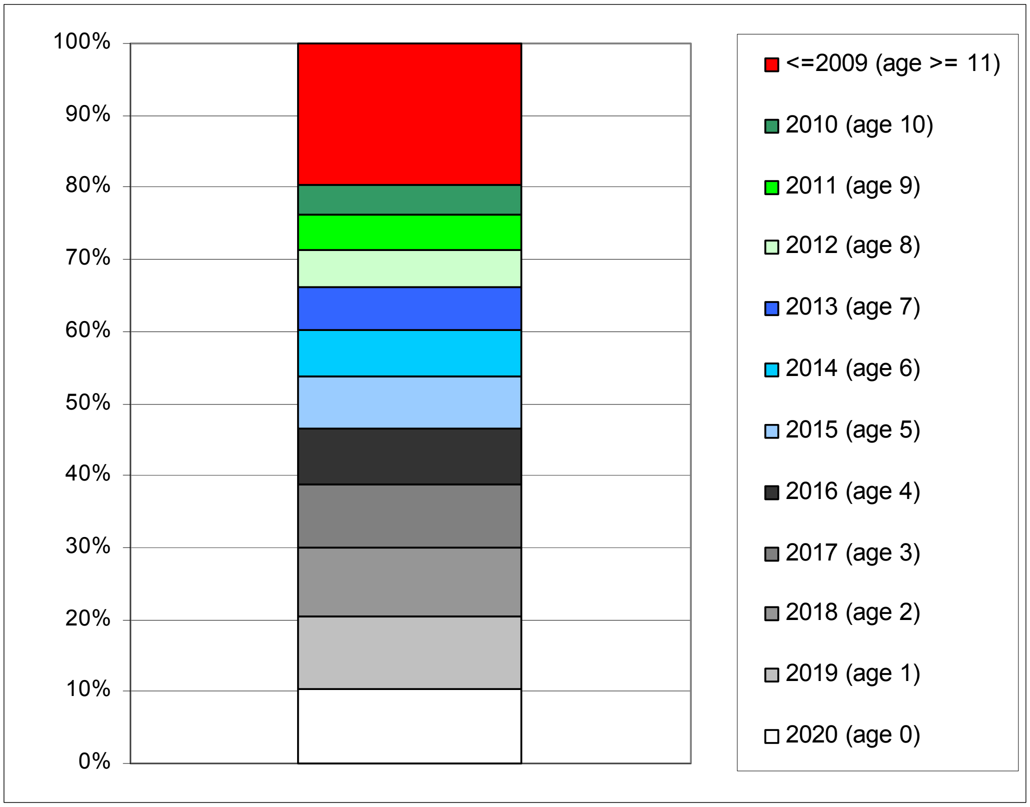

Figure 12: % of car kilometres in 2020 performed by cars of different vintages

4.2 Additional measures in new passenger cars

4.2.1 Proposed and studied measures

In its communication from 07.02.2007 [8], the Commission proposes a combination of fuel efficiency improvements on the test-cycle and additional measures. The reduction potential of the improvements on the test-cycle has been estimated in the previous section. In this part of the report we estimate the GHG reduction potential of the additional measures.

For cars[13] the following additional measures have been put on the table by the Commission:

- Low rolling resistance tyres (LRRT);
- Low viscosity lubricants (LVL);
- Tyre pressure monitoring systems (TPMS);
- Gear shift indicators (GSI);
- Fuel-efficiency improvements for mobile air conditioners (MAC).

For LRRT and TPMS (and related safety issues) a proposal has also been adopted by the European Commission [6].

The Commission's proposal and the TREMOVE simulations performed in the context of the impact assessment [8] are, to a large extent, based on the results of the study on CO_2 reduction potentials performed by TNO, IEEP and LAT [14]. Also for this report we make use of the outcomes of the latter study (more details on the technical aspects of the measures thus can be found in that study report).

a. Low rolling resistance tyres, low viscosity lubricants and tyre pressure monitoring systems

LRRT, LVL and TPMS are three types of car equipment that reduce real-world fuel consumption (and CO_2 emissions) by reducing vehicle and engine resistance factors. The TNO/ IEEP/LAT report estimates the real-world fuel consumption improvement for these technologies as:

- LRRT: 3%
- LVL: 2.5%
- TPMS: 2.5%

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[13] Note that the Commission proposal also includes a policy on N1 vehicles, thus on light commercial vehicles.

Note that, as the reduction potential is expressed as a percentage, the emission reduction per kilometre in absolute terms (grammes) is lower for more fuel-efficient cars. Thus, the more stringent the legislation for the test-cycle emissions is, the lower the reduction potential of these additional technologies.

The TNO/IEEP/LAT report also provides estimates for the penetration of these technologies in a no-policy (BAU) scenario up to 2020. These projections have also been included in the TREMOVE BAU scenarios (see [17] for details). And, as our realistic BAU scenario (see chapter 2) is further developed from these TREMOVE scenarios, our realistic BAU scenario also includes these penetration rates. In our realistic BAU scenario for the year 2020 these technologies are included as follows:

- LRRT: 71% of all cars dating from 1995 or later are equipped with LRRT;
- LVL: 25% of all cars dating from 1995 or later make use of LVL;
- TPMS: 30% of cars dating from 2007 or later are equipped with TPMS.

The policy measure we consider in this report is a compulsory introduction of LRRT, LVL and TMPS for new cars through legislative measures (this is indicated as 'scenario 1' in the report by TNO/IEEP/LAT). This policy would lead to 50% of cars sold in 2010, 75% of cars sold in 2011 and all cars sold from 2012 being equipped with the technologies.

b. Gear shift indicators

GSI equipment can reduce real-world fuel consumption by influencing drivers' gear-changing behaviour. TNO, IEEP and LAT estimated this reduction potential at 1.5% on average. No GSI are expected in a BAU scenario. The GSI policy we consider in this report is similar to that for LRRT, LVL and TMPS ('scenario 1' in the report by TNO/IEEP/LAT). The policy would lead to 50% of cars sold in 2010 , 75% of cars sold in 2011 and all cars sold from 2012 being equipped with GSI.

c. Measures on air conditioning equipment

The MAC measure studied in this report corresponds with the 'additional policy' scenario discussed by TNO/IEEP/LAT. It is a scenario in which policy makers aim to accelerate the introduction of more fuel efficient mobile air conditioning systems. The CO_2 emission reductions that can be achieved by this measure are independent of the test-cycle fuel consumption. Therefore we use following absolute CO_2 reduction potentials for this measure:

- 2010: -0.85 g CO_2/km;
- 2011: -1.2 g CO_2/km;

- 2012-2020: -0.53 g CO_2/km.

Note that the BAU scenario already includes an introduction of improved aircon systems. The policy only aims to stimulate the introduction of these improved systems in the earlier years. As a result the reduction potential in 2012 and the later years is lower than in 2010 and 2011.

d. Studied policy packages

A very wide range of policy packages is possible, combining various objectives for fuel economy increases on the test-cycle with one or more of the additional measures. In this report we study the following combinations of measures:

- 130 g. in 2012 combined with LRRT;
- 130 g. in 2012 combined with LRRT and LVL;
- 130 g. in 2012 combined with LRRT, LVL and TPMS;
- 130 g. in 2012 combined with LRRT, LVL, TPMS and GSI;
- 130 g. in 2012 combined with LRRT, LVL, TPMS, GSI and MAC;
- 120 g. in 2012 combined with LRRT;
- 120 g. in 2012 combined with LRRT and LVL;
- 120 g. in 2012 combined with LRRT, LVL and TPMS;
- 120 g. in 2012 combined with LRRT, LVL, TPMS and GSI;
- 120 g. in 2012 combined with LRRT, LVL, TPMS, GSI and MAC;
- 130 g. in 2012 and 95 g. in 2020 combined with LRRT;
- 130 g. in 2012 and 95 g. in 2020 combined with LRRT and LVL;
- 130 g. in 2012 and 95 g. in 2020 combined with LRRT, LVL and TPMS;
- 130 g. in 2012 and 95 g. in 2020 combined with LRRT, LVL, TPMS and GSI;
- 130 g. in 2012 and 95 g. in 2020 combined with LRRT, LVL, TPMS, GSI and MAC;
- 120 g. in 2012 and 70 g. in 2020 combined with LRRT;
- 120 g. in 2012 and 70 g. in 2020 combined with LRRT and LVL;
- 120 g. in 2012 and 70 g. in 2020 combined with LRRT, LVL and TPMS;
- 120 g. in 2012 and 70 g. in 2020 combined with LRRT, LVL, TPMS and GSI;
- 120 g. in 2012 and 70 g. in 2020 combined with LRRT, LVL, TPMS, GSI and MAC.

4.2.2 Methodology

Simulations of policy packages that combine objectives on the test-cycle with additional measures have been performed earlier by TML with the TREMOVE model for the European Commission. Results of these policy simulations are reported in [17] and [19]. However, to keep consistency with our calculations in section 4.1, we did not make use of these TREMOVE simulation results for this report. Instead, we started from our earlier calculations w.r.t. the measures to increase test-cycle fuel efficiency (section 4.1). Fuel efficiency factors of cars sold after 2009 were then further adapted to reflect the introduction of the additional technologies (LRRT, LVL, TPMS, GSI and MAC).

a. Low rolling resistance tyres, low viscosity lubricants and tyre pressure monitoring systems

LRRT, TPMS and LVL technologies are already present on some cars in our realistic BAU scenario, dependent on the car vintage. For each vintage we calculated the extra share of cars that would be equipped with the technologies if the policy measure is applied, compared to the BAU scenario. For these cars the emission factor was then further lowered by 3% (LRRT), 2.5% (LVL) and 2.5% (TPMS) respectively. Total GHG emissions, reduction potential and gap with the target were then again calculated as in section 4.1.2.

b. Gear shift indicators

GSI are not present on the cars in our realistic BAU scenario. For each vintage we calculated the share of cars that would be equipped with GSI if the policy measure is applied, compared to the BAU scenario. For these cars the emission factor was then lowered further by 1.5%. Total GHG emissions, reduction potential and gap with the target were then again calculated as in section 4.1.2.

e. Measures on air conditioning equipment

In case the MAC measure makes part of the policy package following absolute reductions of the CO_2 emission factors were applied:

- 2010: -0.85 g CO_2/km;
- 2011: -1.2 g CO_2/km;
- 2012-2020: -0.53 g CO_2/km.

Total GHG emissions, reduction potential and gap with the target were then again calculated as in section 4.1.2.

No further changes to 2020 transport demand and fleet composition have been made. I.e. we did not include changes in transport demand or fleet composition that would be caused by the introduction of the additional equipment. In other words, we did not account for consumers reactions to vehicle or equipment cost increases and fuel savings related to these additional measures. Note that the earlier TREMOVE simulations ([19]) did include such effects on demand and fleet composition.

4.2.3 Estimated reduction potentials and gaps with the target

Figure 13 shows the greenhouse gas reductions calculated for the studied policy packages, as well as the potential of some of the measures on only test-cycle fuel economy (from Figure 8).

The graph includes the policy cases of 135 g. (diamond), 130 g. (square), 125 g. (triangle) and 120 g. (cirkle) in 2012 with no further objectives nor additional measures, all shown in black :

The graph shows also the reduction potential of:

- Combinations of a 130 g. objective in 2012 and the additional measures (coloured squares);
- Combinations of a 130 g. objective in 2012 and a 95 g. objective in 2020 and the additional measures (coloured squares);
- Combinations of a 120 g. objective in 2012 and the additional measures (coloured circles);
- Combinations of a 120 g. objective in 2012 and a 70 g. objective in 2020 and the additional measures (coloured squares).

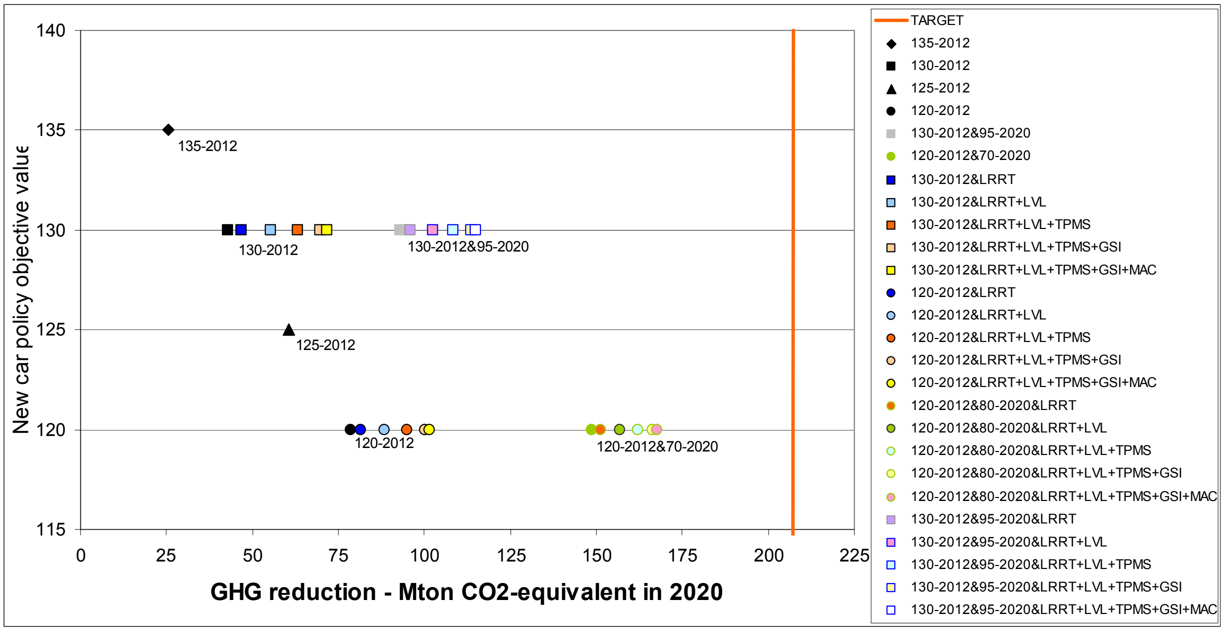

Figure 13: Estimated reduction potential of policy packages combining test-cycle fuel economy measures and additional measures – Mega-tonnes CO_2 equivalent in EU27

The table in the annex includes the numbers shown in the graph and the calculated gap with the target set in chapter 3. None of the studied policy packages is sufficient to reach the reduction target set in chapter 3 (207 mega-tonne reduction). Thus, on top of the policies studied here, additional measures would have to be taken to reach the 2020 target level.

The scenario with a 120 g. objective in 2012, a 70 g. objective in 2020 and LRRT, LVL, TPMS, GSI and MAC comes closest to the target, but still leads to 39 mega-tonnes of CO_2-equivalents more than the target value. For the scenario with a 120 g. objective in 2012, a 70 g. objective in 2020 and no additional measures, the gap with the target is 57 mega-tonnes. I.e. for this scenario the additional measures deliver an extra reduction of 18 mega-tonnes.

Note that for the 130 g. in 2012 scenario the additional measures deliver a larger extra reduction: 29 mega-tonnes (72-43). That this reduction is larger than that for the 120 g. in 2012 & 70 g. in 2020 scenario is straightforward. As LRRT, LVL, TPMS and GSI reduce fuel consumption by a specific percentage, the achieved reduction in absolute terms (tonnes) is larger for more-fuel consuming cars.

4.3 Fuel quality and biofuel measures

4.3.1 Proposed and studied measures

On 31 January 2007, the European Commission issued a proposal [7] for revising the current Fuel Quality Directive. Article 7a/2 of this proposal says:

> "*From 1 January 2011, Member States shall require suppliers of fuels for road transport and non-road mobile machinery that are placed on the market, to reduce the emissions of greenhouse gas emissions from those fuels. The reduction shall equal an additional 1% of the emissions in 2010 per year for each calendar year up to and including 2020. The level of life-cycle greenhouse gas emissions per unit of energy reported in 2020 shall be no greater than 90% of the level reported in 2010.*"

This means that for all fuels brought to the market, the well-to-wheel greenhouse gas emissions per unit of energy should be reduced by 10% by 2020.

This objective could be achieved by combinations of several measures, amongst others:

- Less emissions flaring and venting in the fossil fuel chain;
- Improved energy efficiency in oil refineries;
- Fuel switching in refineries;
- Carbon capture and storage;
- Further introduction of (preferably second generation) biofuels[14].

Several stakeholders have come up with different approaches to reach the 10% objective by 2020. Friends of the Earth Europe (FoEE) states that the objective can be achieved by reducing emissions throughout the fossil fuel chain, without introduction of biofuels. The European Commission has, in its proposal for a Renewables Directive, stated a 10% target for renewable energy in the transport sector. Most of this would come from biofuels that have a 35% emission reduction compared to conventional fuels. Recently, EEA stated that about 3.4% biofuels could be possible in a sustainable manner, most of which would come from second generation pathways. The emission reduction compared to conventional fuels would be 60% for these biofuels.

Given this variety of ideas on ways to reach the 10% objective, we selected three scenarios to be studied in this report. 1:

1. The 10% objective in 2020 is achieved without biofuels by reducing emissions throughout the fossil fuel chain;
2. The 10% objective is achieved through an increase in the share of biofuels to 10% in 2020, whereby these biofuels have a 35% emission reduction potential

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[14] Although very relevant on the longer term, mass introduction of alternative energy sources for road vehicles, as hydrogen and electricity is not considered to be feasible by 2020.

compared to conventional fuels, plus other measures reducing emissions throughout the fossil fuel chain;

3. The 10% objective is achieved through 3.4% biofuels, whereby these biofuels have a 60% emission reduction potential compared to conventional fuels, plus other measures reducing emissions throughout the fossil fuel chain.

Each of these scenarios thus includes a deviation from the assumed 5.75% biofuels share in our BAU scenario. Note that in the first scenario, the EU policies on fuel quality are considered to be separate from the biofuel policy, i.e. biofuels do not contribute to reaching the fuel quality target.

Furthermore, we selected the following policy packages, combining the above scenarios with measures to increase new car fuel economy on the test-cycle (see 4.1) and additional measures (see 4.3):

- 10% fuel quality objective on the BAU scenario, without other measures;
- 120 g. in 2012 combined with 10% fuel quality objective;
- 125 g. in 2012 combined with 10% fuel quality objective;
- 130 g. in 2012 combined with 10% fuel quality objective;
- 135 g. in 2012 combined with 10% fuel quality objective;
- 120 g. in 2012 combined with LRRT, LVL, TPMS, GSI, MAC and 10% fuel quality objective;
- 130 g. in 2012 combined with LRRT, LVL, TPMS, GSI, MAC and 10% fuel quality objective;
- 120 g. in 2012 and 70 g. in 2020 combined with LRRT, LVL, TPMS, GSI, MAC and 10% fuel quality objective;
- 130 g. in 2012 and 95 g. in 2020 combined with LRRT, LVL, TPMS, GSI and MAC and 10% fuel quality objective.

4.3.2 Methodology

The three scenario options have three different assumptions on biofuels. Remember that our realistic BAU scenario also includes biofuels. Both the assumed percentage of biofuels used in transport and their assumed emission abatement effectiveness are different.

Therefore, the calculation of 2020 well-to-wheel greenhouse gas (WTW GHG) emissions for the studied policy packages is performed in two steps. Firstly, we calculate the WTW GHG emissions for the policy package, assuming that no biofuels are used and no other measures are applied to reach the 10% fuel quality target. Secondly, we reduce the calculated WTW GHG emissions by 10%, to reflect the 10% improvement in the WTW emissions.

Note that, this way, the calculated 2020 WTW GHG emissions do not depend on the scenario (1., 2. or 3. as described in 4.3.1). I.e. we calculate one single level of 2020 WTW GHG emissions for each policy package, irrespective of the scenario taken to reach the 10% objective. In a third step, we will calculate the amounts of biofuel used, and these will differ depending on the scenario.

Step 1: Calculating well-to-wheel greenhouse gas emissions assuming no biofuels

In the first calculation step, we calculate the WTW GHG emissions for a policy package, assuming that no biofuels are used and no other measures are taken to reach the 10% fuel quality target. Therefore we can start from the WTW GHG emission level of the policy packages discussed in sections 4.1 and 4.2. Furthermore we know that, in our realistic BAU scenario and in all these policy packages, 5.75% of biofuel is blended into the road transport fuels. Thus, for step 1, we need to identify the emission reduction related to this 5.75% biofuel usage and add this reduction again to the initial WTW GHG level calculated in sections 4.1 and 4.2.

The amount of biofuel used (expressed in ton oil equivalents – 'toe') can be easily calculated as 5.75% of the consumed road transport fuels. In our realistic BAU scenario this is 18025 ktoe[15] (of which 11689 ktoe biodiesel and 6336 ktoe bioethanol). The average WTW GHG reduction achieved by substituting 1 toe of fossil fuel by 1 toe of biofuel can be calculated by comparing total WTW GHG emissions from fossil fuels and biofuels. Table 2 shows the WTW GHG emissions per toe for the fossil and biofuels that are included in the TREMOVE model and our realistic BAU scenario.

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[15] kilo ton oil-equivalent

	Well-to-tank emissions (ton per toe)			
	CO2	CH4	N2O	total (CO2-eq.)
Biodiesel	0.53	0.003	0.003	1.48
Bioethanol	1.32	0.003	0.001	1.67
Diesel	0.60	0.000	0.000	0.60
Petrol	0.51	0.000	0.000	0.51

	Tank-to-wheel emissions (ton per toe)			
	CO2	CH4	N2O	total (CO2-eq.)
Biodiesel	0.00	0.0000	0.0002	0.05
Bioethanol	0.00	0.0005	0.0000	0.02
Diesel	3.11	0.0000	0.0002	3.15
Petrol	3.03	0.0005	0.0000	3.05

	Well-to-wheel emissions (ton per toe)				Reduction by using biofuel	
	CO2	CH4	N2O	total (CO2-eq.)	%	ton CO2-eq. per toe
Biodiesel	0.53	0.003	0.003	1.53	59%	2.23
Bioethanol	1.32	0.003	0.001	1.69	53%	1.87
Diesel	3.71	0.000	0.000	3.76		
Petrol	3.54	0.000	0.000	3.57		
			weighed average:		**57%**	**2.10**

Table 2: Well-to-Wheel greenhouse gas emissions from fossil fuels and biofuels in realistic BAU scenario

TREMOVE and our realistic BAU scenario assume that biodiesel is blended into diesel and bioethanol is blended into petrol. The well-to-tank emission factors for these biofuels and the fossil fuels are derived from the 2004 report by CONCAWE, EUCAR and JRC [1], and assumptions on the mix of biofuel production pathways[16]. Tank-to-wheel emission factors are taken from the Copert 4 [16] methodology and additions to it, as implemented in TREMOVE. Tank-to-wheel CO_2 emissions from the combustion of biofuels are considered not to contribute to the greenhouse effect.

Total well-to-wheel emissions per toe of diesel are 3.76 ton CO_2-equivalent. For biodiesel this is 1.53 ton CO_2-equivalent. Substituting one toe of diesel by one toe of biodiesel thus delivers an emission reduction of 2.23 ton CO_2-equivalent (3.76-1.53). This is 59% of the diesel emission level. For petrol and ethanol, total well-to-wheel emissions per toe are 3.57 and 1.69 ton CO_2-equivalent respectively. Substituting one toe of diesel by one toe of ethanol thus delivers an emission reduction of 1.87 ton CO_2-equivalent (3.76-1.53). This is 53% of the petrol emission level. Calculation a weighted average for the biodiesel and bioethanol, leads to a 2.10 ton CO_2-equivalent (57%) emissions saving for each toe of fossil fuel that is replaced by biofuel.

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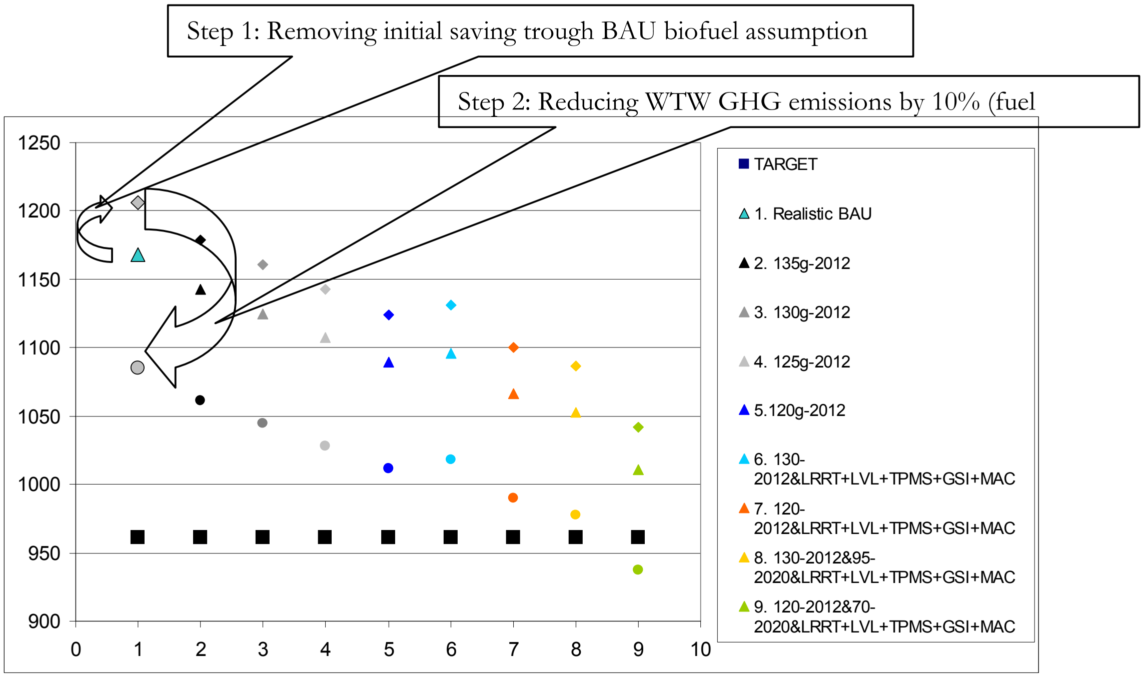
[16] A s suggested by the European Commission we assume in TREMOVE (thus also in our realistic BAU scenario): 80% of biodiesel produced by pathway 'rape, glycerine as chemical', 20%of biodiesel produced by pathway 'sunflower, glycerine as chemical'; 70% of ethanol produced by pathway 'wheat, NG GT + CHP, DDGS to animal feed' and 30% of ethanol produced by pathway 'wheat, NG GT + CHP, DDGS to heat power'. See [1] for more details.

In our realistic BAU scenario, the total WTW GHG saving due to the use of biofuels thus is 38 mega-tonnes CO_2-equivalent (0.001 * 18025 ktoe * 2.10 CO_2-equivalent/toe).

Figure 14 illustrates these calculations. Under "1.", one finds the WTW GHG emissions calculated for our realistic BAU scenario. The grey triangle indicates the BAU emission level as referred to in chapter 2 (1168 mega-tonnes CO_2-equivalent). The grey diamond indicates the emission level for the situation in which no biofuel would be used (1168 + 38 = 1206 mega-tonnes CO_2-equivalent).

The graph shows also the results of this "step 1" calculation for the other policy packages that are studied in this chapter. The coloured triangles indicate the emission levels as calculated in sections 4.1 and 4.2. The coloured diamonds indicate the level if no biofuels were to be used.


Step 1: Removing initial saving trough BAU biofuel assumption

Step 2: Reducing WTW GHG emissions by 10% (fuel

Figure 14: Estimated WTW GHG emisison levels of policy packages and reduction target – Mega-tonnes CO_2 equivalent in EU27

Step 2: Reduction potential of policy packages including the fuel quality policy

In step 1 we calculated the WTW GHG emission levels of policy packages that combine test-cycle fuel economy measures and additional measures (as LRRT) assuming that no biofuels are used. Now, in step 2, the effect of adding the 10% fuel quality policy can be simply included by reducing the level of WTW GHG emissions by 10%

For example, let us consider that the fuel quality policy would be applied on the realistic BAU scenario, without further test-cycle fuel economy measures and additional measures. The WTW GHG reduction caused by the fuel quality policy then would be 121 mega-tonnes CO_2-equivalent (1206/10). The resulting overall WTW GHG emission level for this policy package would then be 1085 mega-tonnes CO_2-equivalent (1206-121). This emission level is illustrated in Figure 14 as a grey circle. This level is 124 mega-tonnes CO_2-equivalent higher than the emission target (961, black square).

Note that, these calculated 2020 WTW GHG emissions do not depend on the scenario (1., 2. or 3. as described in 4.3.1). I.e. we calculate one single level of 2020 WTW GHG emissions for each policy package, irrespective of the scenario taken to reach the 10% objective. We will calculate the amounts of biofuel used in the third step, and these amounts will differ depending on the scenario.

The graph shows also the results of this "step 2" calculation for the other policy packages that are studied in this chapter. The coloured circles represent the overall 2020 WTW GHG emissions for these packages, including the fuel quality policy

Step 3: Biofuel used and related emission reductions

In our realistic 2020 BAU scenario we included 5.75% biofuels blending in the road transport fuels. This corresponds to 18025 ktoe of biofuels[17]. The substitution of fossil fuels by biofuels in this scenario leads to a 57% emission reduction. The total WTW GHG emission reduction due to the use of biofuels in this realistic BAU scenario is 38 mega-tonnes CO_2-equivalent. These figures are summarised in Table 3.

For the fuel quality policy, we consider three possible scenarios to reach the 10% objective:

1. The 10% objective in 2020 is achieved without biofuels by reducing emissions throughout the fossil fuel chain;
2. The 10% objective is achieved through an increase in the share of biofuels to 10% in 2020, whereby these biofuels have a 35% emission reduction potential compared to conventional fuels, plus other measures reducing emissions throughout the fossil fuel chain;
3. The 10% objective is achieved through 3.4% biofuels, whereby these biofuels have a 60% emission reduction potential compared to conventional fuels, plus other measures reducing emissions throughout the fossil fuel chain.

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[17] Note that the Commission's impact assessment for the fuel quality proposal includes 6.9% biofuels in its reference scenario. According to the Commission, this would correspond with 23800 ktoe biofuels.

To calculate the amount of biofuels used in scenario 2 and 3 we applied the 10% and 3.4% to the total amount of fuel (toe) used in these scenarios. The reductions in WTW GHG emissions achieved through this biofuel use then could be calculated by applying the 35% and 60% percentages to the fossil fuel emission factors. The results of these calculations are, for all studied policy packages, in Table 3. The table also indicates the amount of WTW GHG emissions that has to be abated by other fuel quality measures, to reach the 10% objective. As explained earlier, these 'other' measures could include, amongst others:

- Less emissions flaring and venting in the fossil fuel chain;
- Improved energy efficiency in oil refineries;
- Fuel switching in refineries;
- Carbon capture and storage.

Policy package	Fuel scenario	**Biofuel usage**		**WTW GHG reduction fuel quality policy**		
		Amount ktoe	Reduction % of fossil fuel	Use of biofuel	Other measures	Total
				Mtonne CO2-eq.		
Realistic BAU	No policy	18025	57%	38	0	0 0
Realistic BAU	Scenario 1	0	0%	0	121	121
	Scenario 2	31348	35%	40	80	121
	Scenario 3	10658	60%	24	97	121
135g-2012	Scenario 1	0	0%	0	118	118
	Scenario 2	30224	0%	39	79	118
	Scenario 3	10276	0%	23	95	118
130g-2012	Scenario 1	0	0%	0	116	116
	Scenario 2	29696	35%	38	78	116
	Scenario 3	10097	60%	22	94	116
125g-2012	Scenario 1	0	0%	0	114	114
	Scenario 2	29164	35%	38	77	114
	Scenario 3	9916	60%	22	92	114
120g-2012	Scenario 1	0	0%	0	112	112
	Scenario 2	28628	35%	37	75	112
	Scenario 3	9733	60%	22	91	112
130g-2012 LRRT,LVL,TPMS,GSI,MAC	Scenario 1	0	0%	0	113	113
	Scenario 2	28830	35%	37	76	113
	Scenario 3	9802	60%	22	91	113
120g-2012 LRRT,LVL,TPMS,GSI,MAC	Scenario 1	0	0%	0	110	110
	Scenario 2	27934	35%	36	74	110
	Scenario 3	9498	60%	21	89	110
130g-2012&95g-2020 LRRT,LVL,TPMS,GSI,MAC	Scenario 1	0	0%	0	109	109
	Scenario 2	27529	35%	36	73	109
	Scenario 3	9360	60%	21	88	109
120g-2012&70g-2020 LRRT,LVL,TPMS,GSI,MAC	Scenario 1	0	0%	0	104	104
	Scenario 2	25570	35%	33	71	104
	Scenario 3	8694	60%	19	85	104

Table 3: Estimated biofuel use and well-to-wheel greenhouse gas reductions through fuel quality policy – EU27

It is important to note that, in our estimations, no changes to 2020 transport demand and fleet composition have been made. I.e. we did not include changes in transport demand or fleet composition that would be caused by the introduction of the fuel quality policy. Or, in other words, we did not account for consumers' reactions to fuel cost changes related to this policy.

4.3.3 Estimated reduction potentials and gaps with the target

Figure 15 shows the greenhouse gas reductions calculated for the studied policy packages, including the fuel quality policy (the numbers are equal to those for the circles in Figure 14). The figure includes as well the potential of some of the measures on only test-cycle fuel economy and additional measures as LRRT (these are taken from Figure 13).

The table in the annex includes the calculated emission reduction (compared to the realistic BAU scenario) and the gap with the target for all scenarios studied in this report. Note that, given the calculation methodology and assumptions we used; only one policy package would reduce the 2020 well-to-wheel greenhouse gas emissions below the target level specified in chapter 3. This policy package would set very stringent limits on future test-cycle emissions (120 g. in 2012 and 70 g. in 2020), it would include all considered additional measures (LRRT, LVL, TPMS, GSI and MAC) and it would include the 10% fuel quality objective. According to our estimations, such a policy package could reduce emissions to 23 mega-tonnes below the target specified in chapter 3.

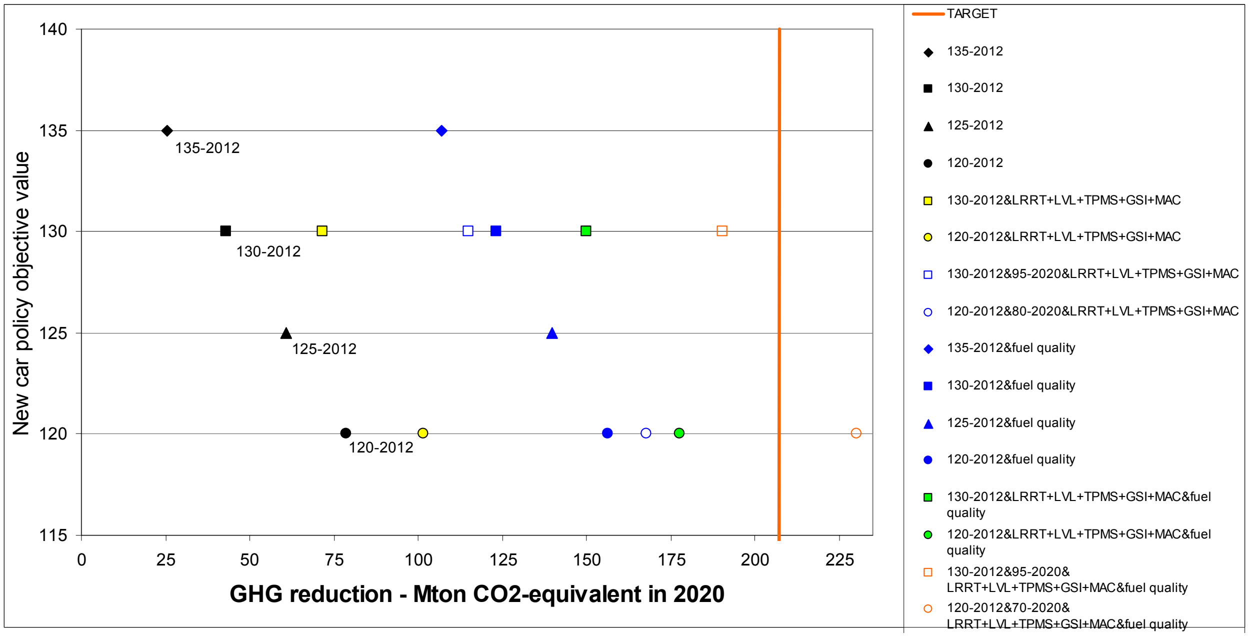

Figure 15: Estimated reduction potential of policy packages combining test-cycle fuel economy measures, additional measures and fuel quality objective – Mega-tonnes CO_2 equivalent in EU27

5 Conclusions

In chapter 1 we learned that estimates for 2020 BAU transport sector CO_2 tank-to-wheel emissions roughly range from 975 to 1100 mega-tonnes. Differences between these estimates mainly stem from different assumptions on future transport activities and on future evolution of car fuel efficiency. Scenarios assuming no further fuel efficiency improvements lead to forecasts close to 1100 mega-tonnes (EEA, TREMOVE 2.7b). Scenarios assuming further fuel efficiency improvements result in estimates close to 1000 mega-tonnes (PRIMES, TREMOVE 2.7).

In our more realistic scenario, presented in chapter 2, we expect further fuel-efficiency improvements for all road vehicle types, even without further policy measures. 2020 CO_2 tank-to-wheel emissions in this scenario equal 987 mega-tonnes. Adding well-to-tank emissions, CH_4 and N_2O and correcting for the use of biofuels leads to an estimate for transport well-to-wheel GHG emissions in 2020 of 1168 mega-tonne CO_2-equivalents.

As explained in chapter 3, we relate the 30% overall GHG reduction objective to a 961 mega-tonne CO_2-equivalent target level for transport well-to-wheel GHG emissions in 2020. Compared to the BAU estimate, the GHG emission reduction needed to reach this target is thus 207 (1168-961) mega-tonne CO_2-equivalents.

In chapter 4 we estimated the GHG emission reduction potential that could result from several policy measures that are on the table and combinations of them.

The first type of measure is car fuel-efficiency improvements on the test-cycle. A large number of possible average limit values and objective years were studied.

A 120 g./km limit value for average new car test-cycle CO_2 emissions in 2012 would reduce GHG emissions by 78 mega-tonnes CO_2-equivalents in 2020. Shifting the objective year to 2015 would reduce this reduction potential to 64 mega-tonnes. Having a 130 g. objective in 2012, as proposed by the European Commission [7], would lead to a 43 mega-tonne reduction. If the objective year for this 130 g. limit is postponed to 2015, the reduction potential is reduced to 32 mega-tonnes.

Also combinations of 2012/2015 test-cycle limits and more stringent limits in 2020 have been studied. A 130 g. limit in 2015 combined with a 110 g. limit in 2020, which is the upper end of the ranges indicated after the Ninth France-German Council of Ministers [24], can lead to a 59 mega-tonne reduction. The European Parliament Member Chris Davies put forward a combination of a 120 g. limit in 2015 and a 95 g. limit in 2020 [2]. This could lead to a reduction by 103 mega-tonnes. The ideas of the German Bundestag Fraction Bündnis 90/Die Grünen and the European Greens/European Free Alliance, i.e.

a 120 g. limit in 2012 and an 80 g. limit in 2020 would result in a 130 mega-tonne reduction. Finally, the most stringent test-cycle policy scenario studied, a 120 g. limit in 2012 combined with a 70 g. limit in 2020, would lead to a 149 mega-tonne reduction.

This latter policy scenario would bring the 2020 GHG emissions down to 1019 (1168-149) mega-tonnes. The gap towards the reduction target would be reduced to 58 (1019-961) mega-tonnes CO_2-equivalents.

The European Commission [8] actually proposed to combine the fuel-efficiency improvements on the test-cycle with additional measures. Studied additional measures were low rolling resistance tyres, low viscosity lubricants, tyre pressure monitoring systems, gear shift indicators and fuel-efficiency improvements for mobile air conditioners. Combining all these additional measures with the Commissions 130 g. target in 2012 would lead to an overall 2020 GHG reduction of 72 mega-tonnes CO_2-equivalents. Combining the additional measures with the stricter 120 g. (2012) and 70 g. (2020) targets can reduce the 2020 emissions by 168 mega-tonnes.

Thus, our most stringent test-cycle policy scenario combined with all additional measures for cars brings the 2020 GHG emissions down to 1000 (1168-168) mega-tonnes. The gap between the reduction achieved by this policy package and the targeted overall reduction is 39 (207-168) mega-tonnes CO_2-equivalent.

The third policy measure studied in this report is a revised Fuel Quality Directive [7]. This proposal aims at reducing the well-to-wheel GHG emissions per unit of energy by 10% in 2020 for all fuels brought to the market.

We studied different ways to achieve this objective, assuming different penetration rates for biofuels. But, the emission reduction potential of the measure is not dependent on the way it is achieved.

Combining a 130 g. in 2012 test-cycle policy, with all additional measures and the revised Fuel Quality Directive would reduce 2020 well-to-wheel GHG emissions to 990 mega-tonnes CO_2-equivalents. This is a reduction of 150 (1168-1018) mega-tonnes compared to our realistic BAU scenario. Combining the Fuel Quality Directive revision and all additional measures with a 120 g. test-cycle limit in 2012 would result in a 178 mega-tonne reduction in 2020. Combining them with a 130 g. limit in 2012 and a 95 g. limit in 2020 would lead to a 190 mega-tonne reduction. The most ambitious policy package we analysed would combine a 120 g. test-cycle limit in 2012, a 70 g. test-cycle limit in 2020, all additional measures and the revised Fuel Quality Directive. Such a policy package could lead to a 230 mega-tonne emission reduction in 2020, which is beyond the 207 mega-tonne reduction target.

Note that we did not make calculations for all possible policy combinations, as the list of possible packages is endless. From the calculations we did however, it is clear that there are other policy packages that would achieve the 207 mega-tonne reduction target. Given that the most ambitious scenario only reduces 23 (230-207) mega-tonnes more than the target, the number of other packages achieving the target is very small. I.e. only a few policy packages that are very close to the most ambitious one also achieve the target. These packages include:

- 120 g. in 2012 (test-cycle), 70 g. in 2012 (test-cycle), Fuel Quality Directive Revision, no additional measures;
- 120 g. in 2012 (test-cycle), 80 g. in 2012 (test-cycle), Fuel Quality Directive Revision, all additional measures;
- 130 g. in 2012 (test-cycle), 70 g. in 2012 (test-cycle), Fuel Quality Directive Revision, all additional measures.

It is important to note that we only studied three policy measures. Our analysis indicates that these selected measures would enable to reach the 2020 reduction target only if extremely strict limits on car emissions would be set. Though, other policy measures are on the table, e.g. kilometre charging, revisions of the regulations on weight and dimensions of road trucks and measures on non-road transport modes. Such policies might also contribute to achieve the GHG reduction target. From our analysis it is clear that the GHG reduction target can only be reached by an integrated policy approach combining the three measures studied in this report with other measures influencing transport demand and technologies of vehicles other than cars.

This report is restricted to the estimation of the GHG emission reduction potential of specific policy measures in the transport sector. Costs or benefits of these measures and cost-effectiveness compared to other possible greenhouse gas abatement measures are not covered by this study.

Also effects on vehicle fleet composition and on transport demand resulting from such costs or benefits are not fully accounted for. More specifically, changes in fleet composition and transport demand resulting from costs or benefits of setting limits on test-cycle emissions in 2012 or 2015 are accounted for, but similar effects of setting further limits in 2020 are not accounted for. E.g. very strict emission limits (e.g. 70 g./km on the test-cycle in 2020) could lead to a strong increase in the cost of car use (through increases of technology costs). This might lead to reductions in demand for transport, thus in further reductions of the emissions. Such second-order effects for limit values set in 2020 have not been quantified in this report.

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Annex:

Estimated reduction potential of the studied policy packages in EU-27

Test-cycle limits				Additional measures	Fuel quality measure	Reduction	Gap with target
limit	year	limit	year			Mton CO2-equivalent	
135	2012	-	-	-	no	26	-181
130	2012	-	-	-	no	43	-164
125	2012	-	-	-	no	61	-146
120	2012	-	-	-	no	78	-129
135	2012	100	2020	-	no	80	-127
135	2012	95	2020	-	no	89	-118
135	2012	90	2020	-	no	98	-109
135	2012	85	2020	-	no	108	-99
135	2012	80	2020	-	no	117	-90
135	2012	75	2020	-	no	127	-80
135	2012	70	2020	-	no	136	-71
130	2012	100	2020	-	no	84	-123
130	2012	95	2020	-	no	93	-114
130	2012	90	2020	-	no	102	-105
130	2012	85	2020	-	no	112	-95
130	2012	80	2020	-	no	121	-86
130	2012	75	2020	-	no	131	-76
130	2012	70	2020	-	no	140	-67
125	2012	100	2020	-	no	88	-119
125	2012	95	2020	-	no	97	-110
125	2012	90	2020	-	no	107	-100
125	2012	85	2020	-	no	116	-91
125	2012	80	2020	-	no	126	-81
125	2012	75	2020	-	no	135	-72
125	2012	70	2020	-	no	144	-63
120	2012	100	2020	-	no	92	-115
120	2012	95	2020	-	no	102	-105
120	2012	90	2020	-	no	111	-96
120	2012	85	2020	-	no	120	-87
120	2012	80	2020	-	no	130	-77
120	2012	75	2020	-	no	139	-68
120	2012	70	2020	-	no	149	-58
130	2012	-	-	LRRT	no	47	-160
130	2012	-	-	LRRT+LVL	no	55	-152
130	2012	-	-	LRRT+LVL+TPMS	no	63	-144
130	2012	-	-	LRRT+LVL+TPMS+GSI	no	70	-137
130	2012	-	-	ALL	no	72	-135
120	2012	-	-	LRRT	no	82	-125
120	2012	-	-	LRRT+LVL	no	89	-118
120	2012	-	-	LRRT+LVL+TPMS	no	95	-112
120	2012	-	-	LRRT+LVL+TPMS+GSI	no	100	-107
120	2012	-	-	ALL	no	102	-105
120	2012	70	2020	LRRT	no	151	-56
120	2012	70	2020	LRRT+LVL	no	157	-50
120	2012	70	2020	LRRT+LVL+TPMS	no	162	-45
120	2012	70	2020	LRRT+LVL+TPMS+GSI	no	166	-41
120	2012	70	2020	ALL	no	168	-39
130	2012	95	2020	LRRT	no	96	-111
130	2012	95	2020	LRRT+LVL	no	103	-104
130	2012	95	2020	LRRT+LVL+TPMS	no	109	-98
130	2012	95	2020	LRRT+LVL+TPMS+GSI	no	114	-93
130	2012	95	2020	ALL	no	115	-92
135	2012	-	-	-	yes	107	-100
130	2012	-	-	-	yes	123	-84
125	2012	-	-	-	yes	140	-67
120	2012	-	-	-	yes	156	-51
120	2012	-	-	ALL	yes	178	-29
130	2012	-	-	ALL	yes	150	-57
120	2012	70	2020	ALL	yes	230	23
130	2012	95	2020	ALL	yes	190	-17

Estimated reduction potential of the studied policy packages in EU-27 (continued)

Test-cycle limits				Additional measures	Fuel quality measure	Reduction	Gap with target
limit	year	limit	year			Mton CO2-equivalent	
135	2015	-	-	-	no	17	-190
130	2015	-	-	-	no	32	-175
125	2015	-	-	-	no	48	-159
120	2015	-	-	-	no	64	-143
135	2015	100	2020	-	no	64	-143
135	2015	95	2020	-	no	71	-136
135	2015	90	2020	-	no	78	-129
135	2015	85	2020	-	no	84	-123
135	2015	80	2020	-	no	91	-116
135	2015	75	2020	-	no	98	-109
135	2015	70	2020	-	no	105	-102
130	2015	100	2020	-	no	73	-134
130	2015	95	2020	-	no	80	-127
130	2015	90	2020	-	no	86	-121
130	2015	85	2020	-	no	93	-114
130	2015	80	2020	-	no	100	-107
130	2015	75	2020	-	no	107	-100
130	2015	70	2020	-	no	114	-93
125	2015	100	2020	-	no	82	-125
125	2015	95	2020	-	no	89	-118
125	2015	90	2020	-	no	96	-111
125	2015	85	2020	-	no	102	-105
125	2015	80	2020	-	no	109	-98
125	2015	75	2020	-	no	116	-91
125	2015	70	2020	-	no	123	-84
120	2015	100	2020	-	no	97	-110
120	2015	95	2020	-	no	103	-104
120	2015	90	2020	-	no	110	-97
120	2015	85	2020	-	no	116	-91
120	2015	80	2020	-	no	123	-84
120	2015	75	2020	-	no	129	-78
120	2015	70	2020	-	no	136	-71
130	2015	110	2020	-	no	59	-148