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TNO report

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Aspects of the transition from NEDC to WLTP for CO_2 values of passenger cars - Phase 3: After the transition

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Samenvatting

De CO_2-emissie van voertuigen wordt bepaald via testen volgens de officiële Europese wetgeving. Geleidelijk wordt de oude bepalingsmethode, de NEDC, vervangen door een nieuwe methode, de WLTP. De overgang bestreek de periode september 2017-september 2018, met een uitloop tot september 2019. Veranderingen in CO_2-waarden hebben gevolgen voor onder andere de toekomstige Europese CO_2-normen en de Nederlandse registratiebelasting op personenauto's, de BPM. In opdracht van het Ministerie van Financiën heeft TNO veranderingen van de CO_2-uitstoot ten gevolge van de introductie van de WLTP in beeld gebracht middels analyses en trends. Het project is uitgevoerd in drie fasen. Het onderhavige rapport is het laatste rapport als resultaat van fase 3. In fase 1 van het project is uitleg gegeven over (de complexiteit van) de conversie van NEDC naar WLTP[1]. In fase 2 zijn eerste kwantitatieve analyses uitgevoerd op de voorlopige gegevens die beschikbaar waren op 1 september 2018[2].

Dit fase 3 rapport vergelijkt de CO_2-waarden van personenauto's, die veranderen met de verandering van de eisen aan voertuigen van oude NEDC typekeuringstest naar de nieuwe WLTP typekeuringstest. In het rapport zijn de voertuigregistraties van voor, tijdens en na, de overgang naar de WLTP meegenomen voor analyse. Aan bod komen de vergelijkbare analyses zoals in het fase 2 rapport, maar ook worden trends en de afhankelijkheden beschreven. De overgang van de NEDC naar WLTP heeft veel impact. In het bijzonder, het Europese doel waarbij elke autofabrikant de gemiddelde CO_2-uitstoot van 95 g/km moet halen vanaf 2021, is gebaseerd op de NEDC. Aangezien per 1 september 2018 alle nieuwe voertuigen WLTP getest moeten worden heeft de Europese Commissie een methode ontwikkeld om de CO_2-uitstoot van de WLTP test procedure om te zetten in NEDC waarden. Op deze manier kan alsnog bepaald worden of het doel, de 95 g/km gebaseerd op de NEDC, gehaald wordt.

Tijdens de overgang van de NEDC naar de WLTP zijn er verschillende CO_2-waarden per voertuig in omloop. Zo zijn er drie soorten CO_2-waarden: <u>NEDC[oud]</u> CO_2; die in 2019 gaat verdwijnen, de <u>NEDC[WLTP]</u> CO_2; als tijdelijke regeling tot 2021 voor het Europese doel, en de <u>WLTP</u> CO_2 voor na 2021 voor Europese doelen. De WLTP CO_2 wordt vanaf 2020 ook toegepast als consumenteninformatie in het Europees energielabel. Op elk van deze waarden kan de BPM gebaseerd worden. Tot dusverre zijn de NEDC[oud] en de NEDC[WLTP] door elkaar gebruikt in de BPM. De RDW is van plan om vanaf september 2019 ook de WLTP CO_2-waarden algemeen beschikbaar te hebben bij de voertuigregistraties.

In de analyses worden de effecten op de CO_2-waarden van de overgang eerst bepaald aan de hand van de vergelijking van deze NEDC[oud] en de NEDC[WLTP] waarden, vergelijkbaar met de eerdere twee studies in deze reeks. Daarnaast,

[1] https://www.rijksoverheid.nl/documenten/kamerstukken/2018/07/05/onderzoek-tno-naar-aspecten-van-de-nedc-wltp-overgang-in-relatie-tot-co2-waarden-van-personenauto's (TNO rapport R10732 (2018)).

[2] https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2018Z18923&did=2018D50439. Aspects of the transition from NEDC to WLTP for CO_2 values of passenger cars - phase 2: preliminary findings, TNO 2018 R11145, 11 October 2018

omdat de uiteindelijke CO_2-waarden, zeker na 2021, de WLTP gebaseerde waarden zijn, worden ook de NEDC[oud] met de WLTP waarden vergeleken. Vanaf eind 2017 tot en met april 2019 zijn er 152.000 WLTP benzineauto's verkocht en 21.000 WLTP dieselauto's. Daarmee is de overgang nagenoeg volledig. Er zijn wel erg weinig dieselauto's verkocht in de hele periode, zodat de gegevens voor dieselauto's voor de analyse beperkt zijn. Dat hangt niet zozeer samen met de WLTP, maar met een jarenlange dalende trend in deze verkoop.

Om een goede vergelijking te maken tussen de CO_2-waarden moet men met veel aspecten rekening houden. Bij de willekeurige vergelijking van een NEDC uitvoering en een WLTP uitvoering van hetzelfde voertuigmodel kan er eenvoudig een verschil van 10 g/km in de uitkomsten optreden. Het centrale uitgangspunt in dit rapport is de weergave van de gemiddelde trend voor Nederlandse situatie per maand en per voertuigmodel. Er zijn ook andere langjarige en seizoentrends in de verkopen van voertuigen. Een trend die reeds ver voor de eerste registratie van een WLTP voertuig begonnen is, is moeilijk aan de WLTP te wijden. Bijvoorbeeld, sinds begin 2016 is de gemiddelde CO_2-waarde aan het stijgen, terwijl het eerste WLTP voertuig in december 2017 geregistreerd is. De WLTP transitie verstoort deze jarenlange trend in gemiddelde CO_2-waarden van nieuwe registraties nauwelijks.

Daarnaast is de verkoop van voertuigen aan het dalen. Deze trend is al meerdere jaren gaande en staat los van de WLTP introductie. Deze daling, zeker voor dieselauto's, doet wel wat afbreuk aan de betrouwbaarheid van de conclusies voor dieselauto's voor de langere termijn. De verkoopaantallen van nieuwe dieselauto's zijn op het laagste niveau in jaren, met ongeveer 3000 per maand. Het totaal aantal dieselauto's in het wagenpark is daarbij niet sterk afgenomen. Er lijkt dus geen grote verschuiving gaande, behalve dat oudere voertuigen langer op de weg blijven. Deze lage aantallen dieselauto's geven mogelijk een vertekend beeld van de overgang naar de WLTP. De invloed van het einde van de 14% bijtellingsregeling, eind dit jaar voor de laatste auto's die in 2015 onder de regeling vielen, zorgt er mogelijk voor dat deze groep auto's vertraagd vervangen wordt. De huidige verkoop van voertuigen betreft vooral vervanging van meer onzuinige auto's (met gemiddeld hogere CO_2-waarde).

De overgang naar de nieuwe eisen aan voertuigen met de WLTP, in combinatie met nieuwe RDE (Real Driving Emission) testen op de weg, is een grote stap geweest voor de fabrikanten. Aan de buitenkant, voor de consument, kan er dan niet veel veranderd zijn, maar onder de motorkap des te meer. Zeker voor dieselvoertuigen is de verandering groot. De eerste resultaten laten zien dat de schadelijke NO_x emissies in de praktijk nu een factor tien lager zijn. De beschikbare fysische eigenschappen zoals gewicht en motorvermogen zijn slechts een indicatie van deze veranderingen. Een ander aspect aan de overgang is het gebruik van de WLTP CO_2-waarden na 2021 voor nieuwe Europese CO_2-doelen. Tot die tijd is de WLTP CO_2 beperkt relevant. Verder lijkt er weinig druk op fabrikanten om lage WLTP CO_2-waarden te meten of op te geven. Het is mogelijk zelfs gunstig voor de fabrikant om hoge WLTP waarden op te geven, omdat een hoge referentiewaarde in 2020 de eisen per fabrikant voor 2025 en 2030 impliciet kan afzwakken.

Uit analyse blijkt dat er een grote spreiding is in de CO_2-waarden tussen fabrikanten en modellen. Dat geldt zowel voor de NEDC[WLTP] als de WLTP waarden. Dat geeft ruimte voor toekomstige verschuivingen in de verkoop richting voertuigen die gunstiger uitvallen in een aangepast belastingregime. De huidige gemiddelde

WLTP CO_2-waarden geven dus nog niet het definitieve beeld voor de toekomst. Een deel van de ruimte kan mogelijk benut worden bij veranderingen aan het belastingregime. Dit aspect is niet verder onderzocht. De verwachting is dat na de overgang een daling van 5 tot 10 g/km in WLTP waarde mogelijk is op basis van de bewegingsruimte. Deze bewegingsruimte is zichtbaar in de variaties in gegevens tussen modellen en tussen fabrikanten.

De resultaten laten zien dat er een 6 g/km toename is in NEDC[oud] naar NEDC[WLTP] op basis van alle registraties. Voor benzineauto's, die deze getallen domineren, geldt dus ook de 6 g/km toename. Het uiteindelijke effect is kleiner dan vooraf ingeschat in het fase 2 rapport op basis van de eerste WLTP voertuigen tot september 2018. In de vergelijking tussen modellen, gebaseerd op de gemiddelde verkoop per model, komt deze 6 g/km ook terug. De resultaten zijn consistent nu meer gegevens beschikbaar zijn. Voor benzinevoertuigen wordt het effect, op 1 g/km na, verklaard door de veranderde eigenschappen: gewicht en motorvermogen.

Voor dieselvoertuigen wordt het verschil van 7 g/km op deze manier niet verklaard, en lijken mogelijk andere eigenschappen van de motor en voertuig de oorzaak. Ondanks dat voertuigen in het laboratorium altijd op dezelfde test aan de CO_2 en de NO_x limieten moesten voldoen en er geen verschuiving tussen eisen kan zijn, veroorzaken mogelijk de nieuwe RDE emissie-eisen de hogere CO_2-waarden door technische veranderingen. Gezien de lage verkoop van dieselvoertuigen is dit slechts een voorlopige conclusie.

De huidige CO_2-waarden voor de WLTP zijn hoger dan te verwachten viel. De extra ruimte die de fabrikanten lijken te nemen bij de opgave van de WLTP CO_2-waarde ligt mogelijk in de orde van 5 tot 10 g/km. Daarnaast is er een grote, schijnbaar willekeurige spreiding in resultaten tussen modellen en fabrikanten. Deze situatie is nader toegelicht in het eerste rapport. Op basis van de geanalyseerde gegevens van de huidige registraties resulteert de overgang van NEDC[oud] naar WLTP in een gemiddelde opslag van 10% en 15 g/km. Dit effect wordt gedomineerd door het verschil in de NEDC[WLTP] en de WLTP waarden van de WLTP registreerde voertuigen. De overgang van NEDC naar WLTP registraties, voor de verschillen tussen NEDC[oud] en NEDC[WLTP], speelt slechts een kleine rol in het geheel.

Summary

This report compares the CO_2 values of passenger cars over the transition from the old NEDC type-approval test, to the new WLTP type-approval test. Since the Dutch tax system is based on the CO_2 values of vehicles, the Ministry of Finance has asked TNO to investigate the effect of the transition to the WLTP.
This transition took place between the third and fourth quarters of 2018.
For the evaluation of the 2021 European 95 g/km CO_2 targets for passenger cars (based on the NEDC), the European Commission has developed an intermediary method to determine comparable NEDC CO_2 value for WLTP approved vehicles. These intermediary values are known as the NEDC[WLTP]. This method results in three different values for comparison: NEDC[old] CO_2 values for NEDC type-approved vehicles, and NEDC[WLTP] and WLTP CO_2 values for WLTP type-approved vehicles. Here the two steps in the transition are compared: from NEDC[old] to NEDC[WLTP], and from NEDC[WLTP] to WLTP CO_2 values.

As of May 2019, 152,000 WLTP petrol vehicles and 21,000 WLTP diesel vehicles have been registered. The transition from NEDC to WLTP type-approved vehicles is almost complete. An overview of the transition can be given by comparing vehicles from just before and just after the transition, i.e., in the months around September 2018. The low number of diesel cars is not directly associated with the WLTP transition, but is part of a broader trend observed in recent years.

Making a fair comparison of the CO_2 values of vehicles before and after transition to a new type-approval test procedure is beset with difficulties. Depending on the type of analysis for comparison, outcomes may differ up to 10 g/km, even based on the same underlying data. The analysis here aims to give the best comparison of the last NEDC vehicles and first WLTP vehicles, on the basis of the Dutch fleet average results. The aspects considered and compensated for are numerous. First, when considering the downward trend of CO_2 values, the transition to the WLTP may seem like a slight hiccup. But the downward trend of CO_2 values stopped well before the first WLTP vehicles were available. Likewise, from 2016, there has been a decreasing trend in new vehicle registrations, only partially compensated by higher import of relatively new vehicles. The effects of the WLTP transition on these existing trends are limited. Moreover, every year there is a seasonal trend in vehicle sales. These seasonal effects interfere with the transition to the WLTP during and around September 2018. Some effects should therefore not be assigned to the WLTP transition. Second, many versions of each vehicle model can be selected for a model-by-model comparison of NEDC and WLTP vehicles, where versions can have different options, transmissions, and engines. The appropriate choice is to use the average CO_2 values of the NEDC and the WLTP vehicle models, based on the average registrations of both. Third, at the time of this study, the WLTP CO_2 values were not yet registered by the RDW during vehicle registration. The CoC (Certificate of Conformity), to be provided and linked to vehicles by the manufacturer, were also absent for a number of registered vehicles. In September 2019 RDW expects to have remedied this problem, and RDW will make WLTP CO_2 values generally available. This date is well ahead of the WLTP-based energy label which is to be implemented from 2020. For the moment, part of the analysis of this report estimates of WLTP CO_2 values for a small fraction of the vehicles.

Fourth, a transition to a new type-approval, with new test procedures, may require new vehicle technologies. This may include significant technology changes while the appearance of the vehicle remains unchanged.

Vehicle characteristics, such as weight and engine power, may indicate technology changes, but not necessarily. Compensating for changing vehicle characteristics reduces the effects of the transition. Fifth, the WLTP CO_2 values are not used in current European CO_2 targets so there are no significant consequences if a manufacturer measures or declares high WLTP CO_2 values. Manufacturers will benefit from high WLTP values with low NEDC[WLTP] values in 2020 when meeting post-2021 CO_2 targets. Therefore, some strategic declaration of CO_2 values can be expected. Sixth, the number of registrations, especially for diesel vehicles, is quite low. This is not associated with a shift in the market, but with a period of high retention of older vehicles, and the resulting low replacement with newer models. The, perhaps strategic but certainly hesitant, behaviour of vehicle buyers affects the overall statistics for diesel cars across the transition.

The effects of the transition can therefore be affected by the specific groups of vehicles, such as the “14% bijtelling” diesel cars, delayed in replacement during the transition. Seventh, there are large variations in the results across vehicles, manufacturers and models. Any tax benefit can lead to a shift towards the bottom of the visible bandwidth and possibly even lower. The results reported here are based on averages given the current tax system and vehicle market, based on the NEDC[old]. It is to be expected that a shift between vehicle models will occur once a new tax system, e.g., based on the WLTP CO_2 values, is introduced. This aspect is not included in this analysis.

The results show an average 6 g/km increase in CO_2 values from NEDC[old] to NEDC[WLTP], if other effects across the transition are not corrected for. In earlier studies, based on limited data, the effect was larger and it was not consistent across different approaches of comparing NEDC and WLTP vehicles. In the current analysis both the fleet average, as well as the model-by-model comparisons, yield this new and same result of 6 g/km. For petrol cars this 6 g/km is almost fully explained by the change in physical characteristics. The difference between NEDC[old] and NEDC[WLTP] decreases to only 1 g/km if the petrol vehicles are comparable in weight and engine power. For diesel vehicles the number of registered cars was quite low, but for these cars a difference of 7 g/km is observed in CO_2 values across the transition. This difference is unexplained by a change in physical characteristics. The difference may be the result of a particular bias in the low number of registrations of WLTP diesel vehicles. The RDE may affect the result, however, vehicles have always needed to comply with pollutant emission limits during the test used to determine CO_2 values. So this trade-off is not necessarily completely new, but the RDE stringency may have changed the vehicle technology fundamentally.

Eventually, a transition to WLTP CO_2 values is needed, as the NEDC[WLTP] registration will be phased out in 2021. Moreover, the WLTP CO_2 value is intended to be more appropriate for informing consumers on the fuel consumption of vehicles. The transition from NEDC[old] to WLTP would yield, based on the current fleet, a change of 10% + 15 g/km, where the majority of the effect is due to the difference between the NEDC[WLTP] and WLTP CO_2 values of the same WLTP vehicles.

The change from NEDC[old] to NEDC[WLTP] values plays only a minor part in the total transition. The effect from NEDC[WLTP] to WLTP is dominant in the total transition to WLTP. The large variation in the results for different vehicle models and manufacturers shows room for new incentives for clean and fuel efficient cars.

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1 Introduction

The CO_2 emissions of passenger cars and light duty commercial vehicles in Europe has to be determined according to official European legislation. In a transition period that started as of 1st of September 2017, the old NEDC method is being replaced by the WLTP. The WLTP is the new method to determine the CO_2 emissions. The transition is completed by 2019 with some run out in 2020 at the latest. Changes in the CO_2 values will have an impact on – among others - the European CO_2 standards and the purchase tax on passenger cars in The Netherlands.

TNO has been asked to evaluate the changes of the CO_2 values of new passenger cars caused by the WLTP introduction. In phase 1 of the project the complexity of the transition from NEDC to WLTP was explained, in TNO report 2018 R10732. In the report of phase 2 the first quantitative analyses on datasets of registered new WLTP vehicles in the Netherlands with reference date 1st of September 2018 were presented. On the reference date insufficient amount of registrations prevented to perform the evaluation to its full extend and to establish results representative for the development of CO_2 values related to WLTP introduction. Since phase 2 was executed, significantly more registrations have become available. Therefore, in current report of phase 3 a more comprehensive analyses can be presented. All three elements: CO_2 values of the previous vehicles: NEDC[old], the comparable values of the new vehicles: NEDC[WLTP], and the new standard WLTP for CO_2 values, are evaluated and compared.

With the publication of the phase 2 report TNO 2018 R11145, in October 2018, the different preliminary findings showed a bandwidth of differences of CO_2 values of NEDC[old] and NEDC[WLTP] across the transition. Moreover, some misunderstanding remained on the effect of the transition to a new test protocol for the determination official CO_2 values with the WLTP. The CO_2 values of new registrations has been varying in the last ten years. Visible trends are not necessarily related to the introduction of the WLTP.

On the other hand, the WLTP is the new reality, intended to provide better official CO_2 values for consumers and policymakers. The focus on the NEDC values, based on NEDC tests and WLTP tests, as was central to the phase 2 report, is limited in this report. A transition to the WLTP CO_2 values, e.g., in the tax systems, must take place ahead of the phasing out of NEDC[WLTP] registrations in 2021. However, since all newly registered vehicles from 2020 onward will have a WLTP CO_2 value available via de CoC (Certificate of Conformity), a transition to the more appropriate WLTP CO_2 values can already take place. For the registration by the RDW it is important to include all CO_2 relevant information like e.g. the Utility Factor for the weighing of electric and combustion engine operation for plug-in vehicles.

Furthermore, this phase 3 report was intended to be a final report, after the transition to the WLTP vehicles on the market. Due to a very low number of newly registered WLTP diesel vehicles, it cannot be said that the results on WLTP vehicles is complete in May 2019. With the limited number of 20,000 diesel vehicles new registered, where normally more than 100,000 diesel vehicles are newly

registered every year, in the past years, the current small number may give a distorted picture on diesel vehicles. For petrol vehicles this problem does not exist. Some preliminary aspects as discussed in the phase 2 and even the phase 1 report are no longer relevant in this phase 3 report due to the higher number of WLTP registrations. The end-of-series stock is almost completely gone. The majority of new registrations exist of the passenger cars type-approved under WLTP.
As WLTP vehicle models are sold abundantly, sufficient information of the typical characteristics of the WLTP version and NEDC version of the same vehicle model was available for the analysis.

Putting all elements together in the analyses led to the current report. It has been the intention to provide a complete picture of the transition from NEDC to WLTP in the broader context of new vehicle registrations in recent years. The report will also provide the necessary background information, on the transition to WLTP in the broader perspective and trends in new vehicles in the last years. The arguments that the total vehicle sales are limited by the introduction of the WLTP, is not supported by the data in which the reduced sales, and changing CO_2 values, is visible well before the introduction of the WLTP.

Notably, this report relies only on registration information of the RDW. Most of this information is publicly available via the RDW, but for the purpose of this report, RDW provided additional WLTP specific information available. The RDW registrations is considered the most reliable and most appropriate information to analyse the effects of NEDC-WLTP transition on the CO_2 values in the Netherlands.

The current report has the following structure:

- In Chapter 2 the trends from 2005 till 2019 of new registrations of vehicles are analysed. This shows that certain trends and effects are already present, well ahead of the introduction of the first WLTP vehicles.
- In Chapter 3, the trends of all registrations of NEDC and WLTP vehicles are compared, showing the fleet average effects across the transition.
- In Chapter 4, specific vehicle models, for which NEDC and WLTP versions are available are compared model-by-model.
- In Chapter 5, for the WLTP vehicles the NEDC[WLTP] and the WLTP CO_2 values are compared and correlated.
- Chapter 6 contains a discussion and some conclusions.

This report should be seen as the third part of a three part study. Some analyses and conclusions can be found in the phase 1 and phase 2 reports. They are not repeated in this report.

2 Registrations of passenger cars from January 2005 until April 2019

The transition from NEDC to WLTP, e.g., the changes of average CO_2, must be seen in the general context of apparent changes in the Dutch fleet. Before the introduction of the WLTP legislation certain trends were already present, and not necessarily the consequence of the transition to WLTP. The lower sales, the higher CO_2 values and the increase in import combined with a substantial export are trends observed over the last ten years and not just the twenty months when the actual transition from NEDC to WLTP took place. To place the transition into a broader perspective, the monthly average data for Dutch newly registered passenger cars from January 2005 until April 2019 is presented in this chapter.

Petrol vehicles are less affected by taxation schemes, than diesel vehicles are. The low sales volume of WLTP diesel vehicles may well be related to the peak in sales at the end of 2015. Likewise, the import of a relatively new diesel vehicles with high CO_2 values is a trend visible since the introduction of the CO_2 related sales tax (BPM), and this can therefore not be attributed to the transition to the WLTP.

2.1 Dataset and method

The data presented in this chapter was generated from all at TNO available monthly data snapshots (currently 36 months), i.e., from May 2016 until April 2019, of petrol and diesel fuelled vehicles.

This so-called backwards cumulative RDW registration dataset was generated by starting with the latest available monthly snapshot, and then step by step adding vehicle information from previous snapshots for vehicles not already present in the dataset. The resulting dataset holds information for over 16 million registered Dutch vehicles, now and in the past, of which about 9.35 million are passenger cars.

Holding three years of registration data, is considered highly representative for the Dutch fleet for the period of May 2016 until April 2019, during which the snapshots were gathered. And for newly registered vehicles it may be considered fairly representative even before this period, though of course with diminishing accuracy for increasing years into the past. Some vehicles may have accidents or could be exported at an early age prior to 2016.

In view of average passenger car lifetimes of 15 to 20 years, the period from January 2005 until April 2019 was therefore selected to generate the graphs presented in this chapter. In these graphs several characteristics are presented, i.e.
- total monthly vehicle number,
- monthly average CO_2 value per vehicle,
- monthly average gross BPM tax value per vehicle,

The graphs are based on first registration date in Europe. In the course of time, CO_2 values of vehicles decreased in the Netherlands and in Europe. In order to make a

fair comparison between the newly registered and imported vehicles, vehicles of the same age are compared with each other.
In the graphs the following three types of newly registered vehicles are plotted as function of time (per month):

- imported vehicles with the same first registration dates as the new vehicles considered here, recognised by the date of first admission (on the European road) being before the date of first admission in the Netherlands;
- Dutch new vehicles, recognised by equality of the date of first admission and the date of first admission in the Netherlands;
- all new vehicles, the previous two types together;

The paragraphs in this chapter are split for three fuel types: all fuels, petrol and diesel.

2.2 All fuels

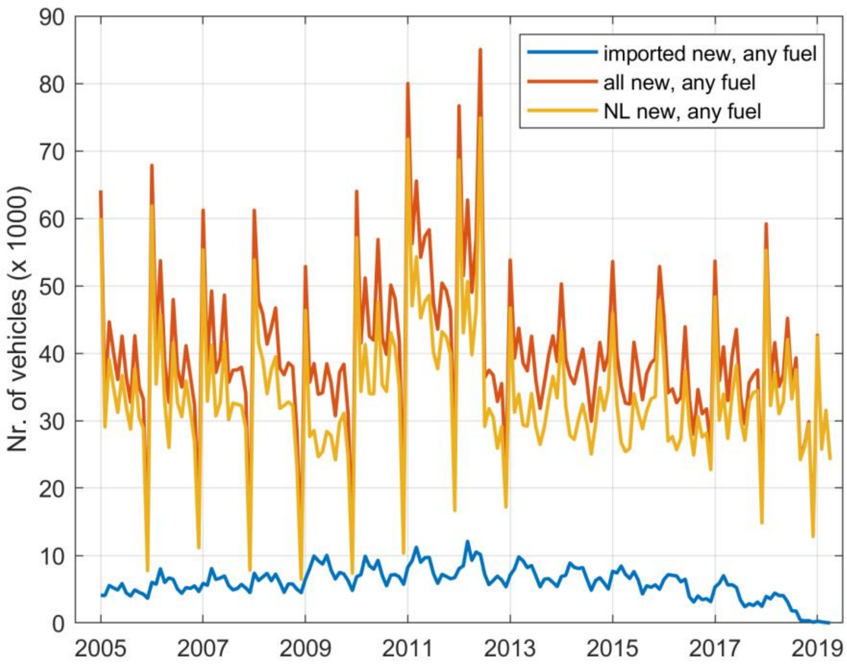

Figure 2-1: Newly registered passenger cars in the Netherlands, any fuel, per European registration month from January 2005 until April 2019.

Commonly, in January of every year the new registrations are higher, while in December the new registrations are low. This annual trend with large variation, does not hide the fact that from 2013 the sales has decreased from high sales in 2010 till 2012, and a part of the fleet of a certain age consists of imported vehicles. For a few occasions in the past years the situation is different. For example there was a high registrations volume at the end of 2015, and a dip in January 2016. This is probably related to the change in the tax system. The vehicles from December 2015 are applicable for lower income tax (i.e., “bijtelling”) till December 2019. Likewise, this tax rule started July 2012. It may very well possible that the

retention, i.e., relatively low outflow (<5%), of vehicles between 1 July 2012 and 31 December 2015 is related to this tax law. See Figure 2-2.
New vehicles sold before 2010 have been leaving the fleet in a regular manner independent of whether they were initially imported or not. However, for vehicles newly sold in the Netherlands, the export starts already at two years. This means that a share of new vehicles sold in 2017 have already been exported by 2019. Large export occurs for the vehicles that were 7 to 9 years old in 2019, which were sold as new vehicles between 2011 to 2013. This is associated with the large influx at that time. Therefore it seems likely that a low sales volume may lead to a lower export and higher retention rate. Moreover, the tax benefits of the vehicles from 2014 and 2015 combined with limited numbers of vehicles available may explain the higher retention of this group of vehicles.

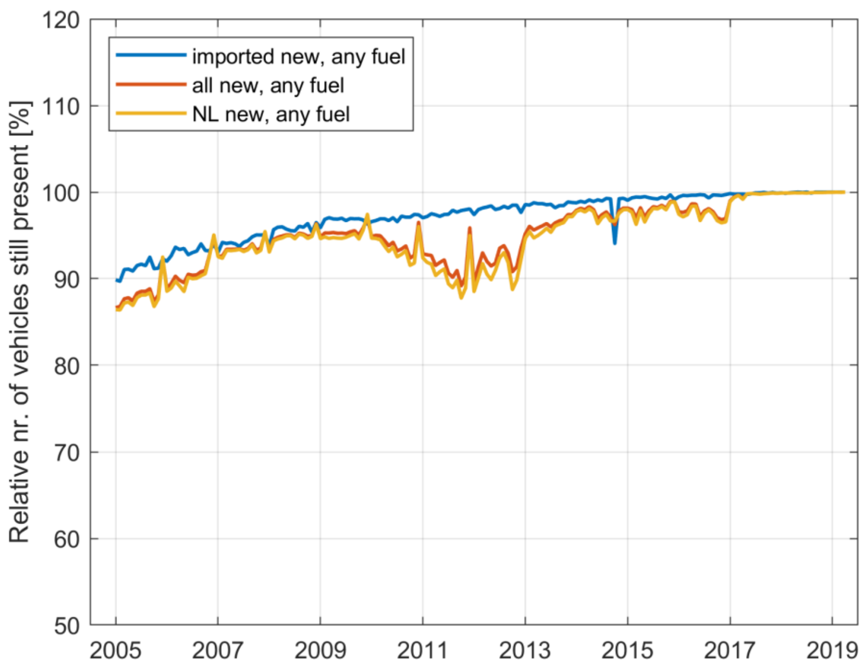

Figure 2-2: Relative number of newly registered vehicles still present in April 2019, any fuel, per European registration month from January 2005 until April 2019.

The import and export are related to the CO_2 emission of the vehicles.
The imported vehicles, albeit a small group, have higher average CO_2 emission values. This might be related to the reduced BPM at import, compared to a new vehicle. But the availability and price of such vehicles depend on many factors. Although the CO_2 values of imported vehicles are substantially higher than those registered newly in the Netherlands, in the order of 20 g/km, the net effect on the total fleet, across the years, is in the order of a few grams per kilometre.

From 2005 till 2013 the average CO_2 emissions have decreased significantly, with about 6 g/km per year. But from 2014 this general trend has stopped, and only for diesel vehicles a weaker downward trend continued till 2016. This coincides with the introduction of Euro-6 legislation in 2016, but it was well before the introduction of WLTP vehicles.

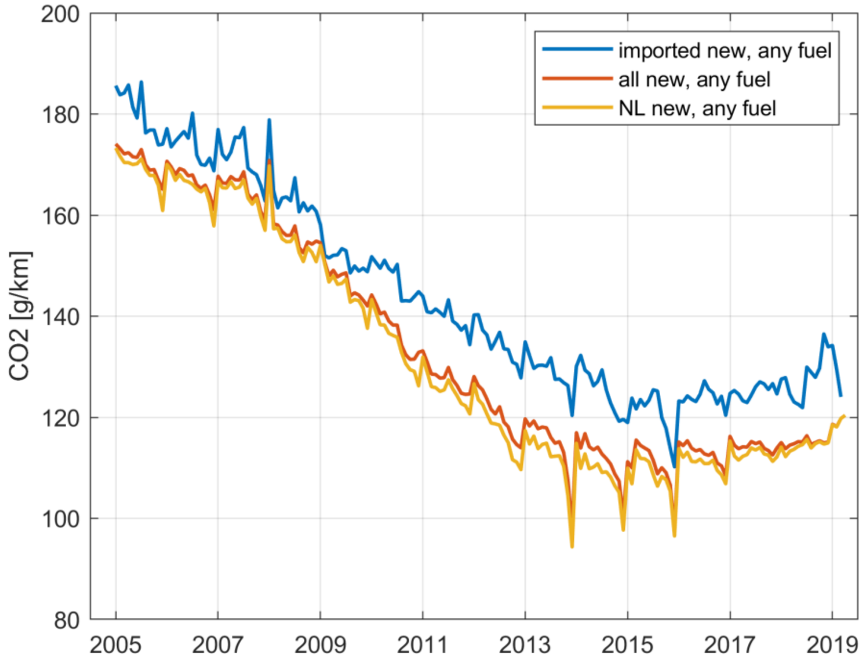

Figure 2-3: Monthly average CO_2 values for newly registered passenger cars, any fuel. Based on the first date of (European) registration.

The average is constantly, monotonically decreasing till 2015, spiked with start-of-year sales with different CO_2 values, but the variation in CO_2 emissions of individual vehicles (the vehicle sold with the lowest and highest CO_2 emission value) is much larger. As shown in Figure 2-4 there is a bandwidth 70 g/km in the CO_2 values, roughly independent of the year.

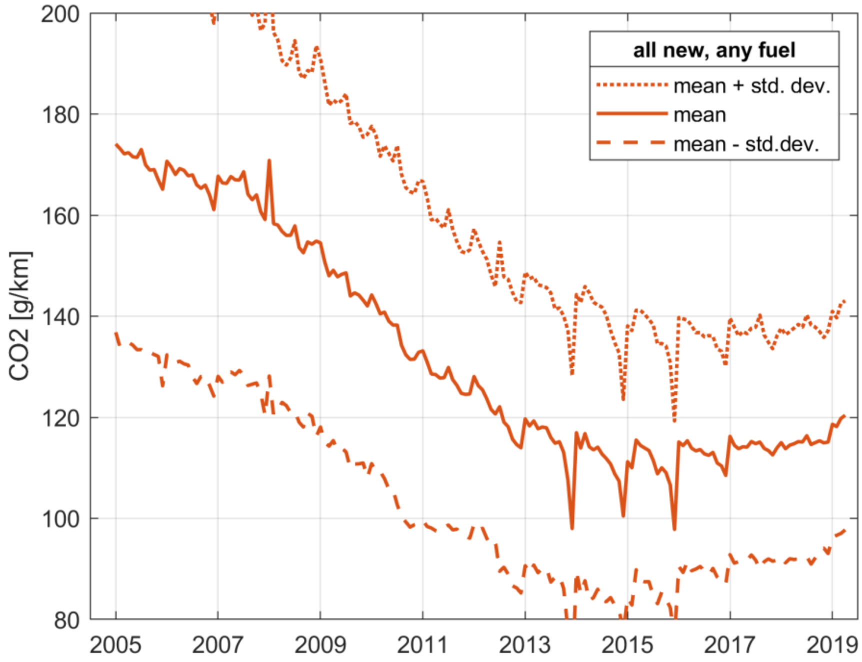

Figure 2-4: Monthly average CO_2 values plus and minus the monthly standard deviation for newly registered passenger cars, all new, any fuel.

Although, a small group of about 10% of the relatively new vehicles imported avoid part of the CO_2-based sales tax, the BPM tax of these vehicles is the same as for newly registered vehicles, indicating an import at an age of close to two years.

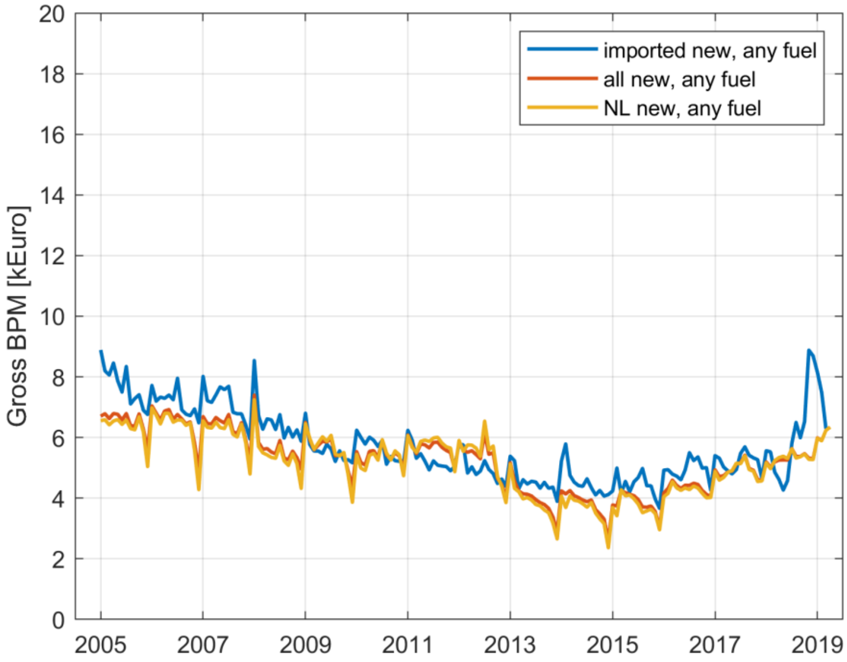

Figure 2-5: Monthly average BPM purchase tax for newly registered passenger cars, any fuel. Average BPM per vehicle for different groups of vehicles.

2.3 Petrol vehicles

From separating the sales to fuel types, it becomes clear that the trends are mainly caused by variations for diesel vehicles. The sales and trends for petrol cars are more continuously and stable. The export of vehicles that are 6 to 10 years old in 2019 (sold between 2009 and 2013) is a fraction of the export of diesel vehicles of this age. Where 30% of the diesel vehicles are exported at an early age, the petrol vehicles are seldom exported. Of all vehicles registered in the Netherlands, up to 14 years of age well over 95% are still present in the current fleet (see Figure 2-7).

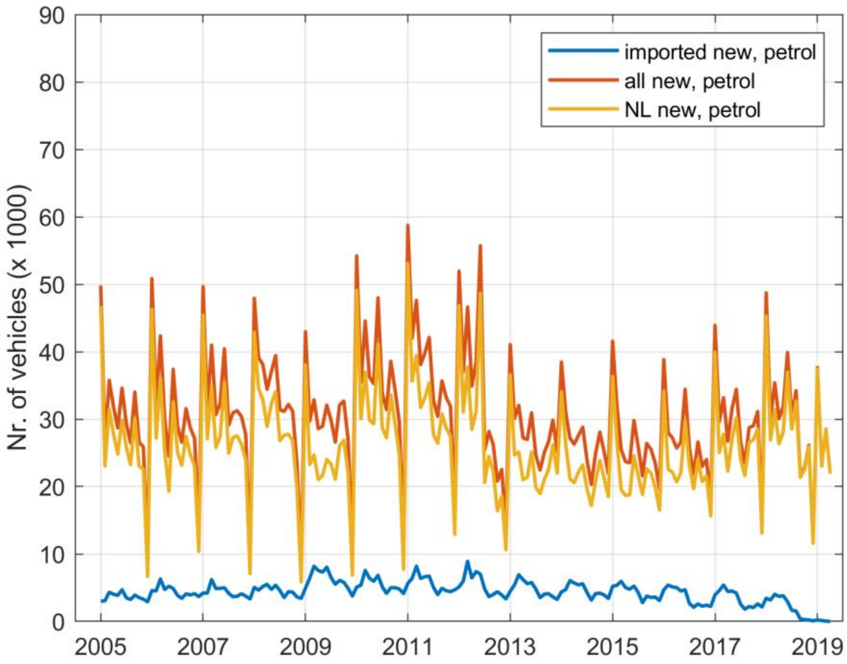

Figure 2-6: Newly registered passenger cars in the Netherlands, on petrol, per registration month from January 2005 until April 2019.

The new registrations of petrol vehicles are around 25,000 per month. Since 2013 new registrations have been lower, and since the second half of 2018 there is a further dip, but not as low as the new registrations in 2014-2015. See Figure 2-6. Petrol vehicles are not exported in large numbers. Export after the first few years, as common with diesel vehicles, are only a minor effect for petrol cars. Consequently, the new registration of petrol vehicles does not have the same dynamics and reactions as diesel cars.

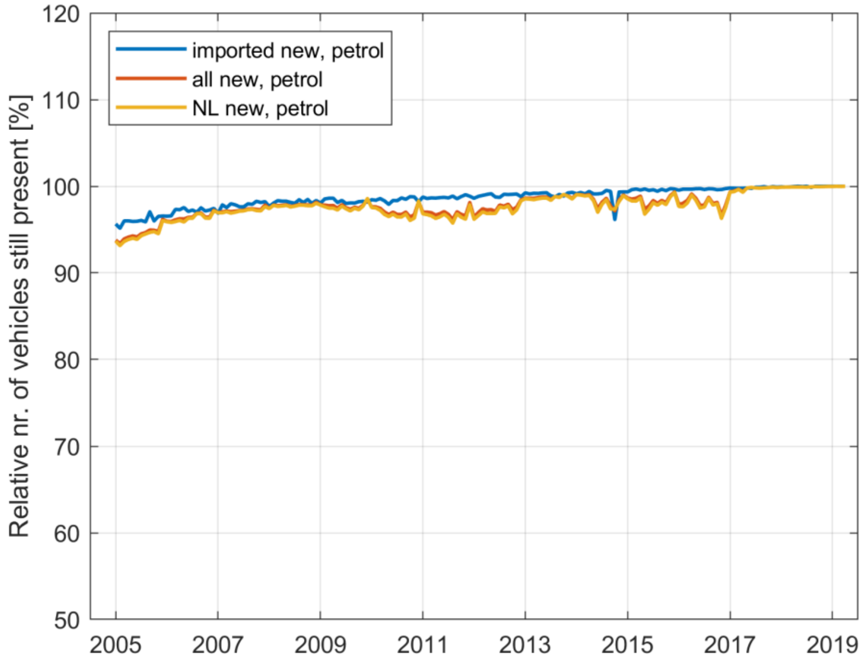

Figure 2-7: Relative number of newly registered vehicles still present in April 2019, on petrol, per registration month from January 2005 until April 2019.

From 2014, the CO_2 values of petrol vehicles seem to have stabilized around 115 g/km, see Figure 2-8. The import vehicles have higher CO_2 values, but fraction is small, such that the average CO_2 emission is hardly affected. On the other hand the BPM per vehicle has increased somewhat from 2015 onward, well before the WLTP introduction. Moreover, the transition from NEDC to WLTP, which occurred in a few months around September 2018, is not visible in the trends, except maybe for changes in the import.

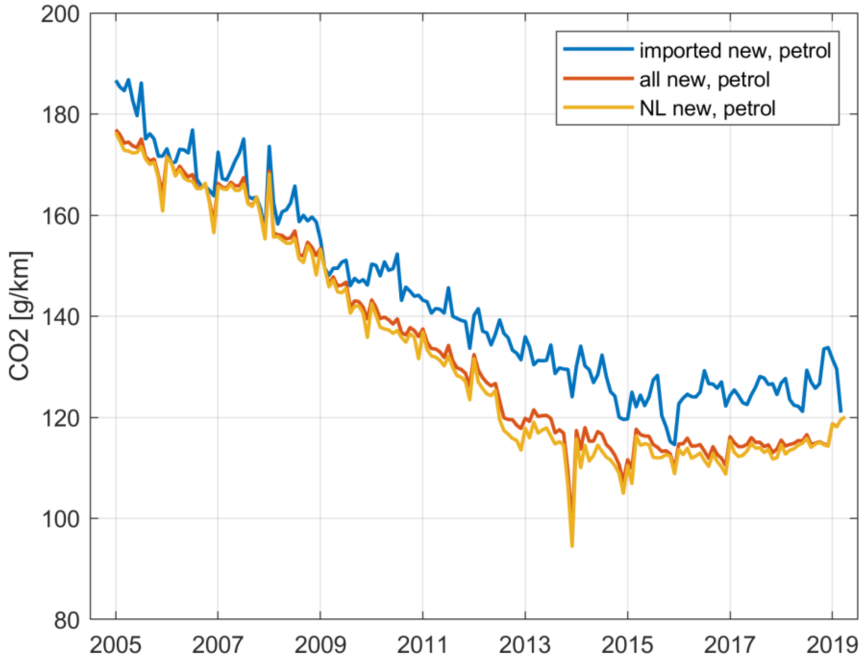

Figure 2-8: Monthly average CO_2 values for newly registered passenger cars, on petrol. On the basis of the date of first registration in Europe on the horizontal axis.

The steep decrease of CO_2 values from 2005 till 2014 has stopped. See Figure 2-8. The reduction from 180 g/km in 2005 to 115 g/km in 2014 is effectively 7 g/km per year fleet average reduction. From 2014 there seems a small increase in CO_2 values. The registration of electric vehicles are only a small part of the total registration, with limited effect. However, since electric vehicles have no associated CO_2 values they are left out of the analyses. For the car manufacturers the CO_2 targets included the electric zero-emission vehicles.

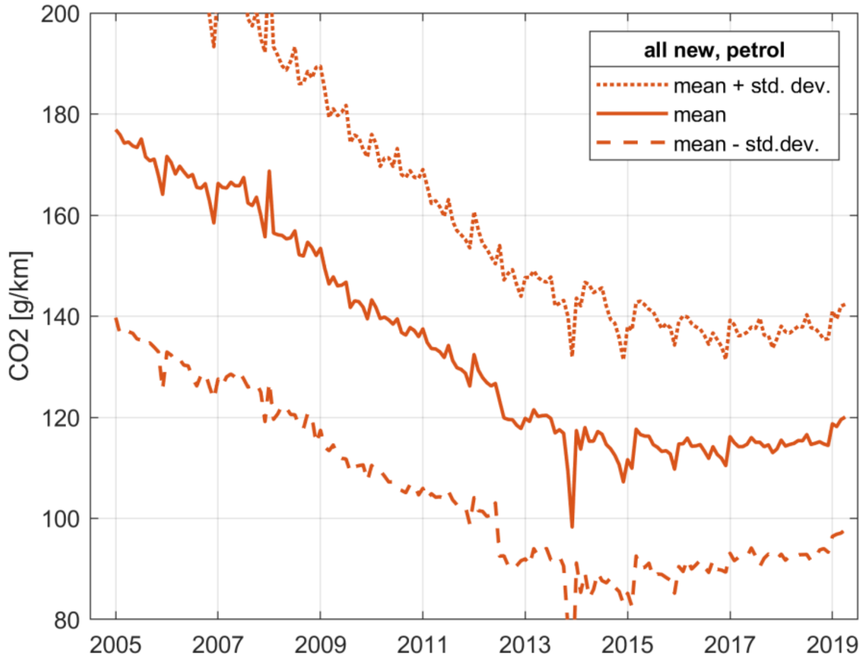

Figure 2-9: Monthly average CO_2 values plus and minus the monthly standard deviation for newly registered passenger cars, all new, on petrol.

The 15 g/km difference between the new registrations and imported petrol vehicles of the same age as seen in Figure 2-8 is not reflected in the BPM in Figure 2-10. The BPM is reduced when the car is older. The import numbers of petrol cars, typically a few years old, affect the total influx of new cars only slightly.

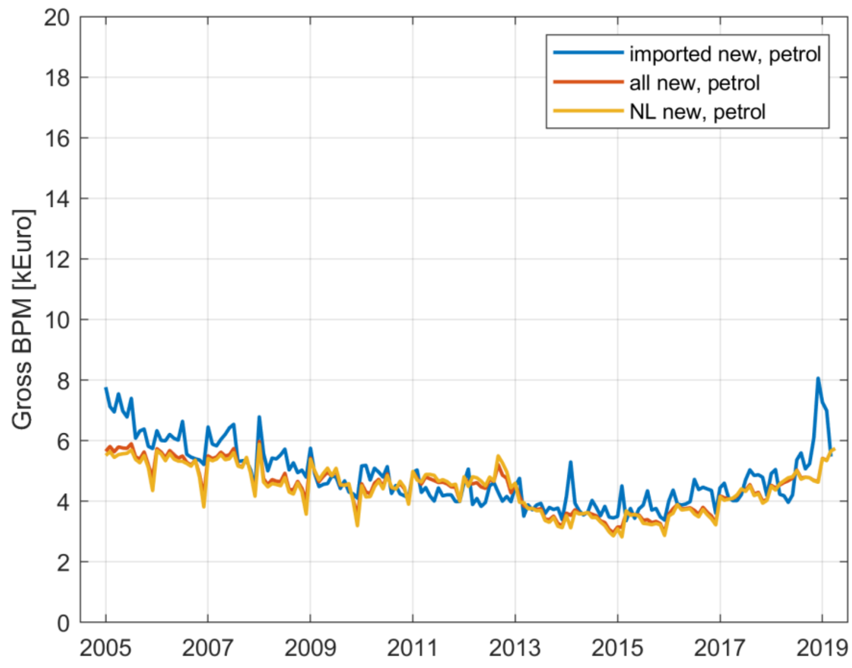

Figure 2-10: Monthly average BPM purchase tax for newly registered passenger cars, on petrol.

2.4 Diesel vehicles

Diesel vehicles are more affected by trends and measures than petrol vehicles. Diesel vehicles are mainly business cars and economic motives play a bigger role in the sales, import, and export of diesel vehicles. The very low sales of diesel cars in the last year affects the certainty with which the effects of the transition to the WLTP can be quantified. Even the low sales of WLTP vehicles may have little to do with the WLTP transition, but it seems to be the culmination of a trend that started well before the introduction of WLTP type-approved vehicles.

Diesel vehicles show much clearer discontinuous trends between 2005 and 2019. For instance, from 2013 the sales of diesel vehicles has decreased continuously. Likewise, the import of new vehicles has decreased as well, in the same period. In the same period both the CO_2 and the catalogue price of diesel vehicles have increased substantially. Therefore, it appears that for the lower market segments, with the large sales volumes, the diesel vehicle is less popular. This may place the trends for petrol vehicles in a different perspective. It seems therefore that CO_2 have been increasing for all fuels, but less apparent for petrol, as it was compensated by a shift in the segments.

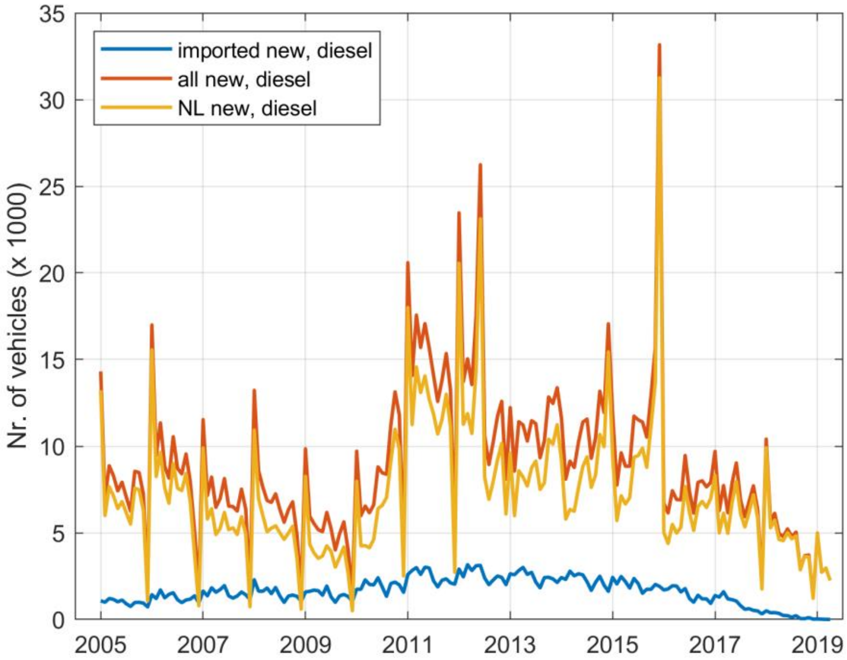

Figure 2-11: Newly registered passenger cars in the Netherlands, on diesel, per registration month from January 2005 until April 2019.

The tapering off from the highest diesel sales in 2011, with a sharp peak in December 2015 related to the end of the fiscal regime of low CO_2 diesel vehicles, seems to continue. Diesel sales are at their lowest value now, since two decades.

However, likewise the export of diesel vehicles are at a low rate. A few years ago more than half the vehicles were exported before the age of six years. Currently, the export has halved. In particular vehicles from 2014 and younger are hardly exported.

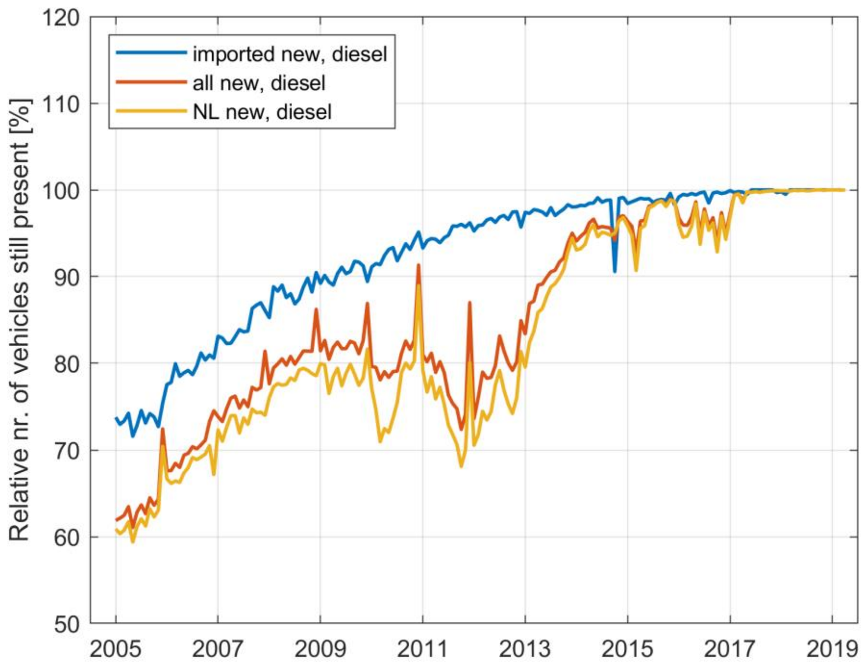

Figure 2-12: Relative number of newly registered diesel vehicles still present in April 2019, per European registration month from January 2005 until April 2019.

For the import of diesel vehicles, some shifts can be observed. In the past diesel vehicles, with higher CO_2 values were at an older age, with reduced BPM below the average BPM of new vehicles. But for vehicles from 2013 the average BPM is higher, signalling the import at an earlier age, accepting a high BPM at import for a newer car. It can also be possible that relatively new diesel cars have become available for lower prices abroad. In particular the German court decision to allow general diesel bans in German cities, made second hand diesel cars a hard sell in Germany, boosting the export, to, for example the Netherlands. In the last year the same number of diesel cars were imported as sold new in the Netherlands. These vehicles were mostly quite new, and they have affected the new registrations slightly. Although such effects may be present, the overall number of new registrations are at a level that little conclusion can be drawn. Overarching to any evaluation of new diesel vehicles is the low registration numbers.

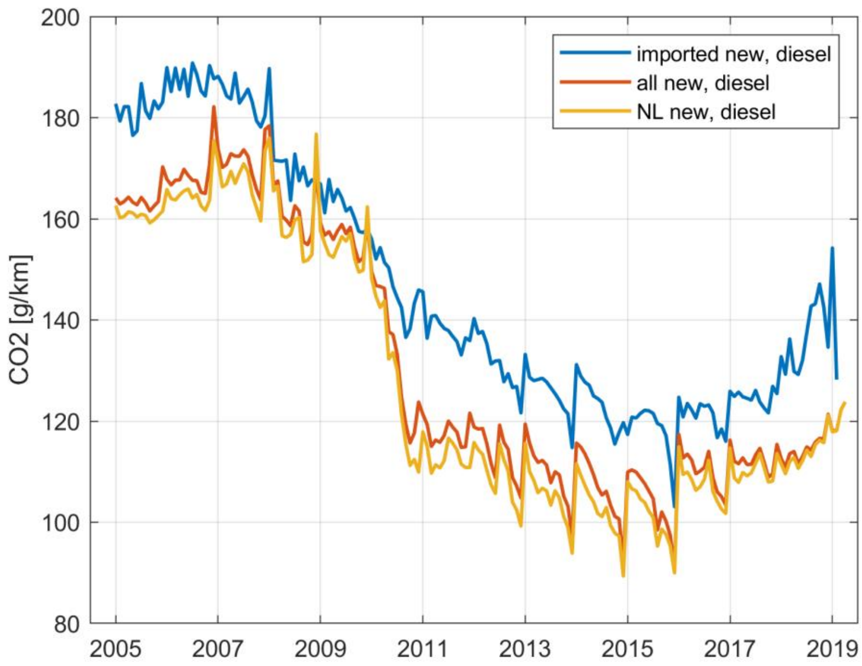

Figure 2-13: Monthly average CO_2 values for newly registered passenger cars, on diesel.

The large variation in CO_2 values are also reflected in the large variation in BPM. The total fleet is a combination of many different segments. The average values from the analyses in this chapter cannot be translated to the same effect for each vehicle segment and vehicle model. In the case of vehicle models, the WLTP transition may affect the effects on changes in CO_2 emission. These elements are discussed in Chapter 4.

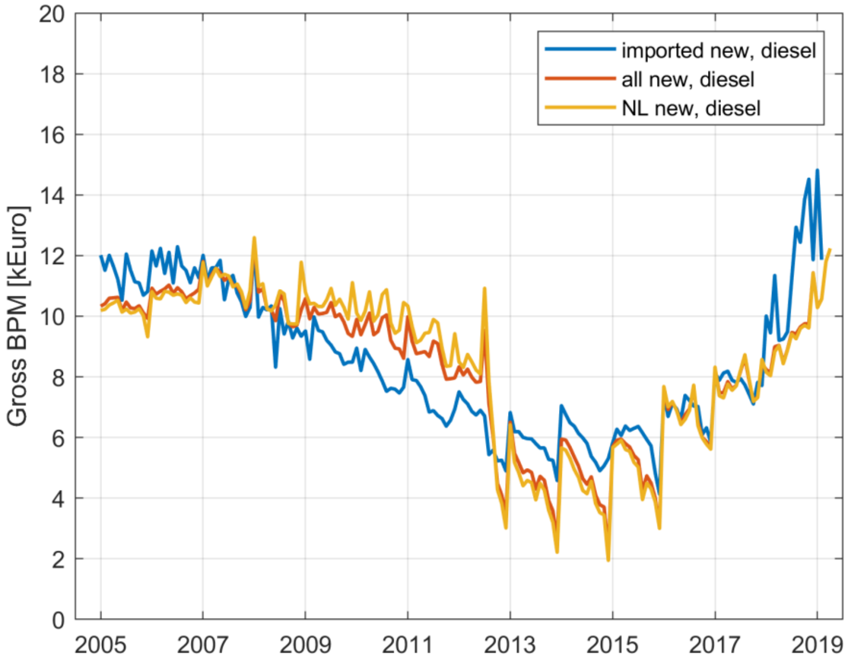

Figure 2-14: Monthly average BPM purchase tax for newly registered passenger cars, on diesel.

The transition for diesel vehicles from 2013 to a higher BPM is linked to the decrease of new registrations from 2016. The import of vehicles with a first European registration from July 2012 till December 2015. Since new vehicles with low taxation ("14% bijtelling") were not new available. Such vehicles were probably sought after abroad. However, in the total fleet, in Figure 2-11, this period correspond to a maximum in import, but not a clear period. So the taxation may have played role in the import of higher BPM vehicles, but it is expected not to be the sole reason.

3 Registrations of passenger cars from September 2017 until April 2019

All normal vehicle registrations are publicly available from the RDW. This makes it possible to follow the trends in vehicle fleet by examining the new registrations. This data does not contain the WLTP CO_2 information, but with the support of the RDW this additional information was obtained for most of the the new registrations. Using this information, the month by month changes in registrations can be analyzed for the type-approval CO_2 values, vehicle mass, and BPM. This chapter visualizes and describes the changes across the transition from NEDC to WLTP. This transition occurred mainly in the second and third quarter of 2018. Vehicles between September 2017 and September 2018 were mainly type-approved under NEDC, while the vehicles from September 2018 till May 2019 were mainly type-approved under WLTP.

Combining all NEDC and WLTP registrations from September 2017 onwards, the transition can be examined. As shown in Figure 3-1, the differences between the NEDC and WLTP vehicles are minor, yet clearly visible. The NEDC[WLTP] CO_2 is 6.6 g/km higher than the NEDC[old] CO_2 but also the vehicle mass and engine power are higher. Since these parameters affect the CO_2 emissions, it cannot be concluded that the higher CO_2 value is the result of the different testing methods (NEDC and WLTP). This is analyzed further in section 0.

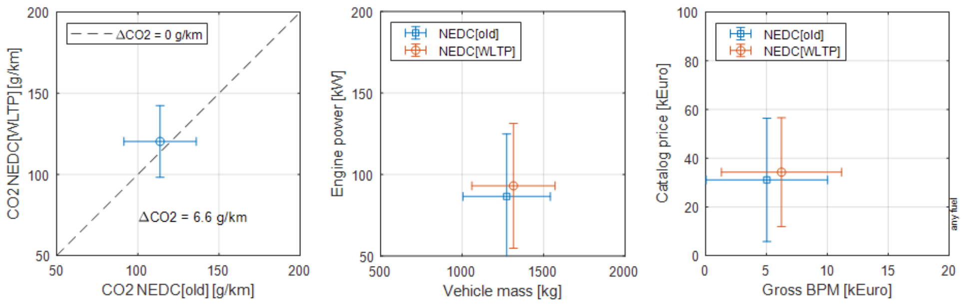

Figure 3-1: The average and bandwidth of all registered vehicles.

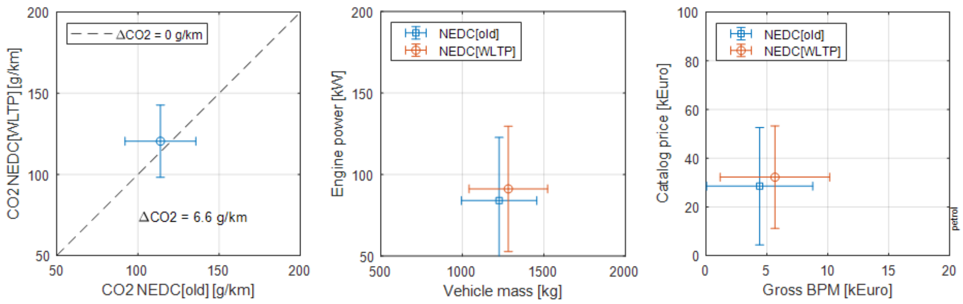

Figure 3-2: The average and bandwidth of all registered petrol vehicles.

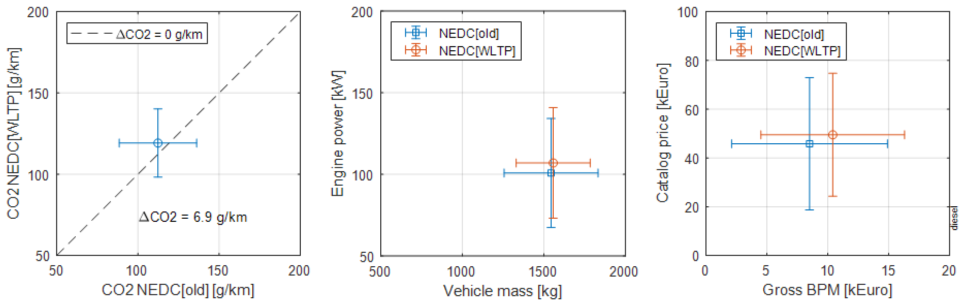

Figure 3-3: The average and bandwidth of all registered diesel vehicles. The vehicle mass hardly increased, but all other aspect show a distinct difference between NEDC and WLTP vehicles.

In the remainder of this Chapter the details for all fuels together, and petrol and diesel separately are examined. The figures show the month by month averages of the different groups. The start of registrations of WLTP vehicles and the end of registrations of NEDC vehicles exhibit some start-up and shut-down effects, associated with low numbers of vehicles. These effects play minor roles in averages, as presented in the figures above. A special group of passenger cars, still registered under NEDC type-approval, such as ambulances and campers, are excluded from the end sales of NEDC vehicles.

3.1 All fuels

From September 2018, the end-date of NEDC type-approval, the Dutch registration was in the middle of the transition to WLTP. About half the vehicles sold in September were based on the new WLTP type-approval. Due to the end-of-series many vehicles with NEDC type-approval were still available. In January 2019, the transition was largely completed for passenger cars with the end-of-series stock much decreased. The NEDC vehicles, in the light-duty passenger category, M1, sold in 2019 are mainly special registrations, such as campers. They are excluded from the analyses.

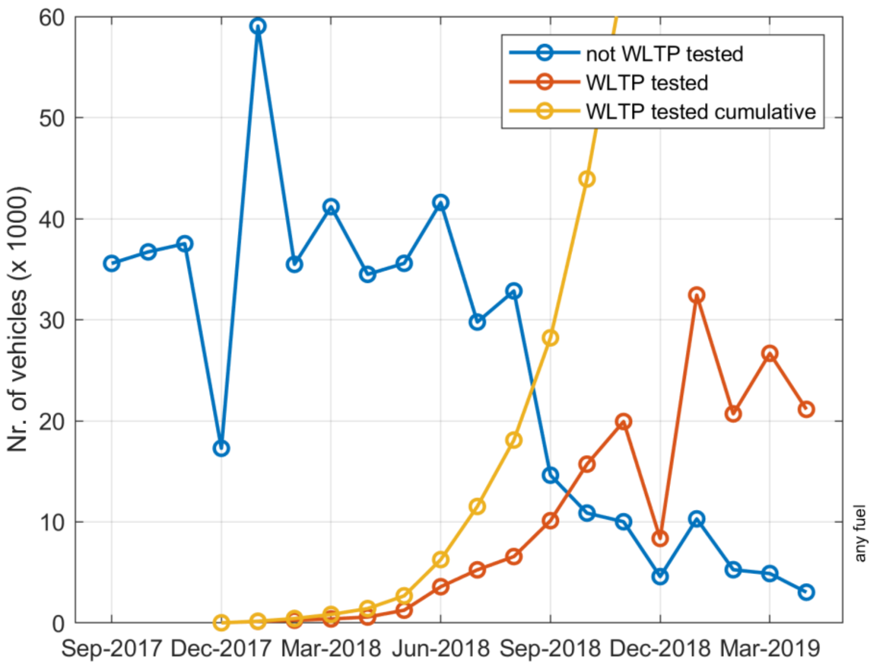

Figure 3-4: Newly registered passenger cars in the Netherlands, any fuel, per registration month from September 2017 until April 2019.

The decrease in new registrations as noted in the previous chapter continued across the WLTP transition. There seems to be no discernible change in the trend due to the transition. The December-January ripple can be averaged out almost completely by the peak in December; not registered in December is compensated in January. In other words January is not a peak but a catching up of a delay in registrations.

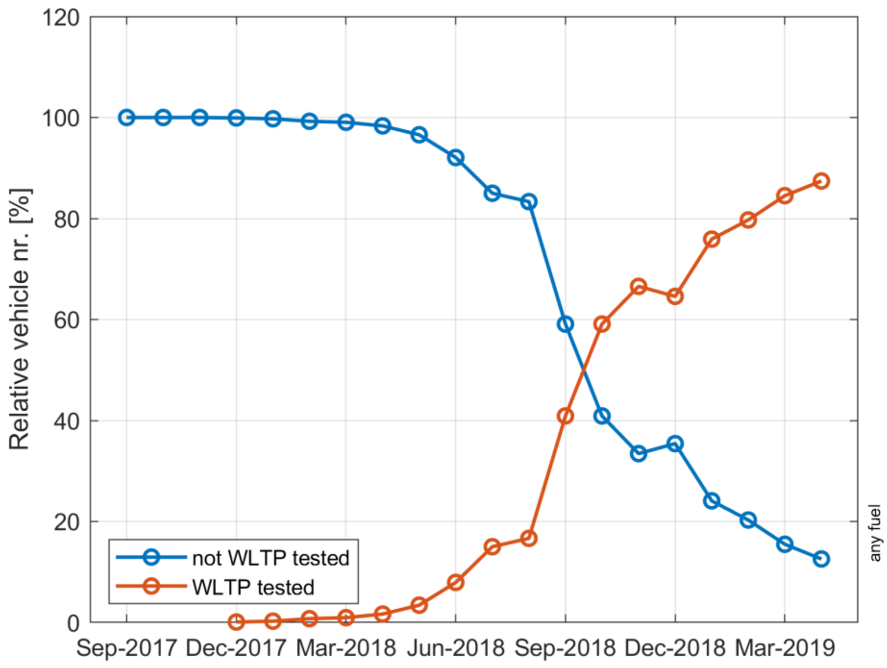

Figure 3-5: Monthly shares of newly registered not WLTP tested and WLTP tested passenger cars, any fuel, from September 2017 until April 2019. The crossover is in September - October 2018.

The transition from NEDC type-approval to WLTP type-approval, as seen in Figure 3-5, is centred around September 2018, with about 3 months before and after. It should be noted therefore that the average characteristics of NEDC vehicles in2019 have little consequences of the total average because of the low numbers, Likewise, the monthly characteristics of WLTP in the first and second quarters of 2018 are associated with low numbers.

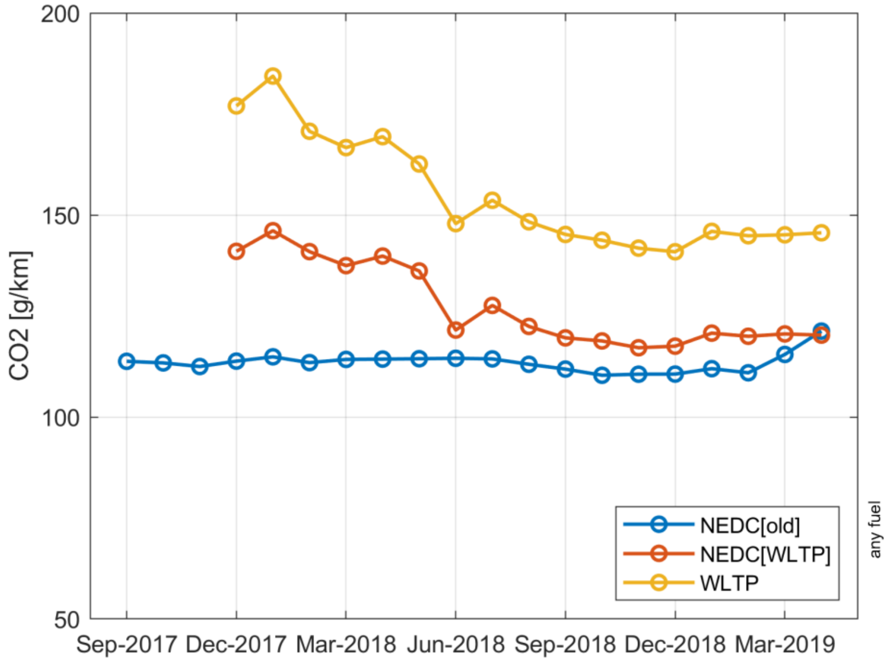

Figure 3-6: Monthly average NEDC[old], NEDC[WLTP] and WLTP CO_2 values for newly registered passenger cars, any fuel. Most (9x %) individual WLTP CO_2 values were directly copied from license plate specific CoC information delivered by RDW.

The monthly averages show a quick convergence to stable results. The gap of 6.6 g/km between NEDC[old] and NEDC[WLTP] values is constant over the months, indicating a limited uncertainty in the magnitude of the difference.

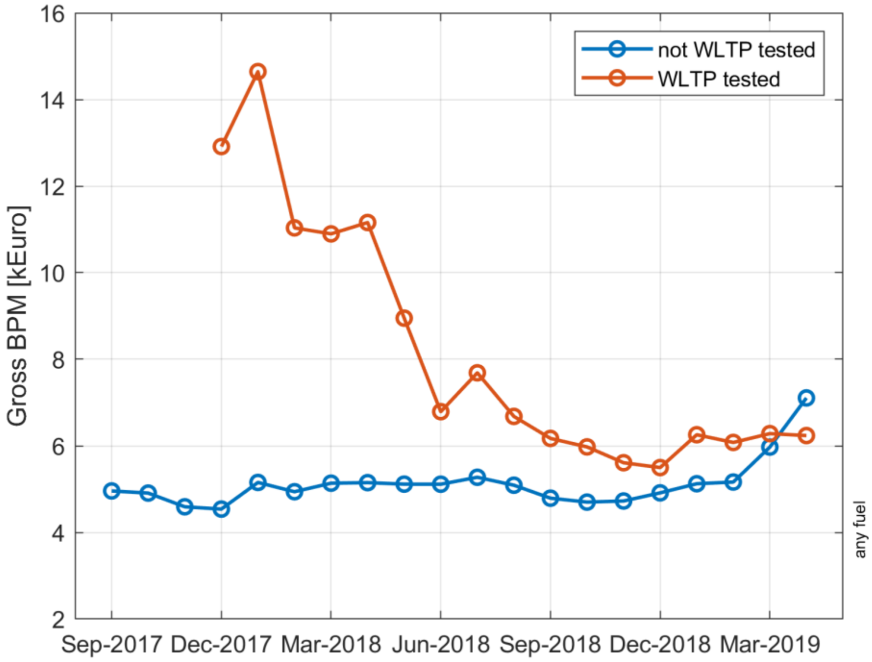

Figure 3-7: Monthly average BPM purchase tax of newly registered not WLTP tested and WLTP tested vehicles, any fuel. The upward trend for NEDC CO_2 comprises of small number of vehicles.

The dip in BPM in the last quarters of 2018 fit in the common trend over the years that BPM decreases over the year as seen in the previous Chapter. The effects across the transition cannot be assigned to the transition, as similar seasonal trends have occurred in the years before.

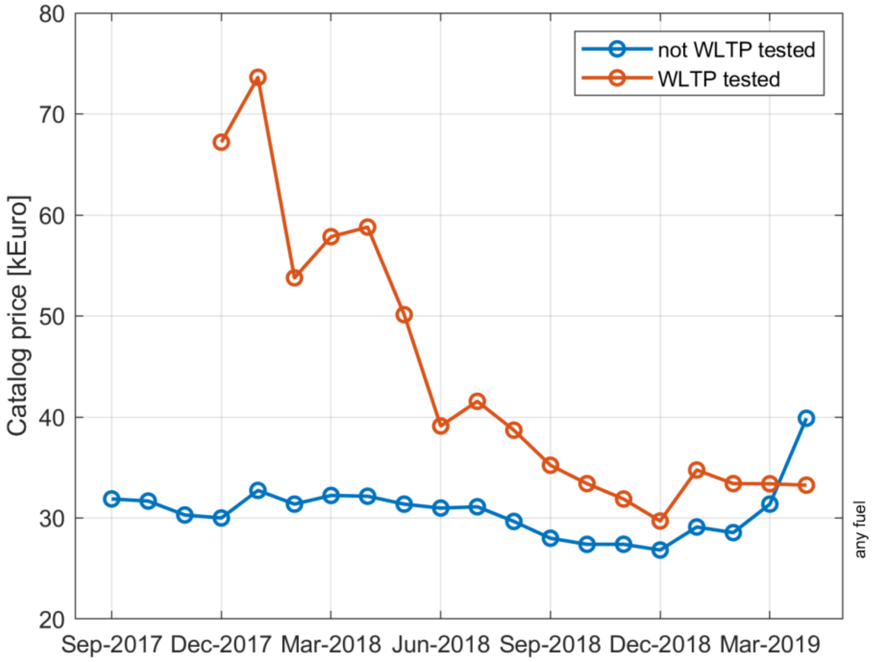

Figure 3-8: Monthly average catalogue price of newly registered not WLTP tested and WLTP tested vehicles, any fuel.

Similar as for BPM the average catalogue price, without BPM, of new registered vehicles follow the same seasonal trend, of higher averages at the start of the year, to lower values at the end. Hence no special significance can be given to the trend of lower catalogue prices across the transition to the WLTP in the second and third quarter of 2018.

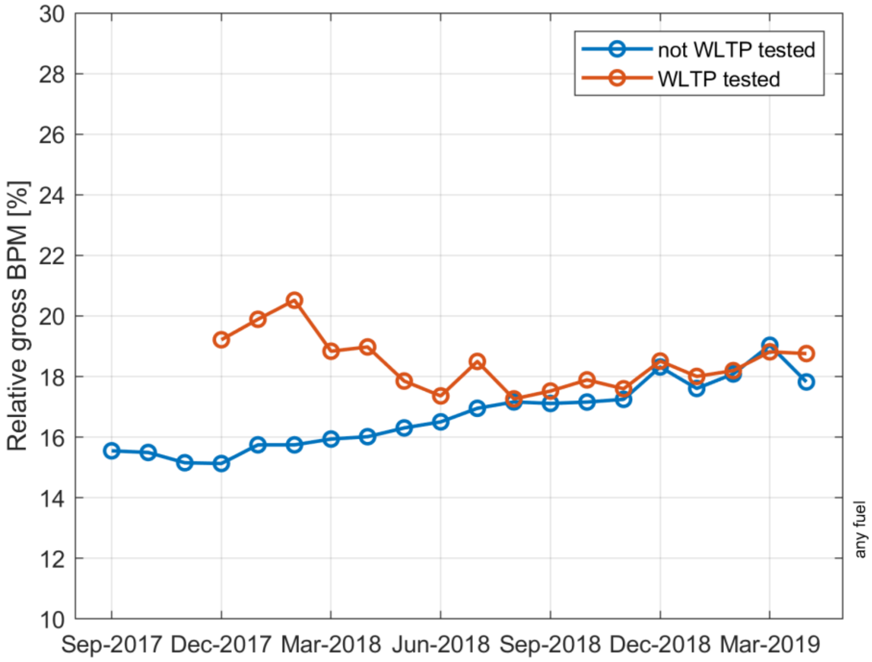

Figure 3-9: Monthly average BPM purchase tax as fraction of monthly average catalogue price of newly registered not WLTP tested and WLTP tested vehicles, any fuel.

The increasing BPM for both NEDC and WLTP vehicles in the third and four quarter of 2018 are contrary to the normal trends over the year. Clearly higher BPM and CO_2 vehicles are sold, during the transition to the WLTP. This does fit in the longer trend of increasing CO_2 values from 2016 onward.

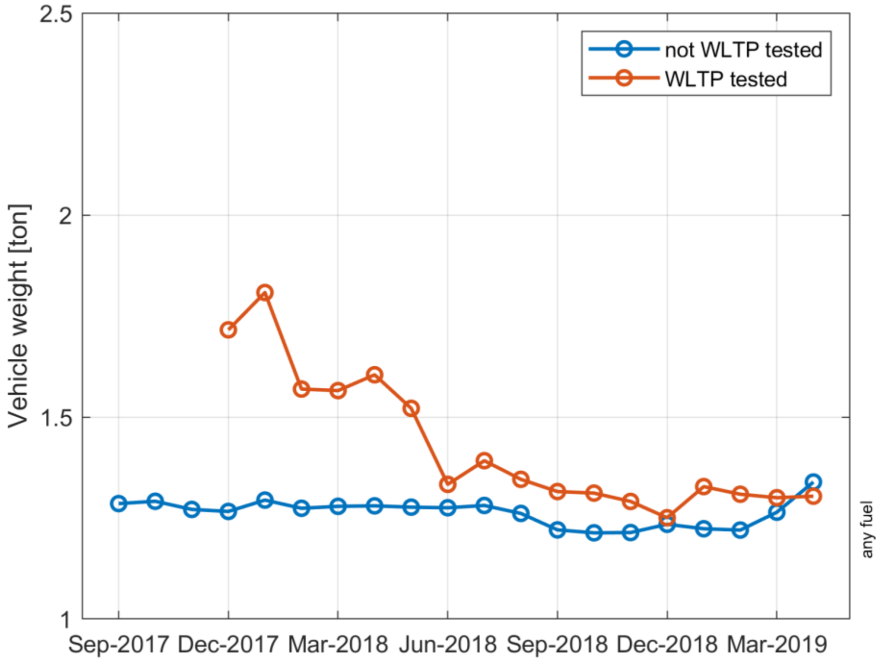

Figure 3-10: Monthly average weight of newly registered not WLTP tested and WLTP tested vehicles, any fuel.

The end-of-year ripple, with low registrations in December and high registrations in January, show clearly an effect in vehicle characteristics, such as vehicle weight and engine power. In particular, the vehicles sold in December have lower power and mass than on average over the year.

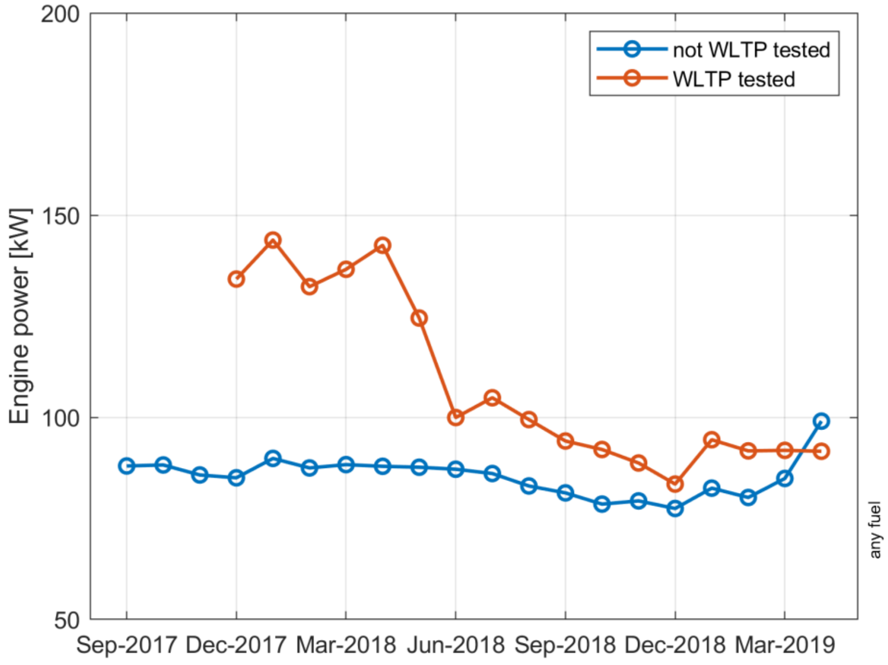

Figure 3-11: Monthly average engine power of newly registered not WLTP tested and WLTP tested vehicles, any fuel.

3.2 Petrol vehicles

The majority of the newly registered vehicles are petrol vehicles. They dominate the total fleet. The general characteristics seem to stabilize from September 2018 onwards. The typical year transition, from December 2018, to January 2019, is visible as a wrinkle in the smooth trends for the last quarter of 2018 and the first quarter of 2019.

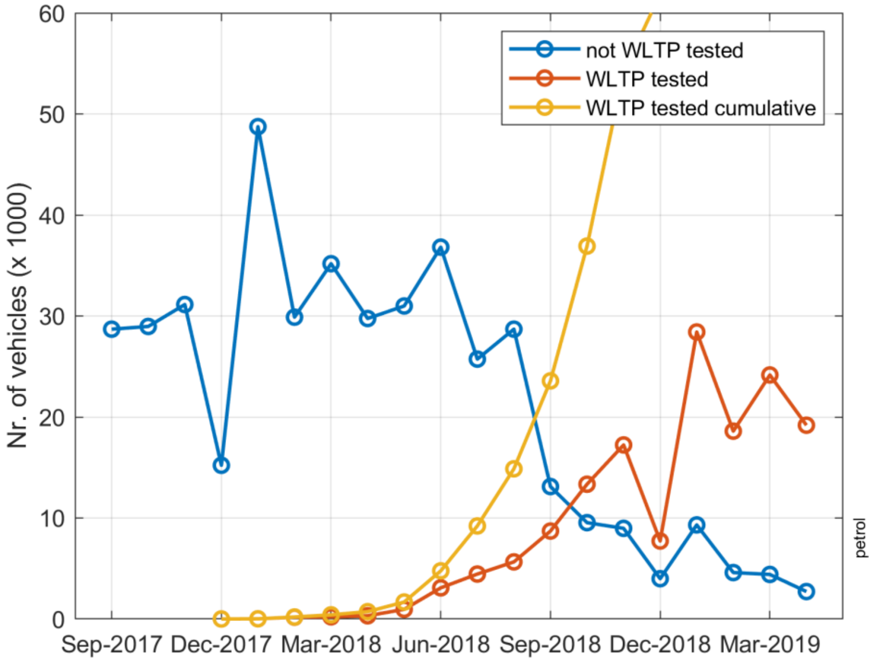

Figure 3-12: Newly registered passenger cars in the Netherlands, on petrol, per registration month from September 2017 until April 2019.

The sale of new petrol cars has a decreasing trend over the years. A monthly average around 30,000 petrol vehicles newly registered has been the trend for a few years now. The transition to the WLTP has not led to a deviation from this trend. From September 2018 onwards the WLTP type-approvals are the majority in the new registrations.

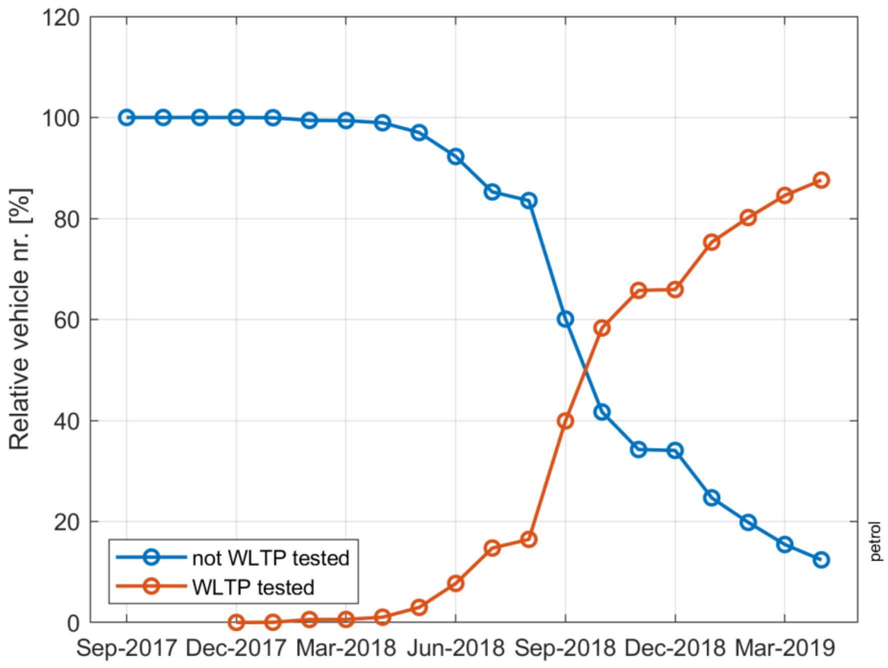

Figure 3-13: Monthly shares of newly registered not WLTP tested and WLTP tested passenger cars, on petrol, from September 2017 until April 2019.

It takes slightly longer, beyond the third quarter of 2018 for the NEDC type-approvals to dissipate from the new registrations. But on the other hand, the close to 100,000 end-of-series stock reported in the phase 2 report, did not fully materialize in vehicles registrations in the Netherlands.

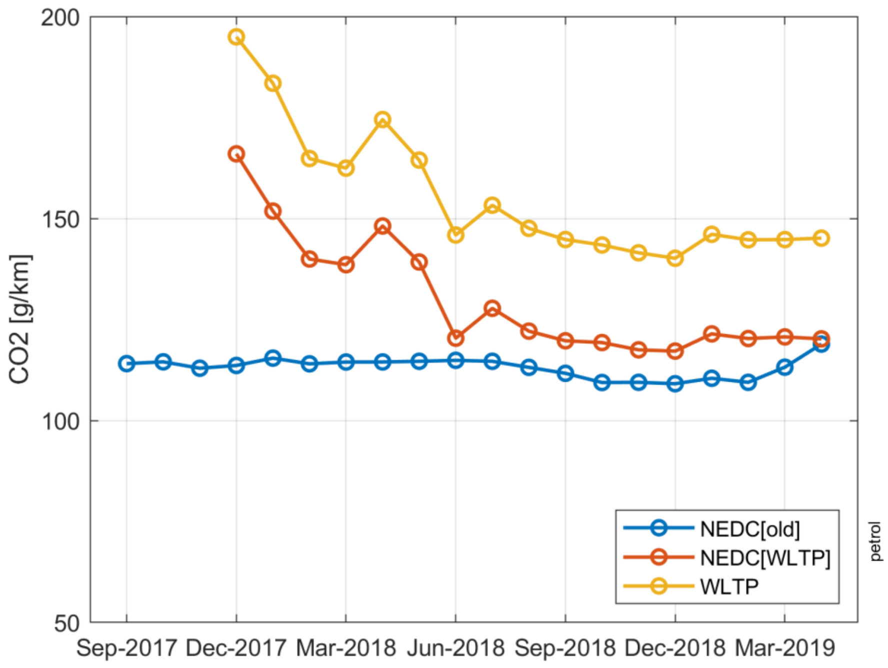

Figure 3-14: Monthly average NEDC[old], NEDC[WLTP] and WLTP CO_2 values for newly registered passenger cars, on petrol. Most individual WLTP CO_2 values were directly copied from license plate specific CoC information delivered by RDW.

The constancy between the NEDC[WLTP] and the WLTP CO_2 value is striking. The 28 g/km difference from the introduction of the first WLTP vehicles has remained at the same level as the market has stabilized across the transition. See Figure 3-14.

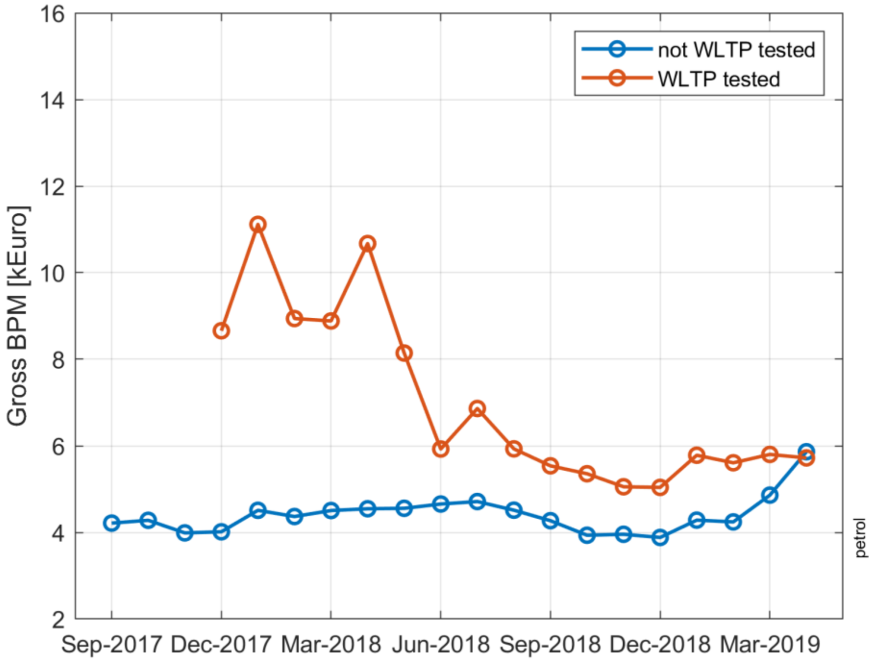

Figure 3-15: Monthly average BPM purchase tax of newly registered not WLTP tested and WLTP tested vehicles, on petrol.

The increase in BPM of NEDC type-approved vehicles in 2019 has no real significance. Only a few thousand vehicles are underlying these monthly averages. Up to that point the variations are well within the typical changes over the year, as occurred in the years before.

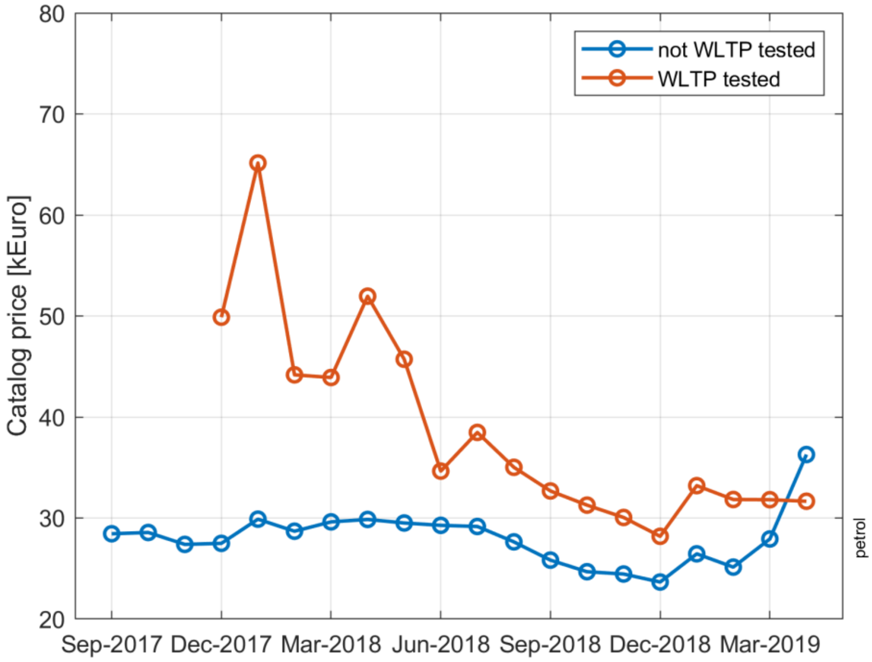

Figure 3-16: Monthly average catalogue price, without BPM, of newly registered not WLTP tested and WLTP tested vehicles, on petrol.

The catalogue price, without BPM, of NEDC vehicles in 2019 follows the trend of the BPM, the CO_2 values, the vehicle weight, and the vehicle power. The last few thousands of vehicles sold as end-of-stock have a higher catalogue price. These more expensive, higher market segment, vehicles may benefit more from BPM based on a NEDC type-approval than a WLTP type-approved version.

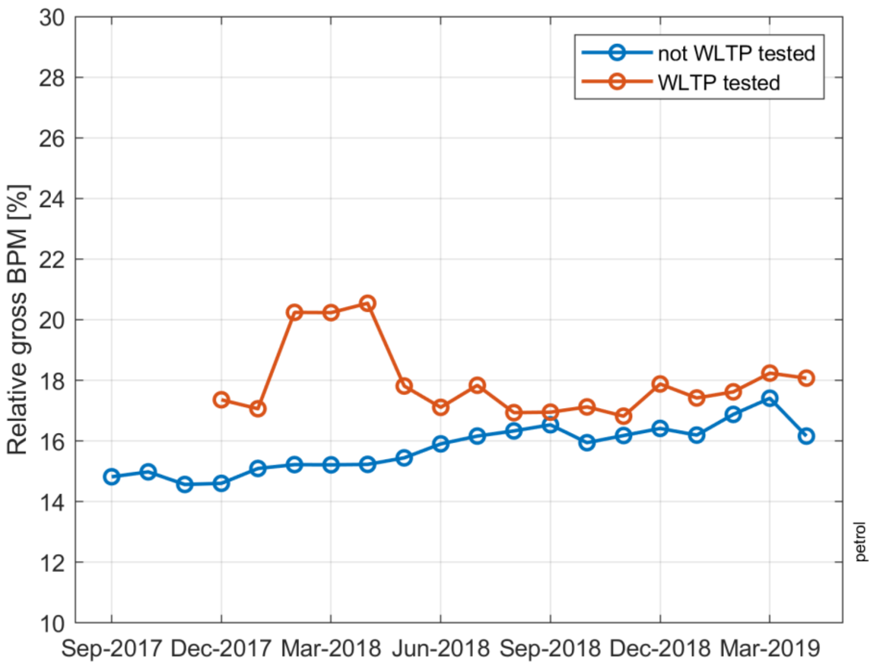

Figure 3-17: Monthly average BPM purchase tax as fraction of monthly average catalogue price of newly registered not WLTP tested and WLTP tested vehicles, on petrol.

The increase in average CO_2 and the associated BPM is part of a trend of the last years. The transition to the WLTP did to change the existing trend.
The physical properties, on the other hand, show more variation. However, this variation is not more than the typical variation over the year, as occurred in the last years.

It should be noted that the trend of weight and engine power of NEDC type-approved vehicles after December 2018 and WLTP type-approved before July 2018 are associated with small number of vehicles. These values should not be interpreted as significant. On the other hand, the overlapping period July 2018 till December 2018 show the higher weight and power of WLTP vehicles compared to the NEDC vehicles.

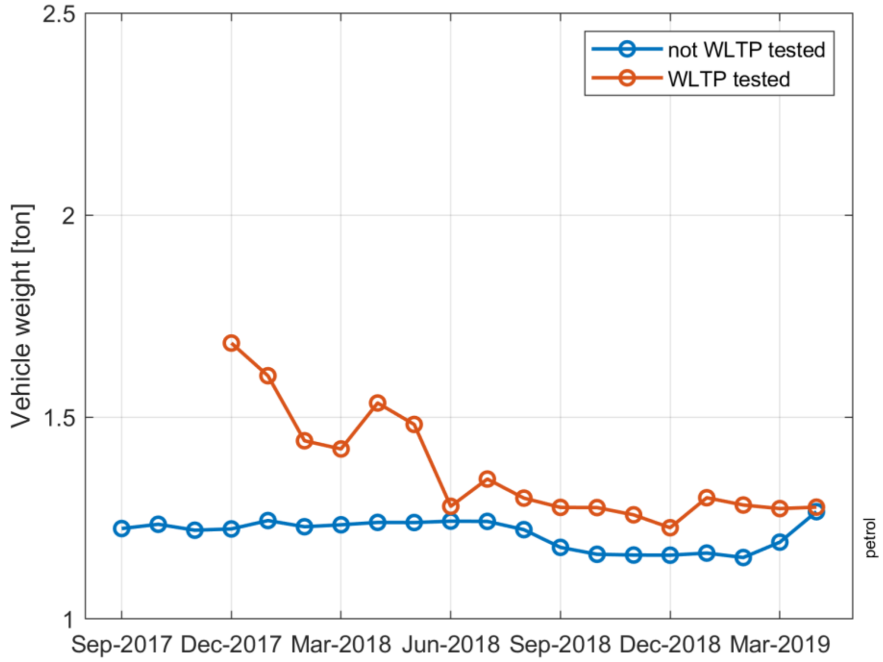

Figure 3-18: Monthly average weight of newly registered not WLTP tested and WLTP tested vehicles, on petrol.

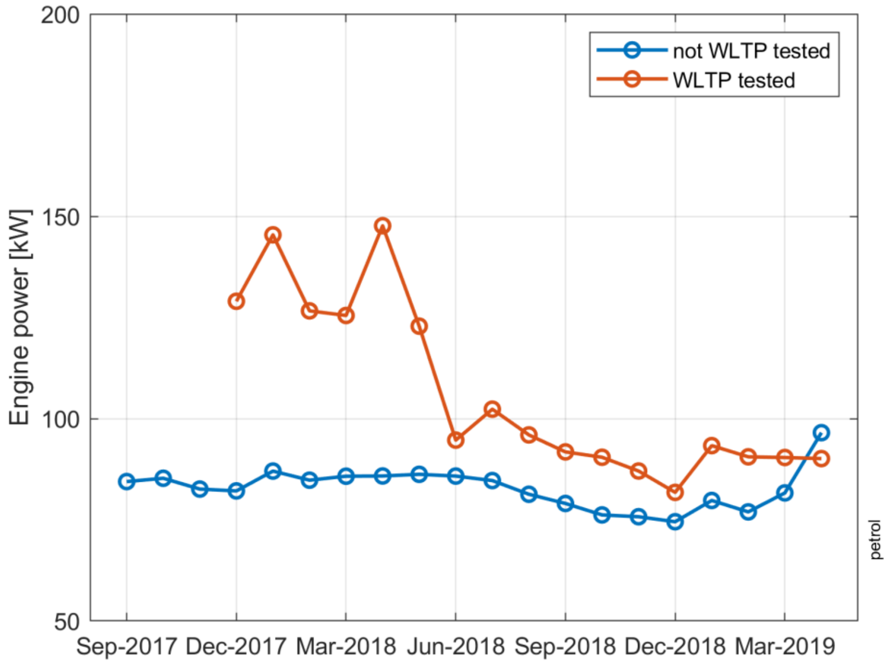

Figure 3-19: Monthly average engine power of newly registered not WLTP tested and WLTP tested vehicles, on petrol.

3.3 Diesel vehicles

The new registrations of diesel vehicles have collapsed to the lowest sales in decades. This trend started well before the introduction of the WLTP, as can be seen in the previous chapter. A few years ago 20,000 new diesel vehicles would be sold about every two months. Since the introduction of the WLTP it took six months to reach 20,000 sold diesels. In December 2015 alone more than 30,000 diesel vehicles were sold in a single month, 50% more than the cumulative sales from September 2018 till April 2019. Consequently, the current number of WLTP vehicles is small, and it may be biased by the replacement vehicles for typical outflow in the last couple of months. Between January 2018 and May 2019 the total number of diesel vehicles present in the fleet has decreased less than 0.2 percent. So it cannot be argued that there is a real shift away from diesel vehicles. It is more likely that the turnover of new diesel vehicles has lowered.

Because of the small number of underlying vehicles, the trends in WLTP diesel vehicles is less stable which makes it difficult to draw robust conclusions. However, it is clear that, the same as for petrol cars, the downward trends in CO_2 and vehicle characteristics associated with limited numbers of WLTP vehicles has stopped years ahead of the transition to the WLTP. This long term trend should not be confused with the effects of the transition to the WLTP.

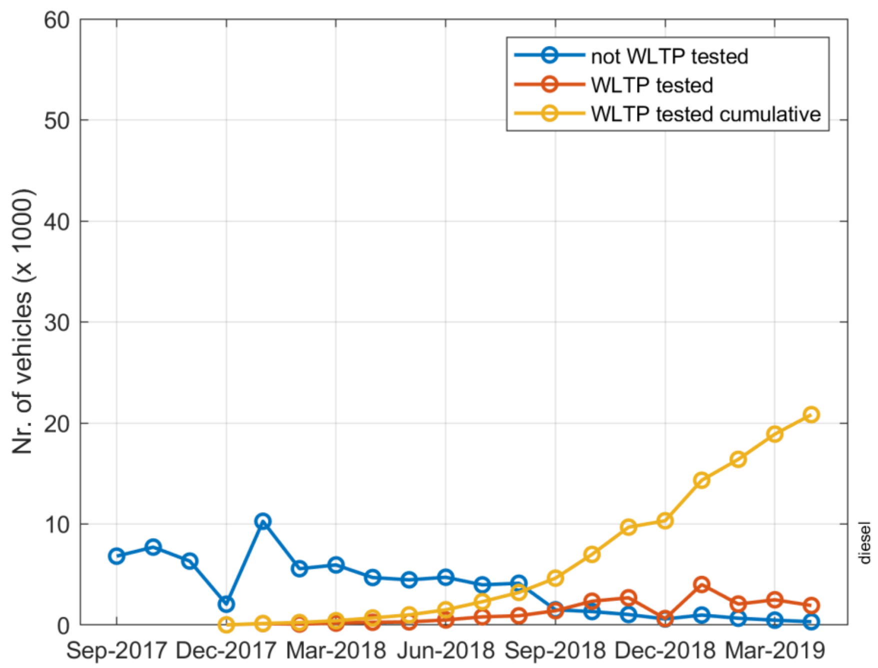

Figure 3-20: Newly registered passenger cars in the Netherlands, on diesel, per registration month from September 2017 until April 2019.

The cumulative registration of WLTP diesel vehicles has reached 20,000 vehicles at the end of April 2019. This is historically low, but part of a strong downward trend since 2016. Despite the low numbers, the transition from NEDC type-approval to WLTP type-approvals happened quickly in the second and third quarter of 2019.

Only December 2019 is an outlier, where the end-of-series registration of NEDC diesel vehicles was about the same as the registration of WLTP vehicles. From February onward the import of diesel vehicles exceeds the new registrations of diesel vehicles, albeit low numbers for both, totalling to about 6000 a month.

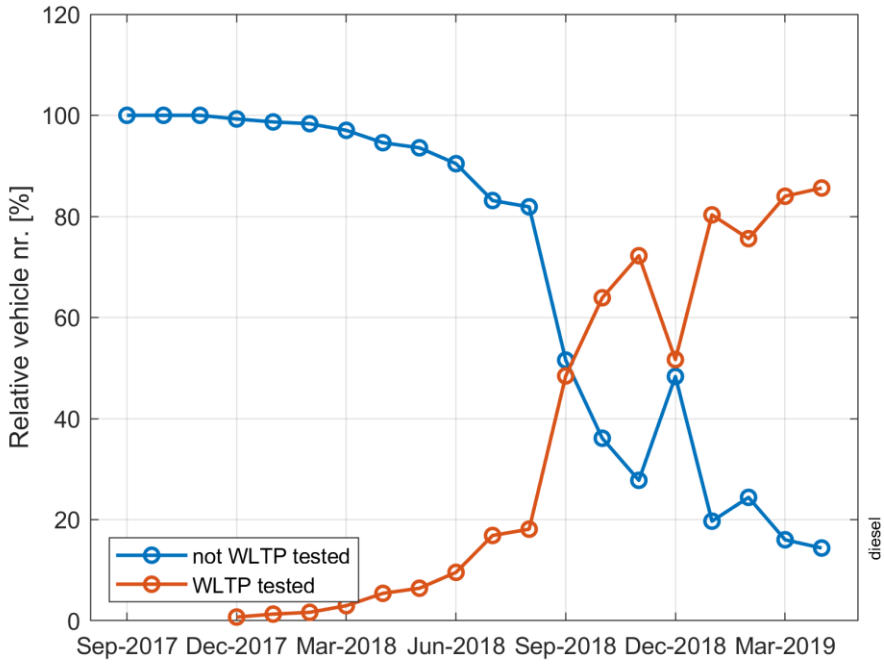

Figure 3-21: Monthly shares of newly registered not WLTP tested and WLTP tested passenger cars, on diesel, from September 2017 until April 2019.

The low number of diesel registrations with the high number of import vehicles makes it difficult to draw conclusions from the trends. However, clear trends can be seen from the monthly averages. The difference between the NEDC[WLTP] and the WLTP CO_2 remains constant over time. Moreover, the fleet averages for the WLTP type-approved vehicles converges after September 2018. On the other hand, from the Summer of 2018 the NEDC type-approved diesel vehicles show a strong trend upward for CO_2, power, and price. This upward trend indicates a particular use of the end-of-series arrangement to registered vehicles in the higher market segments.

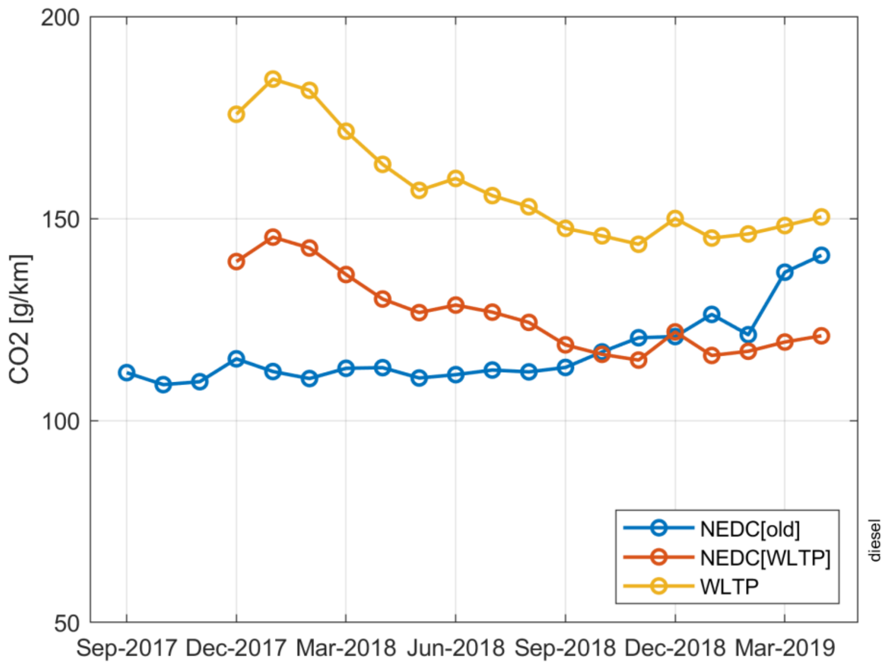

Figure 3-22: Monthly average NEDC[old], NEDC[WLTP] and WLTP CO_2 values for newly registered passenger cars, on diesel. Most (more than 90%) individual WLTP CO_2 values were directly copied from license plate specific CoC information delivered by RDW.

The physical characteristics of the WLTP diesel vehicles, despite the low numbers, seem to converge after the transition to the WLTP around September 2018.
It is therefore surprising that the CO_2 values increase steadily in the same period. The BPM increases as well, as expected. An interesting aspect is the increasing average catalogue price, from 40,000 Euro up towards 50,000 Euros, without BPM. It might be that WLTP type-approved diesel vehicles are shifting to the higher market segments. In the same period the average catalogue net price of petrol cars is 30,000 Euro, which is substantially lower than the diesel car prices.

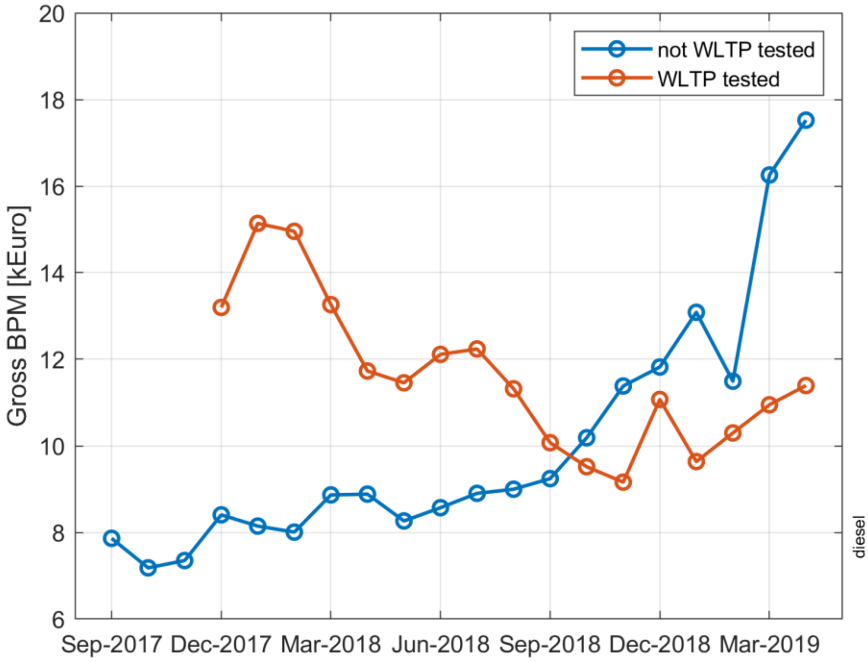

Figure 3-23: Monthly average BPM purchase tax of newly registered not WLTP tested and WLTP tested vehicles, on diesel.

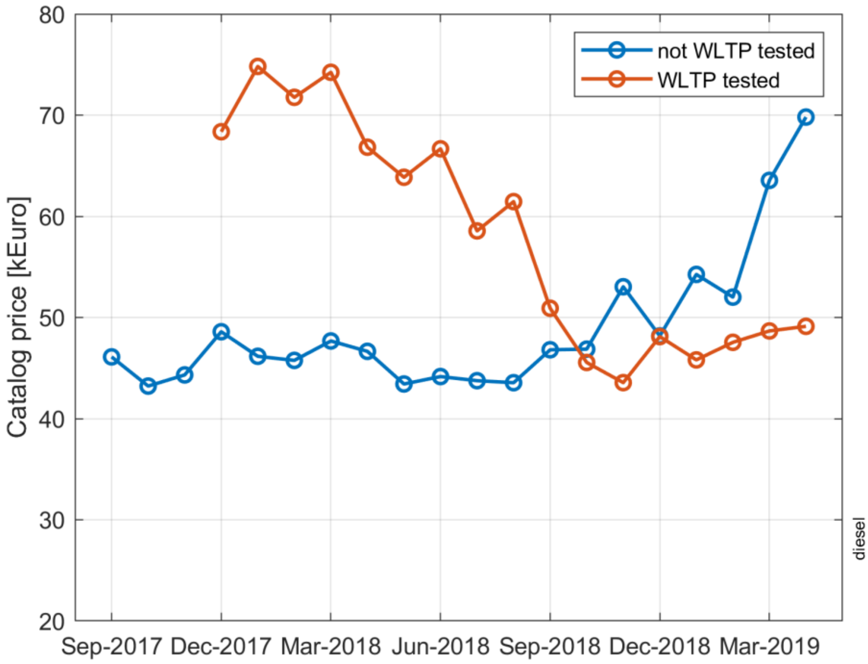

Figure 3-24: Monthly average catalogue price of newly registered not WLTP tested and WLTP tested vehicles, on diesel.

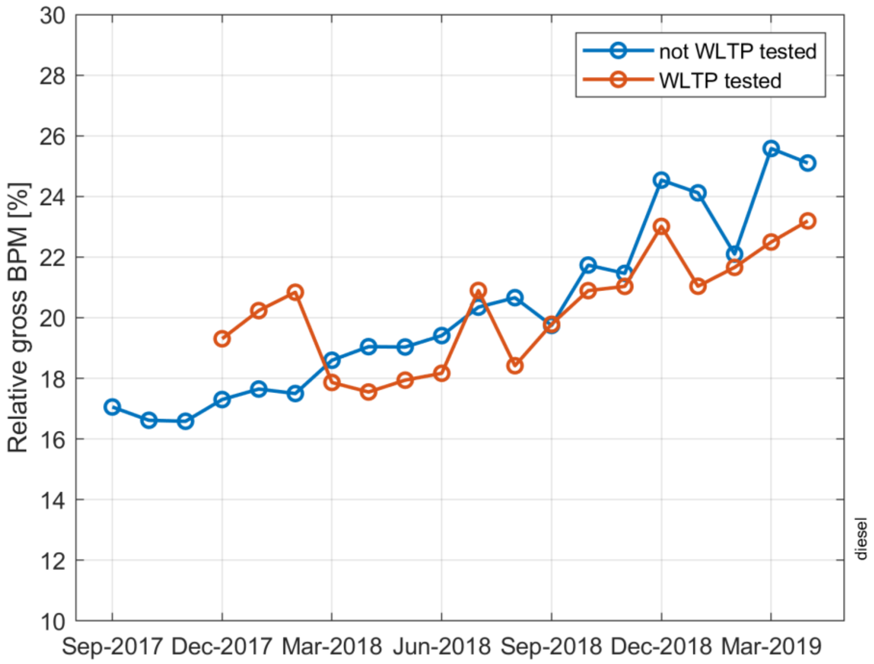

Figure 3-25: Monthly average BPM purchase tax as fraction of monthly average catalogue price of newly registered not WLTP tested and WLTP tested vehicles, on diesel. Note the y-axis is limited, and increase in BPM from July to April with respect to the catalogue price is in the order of 20%.

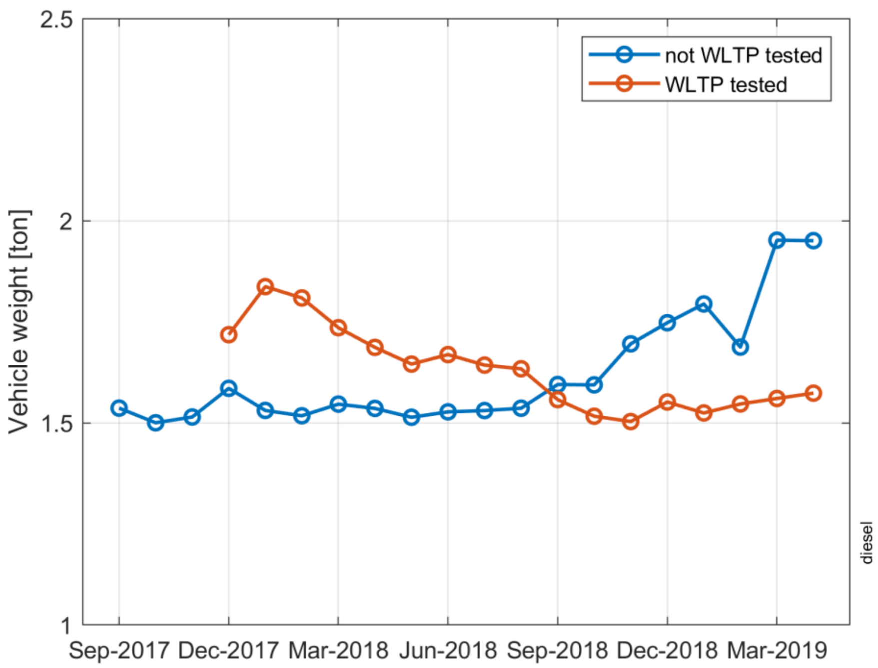

Figure 3-26: Monthly average weight of newly registered not WLTP tested and WLTP tested vehicles, on diesel.

The weight of diesel cars is hardly affected by the transition from NEDC to WLTP. It is likely a combination of different effects. The increase in engine power across the transition is also limited.

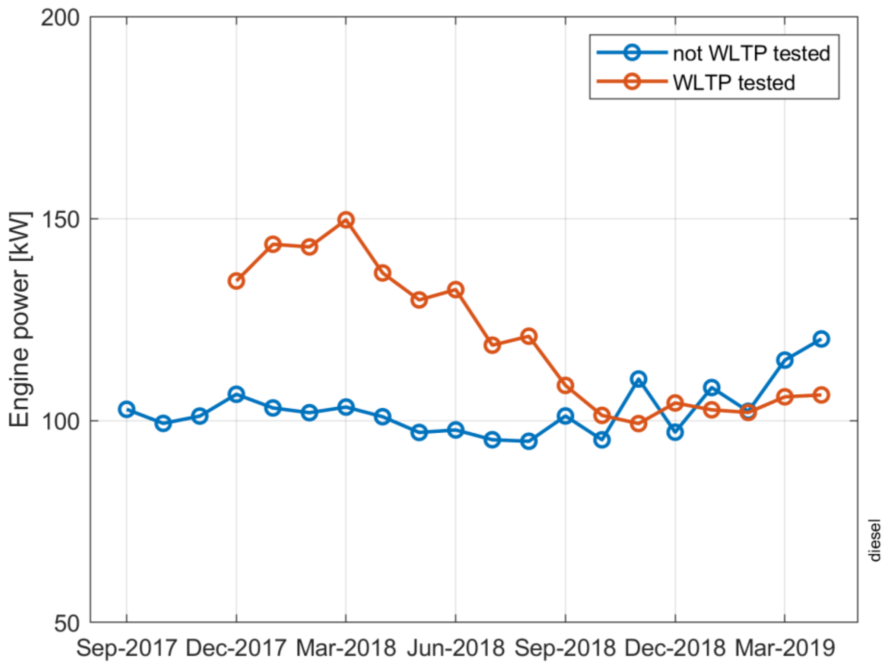

Figure 3-27: Monthly average engine power of newly registered not WLTP tested and WLTP tested vehicles, on diesel.

3.4 Comparable vehicles

Based on vehicles from 1 January 2017 till May 2019, a regression is made on the basis of the physical parameters: mass and engine power, to compare the CO_2 emissions based on NEDC[old] and NEDC[WLTP] for equivalent vehicles. This regression is identical to the regression made in the phase 2 report. For equivalent diesel vehicles with the same characteristics, the difference in terms of CO_2 emissions has increased compared to the preliminary analyses in October 2018, based on a limited amount of data. For petrol the difference remains about 1 g/km. However, for diesel cars the difference in CO_2 emissions are now in the order of 7-8 g/km. This is slightly higher, as compare to the 5 g/km in the phase 2 report.

Table 3-1: The multi-regression fit of the data from 1-1-2017 till 1-5-2019, excluding plug-ins, using the form CO_2 = A * mass + B * power.

Fit results	Compact petrol car	Midsize car	Large car
characteristics	1000 kg, 50 kW	1300 kg, 80 kW	1700 kg, 130 kW
Petrol NEDC	94.0	124.7	167.3
Petrol WLTP	95.2 (+1.2%)	125.7 (+0.8%)	167.7 (+0.2%)
Diesel NEDC	-	97.8	132.0
Diesel WLTP	-	106.2 (+8.5%)	139.1 (+5.3%)

Given the small number of diesel cars registered, around 20,000 vehicles, the fit may be biased by the limited variation of vehicle models. However, the weight trend (Figure 3-26) and engine power trend (Figure 3-27) of these diesel vehicles, is in line with the changing difference for diesel vehicles observed in these fits.

4 Changes in vehicle model from NEDC to WLTP

Comparing the same make and model for the NEDC and the WLTP would be the closest in showing the effect of the transition for the “same vehicle” in the eyes of the buyer or owner. On the other hand, the same make and model will come in many variants with different options. For that comparison, the actual sales numbers of the same make and model for NEDC type-approval and WLTP type-approval, are used to give an indication of the average version of the same make and model. Last year a limited number of vehicle models existed for NEDC and WLTP. This year the number of makes and models for which a comparison can be made of the average NEDC version and the average WLTP version is much larger. From this comparison trends and bandwidths can be distilled.

The buyer now has to face an additional cost of vehicle model options, if the option affects the weight, air-drag, or rolling resistance. Since the WLTP, and also for the NEDC[WLTP] CO_2, these effects of options are factored in the vehicle CO_2 registration. Therefore the options are affecting the BPM. It may be that this effect has influenced the typical choice of options and the CO_2 values of each specific vehicle model. This effect is assumed to be a natural part of the incentive the BPM provides to buy more fuel efficient vehicles.

4.1 NEDC[WLTP] and WLTP CO_2 values of WLTP vehicle models

It is argued that “the same model” is a fair comparison of NEDC[old] and NEDC[WLTP] CO_2 values. In this analysis, all vehicle models for which an NEDC and WLTP vehicle exists are compared. There are large variations between the different pairs, but the average over all comparisons show only a minor deviation from the comparison of all registrations in the previous chapter. In this case the difference is 0.8 g/km less than the 6.6 g/km over the whole fleet. Taking all the models for which an NEDC and WLTP version exists, the average deviation of the two CO_2 values is 5.8 g/km. On the other hand, the mass and engine power of the WLTP model is higher.

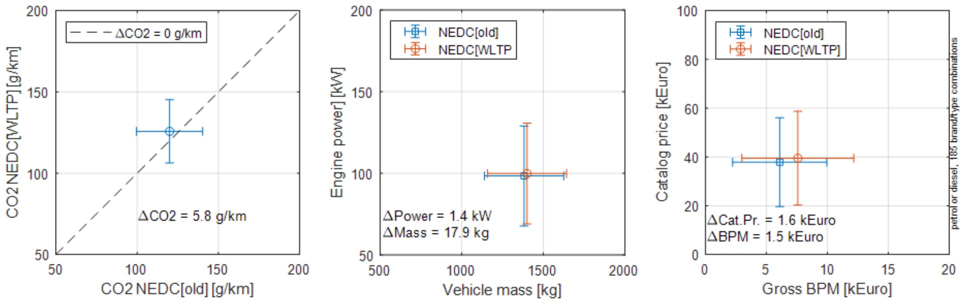

Figure 4-1: The average difference between WLTP and NEDC cars from the 1-on-1 comparison of RDW registrations. Average NEDC CO_2 value (ΔCO_2 = +5.8 g/km), vehicle mass, engine power, BPM and catalogue price all have gone up by a significant amount in the transition from NEDC to WLTP. The bars indicate the spread (std. dev.) in the values for the individual registrations; the spread is larger than the differences in averages observed.

Petrol vehicles dominate the total registrations, 142 models are available for comparison against for diesel vehicles only 43 models. Therefore, the results for petrol vehicle models only show limited deviation from the overall trend.

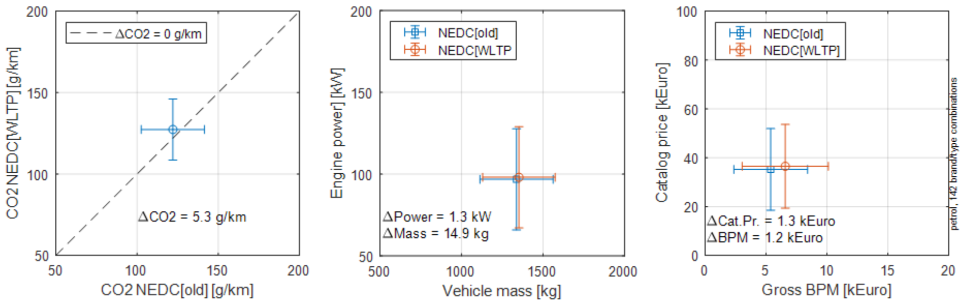

Figure 4-2: For petrol vehicles the differences in CO_2 values and vehicle characteristics linked to the NEDC to WLTP transition are smaller than for diesel vehicles (Figure 4-3).

It seems that more petrol vehicle models are similar than diesel vehicle models across the transition. Some petrol technologies may have remained unchanged across the transition. It might be possible that a number of petrol vehicle models had minor technical adaptions from NEDC to WLTP type-approval. These unchanged models might be the best examples to determine the CO_2 difference between the NEDC and WLTP. However, this result is not supported by fleet average results, where a change in characteristics is clearly visible and can be factored in into the transition.

Historically, it could be expected that vehicles would have lower CO_2 emission values across the transition because of the downward trend. However, since the downward trend stopped in the Netherlands in 2015, as can be seen from the 2005-2019 figures in Chapter 2, this effect should not be compensated for. It is likely that the transition trend therefore is not influenced by factors like, e.g., effects of changes in engine efficiency.

In the average overall fuels, the diesel vehicles play only a minor role, because of the limited diesel sales and models. Moreover, the CO_2 change of diesel models vary only minor from the petrol. In particular the weight increase of diesel vehicles across the transition is smaller.

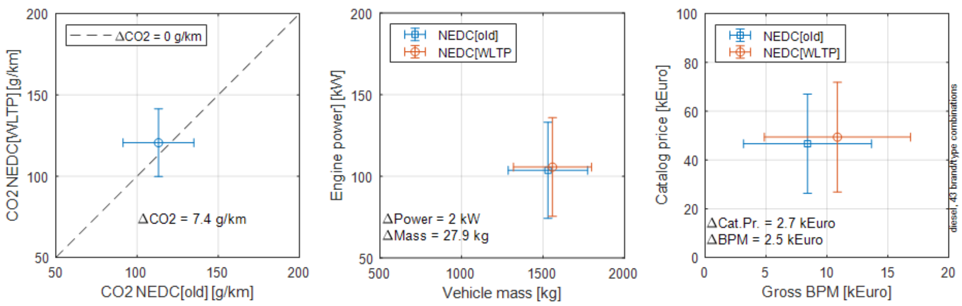

Figure 4-3: For diesel vehicles the differences in CO_2 values and vehicle characteristics, except mass, linked to the NEDC to WLTP transition are higher than for petrol vehicles (Figure 4-2).

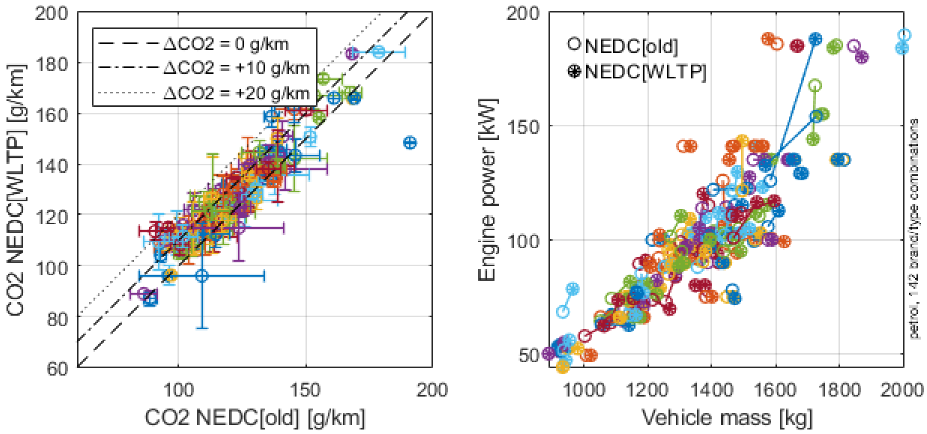

Figure 4-4: For individual petrol vehicle models[3] (142) the NEDC[WLTP] and NEDC[old] average CO_2 values (left), as well as the change in vehicle characteristics average mass and engine power (right) are shown. In the graph on the right, open circles indicate the NEDC characteristics, whereas the circles with asterisk indicate the WLTP characteristics of the same model. A line connecting the two circles shows the direction of the change. Only a few models have a large average change in the transition from the NEDC model to the WLTP model.

For most vehicle models there are minor changes in the physical characteristics in the transition from NEDC to WLTP. When changes occur, this is often an increase in mass, or power, or both. Such trends are also present over the decades. Vehicles have become heavier for safety and comfort. Weight reduction options temper this trend slightly. The power had to increase to keep pace with the weight, but further power increases occurred as well. The NEDC[WLTP] weight seems directly related to the WLTP weight, options are incorporated, and are not the cause of the observed changes. The shift of the fleet to higher mass and power, as observed in the previous chapter, is only visible partly in the model comparisons.

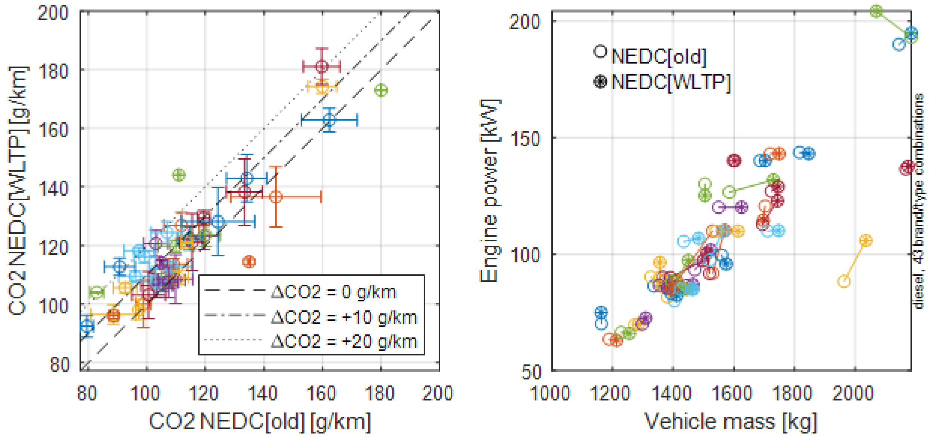

Figure 4-5: For individual diesel vehicle models3 (43) the NEDC[WLTP] and NEDC[old] average CO_2 values (left), as well as the change in vehicle characteristics average mass and engine power (right) are shown. For diesel vehicles fewer models have enough registrations to compare the average. Compared to petrol relatively more diesel models have a large average change in the transition from the NEDC model to the WLTP model.

[3] For these graphs only vehicle models were chosen for which more than 100 individual vehicles were present. For petrol vehicles this was the case for in total 142 models and for diesel vehicles for in total 43 models.

From a trendline, fitted to the data, it can be concluded that difference between the NEDC[old] and NEDC[WLTP] is slightly larger for petrol cars that are heavier or have higher power. However, the effect is minor, certainly with respect to the observed variation in the difference.

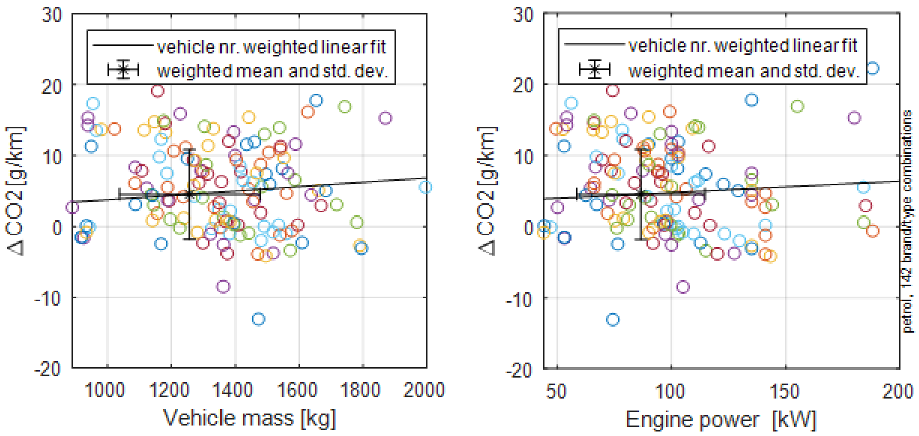

Figure 4-6: For individual petrol vehicle models (142), the delta between NEDC[WLTP] and NEDC[old] model average CO_2 values have been plotted against model average vehicle mass (left) and engine power (right). Per graph, also the vehicle number weighted overall averages and standard deviations (black cross) as well as the similarly calculated linear regression line[4] (black line) have been plotted.

For diesel vehicles, the correlation between the difference in CO_2 and the physical characteristics of the petrol vehicle models is weak. Over the whole range only a few g/km is observed, with a large spread in the results.

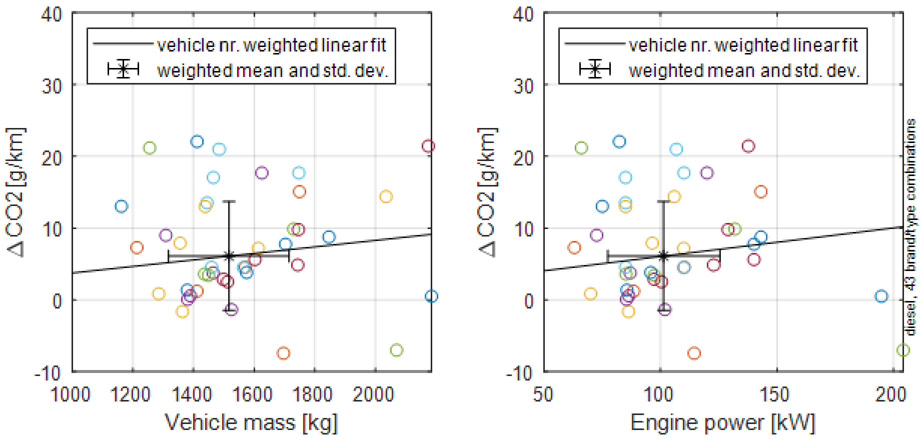

Figure 4-7: Similarly for individual diesel vehicle models (43), the delta between NEDC[WLTP] and NEDC[old] model average CO_2 values have been plotted against model average vehicle mass (left) and engine power (right).

[4] These averages and standard deviations, as well as the linear regression lines have been calculated in a vehicle number weighted fashion as the plotted data points. Each datapoint for a single model, represent widely varying numbers of individual vehicles ranging roughly from 100 to 6000 vehicles per model. Hence, a simple calculation over only the plotted points would be incorrect.

Another representation, with the focus on the difference between CO_2 emissions of the NEDC[old] or NEDC[WLTP], makes the limited change in characteristics on the horizontal axis more apparent. The large variation in CO_2 differences is not correlated with the differences in physical parameters. See Figure 4-7 and Figure 4-8.

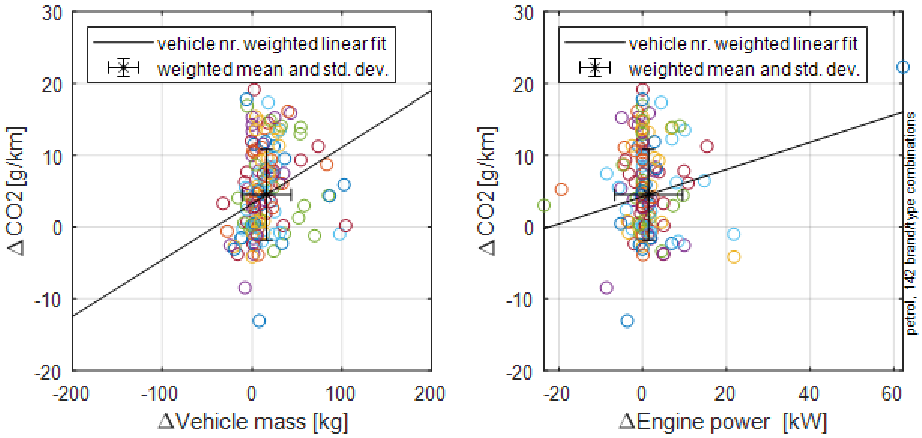

Figure 4-8: Similarly for individual petrol vehicle models (142), the delta between NEDC[WLTP] and NEDC[old] model average CO_2 values have been plotted against the delta in model average vehicle mass (left) and engine power (right).

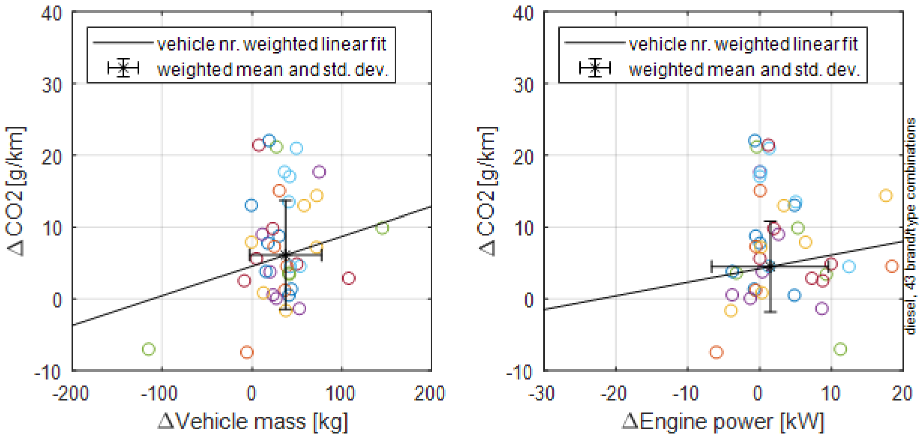

Figure 4-9: Similarly for individual diesel vehicle models (43), the delta between NEDC[WLTP] and NEDC[old] model average CO_2 values have been plotted against the delta in model average vehicle mass (left) and engine power (right).

Putting all the model comparisons together, a number of effects can be observed. First, many models come in different versions with a wide range in CO_2 values, shown in the bandwidths. Therefore, picking one version of a NEDC model and another of the WLTP model can show a large, incidental difference, which are not supported by actual sales. Second, at higher CO_2 and BPM, the differences between NEDC and WLTP models are higher than at lower CO_2 and BPM.
For diesel vehicles this is not observed.

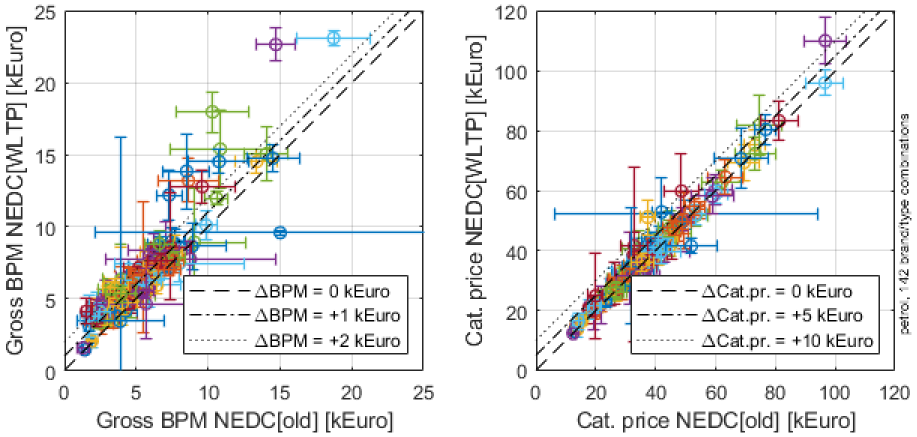

Figure 4-10: For individual petrol vehicle models (142), the NEDC[WLTP] model average BPM tax values plotted against the NEDC[old] model average BPM tax values (left graph) shows an increase as most indicators are above de 45^0 diagonal, due to the NEDC to WLTP transition, of roughly +1 to +2 kEuro. Similarly, the NEDC[WLTP] catalogue price plotted against the NEDC[old] catalogue price (right graph) shows a price change between roughly -5 and +5 kEuro.

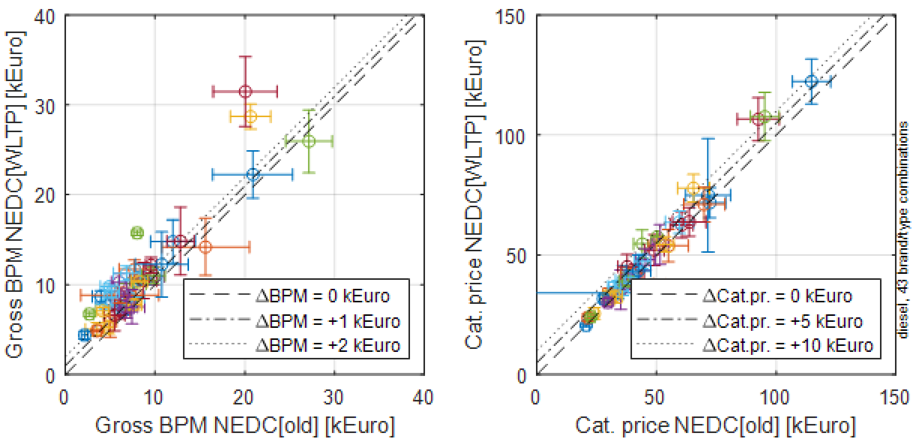

Figure 4-11: Similarly for individual diesel vehicle models (43), the NEDC[WLTP] model average BPM tax values plotted against the NEDC[old] model average BPM tax values (left graph) shows an increase, due to the NEDC to WLTP transition, of roughly +1 to +3 kEuro. Similarly, the NEDC[WLTP] catalogue price plotted against the NEDC[old] catalogue price (right graph) shows a price change between roughly 0 and +10 kEuro.

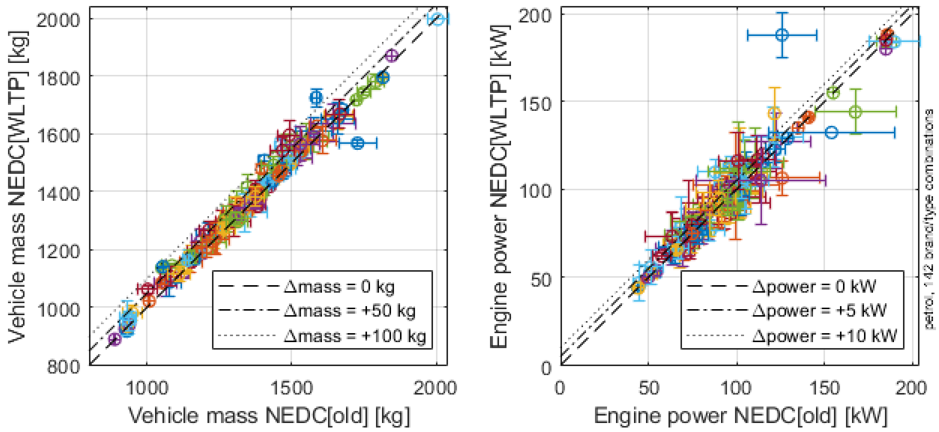

Figure 4-12: The correlation between the mass (left) and engine power (right) of the NEDC and the WLTP versions of the same petrol vehicle models.

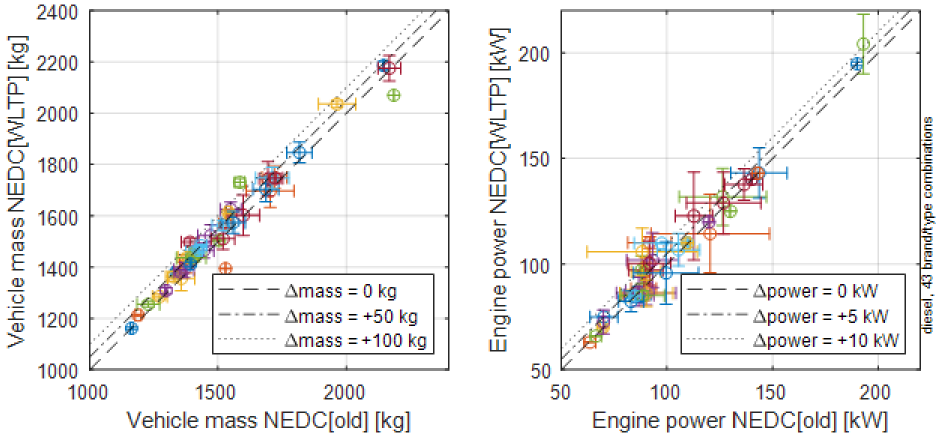

Figure 4-13: The correlation between the mass (left) and engine power (right) of the NEDC and the WLTP versions of the same diesel vehicle models.

5 Comparison of NEDC and WLTP CO_2 values

A large part of this report focusses on the transition from NEDC to WLTP, and the trends observed during this transition. The NEDC[WLTP] value is the key element in this transition, albeit, temporary as the NEDC will phase out. The intention of the WLTP, established already many years ago, is to provide a more representative CO_2 value for the vehicles sold. From 2020 onward, the energy label of vehicles must be based on the WLTP value. Hence the transition to WLTP CO_2 values must be foreseen and planned. Therefore, in this chapter the differences between NEDC[WLTP] and WLTP values are analysed, for a separate transition from NEDC to WLTP based CO_2 values. Some care must be taken with the preliminary results of the current analyses. The results are considered preliminary due to the fact that the phase out of NEDC values is still ongoing with a deadline end of 2021. During and after this phase out period, new trends may be observed.

The current WLTP CO_2 values are generally much higher than the NEDC[WLTP] value. The typical difference is in the order of 25 g/km. About 15 g/km is a constant offset, and another 10% of the NEDC value is an increasing difference with higher NEDC values. For example, a vehicle of 120 g/km NEDC[WLTP], is expected to have a declared WLTP value of 110% * 120 g/km + 15 g/km = 147 g/km. Minor differences exist for petrol and diesel. The diesel CO_2 value is slightly higher, which might be a result of technologic changes to accommodate RDE; the new pollutant emission legislation.

In the figures below the analyses show petrol vehicles with 8% + 15 g/km difference (Figure 5-1). The diesel vehicles have a difference of 12% + 16 g/km (Figure 5-3). Petrol vehicles are the majority of the total sales. This is based on WLTP vehicles only, so the CO_2 values NEDC[WLTP] and WLTP are directly comparable. Combining this effect with the results of Table 3-1, of comparable NEDC[old] and NEDC[WLTP] vehicles, add another 2%, mainly from diesel vehicles.

The 10% + 15 g/km is the combination of the effect of NEDC[old] to NEDC[WLTP], discussed before, on the basis of the same physical characteristics of the vehicle, and the NEDC to WLTP CO_2 of WLTP vehicles. It is dominated by the latter.
A few gram per kilometre less would be the estimated effect of the NEDC[old] to NEDC[WLTP] transition alone.

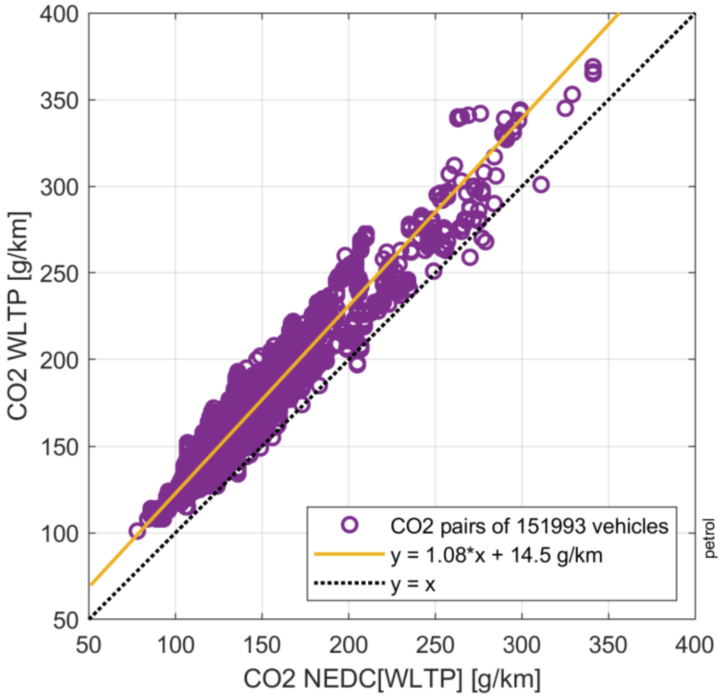

Figure 5-1: The correlation between the NEDC[WLTP] and the WLTP CO_2 values of all registered WLTP petrol vehicles.

Given the spread in the distribution (vehicles with a few g/km extra CO_2 for the WLTP as for the NEDC[WLTP], to vehicles with a 50 g/km or more difference), it is clear that the WLTP value for a given NEDC[WLTP] value is not optimized and these differences exhibit rather large random variations. This may be the results of the interpretation of the WLTP test and reporting procedures among manufacturers, and even among type-approval authorities.

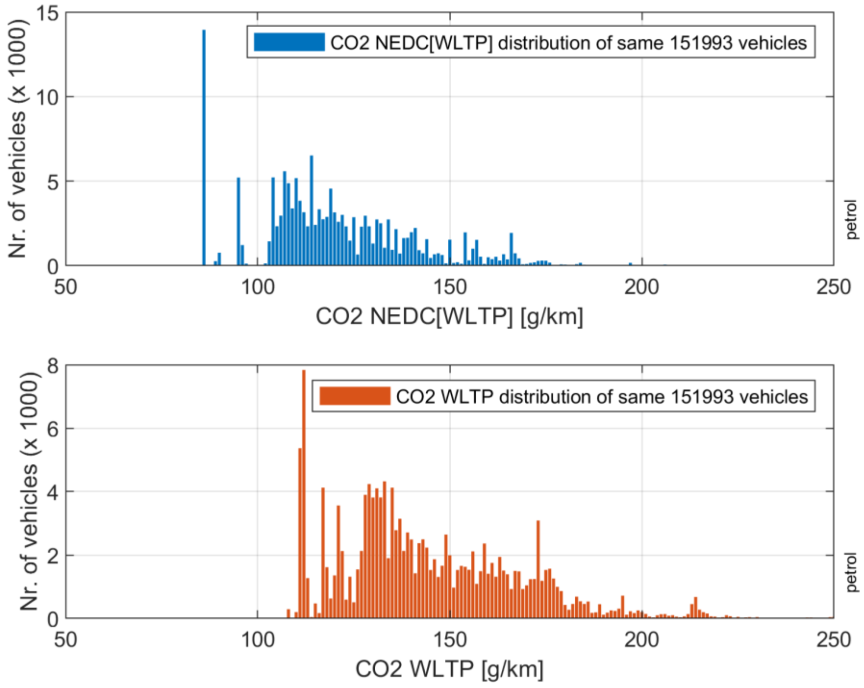

Figure 5-2: The distribution of NEDC[WLTP] and WLTP CO_2 values of petrol vehicles registered.

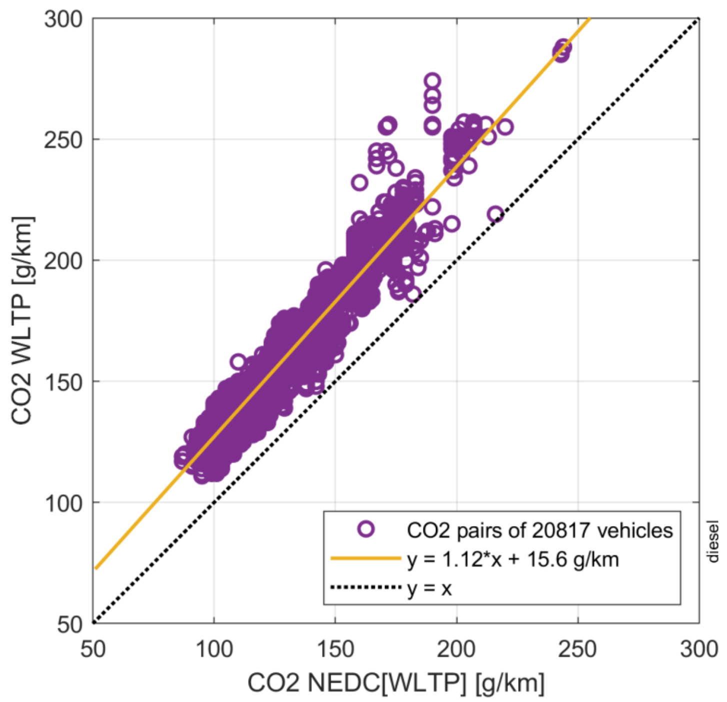

Figure 5-3: The correlation between the NEDC[WLTP] and the WLTP CO_2 values of all registered WLTP diesel vehicles.

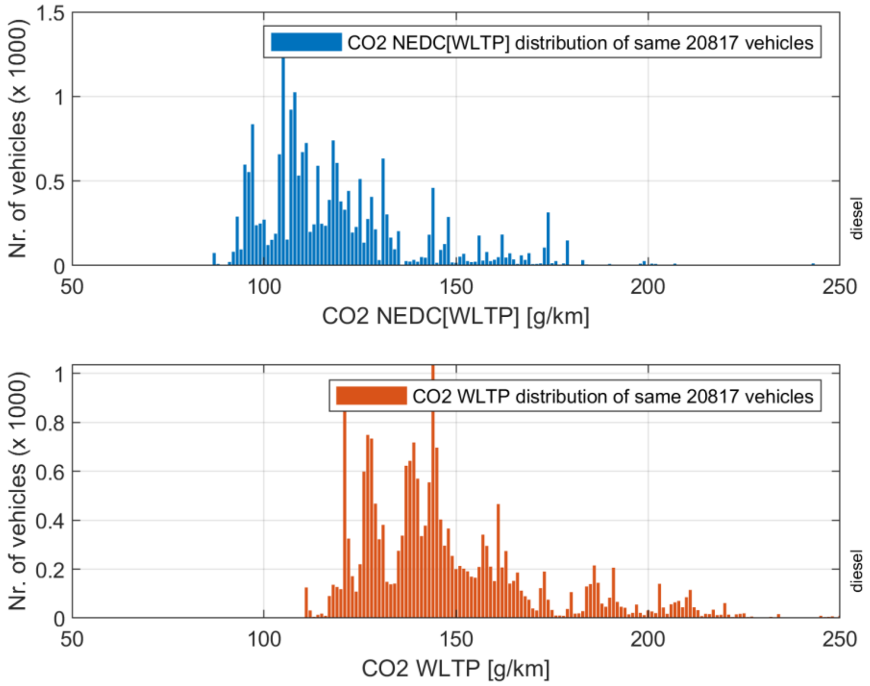

Figure 5-4: The distribution of NEDC[WLTP] and WLTP CO_2 values of diesel vehicles registered.

In Appendix A two tables (petrol and diesel) with numbers are provided that form the basis for Figure 5-2 and Figure 5-4. These tables are intended to provide the necessary information for further analyses for petrol and diesel vehicles. Some care must be taken using the tables. The tables were derived at a time when there was no public registration by the RDW of WLTP values yet.

5.1 The NEDC and WLTP values of the same WLTP vehicle models

The WLTP models, selected for the comparison with NEDC models, can also be analysed on their own by comparing the NEDC[WLTP] with the WLTP CO_2 values. This more structured analyses, grouping data together of common vehicle models, provides the similar result as the analyses of all the WLTP vehicles as a whole. The transition from NEDC to WLTP based on different vehicle models can be biased by the choice of different versions of the same vehicle model. In the analyses, the average characteristics of the NEDC and of the WLTP models weighted by the registrations are used. The bandwidths in versions of a given model are shown by the error bars in the figures (Figure 5-5 and Figure 5-6). The bandwidths of the WLTP values are larger than those of the NEDC values. Despite options for a vehicle model have a larger effect on the WLTP, the variation in NEDC values remain substantial.

For petrol vehicles the average difference is around 25 g/km, for diesel vehicles the difference is around 30 g/km. A large bandwidth is observed, together with an upward trend in the absolute deviation in (Δg/km) for higher absolute values (g/km). The results are consistent for the regressions on all vehicle registrations, yielding the generic +10% and +15 g/km difference, with a large bandwidth.

Examining individual vehicle models, many show large variations, as presented by the bars in Figure 5-5 and Figure 5-6. The bars extend in both directions. It is not only the WLTP value that varies for a given, but the NEDC[WLTP] values too. With the change of the system to WLTP, the individual options on a given vehicle are reflected in the NEDC[WLTP] and the WLTP CO_2 value.

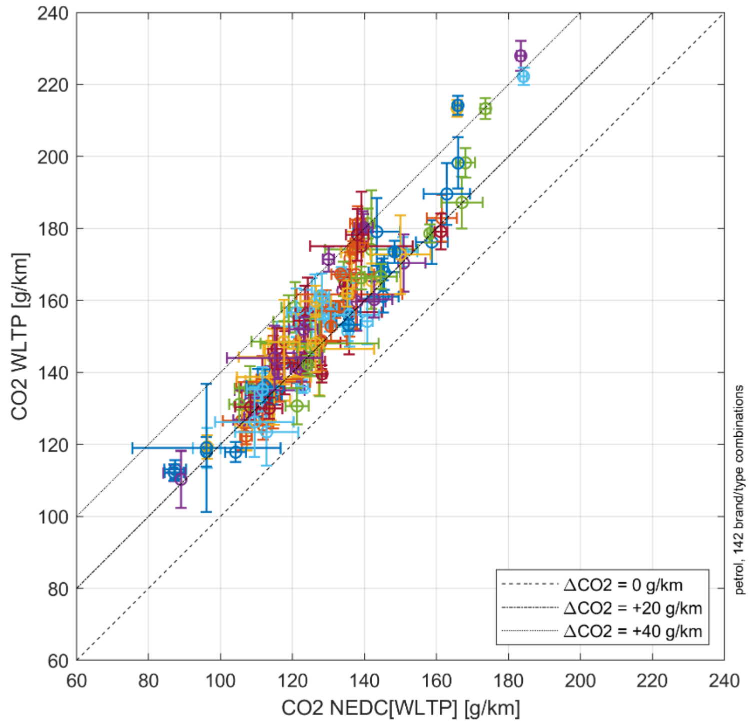

Figure 5-5: The NEDC[WLTP] and the WLTP CO_2 values of specific petrol vehicle models show the same trend as all vehicles. Some of the variations are caused by the model options, which lead to a larger spread in WLTP than in NEDC[WLTP] values.

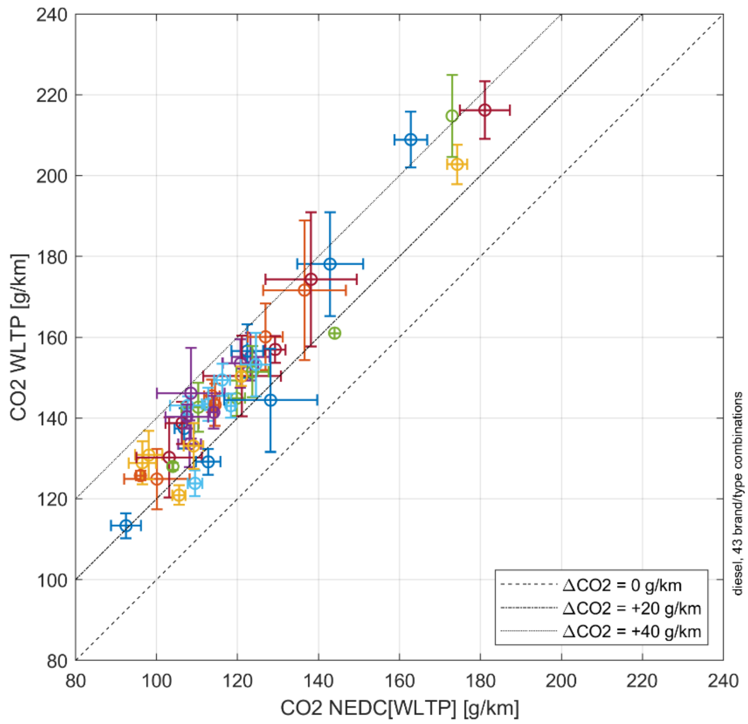

Figure 5-6: The NEDC[WLTP] and the WLTP CO_2 values of specific diesel vehicle models show the same trend as all vehicles. Some of the variations are caused by the model options, which lead to a larger spread in WLTP than in NEDC[WLTP] values. Almost all diesel vehicle have a difference between 20 and 40 g/km, although different models are sold with larger variations within the model options available.

The difference between NEDC[WLTP] and WLTP values vary greatly.
See Figure 5-7. This variation is beyond what can be expected on the basis of the CO_2 increasing aspects covered in the legislation.

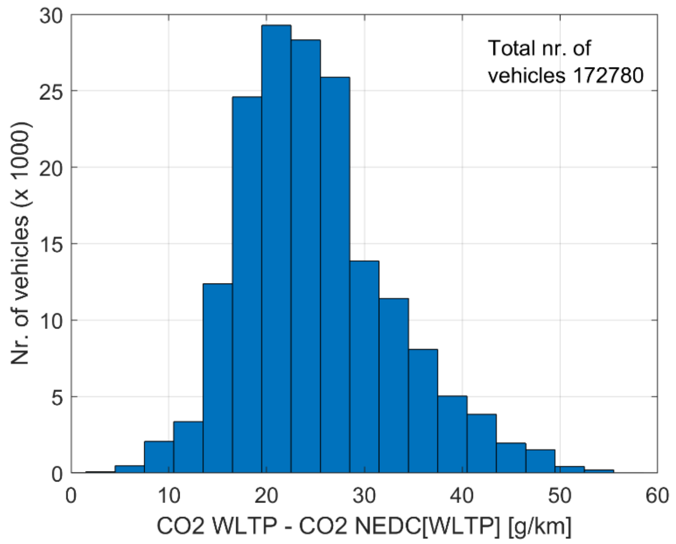

Figure 5-7: The distribution of differences over all WLTP registrations, show al large spread. The difference is 25 g/km, but the normal spread is also 25 g/km with a full range between 5 and 50 g/km.

This large variation in the differences between the CO_2 WLTP and the CO_2 NEDC[WLTP] is remarkable. High values may be construed as “inflated values” for the WLTP CO_2 on top of a legitimate effect. This legitimate effect comes mainly from the procedural changes for determining the NEDC[WLTP] and WLTP value. Only half of the variation can be expected on the basis of the changing vehicle technologies (like changes in test mass, road load settings in the laboratory, and battery state of charge) to improve fuel efficiency.

6 Discussion and conclusions

The current report is the third and final report in a series of three. This report is dedicated to the impact of the transition from NEDC based to WLTP based CO_2 values of new cars on the Dutch car purchase tax (BPM). The second report, issued in October 2018, described the developments up till 1 September 2018. This date is the formal date, all new cars should be registered being type-approved under the new WLTP test procedure instead of the old NEDC test procedure. The only exceptions are vehicles that had been registered by RDW for application of the *end-of-series stock* ("restvoorraad regeling"). The car sales in the period before 1 September 2018 were dominated by NEDC cars. The numbers of WLTP cars slightly increased in the months before September 2018, but stayed well below 20%. Detailed analyses indicated that WLTP cars sold in this period are not representative for trend analysis.

This third report includes the period September 2018 – April 2019. In this period almost all cars from end-of-series stock have been sold and the WLTP cars now represent, close to 90%, of total car sales. The period can be considered to mark the full transition of NEDC to WLTP. At the same time, for different reasons, the sales of diesel (WLTP) vehicles is historically low.

With the current differences between the NEDC[WLTP] and the WLTP values ranging from 5 to 45 g/km it is clear that declared WLTP CO_2 values can be substantially higher than the average WLTP value measured during type approval. The main cause of this discrepancy is the, currently, single purpose of the WLTP value, in the Conformity of Production. If vehicles from the factory have higher CO_2 values than the declared CO_2 value in random sampling, the type-approval have to be adjusted. On the other hand, there are no negative consequences to the inclusion of a substantial, extra margin, up to 10 g/km. This situation may change over time, certainly after 2021, depending on new measures by the European Commission to ensure a proper transition from NEDC to WLTP targets in 2021.

From September 2017 till now, about 500 plug-in hybrid vehicles (PHEV) are sold. Among them about 80 WLTP type approved plug-in hybrids. These limited number of vehicles are mainly in the higher market segments. The CoCs of the WLTP PHEVs were missing, so the necessary vehicle information for analyses was incomplete. Given this number of PHEV vehicles, they were given no special attention. They do not have a significant effect on the Dutch averages presented here.

The manufacturers claim that extra margin in the WLTP CO_2 is needed to meet the Conformity of Production rules. In more detail, the CoP (Conformity of Production) procedure was intended as a check on production vehicles from test results of the prototype vehicle for type-approval. With the WLTP a check on the CO_2 value is now part of the CoP.

Therefore, the causes of the differences and the applied margins by the industry is a complex process involving:

- differences between type-approval prototype versus production model,

- test flexibilities in WLTP testing,
- inherent, uncontrollable test uncertainty,
- effects of the CO_2 interpolation method for individual models,
- effects of the run-in of production vehicle with zero mileage from the factory,
- inter-factory differences and other manufacturer's quality control issues,
- additional safe margins, in relation with the CO_2 targets.

The current WLTP CO_2 values can be used as a basis for a transition of the tax system to WLTP values. A neutral transition, for petrol and diesel combined, would be +10% + 15 g/km, from NEDC[old] to WLTP CO_2. However, as the tax system serves as an incentive for low CO_2 vehicles, a fixed 25 g/km would be considered appropriate to benefit low CO_2 vehicles more. The impression exists that a large fraction of vehicles with high CO_2 values are sold despite the tax incentives for lower CO_2 values, i.e., the current incentive is less effective for the 150 g/km CO_2 and higher values. Compensating for the effect would reward, rather than stem, the upward trend in CO_2 values for new vehicles.

The model-by-model comparison of the NEDC[old] and NEDC[WLTP] values gives a difference in the order of 5.8 g/km. Where the NEDC[WLTP] is higher than the NEDC[old] results. This difference is now close to the fleet average difference of 6.6 g/km. For petrol vehicles, the change in vehicle characteristics, like mass and power explains the majority of this difference. For the same mass and power, the remaining difference is in the order of 1 g/km. For diesel vehicles, the difference of 7 g/km remains, also when compensated for the changed characteristics from NEDC to WLTP.

For petrol vehicles the number of registered vehicles is sufficient to conclude that the results above are the complete effect of the transition to the WLTP. For diesel vehicles the low renewal rate of vehicles, with the low registrations of new vehicles, the results may be biased. For example, the number of imported diesel vehicles in September 2018 till May 2019 is, with 26,000, larger than the new registrations, 20,000 of all WLTP diesel vehicles.

Consequently, in the correlation between NEDC[old] and WLTP CO_2 values, the majority of the average 25 g/km difference is the result from the difference in between NEDC[WLTP] and WLTP. At fleet level 6 g/km of this total difference is visible in the correlation between NEDC[old] and NEDC[WLTP]. The 25 g/km difference will not remain. It is expected that year-by-year changes are dependent on many factors.

These factors include:

- The European sales of Battery Electric Vehicles (BEV) and PHEV compensating the European target of 95 g/km per manufacturer for 2021. In very optimistic scenarios for the introduction of electric vehicles on the European roads, it is assumed that the 15% CO_2 reduction in 2025 and the 37.5% reduction in 2030, are the result of the same fractions of BEV sales, with no further improvement of the conventional vehicles. However, over many decades, it can be observed that real-world fuel efficiency of vehicles improves at a steady pace, also without incentives.
- The discussions on the technical details of the CoP procedure for CO_2 in the UNECE Task Force under WLTP Informal Working Group. Currently, in

practice, the average of every three cars tested, out of the factory, must be below the manufacturer-declared value for these cars. Manufacturers consider this a high risk situation.

- The European Commission, i.e., DG-CLIMA, ability to stem high declared and measured WLTP values. For example, The Commission can decide to base the manufacturer's average CO_2 on the results of the Conformity of Production testing, as a manufacturer is obliged to perform CO_2 testing for every batch of 5000 vehicles produced. This is by far the largest and most representative sample of WLTP CO_2 testing data available on new registrations, based on actual production.
- The differences between NEDC[WLTP] and WLTP CO_2 values of new WLTP vehicles, e.g., by double testing. The situation is as yet unclear. In the case of double testing, there are certainly flexibilities to achieve higher CO_2 values, as legislation, for manufacturers, was mainly intended to avoid inappropriate practice to produce low values. Test flexibilities which increase emissions were not considered relevant.
- The specific vehicle models and sales in the Netherlands. In the past specific models, which met certain tax brackets, were only on sale in the Netherlands. Such situations can occur again, given the taxation scheme.

The current analysis results are considered preliminary due to the fact that the phase out of NEDC values is still ongoing with a deadline end of 2021. During, and after, this phase out period, new trends may be observed. Updating the analysis regularly, e.g. yearly, will make sure new trends are identified in time.

7 Signature

The Hague, 2 July 2019 TNO

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A Tables

Table 7-1: The WLTP petrol cars registrations sorted by NEDC CO_2 values (left), and WLTP CO_2 values (right).

CO_2 NEDC[WLTP]	**Nr. of vehicles**	**CO_2 WLTP, mean**	**CO_2 WLTP, std. dev.**	**CO_2 WLTP**	**Nr. of vehicles**	**CO_2 NEDC[WLTP], mean**	**CO_2 NEDC[WLTP], std. dev.**
78	1	101.0	0.0	**78**	0		
79	0			**79**	0		
80	0			**80**	0		
81	0			**81**	0		
82	0			**82**	0		
83	0			**83**	0		
84	26	108.0	0.0	**84**	0		
85	0			**85**	0		
86	13947	111.6	0.6	**86**	0		
87	3	111.7	2.3	**87**	0		
88	0			**88**	0		
89	268	108.1	0.5	**89**	0		
90	765	112.7	0.6	**90**	0		
91	2	108.0	0.0	**91**	0		
92	0			**92**	0		
93	2	109.0	1.4	**93**	0		
94	4	116.0	0.0	**94**	0		
95	5211	117.9	1.2	**95**	0		
96	1219	117.6	1.0	**96**	0		
97	120	121.1	0.9	**97**	0		
98	1	116.0	0.0	**98**	0		
99	4	117.0	0.0	**99**	0		
100	0			**100**	0		
101	22	118.1	0.4	**101**	1	78.0	0.0
102	133	127.2	0.4	**102**	0		
103	1440	119.8	3.7	**103**	0		
104	5217	122.8	3.2	**104**	0		
105	2330	126.5	5.8	**105**	0		
106	2961	129.6	7.1	**106**	0		
107	5584	128.4	5.4	**107**	0		
108	4874	129.5	3.4	**108**	293	88.6	1.5
109	3384	132.6	5.6	**109**	1	87.0	0.0
110	5178	131.9	3.4	**110**	200	86.0	0.5
111	3839	130.4	5.0	**111**	5369	86.0	0.1
112	3158	137.9	4.9	**112**	7837	86.1	0.7

113	2325	134.1	3.5	**113**	1273	87.5	2.0
114	6517	133.9	4.7	**114**	44	89.5	1.3
115	2411	134.4	4.3	**115**	473	106.1	0.6
116	3335	139.4	7.3	**116**	170	95.1	0.4
117	2744	146.4	6.3	**117**	4125	97.0	3.3
118	2889	145.6	6.2	**118**	1616	95.2	0.7
119	4558	144.0	6.7	**119**	629	95.1	0.5
120	3150	143.4	7.0	**120**	1357	100.1	4.8
121	2594	150.5	8.0	**121**	3563	103.6	2.3
122	3005	140.4	6.9	**122**	2125	105.8	1.8
123	2324	143.0	5.5	**123**	594	104.1	0.7
124	1481	146.7	7.4	**124**	1316	108.4	3.5
125	2868	146.4	6.7	**125**	510	105.4	3.6
126	662	151.3	5.9	**126**	1546	108.0	1.3
127	2306	153.4	8.1	**127**	2130	110.4	5.6
128	2955	158.5	11.2	**128**	3900	108.2	1.8
129	2326	155.5	6.5	**129**	4238	109.0	2.9
130	1309	157.3	4.9	**130**	3814	111.7	3.4
131	2734	162.8	9.3	**131**	4102	109.4	3.6
132	2506	158.4	4.1	**132**	3817	111.1	3.1
133	1059	160.6	6.0	**133**	4324	112.0	3.9
134	2735	164.5	5.7	**134**	1901	113.4	4.3
135	939	159.7	10.0	**135**	4126	114.7	4.5
136	2161	167.3	8.6	**136**	2783	114.4	5.1
137	716	165.6	6.0	**137**	3144	113.5	5.4
138	1633	170.7	5.8	**138**	2130	114.8	6.3
139	1649	166.6	11.1	**139**	2711	117.8	5.0
140	1980	172.4	10.6	**140**	2492	119.1	4.6
141	2231	159.7	8.9	**141**	1424	120.6	5.1
142	918	173.8	10.6	**142**	2376	119.1	5.6
143	731	172.7	11.0	**143**	2496	119.3	5.5
144	1564	166.7	4.7	**144**	2235	121.2	5.0
145	455	168.5	8.5	**145**	1529	120.7	7.8
146	672	168.7	6.9	**146**	1868	122.2	6.3
147	733	167.3	5.9	**147**	1311	119.8	4.3
148	632	169.2	5.4	**148**	1664	120.0	4.5
149	140	174.6	7.9	**149**	2644	125.6	10.1
150	1536	172.5	2.9	**150**	1990	123.3	6.3
151	157	171.6	9.0	**151**	973	123.2	7.1
152	206	175.6	4.0	**152**	1528	125.3	7.4
153	114	171.8	6.0	**153**	1658	124.6	6.8
154	1966	176.2	2.4	**154**	1630	125.4	6.5
155	314	185.2	6.2	**155**	1535	127.0	7.6

156	1005	177.8	4.6	**156**	2113	130.4	6.2
157	1526	174.9	4.8	**157**	1091	131.2	7.5
158	531	177.5	3.3	**158**	1491	131.6	5.0
159	106	185.5	6.1	**159**	2363	131.2	3.5
160	500	179.0	3.6	**160**	1411	130.9	3.7
161	383	183.1	7.3	**161**	1752	135.1	6.3
162	527	187.1	7.1	**162**	1318	133.6	8.5
163	301	195.2	9.1	**163**	1939	135.8	7.2
164	680	191.0	3.8	**164**	1511	136.9	7.2
165	374	191.0	4.9	**165**	1393	139.6	6.7
166	1936	206.5	9.6	**166**	929	136.5	6.5
167	732	203.0	9.8	**167**	1501	135.5	8.2
168	431	198.8	5.1	**168**	1485	137.4	8.8
169	78	191.4	7.8	**169**	929	135.9	7.3
170	99	195.7	7.3	**170**	1045	138.8	7.5
171	162	195.7	5.8	**171**	1238	138.9	5.6
172	195	208.5	6.4	**172**	1243	139.5	6.6
173	285	199.2	10.5	**173**	3090	147.1	8.4
174	302	206.3	8.8	**174**	1188	146.3	11.1
175	293	213.7	2.2	**175**	1528	146.6	9.9
176	178	207.9	6.9	**176**	1570	148.8	8.7
177	3	206.3	5.9	**177**	1258	150.0	8.4
178	17	204.2	10.7	**178**	997	151.7	8.0
179	75	219.4	7.2	**179**	864	151.6	8.8
180	64	223.1	5.8	**180**	427	148.1	9.2
181	31	212.4	8.8	**181**	274	145.0	9.0
182	31	220.1	7.9	**182**	458	147.8	9.1
183	88	227.0	6.3	**183**	688	152.5	10.9
184	167	215.5	9.8	**184**	540	149.8	12.3
185	54	228.7	7.2	**185**	457	151.5	10.7
186	9	226.1	5.3	**186**	533	150.6	9.0
187	5	215.2	18.2	**187**	176	152.5	10.8
188	6	220.7	3.9	**188**	193	154.8	8.7
189	12	228.8	5.6	**189**	449	162.5	5.6
190	0			**190**	118	162.5	6.6
191	1	219.0	0.0	**191**	184	163.9	5.3
192	1	208.0	0.0	**192**	255	165.4	5.3
193	22	230.0	7.5	**193**	237	167.1	5.9
194	2	228.5	27.6	**194**	308	165.7	3.2
195	0			**195**	719	165.8	4.4
196	5	222.8	13.0	**196**	119	165.8	5.3
197	168	249.9	1.0	**197**	228	166.6	4.0
198	1	260.0	0.0	**198**	169	167.6	5.1

199	11	209.2	3.4	**199**	254	168.6	4.4
200	22	251.1	8.8	**200**	204	169.3	6.8
201	5	255.0	0.0	**201**	142	168.3	8.4
202	3	218.0	2.6	**202**	61	170.6	11.6
203	24	217.7	13.7	**203**	34	167.5	7.0
204	12	234.7	21.0	**204**	100	168.8	6.0
205	34	231.6	11.2	**205**	133	168.7	5.1
206	62	242.3	2.1	**206**	139	170.7	8.0
207	23	251.3	22.2	**207**	84	168.8	6.8
208	0			**208**	103	170.1	8.6
209	37	222.2	1.5	**209**	59	168.8	5.1
210	5	271.6	1.5	**210**	37	170.6	6.9
211	0			**211**	66	174.6	7.6
212	0			**212**	139	174.1	10.7
213	8	227.3	0.7	**213**	452	169.9	5.4
214	0			**214**	679	168.9	4.6
215	7	232.1	0.7	**215**	277	168.0	6.2
216	0			**216**	198	169.2	4.9
217	7	230.7	1.9	**217**	157	169.8	4.5
218	0			**218**	68	170.1	7.0
219	2	233.0	2.8	**219**	58	173.9	10.7
220	8	245.0	6.8	**220**	29	178.4	15.4
221	19	239.6	0.5	**221**	41	178.7	5.5
222	2	256.5	7.8	**222**	102	188.0	10.7
223	5	242.2	10.1	**223**	71	185.7	10.1
224	27	245.4	4.2	**224**	27	180.9	2.7
225	20	242.3	0.5	**225**	51	183.2	5.6
226	0			**226**	9	189.6	12.7
227	1	251.0	0.0	**227**	33	192.6	13.2
228	0			**228**	42	188.6	10.6
229	9	243.1	4.8	**229**	26	188.6	9.3
230	11	258.9	9.2	**230**	45	185.8	6.3
231	1	242.0	0.0	**231**	23	188.7	11.3
232	1	244.0	0.0	**232**	22	200.0	16.4
233	0			**233**	6	200.3	18.0
234	7	244.9	0.7	**234**	4	187.3	2.1
235	6	270.2	14.3	**235**	4	194.5	16.4
236	5	262.6	0.5	**236**	0		
237	0			**237**	4	201.3	19.3
238	0			**238**	1	206.0	0.0
239	1	276.0	0.0	**239**	15	213.7	10.0
240	0			**240**	18	216.0	7.3
241	3	271.0	0.0	**241**	20	212.0	10.9

242	9	280.9	1.2	**242**	26	218.9	9.8
243	1	282.0	0.0	**243**	32	214.9	9.1
244	1	263.0	0.0	**244**	31	218.2	10.9
245	5	276.0	0.0	**245**	19	211.9	12.6
246	36	268.0	1.3	**246**	8	214.8	14.9
247	0			**247**	3	200.0	5.2
248	2	280.0	1.4	**248**	13	196.8	0.8
249	6	263.5	13.7	**249**	42	197.1	0.9
250	2	271.0	0.0	**250**	56	197.5	3.5
251	1	295.0	0.0	**251**	61	200.6	12.2
252	0			**252**	10	198.8	1.5
253	7	294.3	2.1	**253**	8	200.9	1.6
254	9	274.2	13.3	**254**	10	204.7	9.9
255	5	274.2	1.3	**255**	9	207.2	11.1
256	2	264.0	1.4	**256**	4	214.0	11.5
257	19	294.1	6.4	**257**	1	204.0	0.0
258	1	307.0	0.0	**258**	1	220.0	0.0
259	0			**259**	2	270.0	0.0
260	0			**260**	1	198.0	0.0
261	1	312.0	0.0	**261**	0		
262	0			**262**	3	231.3	8.1
263	50	339.9	0.3	**263**	16	230.8	11.6
264	1	276.0	0.0	**264**	3	222.7	27.1
265	9	328.6	23.8	**265**	10	225.2	23.6
266	2	277.0	0.0	**266**	9	235.7	21.8
267	1	281.0	0.0	**267**	9	241.7	13.0
268	3	285.7	9.0	**268**	15	251.1	11.7
269	3	341.0	0.0	**269**	10	242.1	12.3
270	4	273.3	16.5	**270**	5	237.8	28.4
271	0			**271**	6	244.8	4.4
272	4	285.8	9.5	**272**	1	210.0	0.0
273	1	298.0	0.0	**273**	4	232.5	26.0
274	0			**274**	2	260.0	7.1
275	5	282.8	2.9	**275**	3	241.7	11.5
276	1	342.0	0.0	**276**	13	246.2	7.8
277	4	290.3	13.5	**277**	2	266.0	0.0
278	28	308.0	0.0	**278**	1	235.0	0.0
279	2	268.0	0.0	**279**	2	245.0	4.2
280	0			**280**	4	256.8	17.3
281	0			**281**	12	259.8	14.9
282	0			**282**	2	242.5	0.7
283	0			**283**	1	242.0	0.0
284	4	303.5	15.6	**284**	0		

285	8	306.0	0.0	**285**	0		
286	0			**286**	2	275.0	0.0
287	0			**287**	1	270.0	0.0
288	0			**288**	1	270.0	0.0
289	2	330.5	0.7	**289**	0		
290	3	339.0	0.0	**290**	2	284.0	0.0
291	2	328.0	1.4	**291**	0		
292	0			**292**	6	253.5	0.5
293	0			**293**	0		
294	0			**294**	3	257.0	0.0
295	2	332.5	2.1	**295**	5	255.8	2.7
296	0			**296**	15	258.0	6.4
297	0			**297**	3	263.7	11.5
298	5	338.0	0.0	**298**	2	275.0	2.8
299	26	343.4	0.5	**299**	0		
300	0			**300**	1	272.0	0.0
301	0			**301**	1	311.0	0.0
302	0			**302**	0		
303	0			**303**	1	265.0	0.0
304	0			**304**	0		
305	0			**305**	0		
306	0			**306**	8	285.0	0.0
307	0			**307**	1	258.0	0.0
308	0			**308**	28	278.0	0.0
309	0			**309**	0		
310	0			**310**	0		
311	1	301.0	0.0	**311**	0		
312	0			**312**	1	261.0	0.0
313	0			**313**	0		
314	0			**314**	0		
315	0			**315**	0		
316	0			**316**	0		
317	0			**317**	2	284.0	0.0
318	0			**318**	0		
319	0			**319**	0		
320	0			**320**	0		
321	0			**321**	0		
322	0			**322**	0		
323	0			**323**	0		
324	0			**324**	0		
325	4	345.0	0.0	**325**	0		
326	0			**326**	0		
327	0			**327**	1	291.0	0.0

328	0			**328**	0		
329	1	353.0	0.0	**329**	1	291.0	0.0
330	0			**330**	1	289.0	0.0
331	0			**331**	2	292.0	4.2
332	0			**332**	0		
333	0			**333**	0		
334	0			**334**	1	295.0	0.0
335	0			**335**	0		
336	0			**336**	0		
337	0			**337**	0		
338	0			**338**	5	298.0	0.0
339	0			**339**	7	274.6	14.4
340	0			**340**	53	263.3	0.7
341	3	366.7	2.1	**341**	3	269.0	0.0
342	0			**342**	1	276.0	0.0
343	0			**343**	15	299.0	0.0
344	0			**344**	11	299.0	0.0
345	0			**345**	4	325.0	0.0
346	0			**346**	0		
347	0			**347**	0		
348	0			**348**	0		
349	0			**349**	0		
350	0			**350**	0		
351	0			**351**	0		
352	0			**352**	0		
353	0			**353**	1	329.0	0.0
354	0			**354**	0		
355	0			**355**	0		
356	0			**356**	0		
357	0			**357**	0		
358	0			**358**	0		
359	0			**359**	0		
360	0			**360**	0		
361	0			**361**	0		
362	0			**362**	0		
363	0			**363**	0		
364	0			**364**	0		
365	0			**365**	1	341.0	0.0
366	0			**366**	1	341.0	0.0
367	0			**367**	0		
368	0			**368**	0		
369	0			**369**	1	341.0	0.0

Table 7-2: Registrations of WLTP diesel vehicles, sorted on the basis of NEDC CO_2 values (left), and WLTP CO_2 values (right)

CO_2 NEDC[WLTP]	**Nr. of vehicles**	**CO_2 WLTP, mean**	**CO_2 WLTP, std. dev.**	**CO_2 WLTP**	**Nr. of vehicles**	**CO_2 NEDC[WLTP], mean**	**CO_2 NEDC[WLTP], std. dev.**
87	74	117.7	1.0	**87**	0		
88	9	120.0	0.0	**88**	0		
89	0			**89**	0		
90	0			**90**	0		
91	21	122.5	5.9	**91**	0		
92	81	121.9	1.2	**92**	0		
93	289	120.4	2.4	**93**	0		
94	95	123.2	2.4	**94**	0		
95	597	122.2	6.7	**95**	0		
96	553	126.4	3.2	**96**	0		
97	836	123.3	3.2	**97**	0		
98	238	128.9	2.4	**98**	0		
99	248	127.9	3.7	**99**	0		
100	271	134.2	5.6	**100**	0		
101	121	124.4	6.9	**101**	0		
102	152	135.0	4.5	**102**	0		
103	188	131.9	5.8	**103**	0		
104	658	132.2	8.0	**104**	0		
105	1264	138.5	2.4	**105**	0		
106	153	135.4	4.7	**106**	0		
107	922	137.6	7.4	**107**	0		
108	1025	126.4	5.9	**108**	0		
109	532	134.2	6.2	**109**	0		
110	671	142.3	3.9	**110**	0		
111	725	132.4	6.3	**111**	125	95.0	0.0
112	199	132.4	5.9	**112**	31	95.5	1.6
113	243	141.2	4.9	**113**	5	100.2	1.1
114	590	141.8	5.5	**114**	13	97.5	3.5
115	247	144.1	2.8	**115**	18	97.8	5.0
116	235	140.8	6.7	**116**	9	98.3	4.7
117	388	139.4	4.8	**117**	90	91.4	4.9
118	740	146.9	4.8	**118**	136	97.4	5.1
119	607	146.0	3.3	**119**	127	95.6	6.5
120	379	148.4	3.9	**120**	118	94.3	3.7
121	330	147.3	6.3	**121**	920	101.9	5.8
122	441	148.4	4.2	**122**	325	100.5	5.4
123	195	153.2	5.5	**123**	171	98.0	6.3

124	228	159.5	5.1	**124**	108	99.2	4.7
125	512	155.9	5.8	**125**	220	101.7	6.5
126	135	155.0	5.0	**126**	599	99.2	6.0
127	275	158.0	8.6	**127**	749	103.0	6.7
128	406	161.9	8.5	**128**	734	101.8	6.0
129	214	160.0	7.5	**129**	468	104.2	5.9
130	32	158.4	3.7	**130**	322	102.9	5.9
131	633	161.8	4.1	**131**	381	108.1	4.4
132	302	163.4	6.1	**132**	148	107.6	6.6
133	165	169.7	5.2	**133**	138	109.6	7.2
134	96	163.7	4.0	**134**	141	106.3	6.0
135	203	166.5	5.4	**135**	275	109.3	6.7
136	4	162.8	7.5	**136**	337	109.5	5.6
137	26	160.0	7.2	**137**	623	107.9	4.3
138	23	162.5	9.4	**138**	643	108.2	5.1
139	33	161.8	7.3	**139**	718	107.0	4.1
140	22	175.1	4.2	**140**	570	107.3	5.3
141	50	172.6	7.4	**141**	335	110.8	5.7
142	46	169.3	10.0	**142**	378	111.1	6.5
143	182	182.7	7.3	**143**	555	110.7	5.2
144	459	168.2	9.8	**144**	1037	113.6	5.2
145	16	177.1	10.8	**145**	697	116.7	5.0
146	92	181.1	10.9	**146**	403	117.9	4.4
147	127	183.7	10.4	**147**	296	118.8	4.4
148	287	182.8	7.4	**148**	366	118.3	4.6
149	18	183.9	2.0	**149**	254	120.5	3.9
150	16	176.2	8.7	**150**	200	120.4	4.0
151	52	188.5	4.8	**151**	213	120.7	2.9
152	69	191.2	4.3	**152**	202	121.5	3.9
153	26	186.4	8.0	**153**	191	121.7	3.8
154	20	189.6	5.3	**154**	169	122.9	5.1
155	22	187.8	5.4	**155**	165	125.4	4.3
156	177	190.4	3.0	**156**	209	125.9	5.0
157	29	192.0	3.0	**157**	341	127.4	3.6
158	80	201.0	7.8	**158**	295	128.2	4.0
159	26	191.9	4.7	**159**	210	128.8	4.0
160	34	195.6	15.1	**160**	151	132.0	5.5
161	49	187.8	6.1	**161**	466	138.4	7.7
162	183	209.3	3.8	**162**	207	130.7	4.9
163	47	201.5	10.0	**163**	274	130.4	5.3
164	72	185.5	1.8	**164**	141	129.9	5.8
165	36	200.1	11.4	**165**	152	129.6	5.7
166	9	196.8	1.7	**166**	186	133.9	6.5

167	60	214.5	13.2	**167**	112	133.8	6.1
168	33	209.8	5.8	**168**	89	132.7	5.8
169	73	206.9	2.5	**169**	75	131.6	4.9
170	8	211.5	10.4	**170**	39	135.6	5.6
171	9	220.3	24.8	**171**	31	135.5	6.2
172	12	241.6	23.8	**172**	122	134.1	4.3
173	106	217.1	5.4	**173**	190	132.3	4.6
174	314	203.1	4.3	**174**	75	133.3	6.2
175	13	200.8	17.6	**175**	33	137.5	8.8
176	26	202.8	7.2	**176**	10	139.7	5.6
177	2	212.5	0.7	**177**	10	143.4	4.7
178	12	220.8	8.5	**178**	9	144.7	5.6
179	148	215.8	7.4	**179**	37	144.2	3.9
180	1	214.0	0.0	**180**	106	143.7	2.1
181	0			**181**	18	147.4	6.9
182	1	186.0	0.0	**182**	19	150.9	7.8
183	32	216.5	11.1	**183**	28	154.5	6.4
184	6	197.0	0.0	**184**	129	152.9	8.7
185	4	204.5	4.0	**185**	139	148.2	5.1
186	0			**186**	215	147.7	5.2
187	1	211.0	0.0	**187**	144	151.2	8.5
188	1	212.0	0.0	**188**	59	150.7	6.5
189	0			**189**	46	153.7	7.2
190	9	261.0	16.1	**190**	83	153.2	9.4
191	2	212.0	1.4	**191**	206	154.2	4.6
192	0			**192**	66	157.7	6.5
193	0			**193**	46	154.5	4.0
194	0			**194**	42	157.2	5.5
195	0			**195**	15	158.1	3.9
196	0			**196**	21	162.7	8.8
197	0			**197**	55	170.7	8.6
198	11	243.5	10.5	**198**	21	163.6	6.9
199	26	238.6	6.2	**199**	12	169.8	5.1
200	0			**200**	31	173.2	2.7
201	11	250.1	1.9	**201**	27	169.7	8.0
202	9	246.4	2.2	**202**	20	172.5	3.6
203	2	252.0	7.1	**203**	140	173.2	3.1
204	0			**204**	43	174.7	6.6
205	4	246.5	5.2	**205**	17	172.5	6.5
206	1	250.0	0.0	**206**	56	171.4	4.4
207	11	255.2	0.8	**207**	64	167.9	6.2
208	0			**208**	70	167.7	8.0
209	0			**209**	44	165.0	5.7

210	0			**210**	85	164.9	4.9
211	0			**211**	115	165.3	6.2
212	2	256.0	0.0	**212**	44	170.7	7.5
213	2	251.0	0.0	**213**	32	169.3	5.4
214	0			**214**	8	170.8	5.9
215	0			**215**	17	174.4	9.4
216	1	219.0	0.0	**216**	16	176.5	3.0
217	0			**217**	34	177.2	4.1
218	0			**218**	12	176.6	2.9
219	0			**219**	13	180.0	11.2
220	1	255.0	0.0	**220**	61	173.1	1.0
221	0			**221**	14	173.6	1.6
222	0			**222**	4	180.3	7.1
223	0			**223**	15	179.9	2.7
224	0			**224**	17	177.4	4.3
225	0			**225**	19	179.6	1.5
226	0			**226**	4	179.5	2.4
227	0			**227**	6	181.3	2.6
228	0			**228**	1	175.0	0.0
229	0			**229**	2	180.5	3.5
230	0			**230**	1	178.0	0.0
231	0			**231**	0		
232	0			**232**	5	164.6	10.3
233	0			**233**	0		
234	0			**234**	16	198.0	4.0
235	0			**235**	0		
236	0			**236**	0		
237	0			**237**	3	198.7	0.6
238	0			**238**	1	175.0	0.0
239	0			**239**	2	186.0	26.9
240	0			**240**	0		
241	0			**241**	2	198.5	0.7
242	0			**242**	2	182.5	21.9
243	12	285.3	0.5	**243**	2	185.5	19.1
244	1	288.0	0.0	**244**	3	202.0	0.0
245	0			**245**	9	171.3	11.6
246	0			**246**	4	198.5	0.6
247	0			**247**	5	201.2	1.5
248	0			**248**	7	201.9	2.7
249	0			**249**	2	199.0	0.0
250	0			**250**	9	201.1	2.2
251	0			**251**	9	203.1	6.0
252	0			**252**	0		

253	0			**253**	0		
254	0			**254**	2	204.0	4.2
255	0			**255**	12	200.7	15.3
256	0			**256**	12	183.1	17.3
257	0			**257**	2	205.0	2.8
258	0			**258**	0		
259	0			**259**	0		
260	0			**260**	0		
261	0			**261**	0		
262	0			**262**	0		
263	0			**263**	0		
264	0			**264**	1	190.0	0.0
265	0			**265**	0		
266	0			**266**	0		
267	0			**267**	0		
268	0			**268**	3	190.0	0.0
269	0			**269**	0		
270	0			**270**	0		
271	0			**271**	0		
272	0			**272**	0		
273	0			**273**	0		
274	0			**274**	2	190.0	0.0
275	0			**275**	0		
276	0			**276**	0		
277	0			**277**	0		
278	0			**278**	0		
279	0			**279**	0		
280	0			**280**	0		
281	0			**281**	0		
282	0			**282**	0		
283	0			**283**	0		
284	0			**284**	0		
285	0			**285**	8	243.0	0.0
286	0			**286**	4	243.0	0.0
287	0			**287**	0		
288	0			**288**	1	244.0	0.0