

Real-world fuel consumption of popular European passenger car models

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Summary

Official fuel consumption values of new passenger cars in Europe are becoming increasingly unrepresentative of real-world performance. The divergence between official and real-world fuel consumption values more than quadrupled over the last fourteen years. After EU-wide CO₂ standards were introduced in 2009, official fuel consumption values decreased by 15 percent while real-world figures only decreased by 2 percent. This divergence undermines climate change mitigation efforts and costs the average car owner €450 per year.

This study compares official fuel consumption values measured in laboratories with the real-world performance of 20 popular vehicle models. All models claim significant improvements in fuel efficiency since 2009, with reductions in official fuel consumption values ranging from 8 to 30 percent. On-road measurements, however, indicate that eight models made little to no improvement in real-world fuel efficiency. Five models achieved more than a 10 percent reduction in real-world fuel consumption since 2009. Model overhauls are frequently followed by abrupt

reductions in official fuel consumption values. Real-world fuel consumption values are, however, rarely reduced to the same extent, indicating that fuel efficiency improvements measured during laboratory testing do not fully materialize on the road.

The trend toward increasingly unrealistic fuel consumption values can be traced back to the exploitation of flexibilities in the current vehicle testing procedure. While the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) will be introduced in the EU in 2017 and will help align official and real-world fuel consumption values, it will not by itself solve the problem of unrealistic fuel consumption values. Further actions are needed, including in-use conformity testing of randomly selected vehicles on the road and the establishment of a EU-wide type-approval authority.

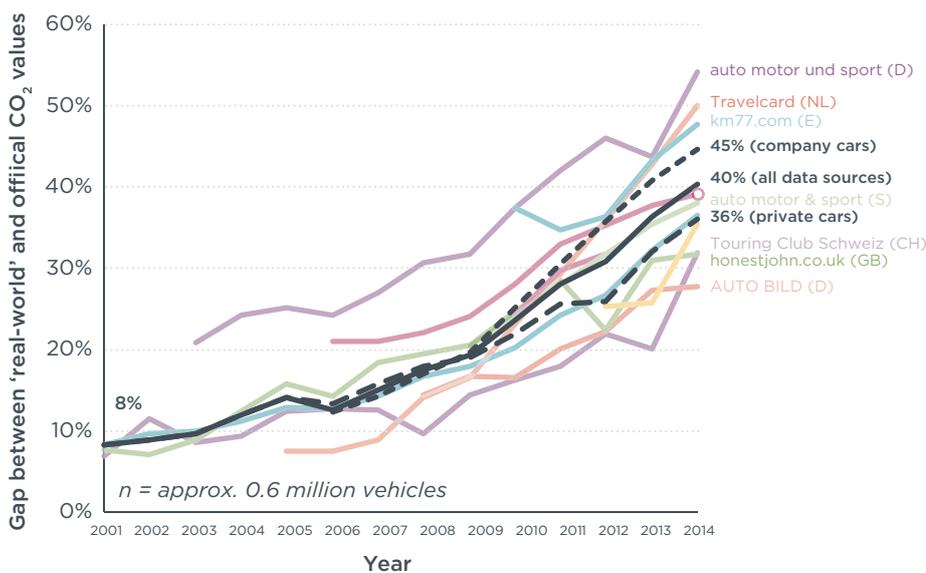


Figure 1: Divergence between real-world and manufacturers' reported CO₂ emissions for various real-world data sources, including average estimates for private cars, company cars, and all data sources.

Introduction

The growing divergence between real-world fuel consumption values and official laboratory measurements of new European passenger cars undermines policies designed to mitigate climate change and reduce fuel expenses for consumers. The latest "From Laboratory to Road" study of the International Council on Clean Transportation (ICCT) estimates real-world fuel

consumption values from data on almost 600,000 cars from eleven data sources covering six European countries.¹ The data sources include websites, records from leasing companies, and on-road vehicle tests. Based on this data, the study concludes that the divergence between real-world and official CO₂ values of new cars increased from about 8 percent in 2001 to 40 percent in 2014 (see Figure 1).

The divergence between official and real-world CO₂ values is important for all stakeholders:

- **For society** as a whole, the gap undermines efforts to mitigate climate change and reduce fossil fuel imports into the EU.
- **For governments**, the gap compromises tax systems and incentive schemes that are based on CO₂ values and can thus lead to lost tax revenues and misallocation of public funds.
- **For car manufacturers**, the divergence puts those that want to report realistic CO₂ emission values at a competitive disadvantage. Manufacturers reporting unrealistic CO₂ values may also damage their credibility and may erode public and regulator trust in the industry.
- **For an average car owner**, the divergence translates into increased fuel expenses of €450 per year.

This paper focuses on the consumer impacts of the growing divergence by presenting real-world fuel consumption values for selected popular car models. For consumers, real-world fuel consumption values have been decreasing less than suggested by official values. After EU-wide CO₂ standards were introduced in 2009, official fuel consumption values decreased

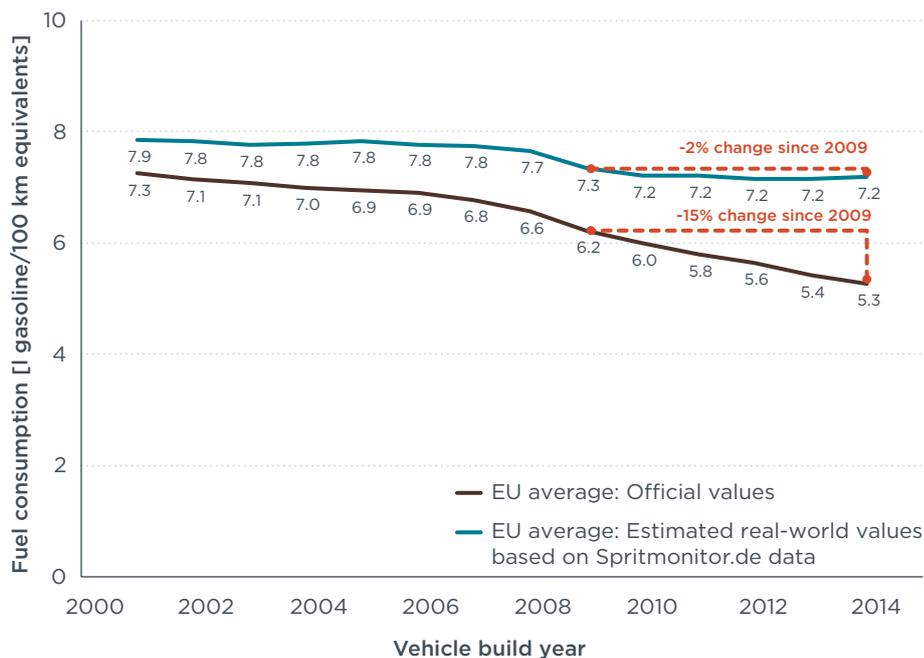


Figure 2. Development of average official and real-world fuel consumption values of new European passenger cars.

by 15 percent through 2014, while real-world values only decreased by 2 percent (see Figure 2). A closer look at individual vehicle models helps explain this trend.

Performance of individual models

Virtually all models in the European market show a growing divergence between on-road and official fuel consumption. Nonetheless, while this is a systemic, industry-wide problem, an examination of individual models reveals that the divergence can vary significantly between different models.

Figure 3 and 4 show the development of official and real-world fuel consumption values for twenty of the most popular car models in Germany from 2001 to 2014.² Each model's share of the German new car

market is presented in the graphs. The twenty models represent roughly 40 percent of all passenger cars registered in Germany during this time. Official fuel consumption values were calculated as gasoline consumption equivalents of the sales-weighted average CO₂ values of both diesel and gasoline vehicles.^{3,4} Real-world values were based on data from Spritmonitor.de,⁵ a free web service that allows users to track their fuel consumption by entering odometer readings and the amount of fuel added during fill-ups. For each model, fuel consumption values of gasoline and diesel variants were adjusted by the gap observed in Spritmonitor.de to arrive at an estimate of real-world fuel consumption.

1 See Tietge, U. et al., "From laboratory to road: A 2015 update," <http://www.theicct.org/laboratory-road-2015-update>

2 For two of the best-selling models, the Mini Cooper Mini (3 percent market share) and Fiat Punto (2 percent market share), the calculation of real-world values was not possible due to insufficient data. The analysis thus covers 20 of the 22 best-selling car models.

3 The ICCT, "European Vehicle Market Statistics," <http://eupocketbook.theicct.org/>

4 CO₂ values of diesel and gasoline cars were converted to gasoline consumption equivalents using a conversion factor of 1 l gasoline/100 km ≈ 23.4 g CO₂/km.

5 See www.spritmonitor.de

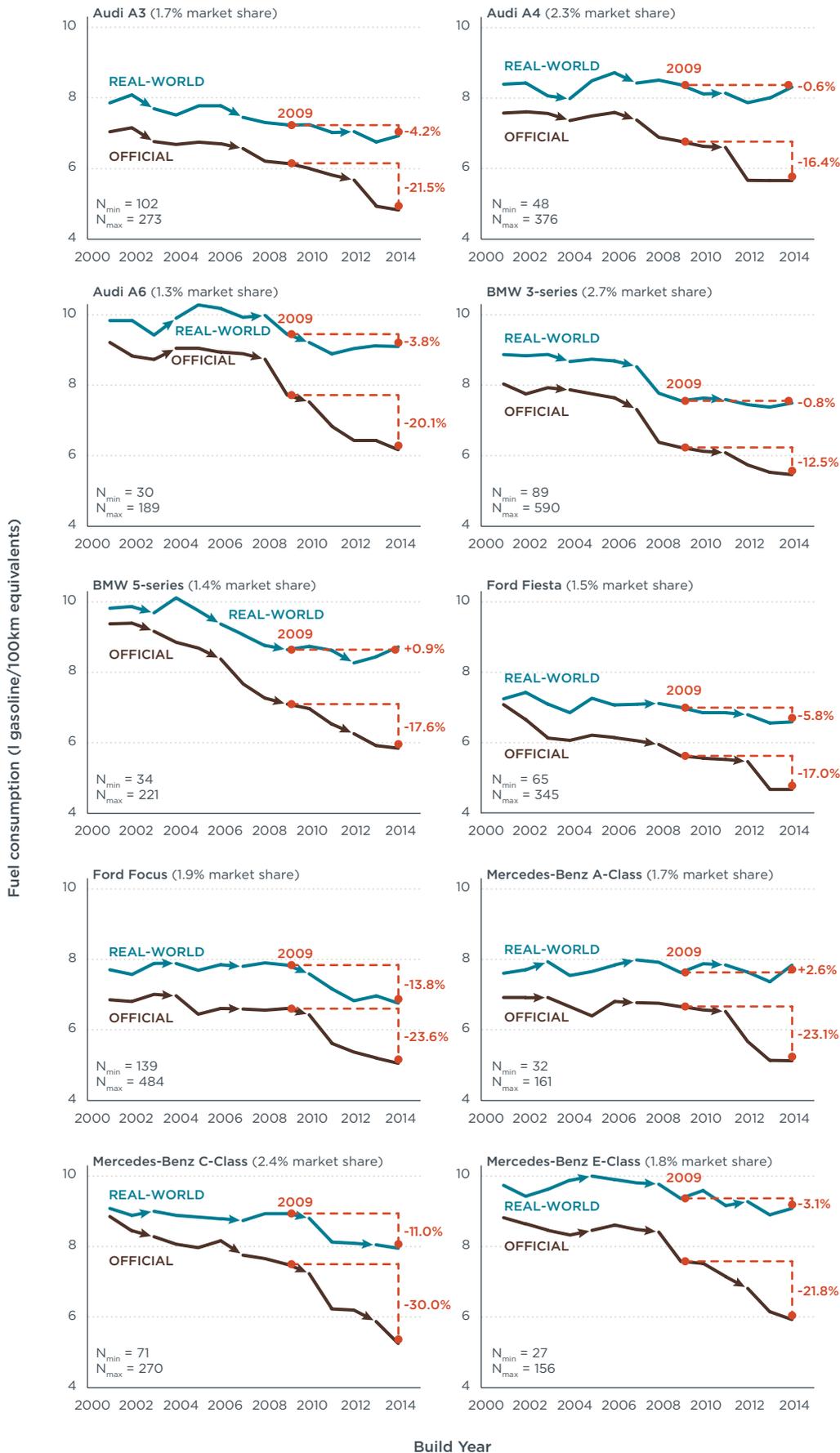


Figure 3: Official and real-world fuel consumption values of popular car models in Germany. Arrowheads mark the timing of major technical overhauls. Minimum and maximum number of Spritmonitor.de entries per year presented in the bottom-left corners.

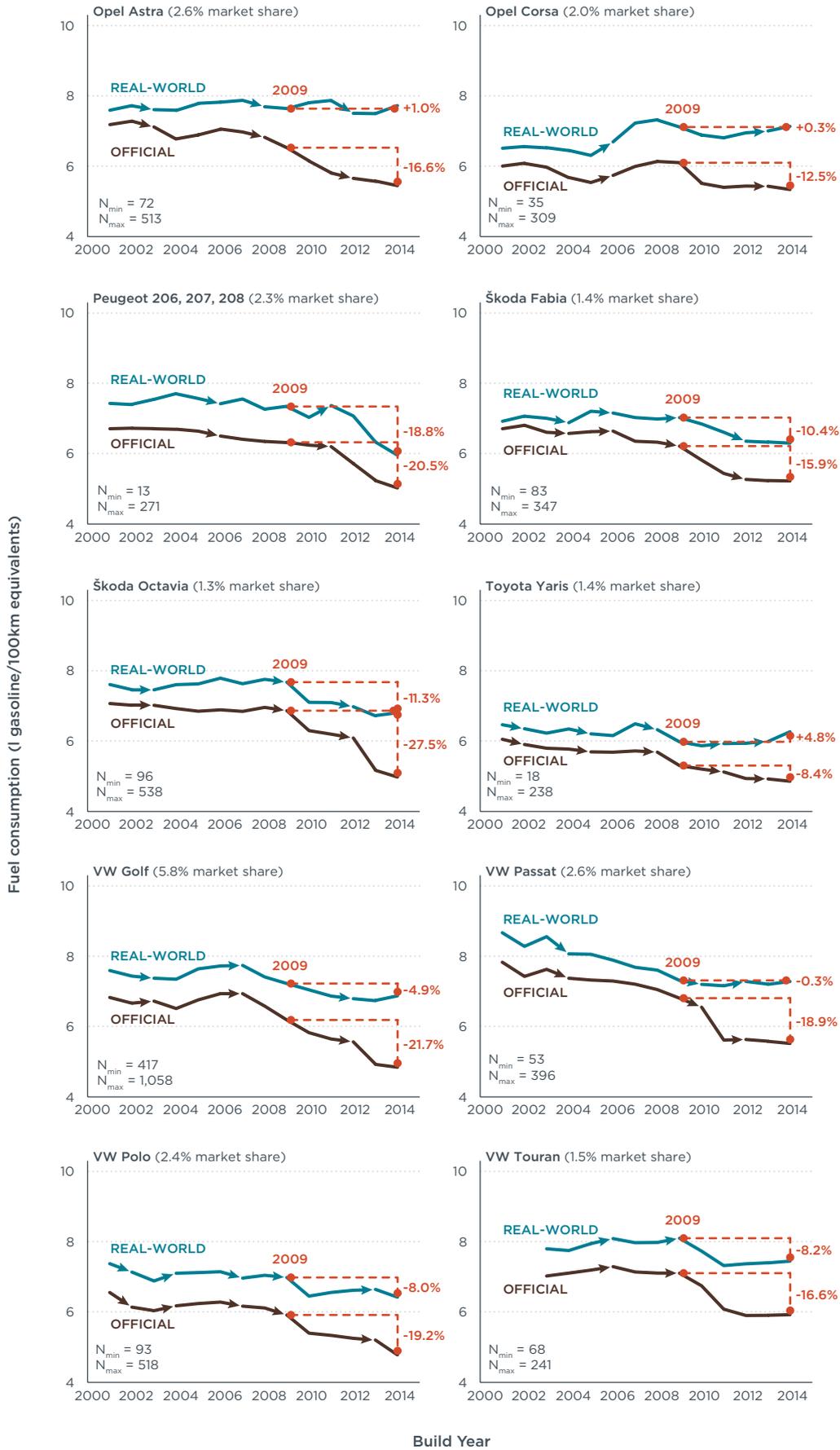


Figure 4. Official and real-world fuel consumption values of popular car models in Germany (continued). Arrowheads mark the timing of major technical overhauls. Minimum and maximum number of Spiritmonitor.de entries per year presented in the bottom-left corners.

All models included in the analysis show a decrease in official fuel consumption values from 2001 to 2014. This trend is particularly pronounced for the Mercedes-Benz C-Class and the BMW 5-series, which achieved a 40 percent decrease in official fuel consumption values between 2001 and 2014. These reductions do not necessarily translate into fuel savings on the road: the divergence between real-world and official fuel consumption values ranged from 33 to 51 percent in 2014.

The analysis of individual car models reveals that technical overhauls (see arrowheads in Figure 3 and Figure 4), particularly after EU-wide CO₂ standards were introduced in 2009, are often followed by sharp decreases in official fuel consumption values while real-world values typically do not decrease by the same magnitude. This development is particularly

pronounced for the VW Passat after the model generation B7 was introduced in 2010. The facelift was followed by a 1.0 l/100 km drop in official fuel consumption values but real-world performance remained virtually unchanged. Other models such as the Audi A4, Ford Fiesta, Mercedes-Benz A-Class, Škoda Octavia, and VW Golf show similar increases in the divergence between real-world and on-road fuel consumption values after technical overhauls.

Figure 5 summarizes the reduction in official and real-world fuel consumption of the 20 selected models from 2009 to 2014. Five models out of the top 20 – the BMW 5-series, Mercedes-Benz A-Class, Opel Astra, Opel Corsa, and Toyota Yaris – actually increased real-world fuel consumption since EU-wide CO₂ standards were introduced in 2009. Another three models – the Audi

A4, BMW 3-series, and VW Passat – made little progress, with less than one percent real-world fuel consumption reductions in the same time period. Among the models evaluated, the Peugeot 206-208 had the highest reduction in real-world fuel consumption values since 2009 (about 19 percent). The Ford Focus, Mercedes-Benz C-Class, Skoda Fabia, and Skoda Octavia all reduced real-world fuel consumption by more than 10% since 2009.

Reasons for the growing gap

Real-world driving is a generic term that covers the wide range of driving conditions that vehicles are subject to during actual use. The real-world, on-road fuel consumption of cars varies depending on vehicle and road characteristics, driving style, and environmental conditions. Nonetheless, when looking at real-world fuel consumption data from a large numbers of vehicles, the results of the vast majority of vehicles tend to cluster around a central estimate, and official fuel consumption values have become increasingly unrepresentative of this estimate over time. More importantly, average real-world driving characteristics do not change significantly from year to year and, thus, should have little impact on the trends from one year to the next.

Spritmonitor.de data show that the share of different driving styles has remained fairly constant over time, indicating that behavioral changes are not a viable explanation for the increasing gap.⁶ Figure 2 shows that driving style, ranging from economical to speedy driving, significantly impacts fuel consumption. According to Spritmonitor.de data, economical driving on average reduces fuel consumption by 7 percent compared to balanced driving, while speedy

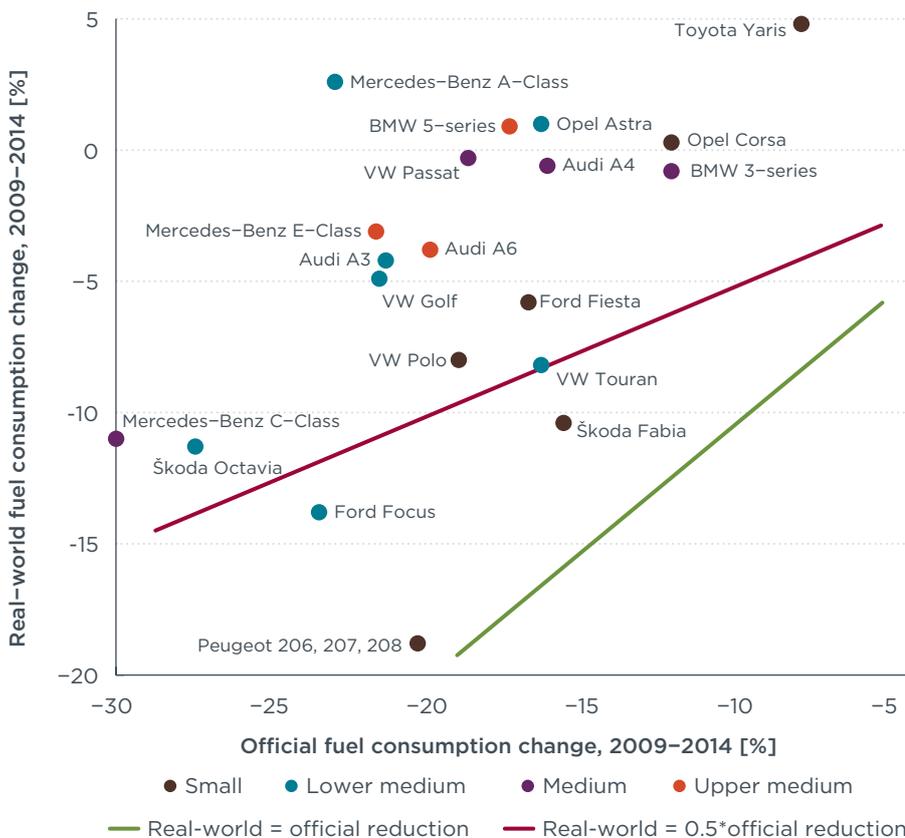


Figure 5. Reduction in official and real-world fuel consumption since 2009 for 20 popular car models. Data points are colored by vehicle segment. The two lines mark the 1:1 and 1:2 ratios between real-world and official fuel consumption reductions.

⁶ Spritmonitor.de users can select one of three driving styles (economical, balanced, or speedy) when entering data after fill-ups.

driving has the opposite effect with a 6 percent increase (both effects being constant over time). In other words, not even economical drivers can achieve the fuel efficiency reported by manufacturers, and the gap has been widening.

It should be noted that EU CO₂ targets apply to the average for all vehicles sold per year by each manufacturer. Vehicle manufacturers are therefore not obliged to reduce fuel consumption values for every model every year and most vehicles are redesigned every five years or so, with occasional significant mid-cycle facelifts. Following the introduction of all-new model generations and model facelifts, official fuel consumption values typically decline (see Figures 3 and 4). Real-world fuel consumption values, however, frequently do not follow this trend, indicating that improvements in fuel efficiency measured during laboratory testing do not fully materialize on the road. The pattern of sudden increases in the divergence between real-world and official fuel consumption values indicates that the growing gap is a product of unrealistic official fuel consumption values.

A joint study by Element Energy and the ICCT identified four key factors for the increasing divergence between real-world and official fuel consumption values in the EU.⁷ These factors are primarily related to different flexibilities in the vehicle testing procedure:

- **Road load determination.** The aerodynamic and rolling resistances that a vehicle has to overcome during driving, the so-called road load, have to be determined prior to laboratory testing. Manufacturers are increasingly exploiting flexibilities and tolerances in this stage, like

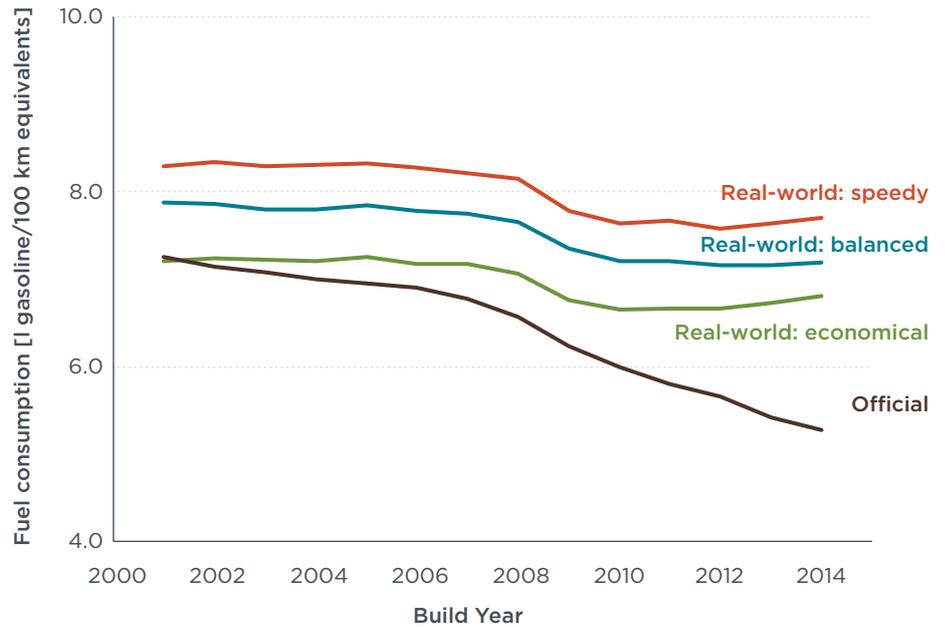


Figure 6. Real-world fuel consumption values for different driving styles, including economical, balanced, and speedy driving (based on Spritmonitor.de data).

removing side mirrors, reducing vehicle weight, and using tolerances in the measurement procedure to their advantage.

- **Laboratory test design.** Vehicles are tested under conditions that are unrepresentative of average real-world conditions (e.g., ambient test temperatures of 20 to 30°C) and regulations allow for flexibilities and tolerances that manufacturers are increasingly exploiting.
- **New technologies.** Some fuel-saving technologies, such as stop-start systems and hybrid powertrains, tend to be more effective during laboratory testing than during real-world driving.
- **Other parameters.** Auxiliary systems, such as air-conditioning and on-board entertainment systems, are switched off during vehicle testing but consume energy during real-world operation.

Conclusions and policy implications

The analysis of 20 popular vehicle models demonstrates that reductions in real-world fuel consumption fall short of the improvements in official values. Moreover, official fuel consumption values have become increasingly unrepresentative of real-world performance over time. The pattern of abrupt increases in the gap after model overhauls indicate that unrealistic official fuel consumption values are the source of the growing gap.

The growing divergence between official and real-world fuel consumption values is primarily a result of the exploitation of flexibilities in the current testing procedure. A new test procedure, the Worldwide Harmonized Light Vehicles Test Procedure (WLTP), will replace the current testing procedure in the EU in 2017. While the WLTP will be an improvement, it will not by itself resolve all known issues. Even with the introduction of the WLTP, fuel consumption tests will still be conducted in laboratories on pre-series vehicles specially prepared by manufacturers

7 Stewart, A., et al., "Impacts of real-world driving on emissions from UK cars and vans," <https://www.theccc.org.uk/publication/impact-of-real-world-driving-emissions/>

(so-called golden cars) and auxiliary systems will continue to be turned off.

While the exploitation of flexibilities in the current testing procedure explains the growing gap, the regulatory and institutional context does little to prevent this development.⁸ Currently, manufacturers can shop around in the EU member states, selecting a type-approval authority as well as a technical service (third-party testing company) to certify their vehicles. This situation creates a conflict of interest, potentially incentivizing type-approval authorities and technical services to support manufacturers in producing favorable emission testing results to attract and retain the manufacturers' business. Establishing an EU-wide type-approval authority, acting as a neutral party between vehicle manufacturers and technical service companies

— and being able to mandate vehicle recalls and impose financial penalties for non-compliance — is therefore seen as a critical step towards more realistic emissions and fuel consumption figures.

Furthermore, the current type-approval process relies solely on laboratory testing of “golden cars”. In-use conformity testing of randomly selected vehicles would ensure that vehicles meet their specified fuel consumption value throughout their useful life. Another measure that should be combined with in-use compliance inspections is on-road fuel consumption testing. For nitrogen oxide (NO_x) emissions, the European Commission adopted the Real-Driving Emissions (RDE) procedure, making use of portable emission measurement systems (PEMS) to verify that light-duty vehicles have reasonably

low emissions of NO_x during conditions that resemble real-world use more closely than laboratory cycles. This system of on-road testing could be extended to cover vehicle CO₂ emissions.

More generally, the current lack of transparency in the type-approval process and real-world performance of cars impedes independent verification of fuel consumption values. For instance, road load values are a vital component of vehicle testing but are not publically available. There is also no EU-wide source of real-world fuel consumption values. In the U.S., the Environmental Protection Agency and Department of Energy created the FuelEconomy.gov website,⁹ allowing consumers to compare real-world and official fuel consumption values before making purchasing decisions.

8 For more details, see Mock, P., German, J., “The future of vehicle emissions testing”, <http://www.theicct.org/future-of-vehicle-testing>

9 See <https://www.fueleconomy.gov/mpg>