Comparison of the fuel consumption measured over EU and US legislated cycles

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Preface

This study was initiated by an email sent by Mr. Karl-Heinz Zierock requesting comments on a presentation given by Feng An and Amanda Sauer at the IEA/UNEP Workshop on Automobile CO_2 Reduction and Fuel Economy Improvement Policies. Subject of this presentation was the Comparison of Automotive Fuel Efficiency and GHG Emission Standards around the world. Conversion factors to CAFE-equivalent MPG and EU-equivalent CO_2 emission rate of g/km were provided in slide 14 of this presentation. In the following paper these values were compared against real measurement data on driving cycles derived from a draft version of the ARTEMIS database [1] as well as simulated cycle data from the vehicle model ADVISOR [2].

Measurement data source

As already mentioned, the ARTEMIS measurement data were used for the comparison. The ARTEMIS database consists of data gathered during the homonymous project [1] as well as the OSCAR [3] and the PARTICULATES [4] research project. In addition to these it includes data from the older MEET project [5]. It should be noted that this database was accessed in its draft version which was close though to finalization.

Database processing

The ARTEMIS database included measurement data of certain vehicles under all cycles of interest (UDC, EUDC, US FTP-1, US FTP-2, US FTP-3 and US Highway). In case more than one measurement on a specific cycle was available, the average was calculated in order to reduce measurement scatter and obtain comparative results. Using the data of the above subcycles, the CO_2 emissions of the main cycles were estimated as follows [6]:

$$NEDC[g/km] = \frac{4059 \times \mathrm{UDC[g/km]} + 6955 \times \mathrm{EUDC[g/km]}}{4059 + 6955}$$

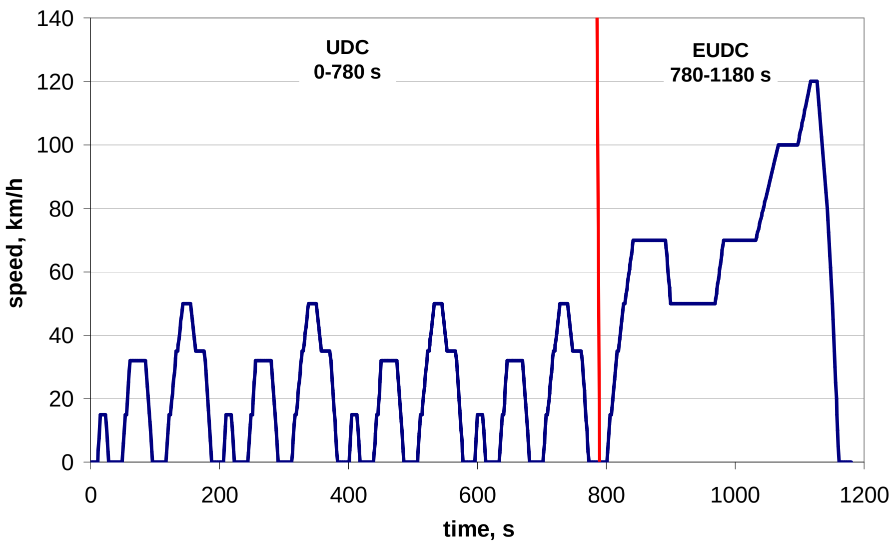

Figure 1: NEDC

$$US\_FTP[g/km] = \frac{0.43 \times \text{FTP1[g/km]} + 1 \times \text{FTP2[g/km]} + 0.57 \times \text{FTP3[g/km]}}{0.43 + 1 + 0.57}$$

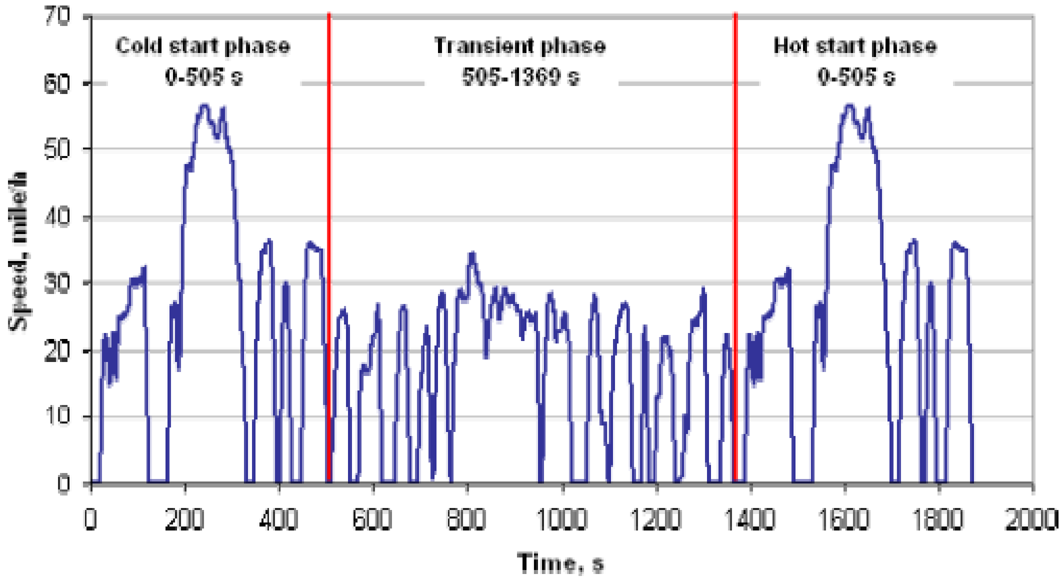

Figure 2: US FTP driving cycle

$$US\_City = \frac{0.43 \times \text{FTP1[g/km]} + 0.57 \times \text{FTP2[g/km]}}{0.43 + 0.57}$$

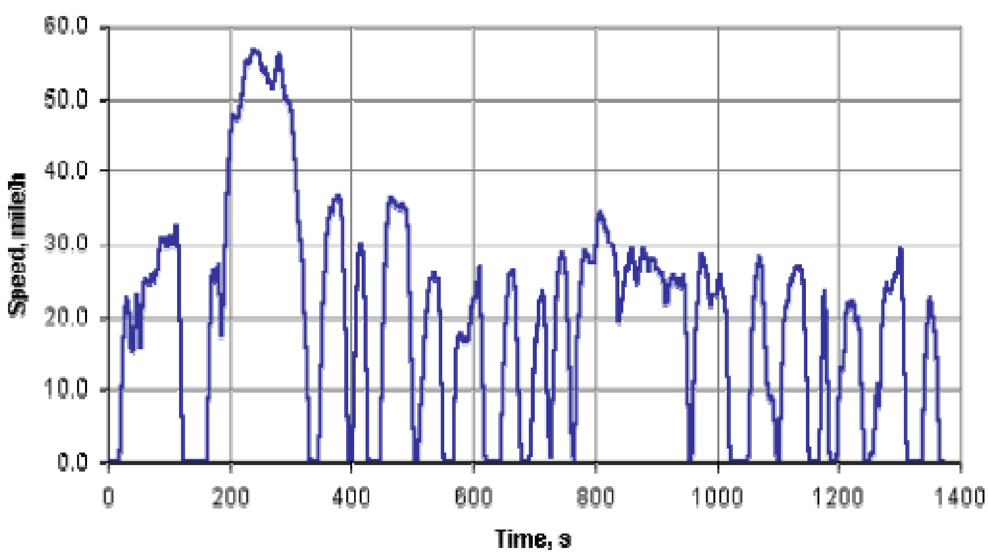

Figure 3: US City driving cycle

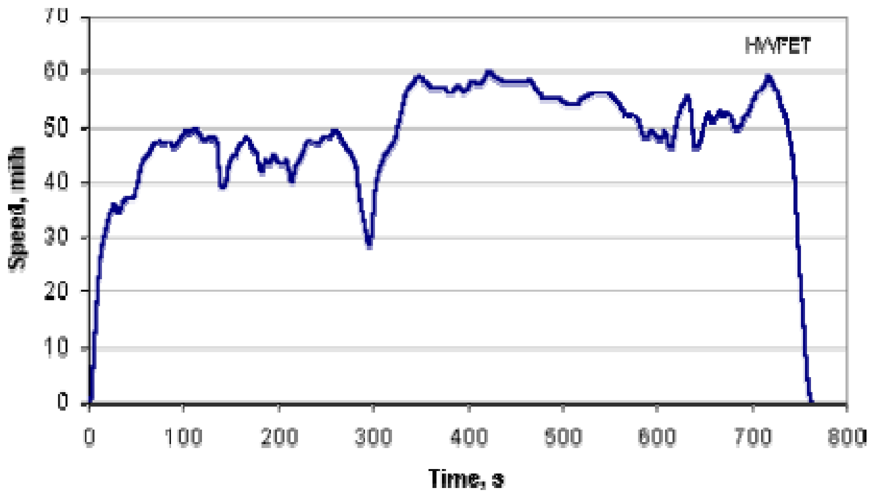

Figure 4: US Highway driving cycle

$$CAFE[g/km] = \frac{0.55 \times \text{US\_City[g/km]} + 0.45 \times \text{US\_highway[g/km]}}{0.55 + 0.45}$$

Vehicle simulation

Two vehicle models were used in ADVISOR for the simulation of the driving cycles. The gasoline vehicle was a Saturn 1.9 while the diesel vehicle was a VW Golf TDi 1.9 l. All subcycles were simulated separately and combined according to the above presented equations to provide the final cycle results. Start conditions (cold-hot) were chosen according to the legislation.

Results and discussion

The correlations between the EU and US legislated cycles as they came up from the ARTEMIS database processing are being presented in Figure 5 to Figure 8:

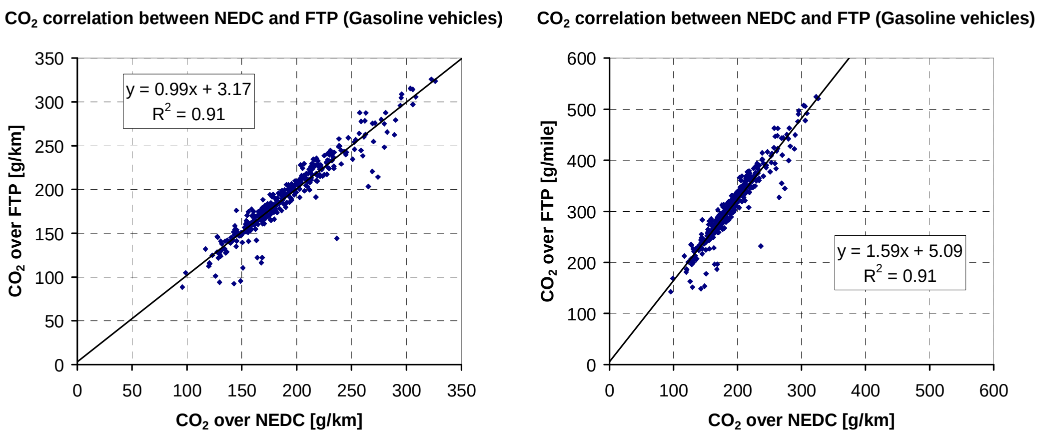

Figure 5: Correlation of CO_2 measured over FTP NEDC (gasoline vehicles)

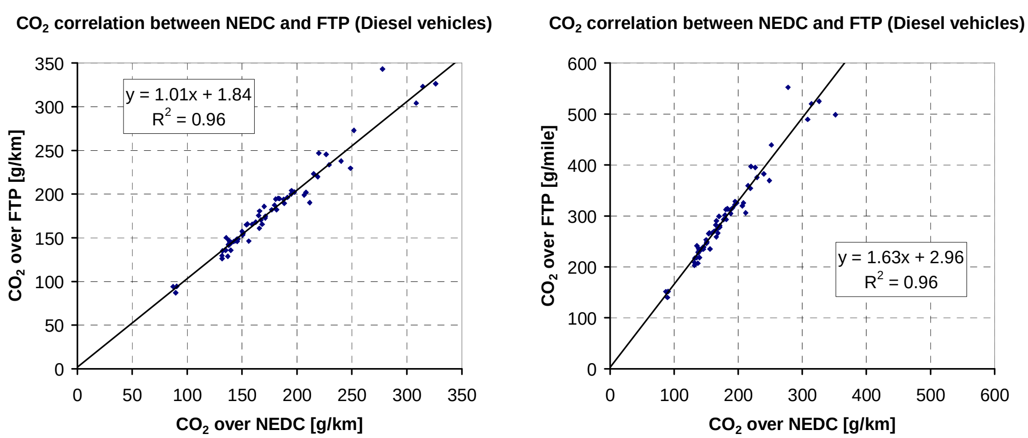

Figure 6: Correlation of CO_2 measured over FTP NEDC (diesel vehicles)

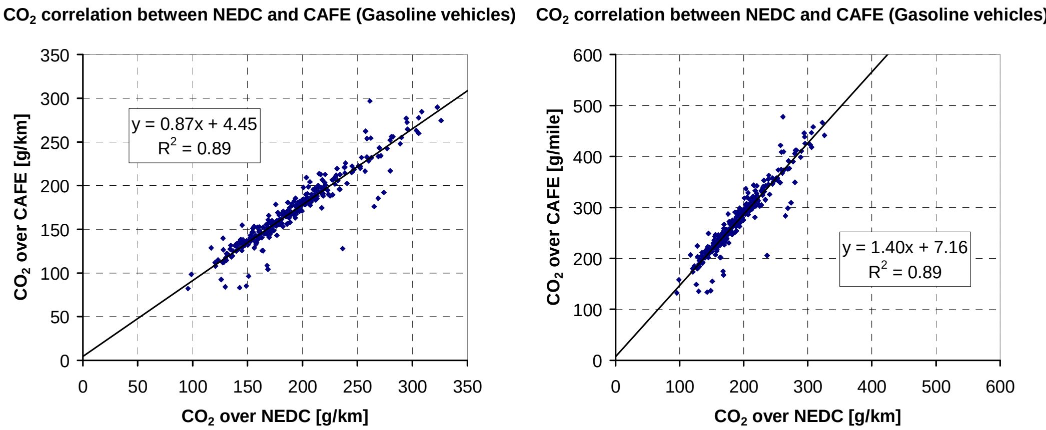

Figure 7: Correlation of CO_2 measured over CAFE NEDC (gasoline vehicles)

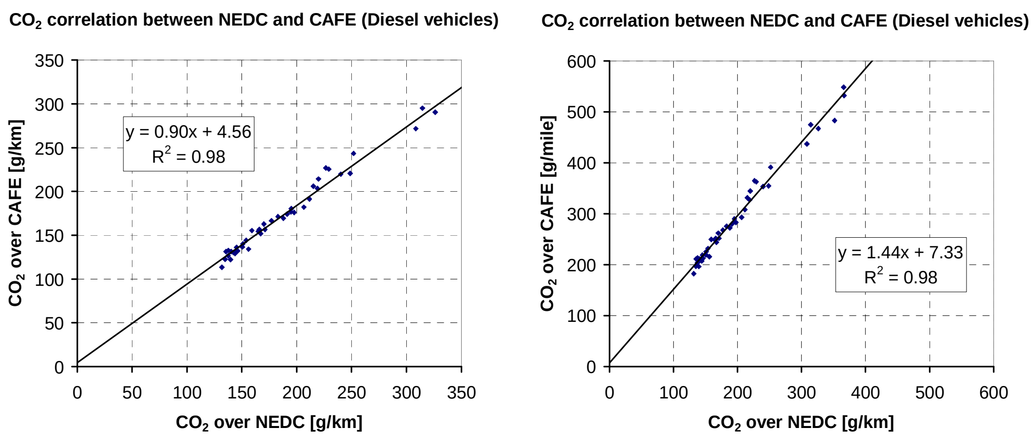

Figure 8: Correlation of CO_2 measured over CAFE NEDC (diesel vehicles)

A good linear fit was observed in all cases. In particular the comparison of FTP (expressed in g/km) against the NEDC showed an almost one to one relationship.

The comparison of conversion factors as produced by the ARTEMIS datatabase processing, the ADVISOR simulation and Feng An et al. is presented in Figure 9 and Figure 10.

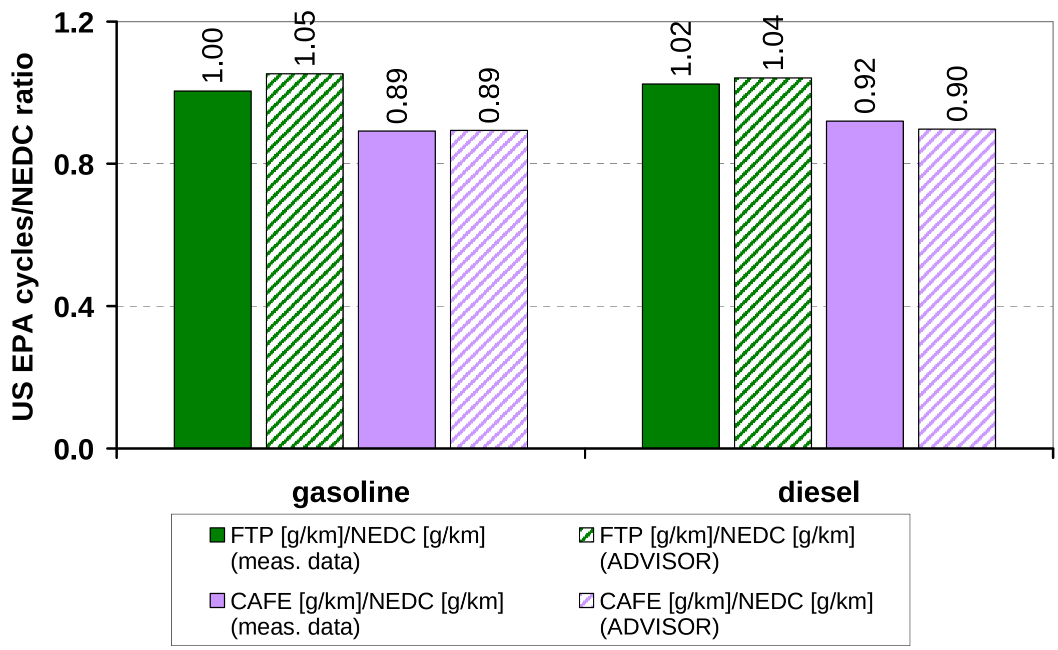

Figure 9: FTP over NEDC ratio (common unit: g/km)

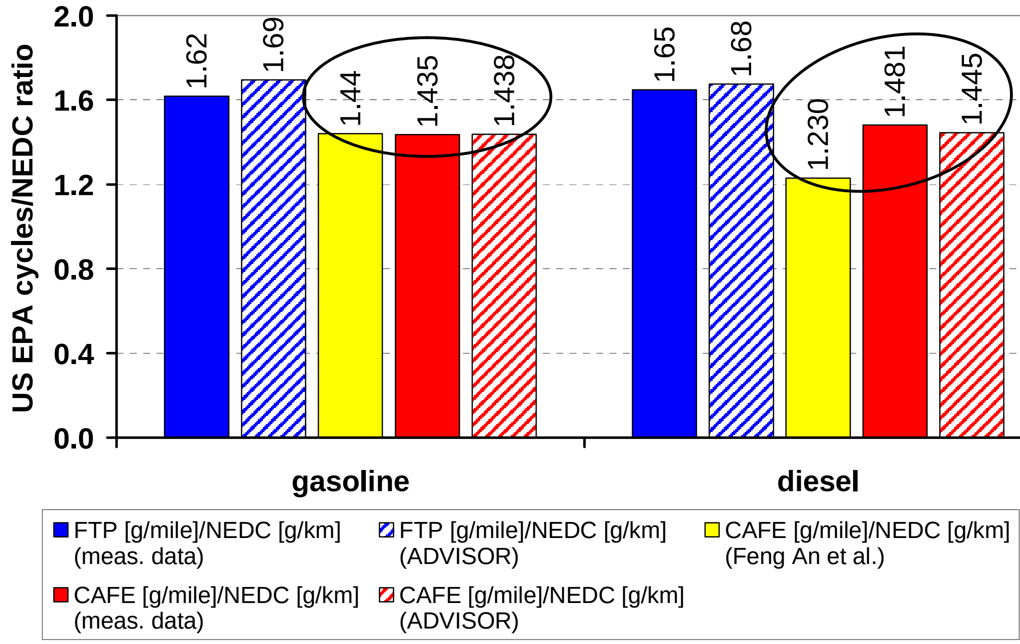

Figure 10: FTP over NEDC ratio (NEDC in g/km, US EPA cycles in g/mile)

As it can be seen in Figure 10, there is a very good agreement between the three data sources as regards the gasoline vehicles. On the other hand the CAFE/NEDC ratio proposed by Feng An et al. is about 17% lower than the one produced by the ARTEMIS database processing. This difference is being confirmed by the ADVISOR simulation as well. This can be attributed though to the definition of conversion factors in the ARTEMIS - ADVISOR estimation. As it can be seen in slide 14 of the presentation, the EU (diesel) conversion factor is 15% lower than the EU (gasoline) conversion factor, which is confirmed by the rest of the conversion factors as well. This probably means that the conversion factors have as reference the gasoline CO_2 emissions. If this is the case, CO_2 emissions of diesel vehicles are converted to gasoline-based CO_2 emissions under the assumption that the CO_2 emissions of diesel vehicles are 15% lower than the CO_2 emissions of gasoline vehicles.

List of figures

References

1. http://www.trl.co.uk/artemis/
2. http://www.ctts.nrel.gov/analysis/advisor.html
3. http://www.eu-oscar.org/
4. http://vergina.eng.auth.gr/mech/lat/particulates/
5. http://www.inrets.fr/infos/cost319/#Heading3
6. http://www.dieselnet.com/standards/cycles/