Exhaust emissions from light vehicles run on alternative fuels

Basic data to NTM (The Network for Transport and Environment)

Miljöinfo AB

Mats-Ola Larsson

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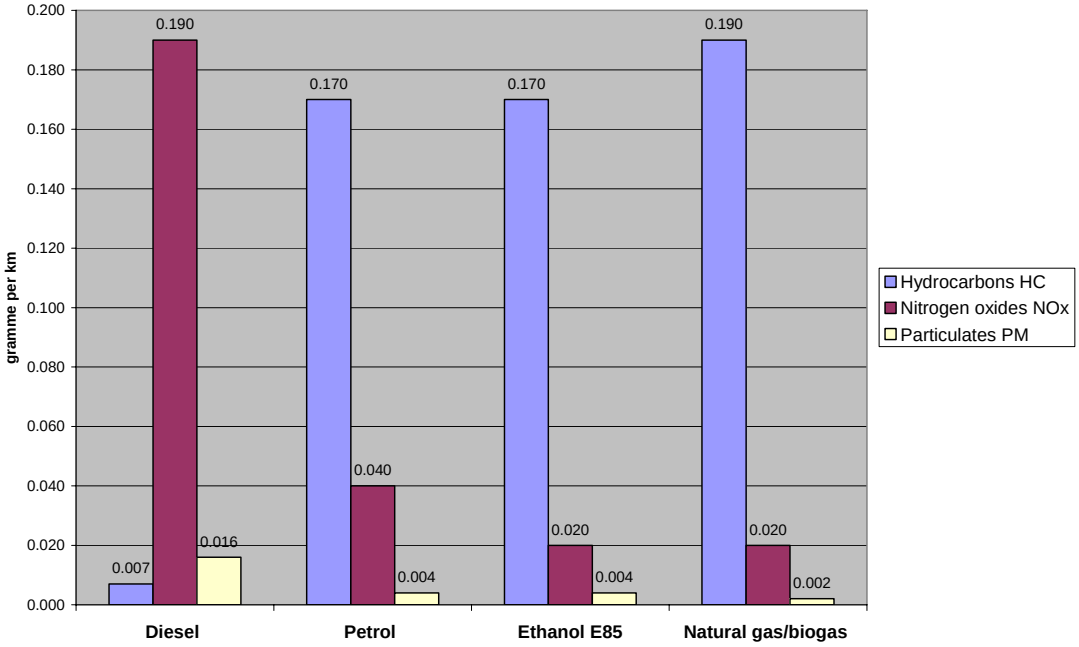
Summary and discussion

This report presents standard values for exhaust emissions from light vehicles run on different fuels. The report is a literature study on emissions from alternative fuels within the framework for NTM (The Network for Transport and Environment). The work is financed by Vägverket (the Swedish Road Administration), the City of Stockholm, the City of Göteborg, Stockholm Transport (SL) and NTM. Emissions of greenhouse gases are presented in a separate report.

The most important results from the study are presented in the figure below. This shows approximate emissions from passenger cars and light transport vehicles in environmental class 2005 during actual operation. The figures relate to vehicles approved by the manufacturer for running on the respective fuels. Simple conversions, where for example the user converts a petrol-powered car to run on ethanol, can give much higher emissions, and the figures do not relate to such vehicles.



Conclusions:

- Flexifuel vehicles run on ethanol E85 emit roughly 50 per cent less nitrogen oxides than when run on petrol. The amounts of hydrocarbons and particles are unchanged.
- Bi-fuel vehicles run on natural gas/biogas emit roughly 50 per cent less nitrogen oxides and particles than when run on petrol. The emissions of hydrocarbons are roughly 20 per cent higher.
- Diesel vehicles without particle filters or equivalent cleaning emit three to four times more nitrogen oxides and at least five times more particles than new petrol, gas and ethanol vehicles. Emissions of hydrocarbons are 90-95 per cent lower. If the vehicle has a particle filter, however, the particle emissions are as low as from petrol vehicles and ethanol vehicles.

If one wants to make an overall assessment of the health and environmental effects of different vehicles and fuels, one must take into consideration the effects on climate (carbon dioxide, nitrous oxide and methane), health (particles and certain hydrocarbons), oxidant formation (certain hydrocarbons) and acidification and fertilizing effects (nitrogen oxides). Such comparisons are complicated and uncertain, but attempts have been made, in for example references (B), (G), (H) and (M).

In reference (M) from 2001, comparison was made between the environmental and health effects of petrol vehicles and diesel vehicles through using a national economic assessment. The study concluded that diesel vehicles have a greater impact on environment and health than equivalent petrol vehicles in urban areas but a lesser impact in rural areas. The breakpoint is considered to be an urban area with a population of 30,000. The study is representative for diesel vehicles without particle filters. In reference (G) from 2002, comparison was made between petrol vehicles and diesel vehicles with particle cleaning. The study concluded that the cancer effect from diesel vehicles with particle cleaning is roughly as low as for equivalent petrol vehicles, whilst the acidification effect is higher regardless of particle cleaning.

In reference (B) from 1999, study was conducted of different fuels in vehicles manufactured in 1992-94. The study concluded that the exhaust gases from petrol vehicles cause greater regional environmental and health effects than diesel, ethanol and gas (in declining order). The data in this study differs to a certain extent from today's emissions values, but in the main the report's conclusions are still valid.

One reason for differences in the environmental impact is of course that the emissions values differ, as shown by the figure on page 2. But the differences are also due to the fact that the hydrocarbon emissions have different compositions. In the case of gas operation, for example, at least three quarters of the hydrocarbons are methane, whilst the corresponding proportion in petrol exhaust gases and ethanol exhaust gases is one tenth. Ethanol vehicles emit more ethanol and acetaldehyde than petrol vehicles and gas vehicles, whilst petrol vehicles emit more polyaromates.

Background

NTM (The Network for Transport and Environment) is a non-profit network with members from authorities, the transport industry, environmentally-active companies, environmental consultants and other stakeholders. The Network's main task is to present common agreed standard values for emissions from transports.

The aim is to be more easily able to make calculations of emissions from travels and transports and to obtain better agreement between different calculations. By making the figures generally available on the organisation's website, the Network also wants to make it easier for external parties to calculate emissions from different transports. More information can be found at http://www.ntm.a.se/ The author can be reached at his e-mail address, mats-ola@miljoinfo.se.

This report is part of a project that aims to produce emissions data for alternative fuels. The figures have been produced together with a working group within NTM. The work has been financed by Vägverket (the Swedish Road Administration), the City of Stockholm, the City of Göteborg, Stockholm Transport (SL) and NTM.

Boundaries

During 2004-05, two consultants were assigned to produce proposals for emissions data for vehicles run on alternative fuels. The values shall be representative for those vehicles and fuel types that are in commercial use in Sweden. A third consultant has subsequently been assigned to update NTM's information on bus traffic.

The following emissions have been studied

- total hydrocarbons, HC
- nitrogen oxides, NOx
- particles
- climate gases expressed as fossil carbon dioxide equivalents

All values are expressed in gram emissions per vehicle kilometre.

The following vehicle types have been studied

- passenger transports by light vehicle
- passenger transports by bus
- goods and waste deliveries by lorry

The following fuels have been selected

- natural gas/biogas
- RME, rape methyl ester
- ethanol and E85

Magnus Blinge at Transek was assigned to produce data for emissions during the manufacture and transport of fuels. His work is presented in a separate report.
Mats-Ola Larsson at Miljöinfo AB was assigned to produce data for emissions from different types of vehicle. In this report, I (Mats-Ola Larsson) present my work. This covers only regulated emissions. Carbon dioxide equivalents are shown in Magnus Blinge's report.

Heavy vehicles subsequently excluded
During the course of the work, it was evident that NTM's input data for heavy vehicles cannot be directly compared with the basic data that I have produced. Therefore I do not present any data for goods deliveries by heavy gas vehicles.

NTM's basic data includes values for buses run on ethanol and gas. It was later decided that these data should be updated during spring 2006 by **Ulrika Franzen** at Transek. Therefore I do not present any such data here. The results of my literature search will instead be included in her report.

Method

I have collected literature references for the selected vehicle and fuel types. The literature study was not particularly extensive because the assignment was limited to a few working days. I have primarily tried to find relatively modern measurements that are relevant for the study.

If several investigations showed the same emissions pattern for a certain fuel, I have interpreted the information to the effect that there is an actual difference in emissions. Then I have worked out an average value of the changes stated in the references. If several tests show contradictory results, such as both higher and lower emission from a certain fuel, I have interpreted this to the effect that no difference exists compared with petrol/diesel oil.

As a staring point, I have chosen the emissions values in NTM Calc, a working material from NTM for passenger transports. The material is said to be representative for emissions from vehicles in actual use and is based on data from Vägverket and VTI (the Swedish National Road and Transport Research Institute).

I have first divided the information from my literature study into the same categories (age and vehicle types) that are used in NTM Calc. Thereafter I have recalculated the emissions from alternative fuels in the literature references so that they are proportional in relation to the NTM Calc values.
Example: If the literature search showed that a certain year of vehicle has 50% lower emissions of NOx if it is run on gas, I have produced an emissions value for gas operation by multiplying the NTM Calc value for petrol vehicles by 0.5. I have thus not used the direct emissions values that are in the literature, as they are not always comparable with NTM Calc data.

Small amount of basic data gives great uncertainty
All of the literature references that I have been able to find have included a single or small number of measurements. One cannot draw any far-reaching conclusions from such measurements, but there has not been any more comprehensive official literature available. The values should therefore not be read too literally but rather as an indication.

Deviations from NTM Calc
When I compared the values in NTM Calc for HC emissions from diesels between the years 1989 and environmental class 3 in 2000 with the literature references, the NTM values were very low. I have not managed to find out why, but have difficulty in working on the basis of NTM Calc data in these cases. The comparison with all other vehicle types is misleading. I have therefore chosen to present other values than NTM's data for these emissions.

Emissions values for different model years and fuels

Proposals are presented below for emissions data from passenger cars and light transport vehicles run on different fuels. The values relate only to vehicles that the manufacturers have approved and adapted for the respective fuels. The table is divided into the categories in NTM Calc, apart from "environmental class 2005 PM" which I have added. The notes are explained on the pages that follow. N.B. The basic data comes from a small number of reports with only a few measurements. All figures that relate to alternative fuels are approximate.

Vehicles before 1988			
Emissions	**HC g/km**	**NOx g/km**	**Particles g/km**
Diesel	0.45 NTM	0.72 NTM	0.393 NTM
Pertol	5.32 NTM	2.55 NTM	0.024 NTM
Year models 1989-96			
Emissions	**HC g/km**	**NOx g/km**	**Particles g/km**
Diesel	0.09 KFB	0.44 NTM	0.062 NTM
Petrol	0.72 NTM	0.59 NTM	0.010 NTM
RME	0.08 1a	0.48 1b	0.050 1c
Ethanol E85	0.99 2a	0.13 2b	0.004 2c
Natural gas/biogas (methane)	0.63 3a	0.33 3b	0.003 3c
Year models 1993-00			
Emissions	**HC g/km**	**NOx g/km**	**Particles g/km**
Diesel environmental class 2 1993-96 and environmental class 3 1997-2000	0.06 VTT	0,43 NTM	0,054 NTM
Petrol	0.45 NTM	0,15 NTM	0,009 NTM
RME	0.06 4a	0,47 4b	0,044 4c
Ethanol E85	Few in Sweden	Few in Sweden	Few in Sweden
Natural gas/biogas (methane)	0.45 5a	0.15 5b	0.007 5c
Environmental class 2000			
Emissions	**HC g/km**	**NOx g/km**	**Particles g/km**
Diesel	0.007 NTM	0.34 NTM	0.038 NTM
Petrol	0.23 NTM	0.07 NTM	0.004 NTM
RME	Data missing	Data missing	Data missing
Ethanol E85	0.23 6a	0.04 6b	0.004 6c
Natural gas/biogas (methane)	0.23 7a	0.04 7b	0.002 7c
Environmental class 2005			
Emissions	**HC g/km**	**NOx g/km**	**Particles g/km**
Diesel	0.007 8a	0.19 8b	0.016 8c
Petrol	0.17 NTM	0.04 NTM	0.004 NTM
RME	Data missing	Data missing	Data missing
Ethanol E85	0.17 9a	0.02 9b	0.004 9c
Natural gas/biogas (methane)	0.19 10a	0.02 10b	0.002 10c
Environmental class 2005 PM			
Emissions	**HC g/km**	**NOx g/km**	**Particles g/km**
Diesel	0.007 11a	0.19 11b	0.004 11c

Notes to tables

NTM Value as stated in NTM Calc working material 2004.

KFB Value from ref (B).
I recommend these data because the authors have aimed to produce values that are representative for vehicles in actual use, year models 1993-94, taking into account cold starts, wear etc. Their values also lie at the same level as several other references.

VTT Value from ref (N).
I have taken an average value of two measurements.

Year models 1989-96 RME

1a) Ref (B) states that HC emissions from 1993-94 vehicles run on RME are 11% lower than from diesel operation.
I have multiplied the KFB value for 1989-96 diesel vehicles by 0.9.

1b) Ref (B) states that NOx emissions from 1993-94 vehicles run on RME are 9% higher than from diesel operation.
I have multiplied the KFB value for 1989-96 diesel vehicles by 1.1.

1c) Ref (B) states that particle emissions from 1993-94 vehicles run on RME are 18% lower than from diesel operation.
I have multiplied the KFB value for 1989-96 diesel vehicles by 0.8.

Year models 1989-96 ethanol E85

2a) Ref (B) states that HC emissions from 1993-94 vehicles run on ethanol are 37% higher than from equivalent petrol vehicles.
I have multiplied the NTM Calc value for 1989-96 petrol vehicles by 1.4.

2b) Ref (B) states that NOx emissions from 1993-94 vehicles run on ethanol are 78% lower than from equivalent petrol vehicles.
I have multiplied the NTM Calc value for 1989-96 petrol vehicles by 0.2.

2c) Ref (B) states that particle emissions from 1993-94 vehicles run on ethanol are 57% lower than from equivalent petrol vehicles.
I have multiplied the NTM Calc value for 1989-96 petrol vehicles by 0.4.

Year models 1989-96 natural gas/biogas (methane)

3a) Ref (B) states that HC emissions from 1993-94 vehicles run on gas are 13% lower than from equivalent petrol vehicles.
I have multiplied the NTM Calc value for 1989-96 petrol vehicles by 0.9.

3b) Ref (B) states that NOx emissions from 1993-94 vehicles run on gas are 44% lower than from equivalent petrol vehicles.
I have multiplied the NTM Calc value for 1989-96 petrol vehicles by 0.6.

3c) Ref (B) states that particle emissions from 1993-94 vehicles run on gas are 71% lower than from equivalent petrol vehicles.
I have multiplied the NTM Calc value for 1989-96 petrol vehicles by 0.3.

Year models 1993-2000 RME

4a) I have not found any direct measurement for vehicles in this age group. Ref (B) states 11% lower HC emission during RME operation compared with diesel. I have worked on the basis of this value.
I have multiplied the KFB value for 1993-2000 diesel vehicles by 0.9.

4b) I have not found any direct measurement for vehicles in this age group. Ref (B) states 9% higher NOx emission during RME operation compared with diesel. I have worked on the basis of this value.
I have multiplied the KFB value for 1993-2000 diesel vehicles by 1.1.

4c) I have not found any direct measurement for vehicles in this age group. Ref (B) states 18% lower particle emission during RME operation compared with diesel. I have worked on the basis of this value.
I have multiplied the KFB value for 1993-2000 diesel vehicles by 0.8.

Year models 1993-2000 natural gas/biogas (methane)

5a) I have found the following relevant references: (B), (H), (J), (K), (N) and (O). Some state higher HC emissions for gas vehicles than equivalent petrol models, whilst others state lower HC emissions during gas operation.
I suggest the same value for gas as for 1993-2000 petrol vehicles.

5b) I have found the following relevant references: (B), (H), (J), (K), (N) and (O). Some state higher NOx emissions for gas vehicles than equivalent petrol models, whilst others state lower NOx emissions during gas operation.
I suggest the same value for gas as for 1993-2000 petrol vehicles.

5c) I have found the following relevant references: (B), (J), (N) and (O).
Ref (B) state 71% lower particle emissions for gas vehicles compared with petrol vehicles.
Ref (J) states same values for gas and petrol.
Ref (N) has tested a gas vehicle and two petrol vehicles in surrounding temperatures of +23, +5 and -7 degrees. The petrol vehicles are of year models 2001 and 2002, whilst the gas vehicle was from 1998. One of the petrol vehicles has direct injection, however, and thus higher particle emissions, and is therefore not interesting here. Emissions of particles from the gas vehicle and the other petrol vehicle were at the same level at room temperature, but emissions from the gas vehicle do not increase at either +5 or -7 degrees, whilst particle emissions from the petrol vehicle doubled at +5 degrees (figure difficult to read, data not stated).

Ref (O) states that emissions of particles are the same for gas vehicle and petrol vehicle (same vehicle tested on different fuels, 1998 model, aftermarket conversion).
I have multiplied the NTM Calc value for 1993-2000 petrol vehicles by 0.75.

Environmental class 2000 ethanol E85

6a) There are a small number of ethanol cars, Ford Focus, that belong to environmental class 2000 in Sweden. I have not found any measurement values for vehicles in this environmental class and have instead worked on the basis of the same assumptions as for environmental class 2005 under 9a) below.
I suggest the same value for ethanol as for petrol vehicles in environmental class 2000.

6b) There are a small number of ethanol cars, Ford Focus, that belong to environmental class 2000 in Sweden. I have not found any measurement values for vehicles in this environmental class and have instead worked on the basis of the same assumptions as for environmental class 2005 under 9b) below.
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2000 by 0.5.

6c) There are a small number of ethanol cars, Ford Focus, that belong to environmental class 2000 in Sweden. I have not found any measurement values for vehicles in this environmental class and have instead worked on the basis of the same assumptions as for environmental class 2005 under 9c) below.
I suggest the same value for ethanol as for petrol vehicles in environmental class 2000.

Environmental class 2000 natural gas/biogas (methane)

7a) I have worked on the basis of references (N) and (R).
Ref (N) has tested a gas vehicle and two petrol vehicles in surrounding temperatures of +23, +5 and -7 degrees. The petrol vehicles are of year models 2001 and 2002, whilst the gas vehicle was from 1998. HC emissions from the gas vehicle were at the same level as the petrol vehicles at room temperature, but increased by only one third as much as emissions from the petrol vehicle at +5 degrees.
In ref (R), comparison is made between two gas vehicles in environmental class 2000 and one in environmental class 2005 between seven petrol vehicles in environmental class 2000. HC emissions from the gas vehicles were 10% lower than the emissions from the petrol vehicles. The report states, however, that the spread was considerable with regard to

the gas vehicles because of different engine technologies, and that the results are therefore of limited value.
I suggest the same value for gas as for petrol vehicles in environmental class 2000.

7b) I have worked on the basis of references (N) and (R).
Ref (N) is described under 7a. This showed that NOx emissions from the gas vehicle were roughly 70% lower than those of the petrol vehicles at +23 degrees and 40% lower at +5 degrees.
Ref (R) is described under 7a. This showed that NOx emissions from the gas vehicles were roughly 60% lower than those of the petrol vehicles. The report states, however, that the spread was considerable with regard to the gas vehicles because of different engine technologies, and that the results are therefore of limited value.
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2000 by 0.5.

7c) I have worked on the basis of references (N) and (R).
Ref (N) is described under 7a. This showed that particle emissions from the gas vehicle and the petrol vehicle without direct injection lie at the same level at room temperature but emissions from the gas vehicle do not increase at either +5 or -7 degrees, whilst particle emissions from the petrol vehicle doubled at +5 degrees (figure difficult to read, data not stated).
One of the petrol vehicles has direct injection, however, and thus higher particle emissions, and is therefore not interesting here.
Ref (R) is described under 7a. This showed that particle emissions from the gas vehicles were roughly 67% lower than those of the petrol vehicles.
The report states, however, that the spread was considerable with regard to the gas vehicles because of different engine technologies, and that the results are therefore of limited value.
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2000 by 0.5.

Environmental class 2005 diesel

8a) NTM Calc states no figures for diesels in environmental class 2005. The certification value for HC from diesel models in environmental class 2005 is *not* lower than from vehicles in environmental class 2000.
I suggest the same value for environmental class 2003 as that which NTM Calc states for environmental class 2000.

8b) NTM Calc states no figures for diesels in environmental class 2005. The certification value for NOx from diesel models in environmental class 2005 is 43% lower than from vehicles in environmental class 2000.
I have produced the value for environmental class 2005 by multiplying the NTM Calc value for environmental class 2000 by 0.6.

8c) NTM Calc states no figures for diesels in environmental class 2005. The certification value for particles from diesel models in environmental class 2005 is 59% lower than from vehicles in environmental class 2000.
I have produced the value for environmental class 2005 by multiplying the NTM Calc value for environmental class 2000 by 0.4.

Environmental class 2005 ethanol E85

9a) I have worked on the basis of references (N), (P) and (X).
Ref (N) is described under 7a. This showed that hydrocarbon emissions lie at the same level at room temperature but increased 30% more during ethanol operation at +5 degrees. The value +5 degrees is a good reference for Sweden's climate on average.
Ref (P) is a measurement on a modern vehicle, same vehicle type, run on petrol and E85. HC emissions are at the same level from both fuels. There is no information on temperature.
Ref (X) has tested three modern Ford Focus Flexifuel cars on different fuel blends with 5, 10, 70 and 85% ethanol content in the petrol. The tests have been performed using two different driving cycles (NEDC and Artemis) in surrounding temperatures of both 23 degrees and minus 7 degrees. Ref (X) is the most important of these three reports, as they tested three of the same vehicles on different fuels. HC emission varied sharply between different vehicles, driving cycles and surrounding temperatures.

These three references do not show any general pattern for HC emissions. Some measured lower emissions during E85 operation than petrol operation, others higher. Some noted that HC emissions increased more in the event of low surrounding temperatures if the vehicle was run on E85 than on petrol, other measurements found no such effect.
I suggest the same value for ethanol as for petrol vehicles in environmental class 2005.

9b) I have worked on the basis of references (N), (P) and (X).
Ref (N) is described under 7a. This showed that NOx emissions lie at the same level at room temperature from all of the vehicles, but the ethanol vehicle's NOx emissions do not increase as much as those of the petrol vehicles at +5 degrees.
Ref (P) is described under 9a. This showed that NOx emissions are roughly 40% lower during ethanol operation than during petrol operation.
Ref (X) is described under 9a. This showed that NOx emissions are 50-70% lower during E85 operation than during petrol operation, depending on the driving cycle and vehicle. The results vary from 0 to 70% decrease. The biggest importance was attached to ref (X).
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2005 by 0.5.

9c) I have worked on the basis of references (N) and (X).
Ref (N) is described under 7a. This showed that particle emissions lie at the same level at all temperatures from all of the vehicles.
Ref (X) is described under 9a. This showed considerable spread between vehicles and fuel blends. No trend can be seen.
I suggest the same value for ethanol as for petrol vehicles in environmental class 2005.

Environmental class 2005 natural gas/biogas (methane)

10a) I have worked on the basis of ref (R) which, however, mainly tested environmental class 2000 vehicles, and data in available certification information for vehicles in environmental class 2005.
Ref (R) states 10% lower HC emissions from gas vehicle than from petrol vehicle, but for environmental class 2000 and not 2005, and with a reservation for considerable spread of the measurement result.
The certification values for the 2004 models of Volvo's bi-fuel models during methane operation and petrol operation show that HC emissions during methane operation are 16% higher than during petrol operation. Note that two thirds of HC from gas vehicles consist of methane and this means that NMHC are much lower from gas vehicles.
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2005 by 1.1.

10b) Ref (R) is described under 10a. This states 60% lower NOx emissions from gas vehicle than from petrol vehicle, but for environmental class 2000 and not 2005, and with a reservation for considerable spread of the measurement result.
The certification values for the 2004 models of Volvo's bi-fuel models during methane operation and petrol operation show that NOx emissions during methane operation are 60% lower than during petrol operation.
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2005 by 0.4.

10c) I have worked on the basis of ref (N), (R) and (T). The first two are measurements with only one vehicle in environmental class 2005 and the rest are older cars. Ref (T) relates to environmental class 2005 vehicle.

Ref (N) is described under 7a. One of the petrol vehicles has direct injection, however, and thus higher particle emissions, and is therefore not interesting here. Emissions of particles from the gas vehicle and the other petrol vehicle were at the same level at room temperature, but emissions from the gas vehicle do not increase at either +5 or -7 degrees, whilst particle emissions from the petrol vehicle doubled at +5 degrees (figure difficult to read, data not stated).
Ref (R), described under 10a, showed that the particle emissions from the gas vehicles were 67% lower than the emissions from the petrol vehicles. The report states, however, that the spread was considerable with regard to the gas vehicles because of different engine technologies, and that the results are therefore of limited value.
Ref (T) contains no numerical information on differences in particle emissions between gas and petrol, and states only that the gas vehicle emits much less.
I have multiplied the NTM Calc value for petrol vehicles in environmental class 2000 by 0.5

Environmental class 2000 PM (diesel vehicle with particle cleaning)

11a) I have worked on the basis of ref (G) and (Z). Diesel vehicles with particle filters have the same emissions as equivalent vehicles without filters.
I have chosen the same NTM Calc value as for diesel vehicles in environmental class 2005.

11b) I have worked on the basis of ref (G) and (Z). Diesel vehicles with particle filters have the same emissions as equivalent vehicles without filters.
I have chosen the same NTM Calc value as for diesel vehicles in environmental class 2005.

11c) I have worked on the basis of ref (C), (G) and (Z). Diesel vehicles with particle filters or equivalent work much more efficiently. They show the same low emissions as petrol vehicles in environmental class 2005.
I have chosen the same NTM Calc value as for diesel vehicles in environmental class 2005.

References

The following references have been included in the literature study.

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(B) Avgasemissioner från lätta fordon drivna med olika drivmedel. Effekter på hälsa, miljö och energianvändning. P Ahlvik, Å Brandberg, KFB and Ecotraffic KFB (The Swedish Transport and Communications Research Board) report 1999:38. (Exhaust emissions from light vehicles run on different fuels. Effects on health, environment and energy use. In Swedish only)

(C) Certification values for light vehicles. Published by the Vehicle Certification Agency, www.vca.gov.uk.

(D) Certification values for various models from Svenska Volkswagen, Fredrik Wiss 2004.

(E) Data from FEAT measurement in exhaust plumes from a number of buses in actual use. The Traffic and Public Transport Authority, City of Göteborg, 2004.

(F) Emissionsjämförelse mellan buss och bil. Vägverket publication 2001:51.
(Comparison of emissions from buses and cars. In Swedish only)

(G) Environmental and health impact from modern cars. A comparison between two petrol and two diesel cars with varying emission control technology. Vägverket publication 2002:62.

(H) Environmental performance and external costs for taxis (Volvo S70) in Göteborg run on different fuels. Blinge, Roth 1999. Chalmers Transportteknik meddelande 105.

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(L) NTM Calc Person. Beskrivnings av beräkningsmetodik och bakgrundsdata. Sammanställning av arbetet inom NTMs arbetsgrupp Miljödata för persontransporter. November 2004. (Description of calculation method and background data. Summary of the work within NTM's working group on environmental data for passenger transport. In Swedish only)

(M) Bensin eller dieseldriven personbil – vad är bäst för miljön? Vägverket publication 2001:40. (Petrol- or diesel-operated passenger cars – what's best for the environment? In Swedish only)

(N) Particle emissions at moderate and cold temperatures using different fuels.
P Aako, N-O Nylund, VTT Processes, SAE Technical paper series 2003-01-3285. 2003.

(O) Particulate emissions from six different fuels in light-duty vehicles. C Serves MTC 6809a. 1999.

(P) Information from manufacturer on emissions during petrol operation and E85 operation from modern vehicle. Unpublished data.

(Q) IEA/AMF Annex XIII: Emission performance of selected biodiesel fuels – VTT´s contribution. Research Report ENE5/33/2000. 2000.

(R) Evaluation of the environmental impact of modern passenger cars on petrol, diesel, automotive LPG and CNG, TNO report 03.OR.VM.055.1/PHE. 2003.

(S) Compatibility of pure and blended biofuels with respect to engine performance, durability and emissions. A literature review. SenterNovem report 2GAVE04.01. 2004.

(T) Unpublished material from test laboratory.

(U) A clean ethanol-fuelled compression ignition bus engine. Report prepared for BioAlcohol Fuel Foundation (BAFF) 2004 by Karl-Erik Egebäck. Autoemission K-E E Consultant. 2004.

(V) Transit bus emission study: Comparison of emissions from diesel and natural gas buses. VTT research report PRO3/P5150/04. 2004.

(X) Emissions from Flexible Fuel Vehicles with different ethanol blends.
C. de Serves, AVL MTC 5509. 2005.

(Y) Unpublished material from exhaust measurement of seven Swedish heavy gas vehicles performed in 2004.

(Z) Measurement of Emissions from Four Diesel-fuelled Passenger Cars Meeting Euro 4 Emission Standards, Hua Lu Karlsson MTC 5505 AVL MTC AB. 2005.

(Å) Redovisning av regeringsuppdrag angående efterkonvertering av personbilar för alternativbränslen. Vägverket FO99 2005:10997. 2005-07-29.
(Report on government assignment concerning aftermarket conversion of passenger cars for alternative fuels. In Swedish only)