

Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services

EMEEES bottom-up case application 14: Vehicle Energy Efficiency

Authors

Susanne Böhler
Frederic Rudolph

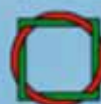
Wuppertal Institute for Climate,
Environment, Energy

Döppersberg 19
42103 Wuppertal/Germany

30 April 2009

evaluate
energy savings 

coordinated by



Wuppertal Institute
for Climate, Environment
and Energy

supported by

Intelligent Energy  Europe

The Project in brief

The objective of this project is to assist the European Commission in developing harmonised evaluation methods. It aims to design methods to evaluate the measures implemented to achieve the 9% energy savings target set out in the EU Directive (2006/32/EC) (ESD) on energy end-use efficiency and energy services. The assistance by the project and its partners is delivered through practical advice, technical support and results. It includes the development of concrete methods for the evaluation of single programmes, services and measures (mostly bottom-up), as well as schemes for monitoring the overall impact of all measures implemented in a Member State (combination of bottom-up and top-down).

Consortium

The project is co-ordinated by the Wuppertal Institute. The 21 project partners are:

Project Partner	Country
Wuppertal Institute for Climate, Environment and Energy (WI)	DE
Agence de l'Environnement et de la Maitrise de l'Energie (ADEME)	FR
SenterNovem	NL
Energy research Centre of the Netherlands (ECN)	NL
Enerdata sas	FR
Fraunhofer-Institut für System- und Innovationsforschung (FhG-ISI)	DE
SRC International A/S (SRCI)	DK
Politecnico di Milano, Dipartimento di Energetica, eERG	IT
AGH University of Science and Technology (AGH-UST)	PL
Österreichische Energieagentur – Austrian Energy Agency (A.E.A.)	AT
Ekodoma	LV
Istituto di Studi per l'Integrazione dei Sistemi (ISIS)	IT
Swedish Energy Agency (STEM)	SE
Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES)	FR
Electricité de France (EdF)	FR
Enova SF	NO
Motiva Oy	FI
Department for Environment, Food and Rural Affairs (DEFRA)	UK
ISR – University of Coimbra (ISR-UC)	PT
DONG Energy (DONG)	DK
Centre for Renewable Energy Sources (CRES)	EL

Contact

Dr. Stefan Thomas, Dr. Ralf Schüle
 Wuppertal Institute
 for Climate, Environment and Energy
 Döppersberg 19
 42103 Wuppertal, Germany

Tel.: +49 (0)202-2492-110
 Fax.: +49 (0)202-2492-250
 Email: info@evaluate-energy-savings.eu
 URL: www.evaluate-energy-savings.eu
www.wupperinst.org

EMEEES bottom-up case application 14: Vehicle Energy Efficiency

Susanne Böhler
Frederic Rudolph

Contents

1 Summary Guidelines	4
1.1 Title of the case application.....	4
1.2 Type of EEI activities covered.....	4
1.3 Detailed definition of EEI activities covered	4
1.4 General specifications	5
1.5 Formula for unitary gross annual energy savings	5
1.6 Indicative value for unitary gross annual energy savings.....	6
1.7 Formula for total ESD annual energy savings.....	7
1.8 Indicative default value for energy savings lifetime	8
1.9 Main data to collect	8
2 Introduction.....	10
2.1 Twenty bottom-up case applications of methods	10
2.2 Three levels of harmonisation	11
2.3 Four steps in the calculation process	12
2.4 Pilot tests.....	13
3 Step 1: Unitary gross annual energy savings.....	15
3.1 Step 1.1: General formula and calculation model	15
3.2 Step 1.2: Baseline	16
3.3 Step 1.3: Requirements for normalisation factors	17
3.4 Step 1.4 Specifying the calculation method and its three related levels ..	18
3.4.1 Conversion factors	18
3.4.2 Considering the direct rebound effect	19
3.4.3 From EMEEES tasks 4.2 to 4.3: defining values and requirements.....	20
4 Step 2: Total gross annual energy savings.....	22
4.1 Step 2.1: Formula for summing up the number of actions	22
4.2 Step 2.2: Requirements for accounting for the number of actions	22

5 Step 3: Total ESD annual energy savings	23
5.1 Step 3.1: Formula for ESD savings	23
5.2 Step 3.2: Requirements for avoiding double counting.....	23
5.3 Step 3.3: Requirements for technical interactions.....	23
5.4 Step 3.4: Requirements for multiplier energy savings.....	24
5.5 Step 3.5: Requirements for the free-rider effect	24
6 Step 4: total ESD energy savings for year “i”	26
6.1 Requirements for the energy saving lifetime	26
6.2 Special requirements for early actions	26
6.3 Uncertainties	27
Appendix I: Justifications and sources	28
Other appendix.....	29

1 Summary Guidelines

1.1 Title of the case application

Vehicle energy efficiency

1.2 Type of EEI activities covered

End-use action	
Sector	Transport
Energy end-use	Vehicle energy efficiency, measured by test cycle consumption
Efficient solution	engine, tyres, lubricant
Facilitating measure	
Types of EEI facilitating measures	<ul style="list-style-type: none"> • Fiscal measures and other financial incentives for purchase of efficient vehicles • National labelling of tyres and lubricants • National labelling of passenger vehicles • Information/motivation tools promoting efficient vehicle technologies • Research, Development and Demonstration • Car scrapping rebates • EU Directive on CO₂ emissions of cars

1.3 Detailed definition of EEI activities covered

This method/case application applies for fiscal measures and other financial incentives, national labelling of tyres/lubricants, information/motivation campaigns, research/development as well as for car scrapping rebates. Every measure covered aims at supporting one single end-use action: The usage of energy efficient vehicle technologies.

Theoretically, the method may be applied for EU-level measures such as the new Cars Directive, aiming at reducing the average fuel consumption of a manufacturer's car fleet, as well as for vehicle labelling (Directive 1999/94/EC). In general, such EU-level facilitating measures will better be evaluated top-down with the help of specific energy consumption indicators. But if one out of these measures is a *selected promotion of efficient vehicles on national or local level and thus the number of participants can be derived bottom-up*, e.g. through monitoring of the number of participants, this case application (N^o 14) does apply and is recommended to be chosen.

1.4 General specifications

The European Automotive Industry distinguishes between passenger cars, light commercial vehicles (up to 3.5 t), trucks above 3.5 t and buses above 3.5 t. This method will distinguish between passenger cars and commercial vehicles. Light commercial vehicles, buses and trucks are summarised as commercial vehicles.

Both fuel-saving lubricants and tyres are produced to lower frictional losses of a vehicle. For the purpose of this method, the following lubricants and tyres are considered fuel-saving:

- eligible lubricants: 5W-30/40 or 0W-30/40
- eligible tyres: environmental label “blue angel” RAL-UZ 89

1.5 Formula for unitary gross annual energy savings

For this method, the unit is one vehicle, which may be equipped with fuel-saving motor oil and tyres. The formula for unitary gross annual energy savings is:

$$ES_{uga} = En_{bas} * (1 - En_{eff} / En_{bas} * EV_{lub} * EV_{tyr}) * ADT - (En_{eff} * RE)$$

(Equation 1)

Where:

- ES_{uga} Unitary gross annual energy savings [kWh]
 En_{bas} Fuel consumption in the baseline case [kWh/km]
 En_{eff} Average fuel consumption of efficient vehicle [kWh/km]
 EV_{lub} Efficiency value for fuel-saving lubricants [0;1]
 EV_{tyr} Efficiency value for fuel-saving tyres [0;1]
 ADT Annual distance travelled [km]
 RE Direct rebound effect [km]; *inclusion of this effect subject to decision by ESD Committee*

This formula must be separately evaluated for the different types of passenger cars (e.g., mini, compact, vans, etc.). It must not be evaluated across the board of all types of vehicles, since this would grossly overestimate the energy savings.

The European Commission has proposed to set the emission target for passenger cars to 130 g CO₂/km from 2012. An emission target for any commercial vehicle category has not yet been set. The EU emissions targets are taken to define the threshold between efficient and inefficient vehicles for this case application. The value of the baseline case (En_{bas}) depends not only on the vehicle category, but as well on the facilitating measure under evaluation:

- For all measures promoting the purchase of efficient new passenger cars, the baseline is the average consumption of inefficient new passenger cars, i.e. all new passenger cars emitting more than 130 g CO₂/km.
- For commercial vehicles, the baseline assumptions should be similar to the approach for passenger cars. But a threshold between efficient and inefficient commercial vehicles still needs to be defined. Commercial vehicles should be classified according to the definition of the European Automotive Industry.
- If the purchase of a new passenger car/commercial vehicle is linked to a scrapping rebate for the old vehicle, then the baseline is the average energy consumption of the vehicle fleet in use five years prior to the year under evaluation.

The conversion factors for the threshold between efficient and inefficient passenger cars are as follows:

Table 1: conversion factors to determine the baseline fuel consumption¹

energy consumption when emitting 130 g CO₂/km
0,489 kWh/km for regular grade petrol
0,498 kWh/km for super petrol
0,487 kWh/km for diesel fuel
0, 618 kWh/km for natural gas

With respect to facilitating measures promoting the purchase of fuel-saving tyres and lubricants, the baseline/reference case ($E_{n_{bas}}$) shall be the average energy consumption of the current vehicle fleet.

1.6 Indicative value for unitary gross annual energy savings

According to Schallaböck et al.², there are numerous options to improve vehicle energy efficiency, and a combination of efficient technologies offers a technical saving potential beyond 50 %.

By contrast, the determination of the saving potential of certain facilitating measures proves to be difficult. According to Irrek/Jarczinsky,³ for passenger transport the net impact achieved by existing policies and measures was not known.

¹ See Appendix I - Justification and Sources, n^o1

² See Appendix I - Justification and Sources, n^o2

³ See Appendix I - Justification and Sources, n^o3

Hence, there is no level 1 default value for $E_{n_{eff}}/E_{n_{bas}}$. $E_{n_{uga}}$ depends on the fuel consumption values measured and is country-specific. The level 1 default efficiency values of fuel-saving tyres and lubricants are listed in table 2.

Table 2: Efficiency values for fuel-saving lubricants and tyres, level 1 evaluation⁴

lubricants	lubricants	tyres	tyres
passenger car	com. vehicle	passenger car	com. vehicle
0.973	0.973	0.971	0.950

1.7 Formula for total ESD annual energy savings

The total ESD annual energy savings comprise the adjusted total gross annual savings. The total gross annual energy savings are derived by multiplying the number of efficient passenger cars/commercial vehicles that are purchased or affected in the context of the EEI measure under evaluation with the average unitary gross annual energy savings.

$$ES_{tga} = N^o * \overline{ES}_{uga}$$

(Equation 2)

Where:

ES_{tga} Total gross annual energy savings

ES_{uga} Unitary gross annual energy savings (derived from equation 1)

N^o Number of participating/equipped passenger cars/commercial vehicles

The adjusted gross savings consider free rider, multiplier and double counting effects. Hence, the formula for the total ESD annual energy savings is as follows:

$$ES_{tna} = ES_{tga} * (1 - \text{free-rider coefficient} + \text{multiplier coefficient}) * \text{double counting factor}$$

(Equation 3)

Where:

ES_{tna} Total net annual energy savings

ES_{tga} Total gross annual energy savings (derived from equation 2)

Free-rider coefficient: [0;1]; *inclusion is subject to decision by ESD Committee*

Multiplier coefficient: ≥ 0

Double counting factor: [0;1]

⁴ See Appendix I - Justification and Sources, n^o4

1.8 Indicative default value for energy savings lifetime

(EU-) default savings lifetime	efficient vehicles	100,000 km (CEN WS 27 Agreement)
	low resistance tyres for cars	50,000 km (CEN WS 27 Agreement)
	low resistance tyres for trucks	100,000 km (CEN WS 27 Agreement)
	fuel-saving lubricants	15,000 km (own estimate)

1.9 Main data to collect

Precision of the data listed below varies strongly. E.g. the vehicle kilometres travelled might in some cases be available for different street categories, while for certain facilitating measures the number of participants might hardly be available at all.

Data needed in calculation for EU values (level 1)	Examples of corresponding data sources
Average annual distance travelled (vehicle kilometres). Distinction between passenger cars and commercial vehicles.	Default value: Passenger cars: 12,000 km ⁵ Commercial vehicles: 18,300 km ⁶
Number of participants (level 3)	Monitoring of number of participants Market shares Surveys
Efficiency values for tyres and lubricants	Default values: see table 2
Fuel consumption to be evaluated on MS-level (level 2)	National statistics or EU monitoring
Data to be collected National method (level 2)	
Average annual distance travelled (vehicle kilometres). Distinction between commercial vehicles and passenger cars. If data available, distinction of street categories as in level 3	National statistics
Average fuel consumption of fleet of inefficient new vehicles, i.e. all vehicles emitting more than baseline levels Average fuel consumption of efficient vehicles, i.e. all vehicles emitting up to baseline levels	National statistics ODYSSEE-indicators statistics from manufacturer's associations
Number of participants	cf. level 1
Efficiency values for tyres and lubricants	cf. level 1
Data to be collected Specific method (level 3)	
Average annual distance travelled (vehicle kilometres) <ul style="list-style-type: none"> • within urban, built-up areas • in rural areas, out of town and • on motorways. Distinction between commercial vehicles and at least three categories of passenger cars	Advanced governmental/local statistics Manufacturers and their associations Surveys

⁵ See Appendix I - Justification and Sources, n^o5

⁶ See Appendix I - Justification and Sources, n^o6

Average fuel consumption of fleet of inefficient new cars	cf. level 2, but differentiated by street categories
Average fuel consumption of efficient vehicles	own data/assumptions, survey
Number of participants	cf. level 1
Efficiency values for tyres and lubricants	own data, default values from the German Federal Environment Agency (see table 4)

2 Introduction

2.1 Twenty bottom-up case applications of methods

Within EMEES, task 4.1 provided methodological materials in the internal working paper “Definition of the process to develop harmonised bottom-up evaluation methods”, version 20 April 2007; an update has been published as an Appendix to the report on Bottom-up methods at www.evaluate-energy-savings.eu. Based on this draft report, concrete bottom-up case applications were developed by EMEES partners within task 4.2, and reference values were to be specified within task 4.3.

This report deals with case application 14 “Vehicle energy efficiency” developed by Wuppertal Institute.

Eleven project partners have developed concrete bottom-up case applications for a specific type of technology or energy efficiency improvement measure or end-use action. All gave comments and input to the methods developed by the other organisations.

The 20 case applications developed are presented in the table below:

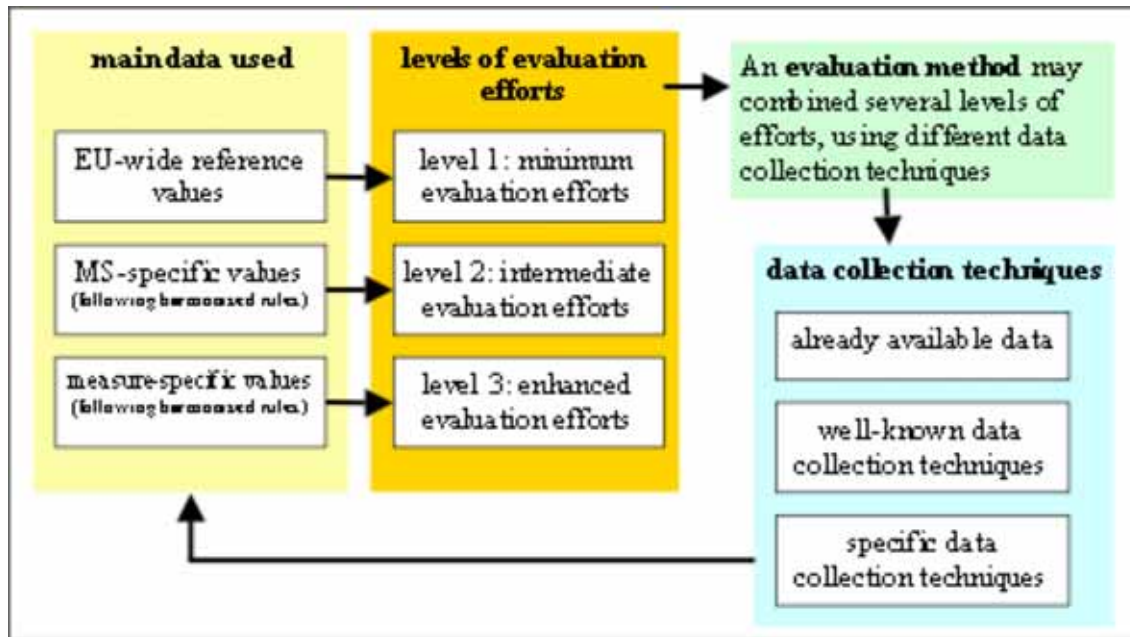
N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
1	Building regulations for new residential buildings	Residential	SenterNovem
2	Improvement of the building envelope of residential buildings	Residential	AEA
3	Biomass boilers	Residential	AGH-UST
4	Residential condensing boilers in space heating	Residential	Armines
5	Energy efficient cold appliances and washing machines	Residential	ADEME
6	Domestic Hot Water – Solar water heaters	Residential	AGH-UST
7	Domestic Hot Water - Heat Pumps	Residential	AGH-UST
8	Non residential space heating improvement in case of heating distribution by a water loop	Tertiary	eERG
9	Improvement of lighting systems	Tertiary (industry)	eERG
10	Improvement of central air conditioning	Tertiary	Armines

N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
11	Office equipment	Tertiary	Fraunhofer
12	Energy-efficient motors	Industry	ISR-UC
13	Variable speed drives	Industry	ISR-UC
14	Vehicle energy efficiency	Transport	Wuppertal Institute
15	Modal shifts in passenger transport	Transport	Wuppertal Institute
16	Ecodriving	Transport	SenterNovem
17	Energy performance contracting	Tertiary and industry end-uses	STEM
18	Energy audits	Tertiary and industry end-uses	Motiva
19	Voluntary agreements – billing analysis method	Tertiary and industry end-uses	SenterNovem
20	Voluntary agreements with individual companies – engineering method	Tertiary and industry end-uses	STEM

2.2 Three levels of harmonisation

In order to be as practicable as possible and to stimulate continued improvement, the harmonised reporting on bottom-up evaluation is structured on three levels (cf. figure 1).

Figure 1: Three levels of harmonisation



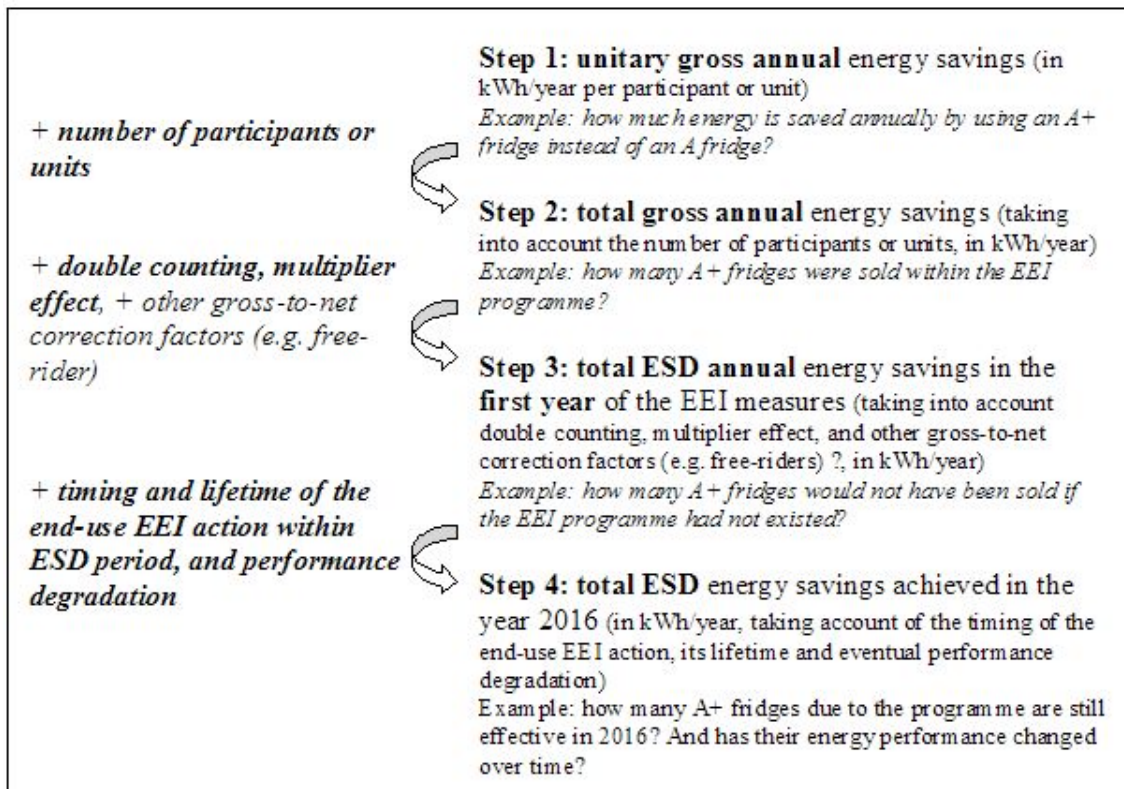
As a consequence, the EMEES case applications for bottom-up evaluation methods present:

- EU wide reference values, if applicable;
- Guidelines how Member States can use country-specific values following harmonised rules;
- Guidelines how measure- or action-specific (national) values can be developed, following harmonised rules.

2.3 Four steps in the calculation process

The harmonised rules for bottom-up evaluation methods are organised around four steps in the calculation process (cf. figure 2). These steps are presented in detail in the report for WP 4.1.

Figure 2: Four steps in the calculation process



The reports on the concrete bottom-up case applications follow the format of these four steps and they each hold six chapters plus some annexes:

1. summary
2. introduction
3. step 1: unitary gross annual energy saving
4. step 2: total gross annual energy savings
5. step 3: total ESD annual energy savings
6. step 4: total ESD energy savings for year “i”

2.4 Pilot tests

Additional to the development of the 20 bottom-up case applications, some of these cases were tested in practice in Work Package 8.

Pilot tests of the following case applications were performed by EMEEES partners in Italy, France, Denmark, and Sweden:

EMEEES case application	Sector	Italy	France	Denmark	Sweden
Building envelope improvement	Residential		X		
Energy-efficient white goods	Residential	X			
Biomass boilers in the residential sector	Residential		X		
Condensing Boilers	Residential	X	X		
Improvement of lighting system	Tertiary (industry)				X
High efficiency electric motors	Industry	X			
Variable speed drives	Industry	X			
Energy audits	Tertiary and industry end uses			X	
Energy performance contracting	Tertiary and industry				X

The following EEI measures were evaluated ex-post using the above-mentioned EMEEES bottom-up case applications:

Country	Subject	Sector(s) addressed
France	Condensing boilers, building envelope improvements and compact fluorescent lamps under the French White Certificates.	Residential
Italy	Schemes under the Italian White Certificates system	Residential, tertiary, industry
Sweden	Energy Efficiency Investment Programme for Public Buildings (2005-2008)	Public non-residential buildings
Denmark	Energy audits performed in Denmark between 2006 and 2008	Industry, tertiary

As a result of the pilot tests, some of the case applications tested were updated to reflect the findings of the tests.

3 Step 1: Unitary gross annual energy savings

The European Automotive Industry distinguishes between cars, light commercial vehicles (up to 3.5 t), trucks above 3.5 t and buses above 3.5 t. Out of 18 million new vehicles registered in the EU in 2006, passenger cars make up for 85.2 %. The share of light commercial vehicles is as high as 12.3 %, while trucks and buses above 3.5 t account for 2.5 % of new vehicles registered in 2006. This method will distinguish between passenger cars and commercial vehicles, i.e. light commercial vehicles, buses and trucks.

Both fuel-saving lubricants and tyres are produced to lower frictional losses of a vehicle. For the purpose of this method, the following lubricants and tyres are considered fuel-saving:

- lubricants: (5W-30/40 or 0W-30/40)
- tyres: environmental label “blue angel” RAL-UZ 89

3.1 Step 1.1: General formula and calculation model

The unit is one vehicle, which may be equipped with fuel-saving lubricants and tyres. The unitary gross annual energy savings are given by the following formula:

$$ES_{uga} = En_{bas} * (1 - En_{eff} / En_{bas} * EV_{lub} * EV_{tyr}) * ADT - (En_{eff} * RE)$$

(Equation 1)

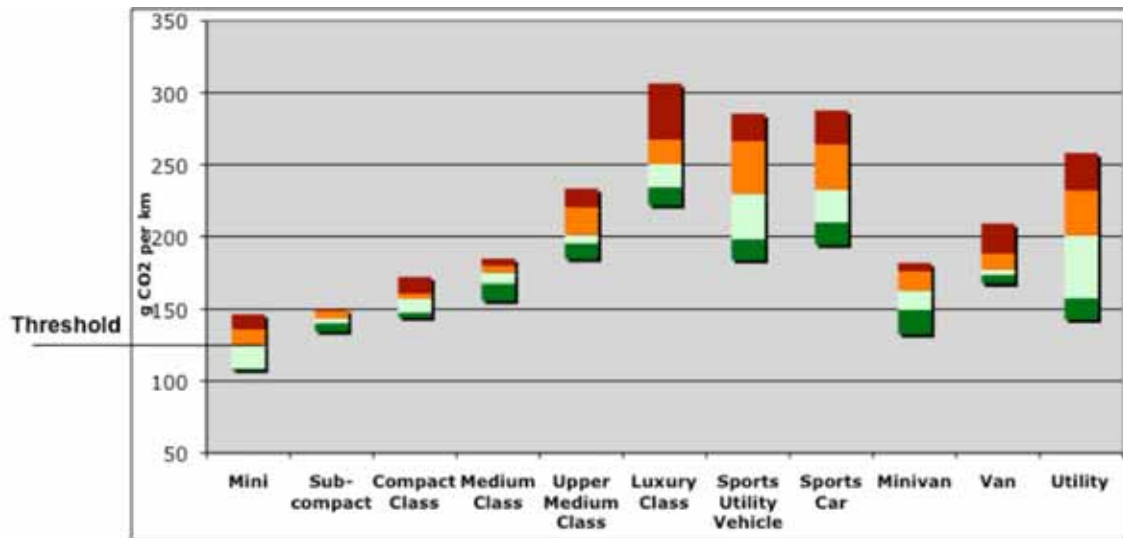
Where:

- ES_{uga} Unitary gross annual energy savings [kWh]
 En_{bas} Fuel consumption in the baseline case [kWh/km]
 En_{eff} Fuel consumption of efficient vehicle [kWh/km]
 EV_{lub} Efficiency value for fuel-saving lubricants [0;1]
 EV_{tyr} Efficiency value for fuel-saving tyres [0;1]
 ADT Annual distance travelled [km]
 RE Direct rebound effect [km]; *inclusion of this effect is subject to decision by ESD Committee*

This formula must be separately evaluated for the different types of passenger cars (e.g., mini, compact, vans, etc.). It must not be evaluated across the board of all types of vehicles, since this would grossly overestimate the energy savings.

Figure 3 presents this approach of separate evaluation for the example of German data. Of course, for the ESD, the values would need to be converted to kWh/km.

Figure 3: Unitary gross annual CO₂ savings and maximum and minimum emission values for different types of cars



In figure 3, the range of emissions values is shown for each class of cars. The 130 g/km threshold is by definition in the Directive depending on car size, so differs by class. The unitary gross annual savings are the difference between the average emissions of the inefficient cars (limit between dark red and lighter orange bars in the upper part of each range) and the average emissions of the efficient cars (limit between dark green and light bars in the lower part of each range). These savings vary between 10 and 80 g/km depending on class, but are typically lower in the classes with high sales volumes. Taking the averages across all classes of cars, the savings would almost equal to 60 g/km and thus be grossly overestimated.

3.2 Step 1.2: Baseline

The Cars Directive sets the fleet average target for *new passenger cars* to emit less than 130 g CO₂/km by 2012, which we propose to be the threshold between efficient and inefficient cars. For commercial vehicles, the threshold between energy-efficient and inefficient vehicles still needs to be defined. All vehicles with higher specific carbon emissions than the EU target are thus considered inefficient. The average emissions of such vehicles constitute the baseline (as is shown in Figure 3). If based on national registration statistics on new cars, this baseline will automatically be dynamic. Energy savings due to the Directive must be evaluated separately.

Table 1 lists the conversion factors that are necessary to determine the threshold between efficient and inefficient passenger cars as expressed in kWh.

Table 1: conversion factors to determine the baseline fuel consumption⁷

energy consumption when emitting 130 g CO ₂ /km
0.489 kWh/km for regular grade petrol
0.498 kWh/km for super petrol
0.487 kWh/km for diesel fuel
0.618 kWh/km for natural gas

The baseline will be different, if the purchase of a new, efficient vehicle is linked to the scrapping of the old vehicle. For measures facilitating this, the baseline is the average fuel consumption of the passenger car/commercial vehicle *fleet in use* 5 years prior to the year in evaluation.

With respect to facilitating measures aiming at fostering the purchase of low resistance tyres and lubricants, the baseline is the average fuel consumption of the fleet of passenger cars/commercial vehicles in use. This will automatically be dynamic. Commercial vehicles should be classified according to the definition of the European Automotive Industry.

level 1	Default baseline: average specific fuel consumption of the European new passenger cars/new commercial vehicles fleet with CO ₂ emissions above the proposed EU target. Source: ACEA
level 2	Baseline: average specific fuel consumption of the new passenger cars/new commercial vehicles fleet with CO ₂ -emissions above the proposed EU target in the particular MS. Source: ODYSSEE indicators, national statistics, statistics of manufacturers' associations
level 3	Baseline: If for some reasons the facilitating measure strictly applies on the local level and/or for a selection of vehicles, such conditions should be taken into account. Data required: own data

3.3 Step 1.3: Requirements for normalisation factors

If there are new/other fuel-saving lubricants and/or low resistance tyres available for purchase, the default values given in chapter 3.4.3 shall be changed.

Weather conditions are another influencing factor, as the annual distance travelled of passenger cars changes with weather. But since the *average* vehicle kilometres travelled are included into equation 1, no further normalisation is necessary. Nevertheless, the average annual distance travelled has to be validated every 2-3 years, in order to account for structural changes.

⁷ See Appendix I - Justification and Sources, n^o1

3.4 Step 1.4 Specifying the calculation method and its three related levels

Method: Deemed savings or mixed deemed and ex post.

level 1	Average annual distance travelled by a passenger car and by a commercial vehicle in the EU. Default value: 12,000 km and 18,300 km. Efficiency values for fuel-saving lubricants and low resistance tyres: see table 2 Rebound effect: 0 km
level 2	Average annual distance (vehicle kilometres) travelled in the respective MS. Distinction between commercial vehicles and at least three categories of passenger cars (Equation 1b).
level 3	Annual distance travelled (vehicle kilometres) <ul style="list-style-type: none"> • within urban, built-up areas, • in rural areas, out of town and • on motorways in the particular MS. Distinction between commercial vehicles and at least three categories of passenger cars (Equation 1b). Efficiency values for fuel-saving lubricants and low resistance tyres: see table 4.

Formula for level 2 & 3 evaluation:

$ES_{uga} =$

$$\sum_{i=1}^m \sum_{j=1}^n En_{bas\ j} * (1 - En_{eff\ j} / En_{bas\ j} * EV_{lub\ j} * EV_{tyr\ j}) * ADT_{ij} - (En_{eff\ j} * RE_{ij})$$

(Equation 1b)

Where:

- i Vehicle category 1-m (level 2&3)
- j Street category a)-c) (level 3 only)

3.4.1 Conversion factors

According to the ESD, end-use efficiency shall be reported in kWh per year. Fuel efficiency of a vehicle is usually described in l/100 km. Fuel consumption ratings of natural gas filled vehicles are provided in kg/100 km, electrically powered cars are measured in kWh/100 km. In order to link the vehicle's fuel consumption to its contribution to global warming, CO₂-emissions as measured in g/km are an important indicative value as well. The following table lists the conversion factors necessary. However, thermophysical properties may always vary slightly, depending on the fuel used. E.g. properties of biofuel differ from those of conventional fuel.

Table 3: Conversion factors for fuel ⁸

	kWh	g CO ₂
1 l regular-grade petrol	8.78	2333
1 l super petrol	9.12	2381
1 l diesel fuel	9.86	2633
1 kg natural gas	13.25	2787

3.4.2 Considering the direct rebound effect

This section only applies for lighting, cars, and for measures related to the internal temperature of dwellings, unless there is clear evidence that it is relevant.

The direct rebound effect is not explicitly mentioned in the ESD. It is created by final energy consumers who increase the intensity of the use of energy-efficient equipment after an EEI measure, e.g., when the internal temperature of a building is increased after insulation. This reduces the energy savings achieved in comparison to the baseline of autonomous consumption changes. Consequently, including energy savings “eaten up” by the direct rebound effect in the total ESD annual energy savings would mean to overestimate energy savings compared to the autonomous energy consumption changes. It has not yet been decided by the European Commission and the ESD Committee, whether this effect shall be included in the total ESD annual energy savings or eliminated from them. In the latter case, the following requirements apply.

The direct rebound effect may occur in such a way that end users who decide to purchase and use certain energy-efficient vehicle technologies might increase their annual distance travelled as a result of the increased mileage of their vehicle. In consequence, energy savings derived from efficient engines, tyres and lubricants might be mitigated or overcompensated. With respect to commercial cars, this rebound effect is not likely to occur. The annual distance travelled of commercial cars depends on its cost effectiveness with customers' orders being the driving factor (rebound effect = 0 km). By contrast, individuals might change their priorities and recalibrate their budget, if the mileage of their car has changed.

The quantification of the rebound effect resulting from an increased usage of energy efficient cars is charged with problems, as changes in annual distance travelled can be explained by different effects. According to the ACEA, motorists in the EU-25 increased their annual distance travelled by 16.4 % between 1995 and 2003 and the rebound effect resulting from an increased

⁸ See Appendix I - Justification and Sources, n^o1

milage constitutes a fraction of this share. Among the effects that constitute the changes in vehicle kilometres travelled are:

- fuel prices (including fuel taxes)
- household budget available
- working conditions and lifestyles
- number of private vehicles owned per household

In conclusion, the direct rebound effect is assumed to be negligible in level 1&2 evaluation for both passenger cars and commercial vehicles. Within level 3 harmonisation, a survey has to be conducted in principle. Such a survey should have an approach as follows: A certain share of participants as well as a control group is asked for the factors that constitute their annual distance travelled. This survey is conducted three years prior to and after the end-use action. The authors recommend to conduct a study at EU-level on the direct rebound effect.

3.4.3 From EMEES tasks 4.2 to 4.3: defining values and requirements

According to the German Federal Environment Agency, synthetic low resistance motor oil and low resistance tyres are able to save up to 10 % fuel in comparison to the respective conventional technologies. The following table lists efficiency values for lubricants and tyres. It distinguishes between three street categories.

Table 4: Efficiency values for fuel-saving lubricants and tyres⁹

	lubricants	lubricants	tyres	tyres
street category	passenger car	com. vehicle	passenger car	com. vehicle
a) within urban, built-up areas	0.948	0.948	0.95	0.91
b) in rural areas, out of town	0.967	0.967	0.96	0.93
c) on motorways	0.982	0.982	0.98	0.97

If the average annual distance travelled for the three street categories listed is not available, as it is supposed to be for level 1 and 2 evaluation, one has to average out the figures in the table above and multiply the average energy savings with a reliability factor of 0.8 in order to assure conservative results.

Table 2: Efficiency values for fuel-saving lubricants and tyres, level 1&2 evaluation

lubricants	lubricants	tyres	tyres
passenger car	com. vehicle	passenger car	com. vehicle
0.973	0.973	0.971	0.950

⁹ See Appendix I - Justification and Sources, n^o4

The average annual distance travelled of passenger cars and commercial vehicles in the European Union is 15,000 km and 22,900 km respectively¹⁰. These values serve as the basis for the default values for level 1 evaluation. They shall be multiplied with a security factor of 0.8 in order to assure conservative results (default values: annual distance travelled of passenger cars 12,000 km, of commercial vehicles 18,300 km).

In the scope of level 2 evaluation, each MS has to derive the national average annual distance travelled. A distinction of street categories should be taken into account, as in some MS national statistics provide such data.

For level 3 evaluation, the annual distance travelled should first be divided into three street categories:

- within urban, built-up areas;
- in rural areas, out of town;
- on motorways.

Second, the evaluating body should try to distinguish different categories of passenger cars, as some categories are supposed to have a higher average annual distance travelled than others. Sources for such data are:

- manufacturers and their associations,
- advanced governmental/local statistics and
- surveys.

¹⁰ See Appendix I - Justification and Sources, n°5 and 6

4 Step 2: Total gross annual energy savings

4.1 Step 2.1: Formula for summing up the number of actions

One unit is each vehicle equipped with a more efficient engine than in the reference case, efficient lubricant and efficient tyres. The total gross annual energy savings are derived by multiplying the number of efficient passenger cars/commercial vehicles that are purchased or affected in the context of the EEI measure under evaluation with the average unitary gross annual energy savings.

$$ES_{tga} = N^o * \overline{ES}_{uga}$$

(Equation 2)

Where:

ES_{tga} Total gross annual energy savings

ES_{uga} Unitary gross annual energy savings (derived from equation 1)

N^o Number of participating/equipped passenger cars/commercial vehicles

4.2 Step 2.2: Requirements for accounting for the number of actions

Table 5: Facilitating measures and the methods to derive the number of end-use actions implied

Facilitating measure	Requirements for accounting for the number of end-use actions
Fiscal measures	Monitoring of number of participants
National labelling of tyres and lubricants	Market shares of the respective products
Information/motivation tools/campaigns	Surveys
Research, Development and Demonstration	Monitoring of number of participants
Car scrapping rebates	Monitoring of number of participants
National labelling of passenger cars	Market share of registered cars

5 Step 3: Total ESD annual energy savings

In this chapter, the correction factors required by the ESD and potential further correction factors are dealt with. Applying these factors will allow to calculate the total ESD annual energy savings from the gross annual energy savings calculated in step 2.

5.1 Step 3.1: Formula for ESD savings

$$ES_{tna} = ES_{tga} * (1 - \text{free-rider coefficient} + \text{multiplier coefficient}) * \text{double counting factor}$$

(Equation 3)

Where:

ES_{tna} Total net annual energy savings

ES_{tga} Total gross annual energy savings (derived from Equation 2)

Free-rider coefficient: [0;1]; *inclusion is subject to decision by ESD Committee*

Multiplier coefficient: ≥ 0

Double counting factor: [0;1]

5.2 Step 3.2: Requirements for avoiding double counting

In the case of overlapping (EEI) facilitating measures, the MS will allocate the corresponding energy savings to the respective measures or evaluate a package of measures. Possible overlaps include:

- National activities using different means of promotion
- Similar activities being conducted on different levels (EU, national, local)

As every facilitating measure aims at fostering the purchase of energy efficient vehicle technologies, there is a high risk of double counting energy savings. If it is possible to evaluate the market diffusion compared to the baseline trend of certain efficiency technologies via diffusion indicators, it may not be necessary to conduct a bottom-up evaluation.

In case that it is impossible to evaluate the market diffusion, the facilitating measures that apply for efficient motors, lubricants and tyres, respectively, shall be evaluated in package(s).

5.3 Step 3.3: Requirements for technical interactions

There are no requirements for technical interactions.

5.4 Step 3.4: Requirements for multiplier energy savings

Each facilitating measure, designed for vehicles and fuel-saving tyres and lubricants, might imply multiplier effects. Extent and precision of an evaluation principally depends on the profile of the target group. If a facilitating measure is provided for a certain well-defined target group, the evaluation can be conducted by different means:

- consumer behaviour of the target group is compared with that of a socioeconomic equal reference group;
- a generally accepted evaluation study has yielded results that are transferable for that particular facilitating measure;
- the target group acts as professional multiplier (e.g. teachers) and a certain success factor can be supposed.

If it is impossible to clearly circumscribe and profile the target group, a representative number of end-users taking the end-use action has to be sampled and asked for the reason of their end-use action. Such an evaluation would be able to figure out not only multiplier effects, but as well free-rider, double-counting and rebound effects.

If there is no source of evaluation at all, the multiplier effect is assumed to be negligible.

5.5 Step 3.5: Requirements for the free-rider effect

The free-rider effect is not explicitly mentioned in the ESD. Free riders are final energy users who are counted when monitoring the effects of facilitating measures but would have taken the end-use actions promoted anyway. Consequently, including energy savings achieved by free riders in the total ESD annual energy savings would mean to include a part of the autonomous energy efficiency improvements. It has not yet been decided by the European Commission and the ESD committee, whether this effect shall be included in the total ESD annual energy savings or eliminated from them. In the latter case, the following requirements apply.

Market penetration of fuel-saving lubricants and tyres has yet hardly been evaluated. According to the European automotive industry, new vehicles are equipped with such technologies since 1998. However, according to a survey of the German market, only 35 % of passenger car owners choose synthetic fuelsaving lubricants when changing oil¹¹. For commercial vehicles this share is supposed to be higher, as cost effectiveness rises with increasing annual distance travelled.

¹¹ See Appendix I - Justification and Sources, n°7

In conclusion, for all new vehicles participating in a certain facilitating measure that aims at fostering the purchase of low resistance tyres or lubricants, the free rider effect is as high as 100 % (free-rider coefficient: 1). The share of new vehicle registrations in the year under evaluation serves as proxy indicator. For vehicles older than one year (i.e. the residual share of participating vehicles), the market diffusion of low resistance tyres and lubricants in the particular MS serves as proxy indicator to obtain the free rider coefficient.

6 Step 4: total ESD energy savings for year “i”

6.1 Requirements for the energy saving lifetime

The 2007 CEN Workshop Agreement (CEN WS 27 Agreement) has set the following saving lifetimes of EEI facilitating measures in bottom-up calculations. Such figures shall be used for level 1 evaluation:

Table 6: Saving lifetimes of vehicle efficiency technologies as defined by the CWA

Efficient engines	100,000 km
low resistance tyres for cars	50,000 km
low resistance tyres for trucks (commercial vehicles)	100,000 km

The CWA does not provide saving lifetimes for efficient lubricants. Manufacturers and garages recommend to change oil after 15,000 km travelled or at least once a year. This corresponds to a recent market survey in Germany¹². Hence it seems reasonable to set the saving lifetime of efficient lubricants to 15,000 km, which is equivalent to the average annual distance travelled by a passenger car in the EU. Level 2 evaluation has to provide national data.

The lifetime of the respective efficient solution (engine, tyres, lubricant in km according to table 6) has to be divided by the average annual distance travelled in the EU (level 1) or by the average annual distance travelled in the particular MS (level 2). Within level 1 evaluation, the security factor of 0.8 has to be considered for both the default lifetimes and the default annual distance travelled. This is to make the conservative estimates consistent.

Level 3 evaluation only applies for special demonstration projects.

6.2 Special requirements for early actions

The definition of early actions may include two possibilities (to be clarified by the European Commission and the ESD Committee):

- *early (EEI) facilitating measures*, and only those energy savings that result from end-use actions that are implemented during 2008-2016, as a result of these facilitating measures that still have a lasting effect during 2008-2016, are eligible

OR

¹² See Appendix I - Justification and Sources, n°7

- *early energy savings* from end-use actions initiated between 1995 and 2008, with the end-use actions having a lasting effect in 2010 (for the intermediate target) or 2016 (for the overall target).

Note:

If early energy savings are accepted, a contribution to the target in 2016 can only be counted if the energy saving lifetime is greater than 8 years plus the time between installation and 2008. This needs to be proven. The same holds, respectively, for the intermediate target in 2010.

With respect to this case application, the authors propose to apply the 2008 baseline, if early actions are considered.

To our knowledge, until now measures aiming at fostering low resistance tyres and lubricants have not yet been implemented, with the exception of a Blue Angel label for tyres in Germany. If there are already measures under implementation, their lifetimes are too small to be considered by 2016. Hence, early actions are irrelevant for such technologies. With respect to efficient engines, level 1 evaluation does not apply for early actions either, as the savings lifetimes do not exceed 5 years.

6.3 Uncertainties

This method/case application provides a lot of uncertainties. Among them, some are of significant scope, others are negligible.

The annual distance travelled is a very important value for this case application. Efforts should be made to gather data for as many vehicle and street categories as possible. This particularly holds true for commercial vehicles.

With respect to the correction factors dealt with in chapter 5, only free-rider and double counting effects are supposed to have significant impact. Hence, uncertainty should be kept as low as possible for these two factors. Whereas it is possible to adequately approach the free-rider effect, evaluation and monitoring of the double counting effects is supposed to prove more difficult.

In general, the decision to purchase a certain vehicle depends on many factors, some of them might be decisive, but at the same time have no relation to vehicle energy efficiency at all.

Facilitating measures aiming at fostering the purchase of fuel-saving motoroil and low resistance tyres are supposed to have insignificant impact on energy savings, as their lifetimes are very limited. Hence, uncertainties for such measures are of minor consequence.

Appendix I: Justifications and sources

1. Robert Bosch GmbH (Ed.) 1991: Kraftstofftechnisches Taschenbuch. Stuttgart 1991, p. 232
2. Schallaböck, K.O.; Fishedick, M.; Brouns, B.; Luhmann, H.-J.; Merten, F.; Ott, H.E.; Pastowski, A.; Venjakob, J.: Klimawirksame Emissionen des Pkw-Verkehrs und Bewertung von Minderungsstrategien. Wuppertal 2006, p. 77
3. Irrek, Wolfgang; Jarczinsky, Lutz: Overall Impact Assessment of current energy Efficiency Policies and Potential 'Good Practise' Policies, Wuppertal 2007, p. XI
4. German Federal Environment Agency 2003: CO₂-Minderung im Verkehr, ein Sachstandsbericht des Umweltbundesamtes – Beschreibung von Maßnahmen und Aktualisierung von Potenzialen, Berlin 2003, p. 34
5. Website ACEA (access: 10-01.2008):
http://www.acea.be/images/uploads/sp/VEHICLES_IN_USE_2005.pdf
6. Hautzinger, H.; Stock, W., Mayer, K.; Schmidt, J.; Heidemann, D. 2005: BAST-Bericht V 120, Institut für angewandte Verkehrs- und Tourismusforschung - IVT, Heilbronn/Mannheim
7. Deutsche Automobil Treuhand GmbH 2007: DAT-Report 2007 Kfz-Betrieb, Ostfildern 2007, p. 32

Other appendix

Reference to existing requirements from other methods (or general requirements for all methods).