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

# EMEEES bottom-up case application 15: Modal Shifts in Passenger Transport


## Authors:
**Susanne Böhler**
**Frederic Rudolph**

Wuppertal Institute for Climate, Environment, Energy

Döppersberg 19
42103 Wuppertal/Germany


30 April 2009


coordinated by Wuppertal Institute for Climate, Environment and Energy

supported by Intelligent Energy Europe

evaluate energy savings EU

## 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 15: Modal Shifts in Passenger Transport

Susanne Böhler
Frederic Rudolph

## Contents

# 1 Summary Guidelines

## 1.1 Title of the method

Modal shifts in passenger transport

## 1.2 Type of EEI activities covered

| End-use EEI action | |
|---|---|
| Sector | Transport |
| Energy end-use | Passenger transportation |
| Efficient solution | **Shift to sustainable transport modes**<br>Transport volume as measured and expressed in person kilometres is taken for granted. The point for this case application is to realise the person kilometres with less energy-intensive transport modes. |
| **EEI Facilitating measure** | |
| Types of EEI facilitating measures | 1. traffic management<br>2. improvement of public transport system<br>3. improvement of infrastructure/organisation of non-motorised transport modes<br>4. improvement of infrastructure of long distance trains |

## 1.3 Detailed definition of EEI activities covered

Modal shift is defined as covering distances that would have been travelled anyway with less energy intensive (“more sustainable”) transport modes. The distance covered remains the same. With respect to short distance trips, policies aim at strengthening non-motorised transport modes and urban public transport. With respect to long distance trips, rail-bound transport is regarded more sustainable than air transportation and individual motor car traffic.

In practice, many existing policies aim at both the shift towards less energy-intensive transport modes and the reduction of distances. This case application only applies for the former aim, but often it proves impossible to isolate it from the latter. E.g. parking pricing policies in shopping areas may make some customers consider non-motorised modes for travelling, while others choose shopping facilities within their neighbourhood.

Instruments facilitating the increase of the share of more sustainable transport modes range from spatial planning, regulatory policies, fiscal incentives to motivation and qualification measures. However, this case application exclusively focuses on the measures that can be evaluated bottom-up. Table 1 lists the facilitating measures that are covered by this case application. With respect to long distance trips, this case application only applies for measures designed for a single line section. Measures designed for a whole country or a network of long distance connections shall be evaluated top-down. With respect to short distance trips, EEI activities are often designed within a package of an integrated land-use policy and hence it is impossible to isolate a certain facilitating measure from another. See page 16 for details.

*Table 1: Facilitating measures covered by this case application*

| Category | | Facilitating measure |
|---|---|---|
| short distance | Improvement of public transport system | fare reduction in local transport |
| | | frequency improvement of transport services |
| | | comfort and service improvement |
| | | improvement of public transport information |
| | Improvement of infra-structure/organisation of non-motorised transport modes | bicycle lanes |
| | | footpaths |
| | Traffic management | park and ride |
| | | bike and ride |
| | | car park limitation |
| | | congestion charge |
| | | parking pricing |
| long distance | Traffic management | road pricing |
| | Improvement of infrastructure of long distance trains | new/faster connections |
| | | comfort improvement |
| | | ticket price reduction |
| | | frequency improvement |

## 1.4 General specifications

The choice of a certain mode of transport is crucially determined by the distance to be covered and other geographic and socio-economic circumstances. The evaluating body thus only considers those modes of transport that offer a viable option to switch to within a certain facilitating measure. Therefore each evaluation should start with a qualitative explanation, to which extent certain modes of transport are concerned and if they have to be considered within the evaluation or not. See chapter 3.4.3 for details.

## 1.5 Formula for unitary gross annual energy savings

The unit is one person. The unitary gross annual energy savings are given by the following formula.

$$ES_{uga} = \sum_{i=1}^{N} \Delta ADT_i * En_i$$

(Equation 1)

Where:

| | |
|---|---|
| $ES_{uga}$ | Unitary gross annual energy savings [kWh/person/year] |
| En | Specific energy consumption of a mode of transport [kWh/person-km] |
| $\Delta$ADT | change of annual distance travelled in a transport mode [km/year], baseline case ($ADT_{bas}$) – new case ($ADT_{new}$) |
| i | Mode of transport |
| N | Number of modes of transports concerned |

$$\sum_{i=1}^{N} ADT_{bas\ i} = \sum_{i=1}^{N} ADT_{new\ i}$$

## 1.6 Indicative default value for unitary gross annual energy savings

As a matter of fact, many different socio-economic and geographic circumstances determine the choice of the mode of transport of a person. For example, remote regions are not in the position to offer a well-functioning public transport system like urban regions might be able to do. Thus, the quantification of the energy saving potential of one person has to consider such case-specific circumstances and there is no default value for the unitary gross annual energy savings available. However, it is possible to provide default values for the specific energy consumption of the different modes of transport.

| **EU default values** | |
|---|---|
| Unitary annual energy savings default | Default values for the specific energy consumption of the different modes of transport are included in this document. See table 2 for details and chapter 3.4.3 for further details.<br>Moreover, chapter 4.1 provides a number of estimates on the total gross annual energy saving potentials of certain transport demand policies and measures. |

*Table 2: default values for the specific energy consumption of modes of transport*[1]

| | aero-plane | passen-ger car | long dis-tance train | long dis-tance bus | motor-bike | local public transport | walking, cycling |
|---|---|---|---|---|---|---|---|
| **specific energy consumption (kWh/person-km)** | see table 4 | see table 4 | 0,11 | not considered at level 1 evaluation | | 0 | 0 |

## 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 persons changing the transport modes 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 persons switching to less energy-intensive transport modes

If all correction factors are included, the adjusted gross savings will consider free-rider, multiplier and double-counting effects. Hence, the formula for the total ESD annual energy savings will be as follows:

$ES_{tna}$ =
$ES_{tga}$ * (1 – *free-rider coefficient* + multiplier coefficient) * 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 European Commission and ESD Committee*
Multiplier coefficient: >=0
Double counting factor: >=0

[1] See chapter 3.4.3 for justifications and sources

## 1.8 Indicative default value for energy savings lifetime

The 2007 CEN Workshop Agreement (CEN WS 27 Agreement) has set the default saving lifetime for modal shifts in passenger transport at 2 years. Member States wishing to apply longer saving lifetimes will thus have to prove persistence of the energy savings by regular surveys (every 2 years).

## 1.9 Main data to collect

| Data needed in calculation for EU values (level 1) | Examples of corresponding data sources |
|---|---|
| change of average annual distance travelled | Only at level 3 |
| Specific energy consumption, distinguished by mode of transport | Default values: See table 2 and chapter 3.4.3 |
| Number of participants/customers/passengers | Passenger count, occupancy count, survey, participant monitoring |
| **Data to be collected National method (level 2)** | |
| Average annual distance travelled (vehicle kilometres). | Only at level 3 |
| Specific energy consumption, distinguished by mode of transport | National statistics, ODYSSEE indicators. See chapter 3.4.3 for details |
| Number of participants/customers/passengers | Passenger count, occupancy count, survey, participant monitoring |
| **Data to be collected Specific method (level 3)** | |
| Average annual distance travelled (vehicle kilometres) | If measure designed for a single line section: distance<br>Local/own statistics (companies and administration): Household survey |
| Specific energy consumption, distinguished by mode of transport | direct measurement, studies, surveys, otherwise level 1/2 approach |
| Number of participants/customers/passengers | Passenger count, occupancy count, survey, participant monitoring |

# 2 Introduction

## 2.1 Twenty bottom-up case applications of methods

Within EMEEES, 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 EMEEES partners within task 4.2, and reference values were to be specified within task 4.3.

This report deals with case application 15 "Modal shifts in passenger transport" 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:

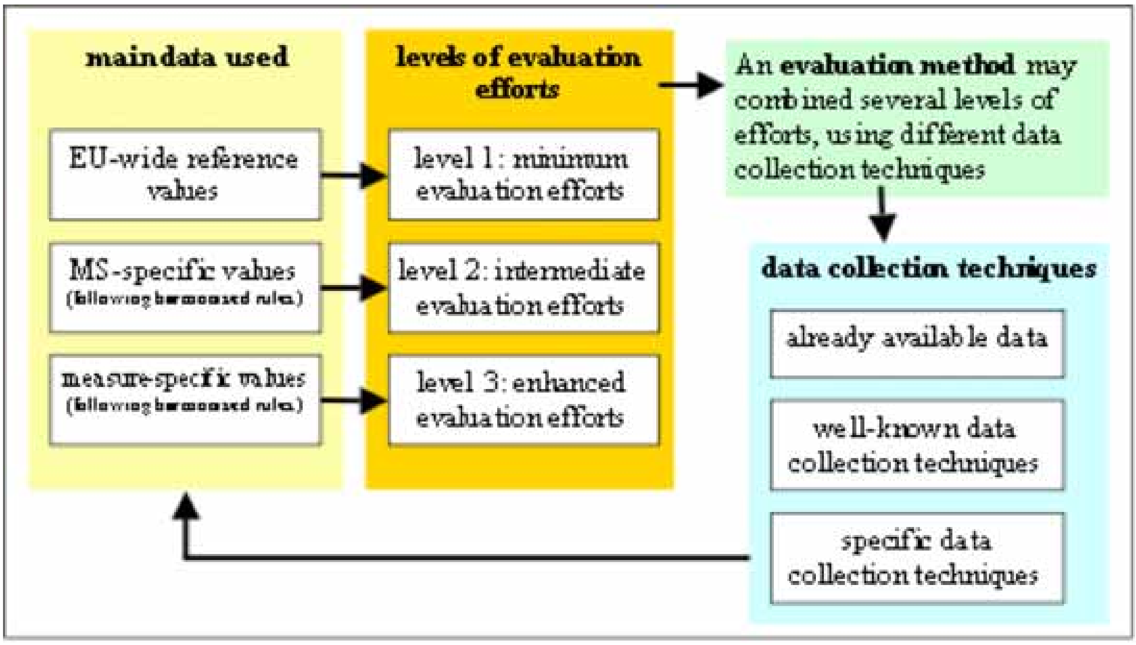
| N° | End-use or end-use action, technology, or facilitating measure | Sector | Responsible organisation |
|---|---|---|---|
| 1 | Building regulations for new residential buildings | Residential | SenterNovem |
| 2 | Improvement of the building envelope of residential buildings | Residential | AEA |
| 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*



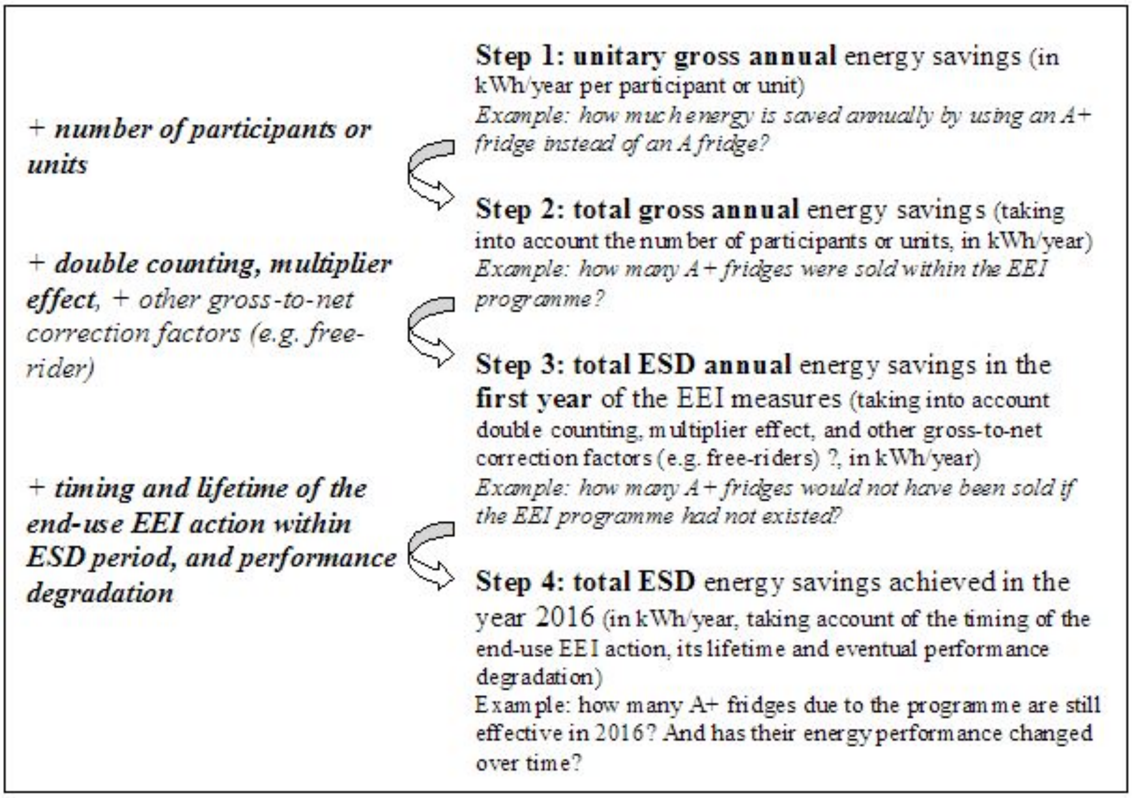

As a consequence, the EMEEES case applications for bottom-up evaluation methods present:

- 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

## 3.1 Step 1.1: General formula and calculation model

The unit is one person. The unitary gross annual energy savings are given by the following formula.

$$ES_{uga} = \sum_{i=1}^{N} \Delta ADT_i * En_i$$

(Equation 1)

Where:

| | |
|---|---|
| $ES_{uga}$ | Unitary gross annual energy savings [kWh/person/year] |
| En | Specific energy consumption of a mode of transport [kWh/person-km] |
| ΔADT | change of annual distance travelled in a transport mode [km/year], baseline case ($ADT_{bas}$) – new case ($ADT_{new}$) |
| i | Mode of transport |
| N | Number of modes of transports concerned |

$$\sum_{i=1}^{N} ADT_{bas\ i} = \sum_{i=1}^{N} ADT_{new\ i}$$

## 3.2 Step 1.2: Baseline

The baseline is the average specific energy consumption of the modes of transport concerned and the respective annual distance travelled (vehicle kilometres) of the year prior to the year under evaluation for the facilitating measure(s) concerned. This baseline will be valid, both if the objective is to calculate additional energy savings compared to autonomous trends, and all energy savings.

| | |
|---|---|
| level 1 | Specific energy consumption of modes of transport: please see chapter 3.4.3 for details<br>Annual distance travelled to be derived only by level 3 evaluation |
| level 2 | Specific energy consumption: Passenger car: ODYSSEE indicators.<br>Annual distance travelled to be derived only by level 3 evaluation |
| level 3 | Specific energy consumption of modes of transport: please see chapter 3.4.3 for details<br>Annual distance travelled to be derived from measure-specific surveys |

A survey of the persons participating in a certain facilitating measure is the most appropriate way to derive the annual distance travelled and the respective modes of transport used in the baseline year. However, a survey might often be too expensive. Therefore, other ways to derive the baseline have to be considered.

If a certain facilitating measure aims at increasing the number of long distance trips covered by train (which is the only efficient solution for long distance trips), the evaluating body can assume (level 1 & 2 evaluation), that the mode of transport used in the baseline case was a passenger car. This is a conservative assumption, as the usage of (more energy intensive) aeroplanes is not taken into account. The easiest way to figure out $\Delta ADT$ is to multiply the number of end-use actions of the unit (i.e. the number of additional train rides of one person within the year under evaluation) with the average distance covered and to divide this value into the average occupancy rate of the mode of transport used in the baseline year (i.e. a passenger car). Level 3 evaluation demands a survey that is designed to figure out $ADT_{bas}$.

There are two possible efficient solutions for covering short distances: Either the unit (one person) chooses non-motorised transport modes or the unit decides to take the local public transport system. In the context of facilitating measures for short distances, it is thus more difficult to figure out the baseline. A facilitating measure might even lead to *negative energy savings*. E.g. a park & ride facility can cause the usage of both car and public transport rather than the usage of public transport right from the beginning of a trip (for further details see chapter 3.4.3, direct rebound effect).

However, the procedure to figure out $\Delta ADT$ of facilitating measures for short distances may be similar to the procedure for long distances: Within level 1 & 2 evaluation the number of end-use actions of the unit, the average distance covered and the average occupancy rate of the mode of transport used in the baseline year has to be found out on level 3. See chapter 3.4 for further details.

## 3.3 Step 1.3: Requirements for normalisation factors

In the recent past, the annual distance travelled has been rising steadily due to different reasons, such as economic circumstances and changing lifestyles. Moreover, the EU is planning to implement facilitating measures that will concern the car stock in such a way that the specific energy consumption of passenger cars and other vehicles might change considerably. For these reasons, the evaluating body has to regularly validate the specific energy consumption as well as any assumption for the annual distance travelled.

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

Type of method:

| | |
|---|---|
| level 1 | mix of deemed and ex-post |
| level 2 | mix of deemed and ex-post |
| level 3 | direct measurement for specific energy consumption ($En_i$), if specific transport technology<br>mix of deemed and ex-post for overall evaluation |

The way to derive ∆ADT varies with different circumstances and it might prove to be difficult to figure out this decisive value. The collection of appropriate data is crucial. Often, only a survey provides exact information, but a survey might be too expensive. In the following, a number of possibilities to approximate ∆ADT without conducting a survey are provided. The evaluating body shall choose one or more of the possibilities described that fit best according to the particular evaluation situation given. The list of possibilites is not comprehensive, there might be other ways to figure out ∆ADT. In any case, the evaluating body shall analyse the potential ways to derive this value and shall justify the way chosen.

<u>Improvement of the urban (local) public transport system or the infrastructure of long distance trains:</u>

If the improvement is on a single line section, ∆ADT can be evaluated by measuring the connection distance and estimating the number of annual trips. In order to account for the energy savings of one person, the connection distance has to be divided by the average occupancy level of the respective mode of transport. If a network of lines and services of a local public transport system or of the national long distance railway system is improved, the evaluating body has to figure out both the average distance covered and the annual number of trips within the network concerned. Ceteris paribus, the average occupancy level has to be evaluated. Furthermore, a measure-specific survey can be avoided by using the average share of modes of transport used for covering short/long distances ("modal choice") as proxy indicator to figure out the modes of transport used in the baseline year.

<u>Traffic management (short and long distances):</u>

An observation of the number plates of cars using a certain (parking) area would yield an approximation of the average distance covered and would thus avoid a survey. With respect to road pricing, only a survey is able to ascertain reliable results for the average distance covered.

Improvement of infrastructure of non-motorised transport modes:

If a facilitating measure aims at improving the infrastructure of non-motorised transport modes (bicycle lanes, footpaths), $\Delta$ADT has to be derived through a user survey.

Number of annual trips:

In order to figure out $\Delta$ADT, the evaluating body has to derive not only the average distance covered with a new transport mode, but as well the number of annual trips undertaken by the person.

The annual number of trips might be derived through regular household surveys. Alternatively, this value can be obtained when proceeding with Step 2. Step 2 demands to count the number of persons that undertake the end-use action, e.g. the number of persons choosing trains instead of aeroplanes for a certain distance. If such a passenger count is carried out on a representative appointed date, then the evaluating body will simply multiply the number of participants with the number of days of a year, i.e. 365.

Evaluation in package:

A number of measures that can be evaluated with this case application are measures on the local level. On the local level, many public transport services regularly conduct passenger counts and other customer evaluations. Moreover, a lot of municipalities regularly conduct household surveys on mobility behaviour in order to prepare their urban planning measures. Such databases might provide data of good quality, but in a different format. Therefore, an alternative formula for the unitary gross annual energy savings is provided. The evaluating body may choose it optionally. This formula provides the opportunity to evaluate municipal facilitating measures in package. The unit is one person.

$$ES_{uga} = ADT * [MC_{bas\,i} - MC_{eff\,i}] * [En_i / OL_i]$$

(Equation 1b)

Where:

| | |
|---|---|
| $ES_{uga}$ | Unitary gross annual energy savings [kWh/person/year] |
| ADT | Annual distance travelled [vehicle-km] |
| En | Specific energy consumption of transport mode [kWh/vehicle-km] |
| $MC_{bas}$ | Share of mode of transport used (Modal Choice), baseline [0;1] |
| $MC_{eff}$ | Share of mode of transport used (Modal Choice), new [0;1] |
| OL | Occupancy level [persons/vehicle] |
| i | Mode of transport |

### 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, $CO_2$-emissions as measured in g/km are an important indicative value as well. With respect to aeroplanes, fuel consumption as expressed in l kerosene has to be converted into kWh.

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*[2]

| | 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 |
| 1 l kerosene | 9.56 | 2552 |

### 3.4.2 Considering the direct rebound effect

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.

This case application exclusively considers the shift between transport modes for trips undertaken anyway. Thus, this method does not consider a potential increase of distances that may result from reduced expenses.

But measures in the local public transport sector might people make change their mobility behaviour in such a way that energy consumption rises. E.g. ticket

[2] See Appendix I - Justification and Sources, n°1

price reductions are supposed to lead to an increased usage of the local public transport system. But this incentive does not only attract people that regularly use their private car, but as well the people that often decide for non-motorised transport modes. If the latter choose public transport instead, their energy consumption will increase.

As such effects are included into the formula, no further consideration of the direct rebound effect is necessary.

### 3.4.3 From EMEEES tasks 4.2 to 4.3: defining values and requirements

Passenger cars

In the EU, the passenger car is the most important mode of transport if measured in person km covered. It represents an efficient solution with respect to aeroplanes, but it remains inefficient with respect to other modes of transport. If motorway sections become subject to pricing policies, this might lead to both positive and negative savings, as people might switch from using their passenger car to using aeroplanes as well as long distance trains. For this reason, the evaluation of motorway pricing shall only be conducted at level 2 or 3 harmonisation, as conservative values cannot be assured ex ante. If the facilitating measure under evaluation is not likely to increase the usage of aeroplanes, the following requirements apply.

The ODYSSEE-indicators provide an appropriate data basis for the fuel consumption of passenger cars. It provides 2004 data of EU-15 Member States. The evaluating body shall check the Website for the most recent indicator of the particular country[3]. The EU-25 average is given as 7.57 l per 100 km. Multiplied with a security factor of 0.8 and converted into kWh (see table 3), the default specific energy consumption of an average passenger car is 0,53 kWh per km. This value shall be divided into the average occupancy level of passenger cars, in order to derive the specific energy consumption of one person vehicle km.

In general, occupancy rates of passenger cars are decreasing in Europe. A main driver behind the decreasing occupancy rates of passenger cars is the growth in car ownership. The European Environmental Agency (EEA) considers average occupancy rates in the United Kingdom, Denmark and Netherlands to be as low as 1.6 passengers per car[4]. In Member States where car ownership is lower, occupancy rates may well be higher. In order to provide conservative results at level 1 evaluation, the occupancy level given by the EEA for these three countries shall be multiplied with a security factor of 1.2 for other EU-15

[3] See: http://www.odyssee-indicators.org. Registration is obligatory for access to the indicators.

[4] See Appendix I - Justification and Sources, n°2

members and with 1.5 for the remaining twelve new Member States (EU-27). See table 4 for details.

Evaluations at level 2 and 3 harmonisation have to consider, that the passenger car type and the trip length have implications on the average specific fuel consumption. Moreover, occupancy levels are a driving factor for the specific fuel consumption and therefore efforts should be made to derive national data.

Long distance trains

The specific energy consumption as expressed in kWh per person vehicle km of long distance trains depends on the technology used, the speed, the number of seats provided and the average occupancy level. Railway companies are able to provide such data, so that an appropriate evaluation at level 2 and 3 should be granted for this mode of transport.

In comparison to other European long distance train services, the German long distance train "ICE" is assumed to be energy intensive due to its high average speed and weight. Thus, direct measurement of this technology provides conservative default values for level 1 evaluation. Energy consumption of an ICE-train with a velocity above 200 km/h is as high as 0,037 kWh per seat-km. If one conservatively assumes the occupancy level to be at 33%, the specific energy consumption per passenger km is at 0,11 kWh per person km[5].

Aeroplanes

Aviation is the most energy intensive mode of transport. The sector is growing dynamically and there are short-distance flights offered all over Europe. For such distances the passenger car or rail-bound transportation may be a viable option for the end-user to choose. Much work has already been devoted to estimate the fuel consumption of aeroplanes. According to such studies, energy consumption depends on many different factors and its estimation thus remains uncertain[6]. The values given in table 4 are based on the assumption that an Airbus A320, equipped with 150 seats represents a standard technology for short distance flights in Europe. The occupancy level is set at 75%, a conservative assumption[7]. The specific energy consumption declines with longer distances covered. It is calculated for three different distances (250 km, 500 km and 750 km)[8]. We propose that the evaluating body shall round down the distance covered when choosing one of the three values, in order to assure a conservative calculation.

[5] See Appendix I - Justification and Sources, n°3
[6] See Appendix I - Justification and Sources, n°4
[7] See Appendix I - Justification and Sources, n°3 & 4
[8] See Appendix I - Justification and Sources, n°3

Motorbikes

This case application does not provide default values for the specific energy consumption of motorbikes. Basically, riding a motorbike usually does not serve as “means to an end”, but as a hobby. Thus, for the majority of facilitating measures motorbikes are no viable option to switch from or to. However, under certain conditions facilitating measures might affect the annual distance travelled with motorbikes and a level 2 or 3 evaluation should take this into account.

Long distance buses

In many Member States, normally scheduled long distance transit buses only exist in a small number. For this reason, level 1 evaluation shall assume effects on this mode of transport to be negligible. This is conservative, as long distance buses often represent the most energy efficient mode of transport due to high occupancy levels. However, any evaluation including long distance buses has to consider that occupancy rates for buses and coaches vary widely between Member States[9].

Local public transport

Local public transport is a service of public interest. This service is provided through different types of bus technologies and rail-bound vehicle technologies. In general, local public transport is more efficient than individual motor car transport, but besides the vehicle technology used, the occupancy level of the vehicle is a driving force for efficiency. A hardly occupied bus might consume more fuel per passenger km travelled than an energy efficient and well-occupied passenger car. In rural and remote areas, it might even be a challenge to organise public transport at all.

As a matter of fact, only local facilitating measures have to consider local public transport. In practice, any kind of local value available is more precise than level 1 or level 2 evaluation.

At level 1 evaluation it is assumed that there is no facilitating measure able to affect the absolute energy consumption of a local public transport system, i.e. facilitating measures *do* raise the occupancy level, but they *do not* raise demand in such a way that more vehicle kilometres are covered. Thus, level 1 harmonisation does not demand a bottom-up calculation. Within the formula, the specific energy consumption of local public transport is considered to be zero (see table 2). This is valid as long as more pasengers use existing bus services. It is also justified in the case that additional buses or trams are

[9] See Appendix I - Justification and Sources, n°5

installed. The reason is that even in this case it still is conservative, as on the local level, fuel consumption of passenger cars is likely to be higher than the national average due to higher average fuel consumption within city traffic. Moreover, local occupancy levels of passenger cars tend to be lower in urban areas than the national average. This is due to the fact that the number of commuters in urban areas is higher than the national average. Average occupancy rates of the travel purpose "commuting" are lower than occupancy rates of leisure and family trips[10]. From this perspective, level 1 evaluation on the local level underestimates energy savings resulting from end-users shifting from private car utilisation to public transport.

However, the transportation companies concerned should be willing to provide appropriate level 3 data derived from direct measurement.

*Table 2: default values for the specific energy consumption of modes of transport*

| | **aero-plane** | **passen-ger car** | **long dis-tance train** | **long dis-tance bus** | **motor-bike** | **local public transport** | **walking, cycling** |
|---|---|---|---|---|---|---|---|
| **specific energy consumption (kwh/pers-km)** | see table 4 | see table 4 | 0,11 | not considered at level 1 evaluation | | 0 | 0 |

*Table 4: default values for the specific energy consumption of aeroplanes and cars*

| | **NL GB, DN (Occupancy level: 1.6)** | **other EU-15 (Occupancy level: 1.92)** | **other EU-27 (Occupancy level: 2.4)** |
|---|---|---|---|
| **specific energy consumption of a passenger car (kwh/pers-km)** | 0,33 | 0,28 | 0,22 |
| | **250-499 km (Occupancy level: 75%)** | **500-749 km (Occupancy level: 75%)** | **at least 750 km (Occupancy level: 75%)** |
| **specific energy consumption of an aeroplane (kwh/pers-km)** | 0,46 | 0,40 | 0,35 |

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

# 4 Step 2: Total gross annual energy savings

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

One unit is one person performing an end-use action. The total gross annual energy savings are derived by multiplying the number of participants 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 persons switching transport modes

In order to get an idea about the total gross annual energy saving potential, table 5 lists the percentage reduction of daily vehicle kilometres travelled for certain transport demand management measures, based on a literature review conducted in the 1990s. Details on how these estimates were made and what specific conditions they refer to were not available.

*Table 5: Estimated reduction of daily vehicle kilometres travelled of transport demand management measures*[11]

| measure | reduction potential |
|---|---|
| Bike and walk facilities | 0.02%-0.03% |
| Park and ride lots | 0.1%-0.5% |
| Area-wide ride-sharing | 0.1%-2.0% |
| Public transit improvements | 0.1%-2.6% |
| Land use planning | 0.1%-5.4% |
| Congestion pricing | 0.2%-5.7% |
| Parking pricing at work | 0.5%-4.0% |
| Parking pricing: non-work | 3.1%-4.2% |

The IEA provides another estimation for policies in the local transport sector. Table 6 shows annual oil savings and the percentage this represents of total road transport fuel use and petroleum fuel use in the European IEA-countries, if the policy were applied.

[11] See Appendix I - Justification and Sources, n°6

*Table 6: Estimated fuel savings from local traffic measures*[12]

| measure | reduction potential |
|---|---|
| 50% fare reduction public transport | 3.0% |
| 100% fare reduction public transport | 6.1% |
| Increased off-peak service | 1.7% |
| Increased peak and off-peak service | 2.1% |

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

*Table 7: Facilitating measures and the respective methods to derive the number of end-use actions*

| Category | | Facilitating measure | Evaluation |
|---|---|---|---|
| short distance | Improvement of public transport system | fare reduction in local transport | passenger count, survey |
| | | frequency improvement of transport services | passenger count, survey |
| | | comfort and service improvement | passenger count, survey |
| | | improvement of public transport information | passenger count, survey |
| | Improvement of infra-structure/organisation of non-motorised transport modes | bicycle lanes | occupancy count, survey |
| | | footpaths | occupancy count, survey |
| | Traffic management | park and ride | occupancy count, survey |
| | | bike and ride | occupancy count, survey |
| | | car park limitation | survey |
| | | congestion charge | participant monitoring, survey |
| | | parking pricing | survey |
| long distance | Traffic management | road pricing | passenger count, survey |
| | Improvement of infrastructure of long distance trains | new/faster connections | passenger count, survey |
| | | comfort improvement | passenger count, survey |
| | | ticket price reduction | passenger count, survey |
| | | frequency improvement | passenger count, survey |

As a matter of course, a passenger/occupancy count has to be conducted during both the baseline year and the year(s) under evaluation.

[12] See Appendix I - Justification and Sources, n°6

# 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

If all correction factors are included, the adjusted gross savings will consider free-rider, multiplier and double-counting effects. Hence, the formula for the total ESD annual energy savings will be as follows:

$ES_{tna}$ =
$ES_{tga}$ * (1 – *free-rider coefficient* + multiplier coefficient) * 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; *inclusion is subject to decision by European Commission and ESD Committee*
Multiplier coefficient: >=0
Double counting factor: [0;1]

## 5.2 Step 3.2: Requirements for double counting

It is hardly possible to isolate measures that aim at shifting towards less energy-intensive means of transport from each other. E.g. measures such as the improvement of comfort and frequency of public transport services, and ticket price reductions are very likely to be implemented in a package. Thus, their evaluation has to be done in package as well.

The influence of a certain facilitating measure on end-use actions could be evaluated in the scope of surveys, participant monitoring and passenger counts that have to be conducted anyway to account for the number of end-use actions.

## 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

In the scope of information and motivation campaigns, multiplier savings are likely to occur, but it is hardly possible to evaluate their effect on energy savings at all. The authors assume the multiplier effect of other measures to be zero or negligible. If the evaluating body assumes the effect to be significant, it shall be proven by means of surveys. The methods proposed here to account for the number of unitary actions using passenger/occupancy counts and surveys will probably produce results that are incorporating multiplier effects anyway.

### 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.

As for each of the facilitating measures that apply for this case application the number of changes in modal shift is the number of end-use actions and has to be evaluated through direct accounting or through a mix of deemed and ex post evaluation, it is plausible to assume the free-rider effect to be zero or negligible – it will automatically be corrected for.

However, in some cases the free-rider effect is supposed to be significant. E.g. a drastically rising oil price might force a considerable number of persons to use public transport systems instead of their private car. The evaluation of a facilitating measure under implementation would have to account for this autonomous effect.

In conclusion, during implementation of a facilitating measure the evaluating body has to figure out under which conditions the free-rider effect is likely to occur. A qualitative description shall highlight, how the effect is dealt with and how far conservative assumptions avoid overestimations. For level 3, a survey figuring out the free-rider coefficient is recommended. This survey can be combined with surveys to evaluate the number of end-use actions.

# 6 Step 4: total ESD energy savings for year "i"

## 6.1 Requirements for the energy saving lifetime

Only the annual energy savings achieved and still existing in 2016 are accounted for. The 2007 CEN Workshop Agreement (CEN WS 27 Agreement) has set the default saving lifetime for modal shifts in passenger traffic at two years. This is a very short time horizon, as facilitating measures would have to be implemented in 2014 earliest, in order that they were countable towards the ESD target.

Hence, we propose to conduct a survey after two years of implementation to assess the continuation of the energy savings. Such a survey could be conducted after every two years, and new lifetimes of two years could be set for the resulting energy savings.

## 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

- *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.

If a Member State wanted to account for early actions for modal shifts in passenger traffic, a survey on the continuation of the particular facilitating measure had to be conducted after every two years. There are no further requirements.

## 6.3 Reminder to treat uncertainties

This case application relies on the specific energy consumption of the modes of transports concerned and the average annual distance covered with the particular transport modes. Slight changes of these values might have considerable impacts on the energy savings calculated. Therefore, every evaluation has to demonstrate conservative assumptions and if possible, a range of values that appear plausible extremes and are showing the sensitivity of results.

The evaluating body should particularly take care of conservative assumptions for passenger cars. This mode of transport might be an efficient and an inefficient solution at the same time.

## Appendix I: Justifications and sources


1. Robert Bosch GmbH (Ed.) 1991: Kraftstofftechnisches Taschenbuch. Stuttgart 1991, p. 232

2. EEA (European Environmental Agency) 2006: Transport and environment: facing a dilemma. TERM 2005: indicators tracking transport and environment in the European Union. EEA Report No. 3/2006, 26-27

3. ifeu - Institut für Energie- und Umweltforschung Heidelberg GmbH: UmweltMobilCheck. Wissenschaftlicher Grundlagenbericht des IFEU-Instituts Heidelberg, 2006, pp 13-19

4. atmosfair gGmbH (Ed.): Der Emissionsrechner, 5-12 http://www.atmosfair.de/fileadmin/user_upload/image4/PDF_Dokumentation_deutsch.pdf

5. EEA (European Environmental Agency) 2001: TERM 2002 29 EU. Occupancy rates of passenger vehicles. http://themes.eea.europa.eu/Sectors_and_activities/transport/indicators/technology/TERM28,2002/Specific_emissions_TERM_2001.doc.pdf

6. International Energy Agency (IEA) 2005: Saving Oil in a Hurry, Paris, 44ff

## Other appendix

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