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- PRELIMINARY DRAFT EXCERPT–

RECOMMENDATIONS ON

MEASUREMENT AND VERIFICATION METHODS

IN THE FRAMEWORK OF

DIRECTIVE 2006/32/EC ON

ENERGY END-USE EFFICIENCY AND ENERGY SERVICES

Introduction

This document puts forward recommended methods on measurement and verification of energy savings in the framework of Article IV of Directive 2006/32/EC on energy end-use efficiency and energy services (ESD) which the Commission has developed with active support and participation of the Member States in the energy demand management committee.

These methods comprise the recommended formulas for top-down energy efficiency indicators, bottom-up calculation models and a list of recommended average lifetimes of energy efficiency improvement measures and programmes for bottom-up calculations of *final energy savings*.

The methods recommended in this document deliver a common, but still flexible basis for the calculation of final energy savings in the scope of ESD – which only represent a fraction of all energy savings available.

However, the methods presented here are not suitable to answer the question raised in the Council discussions on the Europe 2020 strategy on how to check consistency between Member States' national targets and the European Union' overall 20% primary energy savings target as compared to the projections for 2020. The Commission will propose a way forward how to deal with these issues separately at a later stage.

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I. Recommended Top-down energy efficiency indicators

1 Household sector

The recommended energy efficiency indicators for the household sector cover the variations in final energy consumption of private households in residential dwellings for space heating and cooling, water heating, large household appliances and lighting. The energy consumption is split in electricity and non-electricity energy consumption.

The total final energy savings achieved in the household sector are calculated by adding up the savings achieved. The savings achieved are determined by use of one of the following options:

(a) preferred (P) energy efficiency indicators P1 to P5 to show the savings by end-use;

(b) two minimum (M) energy efficiency indicators M1 and M2 to show overall household energy (electricity and non-electricity) consumption;

(c) a combination of preferred and minimum energy efficiency indicators for the electricity and the non-electricity consumption of households (M1 with P4, P5), as long as no double counting occurs.

1.1 Energy consumption of households for space heating in tonnes of oil equivalent (toe) per floor area in m^2 adjusted for climatic conditions (P1)

Indicator P1 is the ratio between the climate corrected energy consumption of households for space heating and the total floor area of permanently occupied dwellings.

The following data is necessary to calculate indicator P1:

§ the number of permanently occupied dwelling;

§ the average dwelling size (m^2);

§ the energy consumption for space heating adjusted for climatic conditions.

To calculate the energy consumption for space heating adjusted for climatic conditions, the following data are necessary:

- the actual energy consumption for space heating;
- the actual number of heating degree-days;
- the mean number of heating degree-days.

There exists different statistics related to the stock of dwellings. The most common ones relate to the total stock and to the stock of permanently occupied dwellings[1]. For energy consumption analysis, the relevant data is the stock of permanently occupied dwellings, which is usually available from the national statistical office.

The average dwelling size (m^2) corresponds to the living area as usually defined in household survey and construction statistics.

[1] The difference between the two data corresponds to summer/weekend residences and vacant dwellings.

The energy consumption for space heating represents the total energy consumption of households for space heating[2]. It is usually not included in national statistics accounts and is not covered by Eurostat. It is estimated by specialised organisation on the basis of surveys and modelling and usually endorsed by national energy agencies or institutions.

The actual heating degree days is an indicator of the winter severity, and thus of the heating requirement. It is calculated as the sum over each day of the heating period (e.g. October to April) of the difference between a reference indoor temperature (usually 18°C) and the average daily temperature[3]. The number of degree-days in EU countries is in a range from 700-800 degree-days for Cyprus and Malta to 4000-5000 degree-days in Nordic and Baltic countries; the EU-27 average stands around 2800 degree-days. The daily outside temperature measurement comes from the various meteorological stations in each country; it is averaged to get a national value[4]. Eurostat calculates these two values for all EU countries, but only the arithmetic national average is available on its web site.

The mean heating degree days represent the number of degree-days for a normal winter or an average winter; it is based on a long-term average of degree-days value. Eurostat uses a 25 years average (1980-2004); some national data are based on a 30 years average[5].

The variation of this indicator over time reflects the impact of building regulation, investment to retrofit existing dwellings and improved efficiency of new heating appliances. It also includes the effect of changes in heating behaviour (e.g. heating temperature, heating season duration), which may correspond to real savings (if there is a temperature decrease) or negative savings due to increased comfort[6].

[2] The consumption of second residence is marginal for most countries and is implicitly included with the consumption of permanently occupied dwellings. However, if it is not negligible for some countries, the energy consumption and stock of dwellings can be separated for permanently occupied dwellings and secondary residences.

[3] If the average temperature of a day in winter is 5°C, the number of degree day of that day is 13 degree days (18-5).

[4] This national average can be calculated as an arithmetic average or as a population weighted average. The second approach should be used as it is more representative of the heating requirement in the country.

[5] Some countries have however shortened the reference period and are calculating the average since 1990 to account for the fact that winters have been warmer since 1990. Some countries are in addition changing the period (moving reference period), which means that the number of normal degree-days is not fixed.

[6] For southern European countries with an increasing penetration of central heating, reflecting improved comfort in winter, with all the rooms of a dwelling well heated, as opposed to room heating where only some rooms are heated with stoves, the specific consumption for heating may be increasing even if energy savings are taking place because of this comfort effect. In that case the specific consumption per m^2 of dwelling equivalent with central heating can be used. This specific consumption relates the energy consumption of the household sector for space heating to the total floor area of dwellings equivalent with central heating.

Energy efficiency indicator	Type	Formula for <u>indicator</u>	Formula for calculating <u>savings</u> compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of households for space heating in toe per floor area in m^2 adjusted for climatic conditions	P1	$\frac{E^{H_{SH}}}{F} * \frac{MDD_{25}^{heating}}{ADD^{heating}}$	$\left[\left(\frac{E_{2007}^{H^{SH}}}{F_{2007}} * \frac{MDD_{25}^{heating}}{ADD_{2007}^{heating}}\right) - \left(\frac{E_{t}^{H^{SH}}}{F_{t}} * \frac{MDD_{25}^{heating}}{ADD_{t}^{heating}}\right) \right] * F_t$	$E_{2007}^{H^{SH}}$, $E_{t}^{H^{SH}}$ = Energy consumption of households for space heating in 2007 and in year t F_{2007}, F_t = Total floor area in m² of permanently occupied dwellings in 2007 and in year t $MDD_{25}^{heating}$ = Mean heating degree days over the last 25 years $ADD_{2007}^{heating}$, $ADD_{t}^{heating}$ = Actual heating degree days in 2007 and in year t	**Step 1: Climatic corrections** $E_{2000}^{H^{SH}}$ = 3.47 mtoe * $\frac{3433}{3106}$ = 3.8 mtoe $E_{2007}^{H^{SH}}$ = 3.71 mtoe * $\frac{3433}{2988}$ = 4.26 mtoe F_{2000} = 270 803 200 m^2 F_{2007} = 293 348 699 m^2 **Step 2: Indicator 2000** $\frac{3.8*10^9}{0.2708*10^9}$ = approx. 14.1 koe/m^2 **Step 3: Indicator 2007** $\frac{4.26*10^9}{0.2933*10^9}$ = 14.5 koe/m2 **Step 4: Indicator variation 2000-2007** 14.5 – 14.1 = +0.5 koe/m^2 (*increase* in the indicator) **Step 5: Activity 2007** 293 348 699 m^2 (total floor area of a permanently occupied dwelling derived by multiplying the stock of permanently occupied dwellings by the average floor area of a dwelling) **Step 6: Savings** Indicator variation * activity In this example no savings achieved in the country presented because the indicator INCREASED between 2000 and 2007 (i.e. increase of 0.5 koe/m2 * 293 348 699 m^2 = + 0.11 mtoe)

1.2 *Energy consumption of households for space cooling in toe per floor area in m2 adjusted for climatic conditions (P2)*

Indicator P2 is the ratio between the climate corrected energy consumption of households for space cooling and the total floor area of permanently occupied dwellings.

The following data is necessary to calculate indicator P2:

- The number of permanently occupied dwellings;
- The average dwelling size (m^2);
- The energy consumption for space cooling adjusted for climatic conditions.

To calculate the energy consumption for space cooling adjusted for climatic conditions, the following additional data is necessary:

- the actual energy consumption for cooling;
- the actual number of cooling degree-days;
- the mean number of cooling degree-days;

The energy consumption for space cooling represents the electricity consumption of households for space cooling. This information is estimated on the basis of surveys on the diffusion of space cooling appliances (e.g. air conditioners) and modelling, taking into account the intensity of use (number of hours in operation) and their average rated power; these estimates are usually endorsed by national energy agencies or institutions.

The actual cooling degree days is an indicator of the summer temperature, and thus of the cooling requirement. It is calculated as the sum over each day of the cooling period (e.g. May to September) of the difference between the average daily temperature and a reference indoor temperature (usually 20°C). For the moment there is no harmonised method to calculate cooling degree days in the EU and Eurostat does not provide such data[7].

The mean cooling degree days represents the number of degree-days for a normal summer; it is based on a long-term average of degree-days value (e.g. 25 years).

The variation of this indicator over time reflects the impact of building regulation, improved efficiency of new air conditioning appliances, but also includes the effect of an increased diffusion of air conditioning (the percentage of dwelling or floor area that is cooled), which may offset the genuine technical savings[8].

[7] The calculation of cooling degree days is common in the US where they used 20°C as a reference.

[8] One way to better capture the real energy savings is to divide the energy consumption for cooling by the number of dwellings with air conditioning.

Energy efficiency indicator	**Type**	**Formula for indicator**	**Formula for calculating savings compared to the base year 2007**	**Definition**	**Example: country calculation (2000-2007)**
Energy consumption of households for space cooling in toe per floor area in m^2 adjusted for climatic conditions	P2	$\frac{E^{H_{SC}}}{F} * \frac{MDD_{25}^{cooling}}{ADD^{cooling}}$	$[(\frac{E_{2007}^{H_{SC}}}{F_{2007}} * \frac{MDD_{25}^{cooling}}{ADD_{2007}^{cooling}}) - (\frac{E_{t}^{H_{SC}}}{F_{t}} * \frac{MDD_{25}^{cooling}}{ADD_{t}^{cooling}})] * F_t$	$E_{2007}^{H_{SC}}$, $E_{t}^{H_{SC}}$ = Energy consumption of households for space cooling in 2007 and in year t F_{2007}, F_t = Total floor area in m² of permanently occupied dwellings in 2007 and in year t $MDD_{25}^{cooling}$ = Mean cooling degree days over the last 25 years $ADD_{2007}^{cooling}$, $ADD_{t}^{cooling}$ = Actual cooling degree days in 2007 and in year t	**No data to complete the example calculation as of early 2010. The algorithm is the same as for P1**

1.3 Energy consumption of households in toe for water heating per inhabitant (P3)

Indicator P3 is the ratio between the energy consumption for water heating in the residential sector and the total population.

The following data is necessary to calculate indicator P3:

- The energy consumption of water heating;
- Total population;

The energy consumption for water heating is not a standard entry in energy statics and is part of more detailed data or estimates. The consumption for water heating includes oil products, gas, coal and lignite, electricity, district heat, biomass and solar. As Directive 2006/32/EC considers the use of solar water heaters as a source of energy saving, energy consumption of water heating should exclude solar energy[9].

Savings from solar water heaters can be calculated bottom-up (see 2.7).

[9] This is different of what is done by Eurostat in its energy statistics that accounts solar energy in the total consumption of households. The directive considers as eligible energy efficiency improvement measures “domestic generation of renewable energy sources, whereby the amount of purchased energy is reduced (e.g.
solar thermal applications, domestic hot water, solar-assisted space heating and cooling” (Annex III).

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of households in toe for water heating per inhabitant	P3	$\frac{E^{H_{WH}}}{P}$	$\left(\frac{E_{2007}^{H_{WH}}}{P_{2007}} - \frac{E_t^{H_{WH}}}{P_t}\right) * \mathrm{P_t}$	$E_{2007}^{H_{WH}}$, $E_t^{H_{WH}}$ = Energy consumption of households for water heating in 2007 and in year t P_{2007}, P_t = Total population in 2007 and in year t	**No data to complete the example calculation as of early 2010**

1.4 Electricity consumption per appliance type in kWh/year (P4)

Indicator P4 is the unit electricity consumption across the existing stock of a given appliance. The following data is necessary to calculate indicator P4:

- The unit electricity consumption of the stock of appliances[10];
- The stock of appliances.

The unit electricity consumption is calculated by dividing the total electricity consumption of each large appliance by the stock of appliances. This total electricity consumption of the stock of a given appliance is usually not covered by national statistics. It may be available from national estimates, usually estimated using a calculation procedure that is specific to each appliance type.

The stock of appliance can either be taken from the national statistics or be estimated in two ways:

- Using a stock model from annual sales and average lifetime of the appliance, or
- From (annual) household surveys on equipment ownership (i.e. % of households owning one or several appliances).

The variation of this indicator over time does not only reflect improvement in the energy efficiency, but may also be influenced by behavioural factors that may offset energy savings (e.g. larger appliances, more intensive use).

[10] Six major household electrical appliances are considered: refrigerators, freezers, washing machines, dishwashers, TV, tumble dryers.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Electricity consumption per appliance type in kWh/year	P4	UEC^X	$(UEC^x_{2007} - UEC^x_t) * Stock^x_t$	UEC^x_{2007}, UEC^x_t = Unit electricity consumption of the stock in 2007 and in year t The calculation procedure for UEC differs by appliance type (e.g. for washing machines consumption per cycle * number of cycles per year) $Stock^x_t$ = Stock of the respective appliance in year t Member States should report on the method used to calculate or estimate UEC of all appliances, for which savings are reported.	**Refrigerators** **Step 1: Establishing the specific consumption of refrigerators** UEC_{2000} = 274 kWh/y UEC_{2007} = 243 kWh/y **Step 2: Indicator variation 2000-2007** 243 – 274 = - 31 kWh/y (*decrease* in the indicator) **Step 5: Stock of refrigerators 2007** 3 545 000 **Step 6: Savings** 31 kWh/y * 3 545 000 = 110 GWh

1.5 Electricity consumption of households for lighting in kWh/year per dwelling (P5)

Indicator P5 is the ratio between the electricity consumption of households for lighting and the number of permanently occupied dwellings.

The following data is necessary to calculate indicator P5:

- Electricity consumption for lighting;
- Number of permanently occupied dwellings.

Electricity consumption for lighting is usually not covered in national energy statistics. For some countries the electricity consumption for lighting is available from national estimates. It is usually estimated via a calculation that takes into account the number of lighting points, or the average lighting power and an average number of hours of lighting per year.

The variation of this indicator over time reflects the impact of the diffusion of efficient lamps, but also captures an increased number of lighting points and a change in the number of hours of lighting. An increase in the number of lighting points and/or in the number of hours of lighting may offset the energy savings and may lead to an underestimate of these savings or to the impossibility to measure any savings[11].

[11] One way to better capture the real energy savings is to divide the energy consumption for lighting by the number of lighting point.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Electricity consumption of households for lighting in kWh/year per dwelling	P5	$\frac{E^{H_{Li}}}{D}$	$\left(\frac{E^{H_{Li}}_{2007}}{D_{2007}} - \frac{E^{H_{Li}}_{t}}{D_{t}} \right) * D_t$	$E^{H_{Li}}_{2007}$, $E^{H_{Li}}_{t}$ = Electricity consumption of households for lighting in 2007 and in year t D_{2007}, D_t = Number of permanently occupied dwellings in 2007 and in year t	**Step 1: Electricity consumption of households for lighting** $E^{H_{Li}}_{2000}$ = 0.13 mtoe $E^{H_{Li}}_{2007}$ = 0.14 mtoe D_{2000} = 2 489 000 dwellings D_{2007} = 2 653 000 dwellings **Step 2: Indicator 2000** $\frac{0.13*11.63*10^9}{2489*10^3}$ = 607 kWh/dw **Step 3: Indicator 2007** $\frac{0.14*11.63*10^9}{2653*10^3}$ = 614 kWh/dw **Step 4: Indicator variation 2000-2007** 614 – 607 = + 7 kWh/dwelling (*increase* in the indicator) **Step 5: Activity 2007** Stock of dwellings: 2 653 000 (permanently occupied) **Step 6: Savings** Indicator variation * activity In this example no savings achieved in the country presented because the indicator INCREASED between 2000 and 2007 (i.e. increase of 7 kWh/dw * 2 653 000 dwellings = +18.6 GWh)

1.6 *Non-electricity energy consumption of households in toe per dwelling adjusted for climatic conditions (M1)*

Indicator M1 is the ratio between the climate corrected non-electricity energy consumption of households and the number of permanently occupied dwellings.

The following data is necessary to calculate indicator M1:

- The non-electricity consumption adjusted for climatic conditions (see P1);
- The number of permanently occupied dwelling.

See P1 for the adjustment for climatic conditions. The non electricity consumption should exclude solar as Directive 2006/32/EC considers the use of solar water heaters as a source of energy saving[12].

[12] This is different of what is done by Eurostat in its energy statistics that accounts solar energy in the total consumption of households.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Non-electricity energy consumption of households in toe per dwelling adjusted for climatic conditions	M1	$\frac{E^{H_{NON-EL}}}{D} * \frac{MDD_{25}^{heating}}{ADD^{heating}}$	$[\ (\frac{E_{2007}^{H_{NON-EL}}}{D_{2007}} * \frac{MDD_{25}^{heating}}{ADD_{2007}^{heating}}) - (\frac{E_{t}^{H_{NON-EL}}}{D_{t}} * \frac{MDD_{25}^{heating}}{ADD_{t}^{heating}})$	$E_{2007}^{H_{NON-EL}}$, $E_{t}^{H_{NON-EL}}$ = Non-electricity energy consumption of households in 2007 and in year t $MDD_{25}^{heating}$ = Mean heating degree days over the last 25 years $ADD_{2007}^{heating}$, $ADD_{t}^{heating}$ =Actual heating degree days in 2007 and in year t D_{2007} , D_t = Number of permanently occupied dwellings in 2007 and in year t	**Step 1: Non-electric consumption of residential** $E_{2000}^{H_{NON-EL}}$ =4.22 – 0.88 = 3.34 mtoe $E_{2007}^{H_{NON-EL}}$ = 4.52 – 0.89 = 3.63 mtoe **Step 2: Climatic corrections** $E_{2000}^{H_{NON-EL}}$ = 3.34 mtoe * $\frac{3433}{3106}$ = 3.7 mtoe $E_{2007}^{H_{NON-EL}}$ = 3.63 mtoe * $\frac{3433}{2988}$ = 4.2 mtoe **Step 3: Indicator 2000** $\frac{3.7*10^6}{2489*10^3}$ = 1.48 toe/dwelling **Step 4: Indicator 2007** $\frac{4.2*10^6}{2653*10^3}$ = 1.58 toe/dwelling **Step 5: Indicator variation 2000-2007** 1.58 – 1.48 = +0.1 toe/dwelling (*increase* in the indicator) **Step 6: Activity 2007** Stock of permanently occupied dwellings 2 653 000 **Step 7: Savings** Indicator variation * activity In this example no savings achieved in the country presented because the indicator INCREASED between 2000 and 2007 (i.e. increase of 0.1 toe/dwelling * 2653000 dwellings = + 265 koe)

1.7 Electricity consumption of households in kWh per dwelling (M2)

Indicator M2 is the ratio between the electricity consumption of households and the number of permanently occupied dwellings.

The following data is necessary to calculate indicator M2:

- The number of permanently occupied dwelling (see P1);
- The electricity consumption of households, which is available in Eurostat.

Electricity consumption is usually growing due to the diffusion of ever more appliances, even if these are more efficient. Unless there is saturation in the diffusion of appliances, it may prove difficult to account for savings using this indicator.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Electricity consumption of households in kWh per dwelling	M2	$\frac{E^{H_{EL}}}{D}$	$\left(\frac{E_{2007}^{H_{EL}}}{D_{2007}} - \frac{E_t^{H_{EL}}}{D_t}\right) * D_t$	$E_{2007}^{H_{EL}}$, $E_t^{H_{EL}}$ = Electricity consumption of households in 2007 and in year t D_{2007}, D_t = Number of permanently occupied dwellings in 2007 and in year t	**Step 1: Electricity consumption of households** E_{2000}^{H} = 0.878 mtoe E_{2007}^{H} = 0.889 mtoe D_{2000} = 2 489 000 dwellings D_{2007} = 2 653 000 dwellings **Step 2: Indicator 2000** $E_{2000}^{H_{EL}} = \frac{0.878*11.63*10^9}{2489*10^3}$ = 4102 kWh/dwelling **Step 2: Indicator 2007** $E_{2007}^{H_{EL}} = \frac{0.889*11.63*10^9}{2653*10^3}$ = 3897 kWh/dwelling **Step 3: Indicator variation 2000-2007** 3897 – 4102 = -205 kWh/dwelling (*decrease* in the indicator) **Step 4: Activity 2007** Stock of permanently occupied dwellings 2 653 000 **Step 6: Savings** Indicator variation * activity 205 kWh/dwelling * 2 653 000 permanently occupied dwellings = 544 GWh savings

2 Service sector

The energy efficiency indicators for the service sector cover electricity and non-electricity energy consumption in the overall service sector or in the sub-sectors such as hotels and restaurants, retail and wholesale trade, public administration, and educative, social and health care services. Member States can choose to calculate savings by end-use.

The total final energy savings achieved in the service sector can be calculated by adding up the savings achieved in the sub-sectors. The savings achieved are determined by use of one of the following options:

(a) preferred indicator P6 and P7 to show the savings achieved by non-electricity and electricity consumption by sub-sectors;

(b) minimum indicators M3 and M4 to show the savings achieved by non-electricity and electricity consumption of the overall service sector;

(c) a combination of minimum and preferred energy efficiency indicators as long as no double counting occurs (e.g. one of the combinations M3 with P7 or M4 and P6).

Member States can use the indicator of m² or a physical indicator of activity at sub-sectoral level. The physical indicator of activity should be verifiable and compatible with the respective energy efficiency indicator.

For the preferred indicators P6 and P7, the energy efficiency indicators can be defined by sub-sector, for instance using the NACE correspondence:

- Whole and retail trade (Section G),
- Office buildings: Sections H (Transportation and storage), J (Information and Communication), K (Financial and insurance), L (Real estate), M (Professional, scientific and technical activities), and N (Administration and support services).
- Hotels and restaurant (Section I):
- Public administration and defence (Section O)
- Education (Section P):
- Health and social work activities (Section Q)
- Arts, entertainment and recreation (Section R)

2.1 Non-electricity energy consumption in sub-sector x in the service sector per indicator of activity adjusted for climatic conditions (P6)

Indicator P6 is the ratio between the climate corrected non-electricity energy consumption of a sub-sector in the service sector and an indicator of activity (e.g. toe/number of beds or toe/m^2 for hospitals, toe/ person-nights or toe/m^2 for hotels, etc.).

The following data is necessary to calculate indicator P6:

§ An indicator of activity of the sub–sector: the floor area size (m^2) or a physical indicator of activity characteristic of the sub-sector. The choice of the physical indicator of activity should be verifiable and consistent with the respective energy consumption;

- The non-electricity consumption of the sub –sector adjusted for climatic conditions. To calculate the non-electricity consumption adjusted for climatic conditions, see P1.

The actual non-electricity consumption corresponds to the total energy consumption outside the electricity consumption, i.e. fossil fuels, biomass, geothermal heat and heat. Solar energy should not be included as its use is considered as energy savings according to Directive 2006/32/EC.

The variation of this indicator over time may be due to genuine energy savings, linked to building retrofit, change of boilers and installation of solar heaters, but also to a shift from fuels to electricity for thermal uses.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007) – hotels and restaurants
Non-electricity energy consumption in sub-sector x in the service sector per indicator of activity adjusted for climatic conditions	P6	$\frac{E^{S^X_{NON-EL}}}{IA^{S^X}} * \frac{MDD_{25}^{heating}}{ADD^{heating}}$	$[(\frac{E_{2007}^{S^X_{NON-EL}}}{IA_{2007}^{S^X}} * \frac{MDD_{25}^{heating}}{ADD_{2007}^{heating}}) - (\frac{E_t^{S^X_{NON-EL}}}{IA_t^{S^X}} * \frac{MDD_{25}^{heating}}{ADD_t^{heating}})]$	$E_{2007}^{S^X_{NON-EL}}$, $E_t^{S^X_{NON-EL}}$ = Non-electricity consumption of sub-sector X in the service sector in 2007 and in year t $IA_{2007}^{S^X}$, $IA_t^{S^X}$ = Indicator of activity in sub-sector X in 2007 and in year t $MDD_{25}^{heating}$ = Mean heating degree days over the last 25 years $ADD_{2007}^{heating}$, $ADD_t^{heating}$ =Actual heating degree days in 2007 and in year t	**Step 1: Non-electric consumption of hotels and restaurants** $E_{2000}^{H_{NON-EL}}$ = 0.13 – 0.06 = 0.07 mtoe $E_{2007}^{H_{NON-EL}}$ = 0.14 – 0.06 = 0.08 mtoe $IA_{2000}^{S^X}$ = 9 200 000 (nights spent in hotels) $IA_{2007}^{S^X}$ = 11 080 000 (nights spent in hotels) **Step 2: Climatic corrections** $E_{2000}^{H_{NON-EL}}$ = 0.07 mtoe * $\frac{3433}{3106}$ = 0.077 mtoe $E_{2007}^{H_{NON-EL}}$ = 0.08 mtoe * $\frac{3433}{2988}$ = 0.092 mtoe **Step 3: Indicator 2000** $\frac{0.077*10^6}{9200*10^3}$ = 0.0084 toe/night **Step 4: Indicator 2007** $\frac{0.092*10^6}{11080*10^3}$ = 0.0083 toe/night **Step 5: Indicator variation 2000-2007** 0.0083 – 0.0084 = -0.0001 toe/night (*decrease* in the indicator) **Step 6: Activity 2007** Number of nights in hotels and similar establishments (total) : 11 080 000 **Step 7: Savings** Indicator variation * activity 0.0001 toe/night * 11 080 000 nights = 1108 toe

2.2 Electricity consumption in sub-sector x in the service sector per indicator of activity (P7)

Indicator P6 is the ratio between the electricity consumption of a sub-sector in the service sector and an indicator of activity (e.g. kWh/bed or toe/m^2 for hospitals, kWh/person-nights or kWh/m^2 for hotels, etc.).

The following data is necessary to calculate indicator P7:

§ An indicator of activity of the sub –sector, as explained above for P6.

§ The electricity consumption of the sub–sector, as available in the statistical accounts.

The variation of this indicator over time may be due to genuine energy savings, linked to the installation of more efficient air conditioning or lighting equipment. Unit consumption can increase because of a shift from fuels to electricity for thermal uses and also due to a larger diffusion of new appliances (especially ICT).

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007) – hotels and restaurants
Electricity consumption in sub-sector x in the service sector per indicator of activity	P7	$\frac{E^{S^X_{EL}}}{IA^{S^X}}$	$\left(\frac{E^{S^X_{EL}}_{2007}}{IA^{S^X}_{2007}} - \frac{E^{S^X_{EL}}_{t}}{IA^{S^X}_{t}}\right) * \mathrm{IA}^{S^X}_{t}$	$E^{S^X_{EL}}_{2007}$, $E^{S^X_{EL}}_{t}$ = Electricity consumption of sub-sector X in the service sector in 2007 and in year t $IA^{S^X}_{2007}$, $\mathrm{IA}^{S^X}_{t}$ = Indicator of activity in sub-sector X in 2007 and in year t	**Step 1: Electricity consumption of hotels and restaurants** $E^{S^X_{EL}}_{2000}$ = 0.06 mtoe $E^{S^X_{EL}}_{2007}$ = 0.06 mtoe $\mathrm{IA}^{S^X}_{2000}$ = 9 200 000 nights spent in hotels and similar accommodations $IA^{S^X}_{2007}$ = 11 080 000 nights spent in hotels and similar accommodations **Step 2: Indicator 2000** $\frac{0.06*11.63*10^9}{9200*10^3}$ = approx. 76 kWh/night **Step 3: Indicator 2007** $\frac{0.06*11.63*10^9}{11080*10^3}$ = 63 kWh/night **Step 5: Indicator variation 2000-2007** 63 – 76 = -13 kWh/night (*decrease* in the indicator) **Step 6: Activity 2007** Number of nights in hotels and similar establishments (total) : 11 080 000 **Step 7: Savings** Indicator variation * activity 13 kWh/night * 11 080 000 nights = 0.144 TWh

2.3 Non-electricity energy consumption of the service sector in toe per employee in full time equivalent adjusted for climatic conditions (M3)

Indicator M3 is the ratio between the climate corrected non-electricity energy consumption of the service sector and the number of full-time employees in the service sector.

The following data is necessary to calculate indicator M3:

- Non-electricity consumption of the service sector adjusted for climatic correction. To calculate the non-electricity consumption adjusted for climatic conditions, see P1;
- Number of full-time equivalent employees in the service sectors, as provided by Eurostat.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Non-electricity energy consumption of the service sector in toe per employee in full time equivalent adjusted for climatic conditions	M3	$\frac{E^{S_{NON-EL}}}{em^{S^{fte}}} * \frac{MDD_{25}}{ADD^{heating}}$	$[\ (\frac{E_{2007}^{S_{NON-EL}}}{em_{2007}^{S^{fte}}} * \frac{MDD_{25}^{heating}}{ADD_{2007}^{heating}}) - (\frac{E_{t}^{S_{NON-EL}}}{em_{t}^{S^{fte}}} * \frac{MDD_{25}^{heating}}{ADD_{t}^{heating}})\ ]$	$E_{2007}^{S_{NON-EL}}$, $E_{t}^{S_{NON-EL}}$ = Non-electricity energy consumption of the service sector in 2007 and in year t $em_{2007}^{S^{fte}}$, $em_{t}^{S^{fte}}$ = Total number of employee in the service sector (in full time equivalent) in 2007 and in year t MDD_{25} = Mean heating degree days over the last 25 years $ADD_{2007}^{heating}$, $ADD_{t}^{heating}$ =Actual heating degree days in 2007 and in year t	**Step 1: Non-electric consumption of tertiary** $E_{2000}^{H_{NON-EL}}$ =1.84 – 0.85 = 0.99 mtoe $E_{2007}^{H_{NON-EL}}$ = 1.99 – 0.94 = 1.05 mtoe $em_{2000}^{S^{fte}}$ = 1 973 000 $em_{2007}^{S^{fte}}$ = 2 161 000 **Step 2: Climatic corrections** $E_{2000}^{H_{NON-EL}}$ = 0.99 mtoe * $\frac{3433}{3106}$ = 1.09 mtoe $E_{2007}^{H_{NON-EL}}$ = 1.05 mtoe * $\frac{3433}{2988}$ = 1.2 mtoe **Step 3: Indicator 2000** $\frac{1.09*10^6}{1973*10^3}$ = 0.55 toe/emp **Step 4: Indicator 2007** $\frac{1.2*10^6}{2161*10^3}$ = 0.56 toe/emp **Step 5: Indicator variation 2000-2007** 0.56 – 0.55 = +0.01 toe/employee (*increase* in the indicator) **Step 6: Activity 2007** Employment in tertiary: 2 161 000 **Step 7: Savings** Indicator variation * activity In this example no savings achieved in the country presented because the indicator INCREASED between 2000 and 2007 (i.e. increase of 0.01 toe/employee * 2161000 employees = + 0.0216 mtoe)

2.4 Electricity consumption of the service sector in kWh per employee in full time equivalent (M4)

Indicator M4 is the ratio between electricity consumption of the service sector and the number of full-time employees in the service sector.

The following data is necessary to calculate indicator M4:

- Electricity consumption of the service sector;
- Number of full-time equivalent employees in the service sectors, as provided by Eurostat.

The variation of this indicator over time may be due to genuine energy savings, linked to the installation of more efficient air conditioning or lighting equipment. The variation can be upwards (i.e. no savings) because of a shift from fuels to electricity for thermal uses and also a larger diffusion of new appliances (especially ICT).

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Electricity consumption of the service sector in kWh per employee in full time equivalent	M4	$\frac{E^{S_{EL}}}{em^{S^{fte}}}$	$\left(\frac{E_{2007}^{S_{EL}}}{em_{2007}^{S^{fte}}} - \frac{E_t^{E_{EL}}}{em_t^{S^{fte}}}\right) * \mathrm{em}_t^{S^{fte}}$	$E_{2007}^{S_{EL}}$, $E_t^{E_{EL}}$ = Total electricity consumption of the service sector in 2007 and in year t $em_{2007}^{S^{fte}}$, $em_t^{S^{fte}}$ = Total number of employee in the service sector (in full time equivalent) in 2007 and in year t	**Step 1: Electricity consumption of tertiary** $E_{2000}^{E_{EL}}$ = 0.85 mtoe $E_{2007}^{S_{EL}}$ = 0.94 mtoe $em_{2000}^{S^{fte}}$ =1 973 000 $em_{2007}^{S^{fte}}$ = 2 161 000 **Step 2: Indicator 2000** $E_{2000}^{H_{EL}} = \frac{0.85*11.63*10^9}{1973*10^3}$ = 5010 kWh/employee **Step 3: Indicator 2007** $E_{2000}^{H_{EL}} = \frac{0.94*11.63*10^9}{2161*10^3}$ = 5058 kWh/employee **Step 3: Indicator variation 2000-2007** 5058 – 5010 = +48 kWh/employee (increase in the indicator) **Step 4: Activity 2007** Number of employees: 2 161 000 **Step 6: Savings** In this example no savings achieved in the country presented because the indicator INCREASED between 2000 and 2007 45 kWh/employee * 2 161 000 employees= 97 GWh increase

3 Transport sector

The energy efficiency indicators for the transport sector cover energy consumed by passenger and freight transport by road, rail and inland waterways. Final energy savings reported are calculated as the sum of savings achieved by vehicle type ((P8 (A1), P9 (A2), P10, P11, and M5, M6 and M7)) and by transport mode (P12, P13).

The total final energy savings achieved in the transport sector are calculated by adding up the savings achieved. The savings are determined by use of one of the following options:

(a) preferred or alternative indicators P8 (or A1), P9 (or A2), P10, P11, P12 and P13 in combination with the minimum indicator M7;

(b) preferred or alternative indicators P8 (or A1), P9 (or A2), P12 and P13 in combination with the minimum indicators M6 and M7;

(c) minimum indicators M5 to M7 in combination with the preferred indicators P12 and P13.

The energy efficiency indicators for the transport sector cover gasoline and diesel consumption together. Member States may choose to correct savings for fuel substitution between gasoline and diesel by calculating the savings separately for gasoline and diesel vehicles and then summing them up.

Member States that so wish may correct for transit transport and/or fuel tourism using their national correction methodology. The reporting to the Commission should be accompanied by the method of calculation applied.

The energy savings for *road transport* can be calculated in two ways depending on the data availability:

- the sum of the energy savings for cars and trucks and light vehicles calculated from the preferred energy efficiency indicators P8 (or A1 for P8) and P9 (or A2 for P9);
- the variation of the minimum energy efficiency indicator M5.

The energy savings for *rail transport* can be calculated in two ways depending on the data availability:

- the sum of the energy savings for passenger rail transport and rail transport of goods calculated from the preferred energy efficiency indicators P10 and P11;
- the variation of the minimum energy efficiency indicator M6.

The energy savings for *inland waterways* can be calculated with indicator M7.

The energy savings from *modal shift* are equal to the sum of savings calculated with indicators P12 and P13.

Working with preferred energy efficiency indicators is more accurate as it is the closest to energy savings from a technical viewpoint. The minimum indicators are likely to underestimate the savings as they contain the effect of factors, which are not linked to energy efficiency.

3.1 Energy consumption of cars in grams of oil equivalent (goe) per passenger-km (P8)

The average specific consumption of cars per passenger-km is calculated as the division of the yearly motor fuel consumption of cars divided by the traffic of cars expressed in passengers-km.

The following data is necessary to calculate indicator P8:

- The energy consumption of cars;
- The car passenger traffic in passenger-km.

The energy consumption of cars is not a standard entry in energy statistics. It is derived from official statistics on motor fuel sales (e.g. gasoline, diesel), stocks of vehicles and results of surveys on vehicle use in km per year or traffic in vehicle–km, as well as on specific fuel consumption (litre/100km), through simple modelling. Generally, the estimate is not done for cars only but is part of a general allocation of motor fuel consumption by type of road vehicle (e.g. cars, trucks, light duty vehicles, buses, motorcycles). For some countries, a distinction is made between the consumption of domestic cars and total consumption, including foreign vehicles.

Traffic data on passenger–km is available for all countries, published regularly by the Commission in its Statistical Pocketbook, based on national reporting and Eurostat data. They are usually based on vehicles traffic in vehicle-km and an estimate of the average rate of occupancy of cars (persons per vehicle).

The variation of this indicator over time reflects all sources of savings: technical savings, savings linked to driving behaviour, savings due a reduced mobility by car and savings due to an increase in the average rate of occupancy of cars.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of cars in grams of oil equivalent (goe) per passenger-km	P8	$\frac{E^{CA}}{T^{CA}}$	$\left(\frac{E_{2007}^{CA}}{T_{2007}^{CA}} - \frac{E_t^{CA}}{T_t^{CA}} \right) * T_t^{CA}$	E^{CA} = Energy consumption of cars (motor fuels) T^{CA} = Total traffic of cars in passenger-km	**Step 1: Energy consumption of cars** E_{2000}^{CA} = 2.19 mtoe (2.19 * 10^{12} goe) E_{2007}^{CA} = 2.26 mtoe (2.26 * 10^{12} goe) T_{2000}^{CA} = 51 Gpkm (51 * 10^9 pkm) T_{2007}^{CA} = 55 Gpkm (55 * 10^9 pkm) **Step 2: Indicator 2000** $\frac{2.19 * 10^{12}}{51 * 10^9}$ = 43 goe/pkm **Step 3: Indicator 2007** $\frac{2.26 * 10^{12}}{55 * 10^9}$ = 41.1 goe/pkm **Step 4: Indicator variation 2000-2007** 41.1 – 43 = -1.9 goe/pkm (decrease in the indicator) **Step 5: Activity 2007** 55 Gpkm **Step 6: Savings** Indicator variation * activity 1.9 * 55 Gpkm = 0.1045 mtoe

3.2 Energy consumption of cars in l per 100 km driven (A1 for P8)

The average specific consumption of cars in litre/100km is calculated from the total consumption of cars, the stock of cars and the average distance travelled by year by car.

The following data is necessary to calculate indicator A1:

§ The energy consumption of cars (see indicator P8);

§ The stock of cars;

§ The average distance travelled by year by car;

§ The conversion coefficient from litre to toe for motor fuels (gasoline, diesel, biofuels, LPG).

The stock of vehicles corresponds to the number of road vehicles registered at a given date in a country and licensed to use roads open to public traffic[13].

The average distance travelled by year by car is usually available from household or transport surveys. It should be based on observed annual data and should not be extrapolated, as it can fluctuate a lot from one year to the other depending on the economic situation and fuel prices.

The conversion coefficient from litre to toe for gasoline and diesel takes into account the average density (i.e. 0.75 for motor gasoline and 0.85 for diesel[14]) of the products and their average heat content (i.e. 1.051 toe/t for motor gasoline and 1.017 toe/t for diesel)[15]. The coefficients are therefore: 0.788 koe/ litre for motor gasoline and 0.88 koe/ litre for diesel)[16]. These coefficients will have to be adapted to reflect the penetration of biofuels[17].

The variation of this indicator over time reflects both technological improvements and changes in driving behaviours. The difference between the values calculated with A1 and with P8 gives the effect of change in car occupancy and change in the fuel mix, due to the fact that gasoline and diesel have different heat content per litre[18].

[13] Official data sometimes relate to all registered vehicles (i.e. including vehicle that have been scrapped and are not used any more), as they cumulate all the new registrations to the existing stock of vehicles without retiring the vehicles that are no longer used.

[14] Range of 0.70-0.78 for motor gasoline and 0.82-0.90 for diesel

[15] New harmonised values between Eurostat and IEA introduced in 2009: 1.051 toe/t for motor gasoline (44000 kJ/kg) and 1.017 toe/t for diesel (42600 kJ/kg).

[16] Respectively 33000 kJ/l and 36210 kJ/l.

[17] There are two ways to measure the gasoline consumption in energy statistics, depending on the data source: i.e. by referring to the oil part only (case of the energy balance) or to the sum of oil and biofuels (case of oil companies statistics and usual car consumption data). If biofuels are included in the fuel data, the coefficient to be used should be adapted to reflect the average density and heat content of the mix gasoline/biofuels. If they are not included the equation should be completed with the biofuel consumption. The average value proposed by the European Commission are the following: 0.78 koe/l for bioethanol and 0.51 koe/ l for biodiesel.

[18] For instance the increased penetration of diesel results in an increase of the average heat content of one litre of motor fuel, which leads to lower the savings with the indicator in goe/pkm compared to a calculation with the indicator l/100km.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of cars in l per 100 km driven	A1 for P8	$E^{CAspec.}$	$\left[\left(E_{2007}^{CAspec} - E_t^{CAspec}\right)\right] * \frac{Di_t^{av.km.CA}}{100} * S_t^{CA} * K_t$ **With** $K_t = \frac{\left(E_t^{CA^{gasoline}} * F_{gasoline}^{conversion}\right) + \left(E_t^{CA^{diesel}} * F_{diesel}^{conversion}\right)}{E_t^{CA}}$ Conversion factors: $F_{gasoline}^{conversion}$ = 0.80 $F_{diesel}^{conversion}$ = 0.88 Alternative density conversion factors may be used when justified.	E_{2007}^{CAspec}, E_t^{CAspec} = Specific energy consumption of cars in l/100 km in 2007 and in year t $Di_t^{av.km.CA}$ = Average distance in km driven per car per year in year t S_t^{CA} = Total stock of cars in year t K_t = Weighted average coefficient for gasoline and diesel in year t $E_t^{CA^{gasoline}}$ = Gasoline consumption of cars in year t $E_t^{CA^{diesel}}$ = Diesel consumption of cars in year t E_t^{CA} = Total energy (gasoline and diesel) consumption of cars in year t	**Step 1: Energy consumption of cars** E_{2000}^{CAspec} = 7.1 l/100 km E_{2007}^{CAspec} = 6.8 l/100 km $Di_{2007}^{av.km.CA}$ = 18947 km/vehicle S_{2007}^{CA} = 2.15 million K = $\frac{(1.7 mtoe * 0.8) + (0.5 mtoe * 0.88)}{2.2}$ = 0.82 **Step 2: Savings** -(6.8 – 7.1 l/100km)*(18947/100 km/vehicle) * 2 150 000 vehicles * 0.82 = 97 ktoe Another way of calculating may be to first convert the l/100 km into toe (1000 litres = 0.81 toe)

3.3 Energy consumption of trucks and light vehicles in grams of oil equivalent (goe) per tonne-km (P9)

This indicator is the ratio between the consumption of trucks and light vehicles and the road traffic of goods measured in tonne-km. It provides information on the energy efficiency of the overall transport services.

The following data is necessary to calculate indicator P9:

- The fuel consumption of trucks and light vehicles.
- The road traffic of goods measured in tonne-km.

The fuel consumption of trucks and light vehicles is based on the breakdown of motor fuel sales by type of road vehicles (see explanation under indicator P8). The road traffic of goods measured in tonne-km is a usual transport statistics entry covered by Eurostat and DG ENER in its Statistical Pocketbook. A distinction is often made between domestic traffic and international traffic and between domestic and foreign vehicles. For the calculation of energy savings, the traffic should relate to the traffic performed in the country by both domestic and foreign vehicles.

The variation of this indicator over time reflects the effect of an overall progress in the efficiency of freight transport by road: this may come from an increase in the technical efficiency (i.e. a reduction in the specific consumption of vehicles in litre/100km), from improvements in the fleet management, resulting in a reduction of empty hauls and an increase in the average load of the vehicles, and finally from a shift towards bigger trucks, that, while increasing the specific consumption per vehicle, decreases the specific consumption per tonne-km.

Energy savings related to trucks should be interpreted with care because in some countries an increasing amount of diesel may be used by foreign trucks (transit traffic), which may not be corrected in the energy consumption data.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of trucks and light vehicles in grams of oil equivalent per tonne-km (goe/tkm)	P9	$\frac{E^{TLV}}{T^{TLV}}$	$\left(\frac{E_{2007}^{TLV}}{T_{2007}^{TLV}} - \frac{E_t^{TLV}}{T_t^{TLV}}\right) * \mathrm{T}_t^{\mathrm{TLV}}$	E_{2007}^{TLV}, E_t^{TLV} = Energy consumption of trucks and light vehicles in 2007 and in year t T_{2007}^{TLV}, T_t^{TLV} = Total traffic of trucks and light vehicles in tonne-km in 2007 and in year t	**Step 1: Energy consumption of truck and light vehicles** E_{2000}^{TLV} = 1.3 mtoe (1.3*10^{12}goe) E_{2007}^{TLV} = 1.69 mtoe (1.69*10^{12} goe) T_{2000}^{TLV} = 24 Gtkm (24 *10^{9} tkm) T_{2007}^{TLV} = 21 Gtkm (21 *10^{9} tkm) **Step 2: Indicator 2000** $\frac{1.3*10^{12}}{24*10^{9}}$ = 54.2 goe/tkm **Step 3: Indicator 2007** $\frac{1.69*10^{12}}{21*10^{9}}$ = 80.5 goe/tkm **Step 4: Indicator variation 2000-2007** 80.5 – 54.2 = +26.3 goe/tkm (increase of the indicator **Step 5: Activity 2007** 21 Gtkm **Step 6: Savings** Indicator variation * activity In this example no savings achieved in the country presented because the indicator INCREASED between 2000 and 2007 (i.e. increase of 26.3 goe/tkm * 21*10^{9} tkm = + 0.552 mtoe)

3.4 Energy consumption of trucks and light vehicles in tonnes of oil equivalent (toe) per vehicle (A2 for P9)

The annual energy consumption of trucks and light vehicles is calculated by dividing the annual motor fuel consumption of trucks and light vehicles by the stock of trucks and light vehicles.

The following data is necessary to calculate indicator A2 for P9:

- The motor fuel consumption of trucks and light vehicles;
- The stock of trucks and light vehicles.

The variation of this indicator over time reflects primarily technical savings (i.e. reduction in the specific consumption of vehicles, in litre/100 km) and the effect of a reduction in the average size of vehicles.

The difference between the savings measured with P9 and A2 is due to better management of the vehicle fleet (increased load factors, reduced empty hauls) and change in the average size of vehicles. With A2 a shift towards smaller vehicles will appear as a saving whereas with P9 this is not necessarily the case. A reduction of empty hauls and an increase in the average load of the vehicle corresponds to a saving with the preferred indicator, whereas it is not necessarily the case with its alternative indicator.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of trucks and light vehicles in tonnes of oil equivalent (toe) per vehicle	A2 for P9	$\frac{E^{TLV}}{S^{TLV}}$	$\left(\frac{E_{2007}^{TLV}}{S_{2007}^{TLV}} - \frac{E_{t}^{TLV}}{S_{t}^{TLV}}\right) * \mathrm{S}_{\mathrm{t}}^{\mathrm{TLV}}$	E_{2007}^{TLV} , E_{t}^{TLV} = Energy consumption (motor fuels) of trucks and light vehicles in toe in 2007 and in year t S_{2007}^{TLV}, S_{t}^{TLV} = Stock of trucks and light vehicles in 2007 and in year t	**Step 1: Energy consumption of truck and light vehicles** E_{2000}^{TLV} = 1.3 mtoe (1.3*10^6 toe) E_{2007}^{TLV} = 1.69 mtoe (1.69*10^6 toe) S_{2000}^{TLV} = 0.32 million vehicles S_{2007}^{TLV} = 0.45 million vehicles **Step 2: Indicator 2000** $\frac{1.3}{0.32}$ = 4.06 toe/vehicle **Step 3: Indicator 2007** $\frac{1.69}{0.45}$ = 3.76 toe/vehicle **Step 4: Indicator variation 2000-2007** 3.76 – 4.06 = - 0.3 toe/vehicle (*decrease* of the indicator **Step 5: Activity 2007** 450 000 vehicles **Step 6: Savings** Indicator variation * activity 0.3 * 450 000 = 0.135 mtoe

3.5 Energy consumption of passenger rail transport in grams of oil equivalent (goe) per passenger-km (P10)

The specific consumption of passenger rail transport is calculated as the ratio between the energy consumption of passenger trains and the passenger traffic, measured in passenger-km (pkm).

The following data is necessary to calculate indicator P10:

- The energy consumption of passenger rail transport;
- The passenger rail traffic.

The official energy statistics provide the energy consumption of rail transport in total, without a differentiation between passenger and goods. If no data is available on the consumption of passenger rail transport separately, one approximation can be to express the traffic of passengers and goods in the same unit – gross ton-km hauled (tkbr) – reflecting the total weight to be moved, including the weight of locomotives and carriages. For this purpose, a coefficient is used that express the average gross weight per passenger and per ton of goods[19]. The total energy consumption of rail transport that is available from Eurostat energy balances is then allocated between passenger and goods traffic according to the share of passenger and goods traffic respectively in the total traffic in gross tonne-km hauled[20].

The passenger rail traffic measured in passengers-km is a standard transport statistics entry covered by Eurostat and DG TREN in its Statistical Pocketbook.

The variation of this indicator over time reflects both technical energy savings and an increase in the average load factor of trains. The development of high speed trains may offset these energy savings, as high speed increases specific consumption of trains. On the other hand high speed trains attract part of the air traffic, thus leading to other energy savings not accounted for here.

[19] A default value can be used as follows: 1.7 gtkm per passenger-km for passengers and 2.5 gtkm per ton-km for goods.

[20] Depending on the definition of energy consumption statistics the electricity consumption of metro and tram may be included in rail transport. Therefore the calculation of the gross ton-km should be consistent with the coverage of the energy consumption. Ideally, it would be better, if the information is available to well separate the consumption of trains from that of metro and tramways.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of passenger rail transport in grams of oil equivalent (goe) per passenger-km	P10	$\frac{E^{RPa}}{T^{RPa}}$	$\left(\frac{E_{2007}^{RPa}}{T_{2007}^{RPa}} - \frac{E_t^{RPa}}{T_t^{RPa}}\right) * \mathrm{T}_t^{\mathrm{RPa}}$	E_{2007}^{RPa}, E_t^{RPa} = Energy consumption of passenger rail transport in 2007 and in year t T_{2007}^{RPa}, T_t^{RPa} = Total passenger rail traffic in passenger-km in 2007 and in year t	**No data on the spilt of energy consumption in rail transport between passenger and freight**

3.6 Energy consumption of freight rail transport in grams of oil equivalent (goe) per tonne-km (P11)

The specific consumption of rail transport of goods is calculated as the ratio between the energy consumption of goods trains and the traffic of goods, measured in tonne-km (tkm).

The following data is necessary to calculate indicator P11:

- § The energy consumption of rail transport of goods;
- § The rail traffic of goods.

The definition and calculation of the energy consumption of rail transport of goods is similar to that for passengers (see indicator P10). The rail traffic of goods measured in tonne-km is a standard transport statistics entry covered by Eurostat and DG ENER's Statistical Pocketbook.

The variation of this indicator over time reflects both technical energy savings and an increase in the average load factor of trains.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of freight rail transport grams of oil equivalent (goe) per tonne-km	P11	$\frac{E^{RFr}}{T^{RRr}}$	$\left(\frac{E_{2007}^{RFr}}{T_{2007}^{RFR}} - \frac{E_t^{RFr}}{T_t^{RFr}} \right) * \mathrm{T}_t^{\mathrm{RFr}}$	E_{2007}^{RFr}, E_t^{RFr} = Energy consumption of rail transport in 2007 and in year t T_{2007}^{RFr}, T_t^{RFr} = Total freight rail traffic in tonne-km in 2007 and in year t	**No data on the spilt of energy consumption in rail transport between passenger and freight**

3.7 Share of public transport in total land passenger transport in % (P12)

The unit energy consumption of public transport expressed in goe/pkm is the ratio between the energy consumption of public transport modes and the passenger traffic by public transport in passenger-km. The energy consumption of public transport modes is not directly available from Eurostat energy balance; it is calculated based on a breakdown of the motor fuel consumption by type of vehicle (see indicator P8) and the energy consumption of rail between passenger and rail (see indicator P10).

The following data is necessary to calculate indicator P12:

- The total passenger traffic;
- The passenger traffic by public transport;
- The unit energy consumption of cars;
- The unit energy consumption of public transport.

The total traffic of land passenger transport includes the traffic of the following modes: cars, motorcycles, buses, metro, trams and trains, all measured in passenger-km. The passenger traffic by public transport includes the traffic of the following modes: bus, metro, trams and trains, all measured in passenger-km. The unit energy consumption of cars in goe/pkm corresponds to the indicator P8 (see above).

The variation of this indicator over time reflects the change in the share of public transport in the total passenger traffic. In most countries, the present trend is rather towards a decrease of the share of public transport, which corresponds to zero savings from modal shift.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Share of public transport (bus, train, metro, tram) in total land passenger transport in %	P12	$PT = \frac{T_{public}^{Pa}}{T^{Pa}}$	$(PT_t - PT_{2007}) * T_t^{Pa} * (UE_t^{CA} - UE_t^{PT})$	PT_{2007}, PT_t, = Share of public transport 2007 and in year t T_t^{Pa} = Total passenger traffic in year t in passenger-km T_{public}^{Pa} = Passenger traffic by public transport in passenger-km UE_t^{CA} = Unit energy consumption of cars in year t (goe/pkm) UE_t^{PT} = Unit energy consumption of public transport in year t (in goe/pkm)	**Step 1: Share of public transport in total land passenger transport** $PT_{2000} = \frac{5+7Gpkm}{5+7+51GPkm}$ = 19.04% $PT_{2007} = \frac{6+7Gpkm}{6+7+55GPkm}$ = 19.12% **Step 2: Indicator variation 2000-2007** 19.12%-19.04% = 0.08% (*increase* in the indicator, but in the case of share of public transport this points to savings) T_{2007}^{Pa} (car + road+ rail) = 55 + 7 + 6 = 68 Gpkm UE_{2007}^{CA} = 41 goe/pkm UE_{2007}^{PT} = 18.7 goe/pkm **Step 3: Savings** 0.08 % * (68 * 10^9) pkm * (41-18.7) goe/pkm = 1213 toe

3.8 Share of rail and inland waterways freight transport in total freight transport in % (P13)

The unit energy consumption of rail and inland water transport is the ratio, expressed in goe/tkm, between the energy consumption of rail and inland water transport and the traffic of goods by rail and inland water transport in tonne-km. The energy consumption of rail and inland water transport is available from Eurostat energy balance.

The following data is necessary to calculate indicator P13:

- The total traffic of goods;
- The traffic of goods by rail and inland water transport;
- The unit energy consumption of road transport of goods;
- The unit energy consumption of rail and inland water transport.

The total traffic of goods includes the traffic of the following modes: trucks and light vehicles, trains and inland waterways, all measured in tonne-km. The traffic of goods by rail and inland water transport is a standard transport statistics entry covered by Eurostat and DG ENER. The unit energy consumption of trucks and light vehicles in goe/tkm corresponds to the indicator P9.

The variation of this indicator over time reflects the savings due to an increase in the share of rail and water transport in the total traffic of goods. As for passenger transport, in most countries the present trend is rather towards a decrease of the share of these two modes, which corresponds to zero savings from modal shift.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Share of rail and inland waterways freight transport in total freight transport in %	P13	$RW = \frac{T_{RW}^{Fr}}{T^{Fr}}$	$(RW_t - RW_{2007})*T_t^{Fr}*(UE_{RV_t}^{Fr} - UE_{RW_t}^{Fr})$	RW_t, RW_{2007} = Share of rail and inland waterways freight transport in year t and in 2007 in total freight transport T_{RW}^{Fr} = Freight traffic of rail and inland waterways T_t^{Fr} = Total freight traffic (rail, road, waterways) in year t $UE_{RV\,t}^{Fr}$ = Unit energy consumption of freight road vehicle transport in year t $UE_{RW\,t}^{Fr}$ = Unit energy consumption of rail and inland waterways freight transport in year t	**Step 1: Share of public transport in total land passenger transport** $RW_{2000} = \frac{1.16Gtkm}{1.16+24.02Gtkm} = 4.6\%$ $RW_{2007} = \frac{0.56Gtkm}{0.56+20.96Gtkm} = 2.6\%$ **Step 2: Indicator variation 2000-2007** 2.6%-4.6% = -2% (decrease in the indicator, but in the case of share of public transport this points to increased consumption) T_{2007}^{Fr} (road+ rail+inland water) = 24.02+1.15= 25.17 Gtkm $UE_{RV_{2007}}^{Fr}$ = 81 goe/tkm (trucks and light vehicles) $UE_{RW\,2007}^{Fr}$ = 21.3 goe/7km **Step 3: Savings** No savings as the share of public transport in freight transport has decreased.

3.9 Energy consumption of road vehicles in toe per car equivalent (M5)

Indicator M5 replaces indicators P8 and P9 if they cannot be calculated because of a lack of data on the breakdown of the energy consumption of road transport by type of vehicle. Indicator M5 relates the total consumption of road transport to a fictitious stock of all road vehicles, measured in terms of a number of equivalent cars.

The following data is necessary to calculate indicator M5:

- The total energy consumption of road transport;
- The stock of road vehicles by type;
- Coefficients reflecting the difference in average yearly consumption between each type of vehicle and a car.

The total energy consumption of road transport is available from Eurostat energy balance. For some countries, a distinction may be made between the consumption of domestic vehicles, excluding the fuel consumption of foreign vehicles ("domestic road transport"), and total consumption (from the energy balance). The energy savings may be calculated on the basis of this domestic consumption only, provided that appropriate estimates of the consumption of foreign vehicles exist.

The stock of road vehicles by type (cars, trucks, light duty vehicles, buses, motorcycles) is available from national statistics, Eurostat or DG ENER's Statistical Pocketbook.

The coefficients of conversion of each type of vehicle in terms of car equivalent reflect the difference in average yearly consumption between ea car and ach type of other vehicle. If, for instance, a bus consumes on average 15 toe/year and a car 1 toe/year, one bus equals 15 car equivalent. These coefficients can be derived from surveys (or estimates) of distance travelled and specific consumption (l/100km) for selected years; they can also be adapted from similar countries in terms of vehicle characteristics and patterns of use. Possible values to use are listed below:

- 1 truck and light vehicle = 4 cars equivalent[21],
- 1 bus = 15 car equivalent, and
- 1 motorcycle = 0.15 car equivalent

The variation of this indicator over time reflects different types of savings: technical savings (increased energy efficiency of vehicles), savings linked to driving behaviours (car pooling) and reduction in the distance travelled by vehicles.

[21] If trucks and light vehicles are considered separately, a truck=15 car equivalent and a light vehicle= 1.8 car equivalent.

Energy efficiency indicator	**Type**	**Formula for indicator**	**Formula for calculating savings compared to the base year 2007**	**Definition**	**Example: country calculation (2000-2007)**
Energy consumption of road vehicles in toe per car equivalent	M5	$\frac{E^{RV}}{S^{RV^{CAeq}}}$	$\left(\frac{E^{RV}_{2007}}{S^{RV^{CAeq}}_{2007}} - \frac{E^{RV}_{t}}{S^{RV^{CAeq}}_{t}} \right) * S^{RV^{CAeq}}_{t}$	E^{RV}_{2007} , E^{RV}_{t} = Energy consumption of road vehicles (cars, trucks and light vehicles, motorcycles, buses) in 2007 and in year t $S^{RV^{CAeq}}_{2007}$, $S^{RV^{CAeq}}_{t}$ = Stock of road vehicles in car equivalent in 2007 and in year t **With:** 1 truck or light vehicle = 4 cars equivalent 1 bus = 15 car equivalent 1 motorcycle = 0.15 car equivalent	**Step 1: Energy consumption of road transport** E^{RV}_{2000} = 3.67 mtoe E^{RV}_{2007} = 4.16 mtoe $S^{RV^{CAeq}}_{2000}$ = 3.4 million car equivalent $S^{RV^{CAeq}}_{2007}$ = 4.2 million car equivalent **Step 2: Indicator 2000** $\frac{3.67 * 10^6}{3.4 * 10^6}$ = 1.08 toe/car equivalent **Step 3: Indicator 2007** $\frac{4.16}{4.2}$ = 0.99 toe/car equivalent **Step 4: Indicator variation 2000-2007–** 0.99 - 1.08 = -0.09 toe/car equivalent (*decrease* in the indicator) **Step 5: Activity 2007** 4.2 million car equivalent **Step 6: Savings** Indicator variation * activity 0.09 * 4.2 * 10^3 ktoe = 0.378 mtoe

3.10 Energy consumption of rail transport in grams of oil equivalent (goe) per tonne-km (M6)

The energy consumption of rail transport in goe per gross tonne-km is calculated as the ratio between the energy consumption of rail transport and the total traffic, measured in gross ton-km[22].

The following data is necessary to calculate indicator M6:

- The energy consumption of rail transport;
- The passenger rail traffic;
- The traffic of goods by rail.

The energy consumption of rail transport is available from official energy balance statistics. The passenger rail traffic measured in passengers-km and the traffic of goods by rail in ton-km are usual transport statistics covered by Eurostat and DG ENER in its Statistical Pocketbook.

The variation of this indicator over time reflects the total savings coming from an improved energy efficiency of trains and an increase of load factors.

[22] The traffic in gross tonne-km is the usual unit of measurement of the total traffic of goods and passenger in tonne-km, including the weight of locomotives and carriages. It is used to aggregate passenger and freight traffic. The energy consumption is usually allocated between passenger and freight traffic according to the share of passenger and freight traffic in the total traffic in gtkm.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of rail transport in grams of oil equivalent (goe) per tonne-km	M6	$\frac{E^R}{T^R}$	$\left(\frac{E^R_{2007}}{T^R_{2007}} - \frac{E^R_t}{T^R_t}\right) * T^R_t$	E^R_{2007} , E^R_t = Energy consumption of rail transport in 2007 and in year t T^R_{2007} , T^R_t = Total rail traffic in tonne-km in 2007 and in year t	**Step 1: Energy consumption of rail transport** E^R_{2000} = 0.1035 mtoe E^R_{2007} = 0.1041 mtoe T^R_{2000} = 12.035 Gtkbr (gross tonne-km) T^R_{2007} = 12.208 Gtkbr (gross tonne-km) **Step 2: Indicator 2000** $\frac{0.1035*10^{12}}{12.035*10^9}$ = 8.6 goe/tkbr **Step 3: Indicator 2007** $\frac{0.1041*10^{12}}{12.208*10^9}$ = 8.5 goe/tkbr **Step 4: Indicator variation 2000-2007–** 8.5 – 8.6 = -0.1 goe/tkbr (*decrease* in the indicator) **Step 5: Activity 2007** 12.208 Gtkbr **Step 6: Savings** Indicator variation * activity 0.1 * 12.208 * 10^9= 1221 toe

3.11 Energy consumption of inland waterways transport in koe per tonne-km (M7)

The energy consumption of inland waterways transport in koe per tonne-km is calculated as the ratio between the energy consumption of inland waterways transport and the inland waterways traffic, measured in tonne-km.

The following data is necessary to calculate indicator M7:

- The energy consumption of inland waterways transport;
- The traffic of goods by inland waterways.

The energy consumption of inland waterways transport is currently available from official energy balance statistics (e.g. Eurostat). The inland waterways traffic measured in tonne-km is a standard transport statistics entry covered by Eurostat and DG ENER in its Statistical Pocketbook.

In countries in which the traffic of passenger by inland waterways is significant, the passenger traffic could be converted in terms of passenger-km, in the same way as for rail (see indicator M6).

The variation of this indicator over time reflects improved energy efficiency of boats and increase of load factors.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007)
Energy consumption of inland waterways transport in koe per tonne-km	M7	$\frac{E^W}{T^W}$	$\left(\frac{E_{2007}^W}{T_{2007}^W} - \frac{E_t^W}{T_t^W}\right) * T_t^W$	E_{2007}^W, E_t^W = Energy consumption of inland waterways transport in 2007 and in year t T_{2007}^W, T_t^W = Total inland waterways traffic in tonne-km in 2007 and in year t	**No data for domestic water transport**

4 Industry sector

Energy efficiency indicators for the industry sector cover the final energy consumption in all industrial sub-sectors falling within the scope of Directive 2006/32/EC. Agriculture can be included as one sub-sector.

In their reporting to the Commission, Member States should disclose the method used to exclude energy savings from undertakings involved in categories of activities listed in Annex I to Directive 2003/87/EC. The proposed method is to correct the savings obtained in each industrial sub-sector by the share of energy consumption of the respective industrial sub-sector falling under the scope of Directive 2003/87/EC in the respective year (Factor K in indicators P14 and M8). .

4.1 Energy consumption of industrial sub-sectors per unit of production (P14)

The energy consumption per unit of output of industrial sub-sector (or industrial sub-sector) is defined as the ratio between the final energy consumption of the sub-sector and the production index of the sub-sector.

The following data is necessary to calculate indicator P14:

§ The final energy consumption of the sub-sector;

§ The production index of the sub-sector;

§ The share of energy consumption of industrial sub-sector falling under the scope of Directive 2006/32/EC;

The final energy consumption by industrial sub-sector is available from Eurostat for 13 sub-sectors corresponding to the 2 digits level NACE classification as follows:

- non energy mining (NACE 13-14)
- food, beverage, tobacco (NACE 15-16)
- textiles, clothing, leather (NACE 17-19)
- wood industry (NACE 20)
- paper, pulp and printing (NACE 21-22)
- chemicals (NACE 24)
- non metallic minerals (NACE 26), of which cement (NACE 26.51)
- iron and steel (27.1)
- non ferrous (27.2)
- machinery & metal products (NACE 28-32), of which fabricated metals (NACE 28)
- transport equipment (NACE 34-35)
- other manufacturing (NACE 25+33+36+37), of which rubber and plastics (NACE 25)
- construction (NACE 45)

The industrial production index by sub-sector is the most common indicator used to measure the industrial output[23]; it is usually measured in relation to a base year (e.g. index base 100 in 2000 for instance). It is well covered by Eurostat and national statistics.

The share of energy consumption of industrial sub-sector falling under the scope of Directive 2006/32/EC corresponds to the part of the consumption that is not covered by the Emission Trading Scheme. It can be based on data collected once preparing the National Allocation Plans and kept constant over the period 2008-2016 if no yearly follow up is available. If yearly data are available, this share should be updated every year.

Energy savings calculated from the variation of energy consumption related to a production index capture technical savings but may also include for some branches the effect of non-structural changes in the production mix, especially in the chemical industry the effect of a shift from heavy chemicals to light chemicals (e.g. cosmetics, pharmaceuticals).

Combined heat and power (cogeneration) is one of the main measures considered in industry to get energy savings. Due to the way **final energy statistics** are made by international organisations, an increase in the penetration of cogeneration will result in fuel savings at the level of each industrial branch; the resulting savings are thus already included in the energy savings calculated from the variation of the specific energy consumption by **industrial branch**. Their contribution could be calculated from the variation in the market penetration of cogeneration, i.e. using a market diffusion indicator but should not be added to the savings by branch.

[23] Production index are measured at a very detailed level (4 to 5 digits) on the basis of physical production in different units (e.g. number of litres of milk processed, of tons of meat produced for the food industry). To get the production index of a two digits branch (e.g. food), detailed index are aggregated on the basis of the weight of each sub-branch in the value added of the branch in the base year (2000).

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007) – food industry
Energy consumption of industrial sub-sectors per unit of production	P14	$\frac{E^{I^X}}{IPI^{I^X}}$	$\left(\frac{E^{I^X}_{2007}}{IPI^{I^X}_{2007}} - \frac{E^{I^X}_{t}}{IPI^{I^X}_{t}}\right) * IPI^{I^X}_{t} * K^{I^X}_{2007})$	$E^{I^X}_{2007}$, $E^{I^X}_{t}$ = Energy consumption of industrial sub-sector x in 2007 and in year t $K^{I^X}_{2007}$ = Share of energy consumption of industrial sub-sector x falling under the scope of Directive 2006/32/EC in 2007 $IPI^{I^X}_{2007}$, $IPI^{I^X}_{t}$ = Industrial production index of industry sub-sector x in 2007 and in year t	**Step 1: Energy consumption of food industry** $E^{I^X}_{t}$ = 0.76 mtoe $E^{I^X}_{2007}$ = 0.72 mtoe $K^{I^X}_{2007}$ = 0.8 (share of ETS in food industry energy consumption is 20%, hence the share under Directive 2006/32/EC is 80% or a factor of 0.8) $IPI^{I^X}_{2000}$ = 100 $IPI^{I^X}_{2007}$ = 111 **Step 2: Indicator 2000** $\frac{0.76}{100} * 100$ = 0.76 **Step 3: Indicator 2007** $\frac{0.72}{111} * 100$ = 0.65 **Step 4: Indicator variation 2000-2007**– 0.65 – 0.76 = -0.11 (decrease in the indicator) **Step 5: Activity 2007** 111 **Step 6: Savings** 0.11 * 111 * 0.8/100 * 1000 = 98 ktoe

4.2 Energy consumption of industrial sub-sectors per valued added (M8)

Indicator M8 is defined as the ratio between the final energy consumption of the sub-sector and the value added of the sub-sector. The sub-sector covered in the evaluation of energy savings should exclude, according to Directive 2006/32/EC, the scope of the Emission Trading Scheme. See the proposed method for correction in 4.1.

The following data is necessary to calculate indicator M8:

- The final energy consumption of the sub-sector (see indicator P12);
- The value added in real terms of the sub-sector;
- The share of energy consumption of industrial sub-sector falling under the scope of Directive 2006/32/EC (see indicator P12 for details on the factor K).

The value added in real terms, by sub-sector is the most common indicator used to measure the industrial output in monetary value (Euro). It is well covered by Eurostat and national statistics.

Savings calculated from the variation of the energy consumption per unit of value added capture technical savings but also the influence of non technical factors that are not linked to energy efficiency measures (e.g. change in profit, in product mix and quality). This is why indicator P14 should be preferred.

Energy efficiency indicator	Type	Formula for indicator	Formula for calculating savings compared to the base year 2007	Definition	Example: country calculation (2000-2007) – food industry
Energy consumption of industrial sub-sectors per unit of value added in real terms	M8	$\frac{E^{I^X}}{VA^{I^X}}$	$\left(\frac{E_{2007}^{I^X}}{VA_{2007}^{I^X}} - \frac{E_t^{I^X}}{VA_t^{I^X}}\right) * VA_t^{I^X} * K_{2007}^{I^X})$	$E_{2007}^{I^X}$, $E_t^{I^X}$ = Energy consumption of industrial sub-sector x in 2007 and in year t $K_{2007}^{I^X}$ = Share of energy consumption of industrial sub-sector x falling under the scope of Directive 2006/32/EC in 2007 $VA_{2007}^{I^X}$, $VA_t^{I^X}$ = Value added in real terms of industry sub-sector x in 2007 and in year t	**Step 1: Energy consumption of food industry** $E_t^{I^X}$ = 0.76 mtoe $E_{2007}^{I^X}$ = 0.72 mtoe $K_{2007}^{I^X}$ = 0.8 (share of ETS in food industry energy consumption is 20%, hence the share under Directive 2006/32/EC is 80%) $VA_{2000}^{I^X}$ = 3635.5 million Euro (gross value added at basic prices for food and beverage industry) $VA_{2007}^{I^X}$ = 4299.9 million Euro (gross value added at basic prices for food and beverage industry) **Step 2: Indicator 2000** $\frac{0.76*10^{12}}{3635.5*10^6}$ = 209 goe/Euro Step 3: Indicator 2007 $\frac{0.72*10^{12}}{4299.9*10^6}$ = 167.4 goe/Euro **Step 4: Indicator variation 2000-2007** 167.4 – 209 = 41.6 goe/Euro **Step 5: Activity 2007** 4299.9 million Euro **Step 6: Savings** 41.6 goe/Euro * 4299.9 *10^6 * 0.8 = 0.143 mtoe

5 Calculating the P-level indicators: a combined approach

The model presented in the previous sections, which is largely based on estimating energy savings from P-level indicators by multiplying the variation of an indicator (energy consumption/activity) between a reference year (2007) and a final year by an indicator of activity in the final year, may at least initially cause difficulties due to lack of disaggregated energy consumption data at the level of subsectors or end uses.

In order to avoid excessive use of the aggregated M-level indicators (which are much less accurate), insofar as appropriate MS can choose to calculate a **combination (basket) of similar P-level indicators** (by subsectors or by end-uses) - e.g. P8 and P9 for transport, or P10 and P11 for transport, or P6 for subsectors at NACE3 level in the service sector, or P7 for subsectors at NACE3 level in the service sector – then MS can use the **aggregate energy consumption in year t** for the selected subsectors or end uses, rather than the energy consumption of individual subsectors or end uses for year t. In this case, the energy consumption by individual subsectors is only required for the reference year (2007).

This approach is optional and does not prevent MS from calculating energy savings by subsector, on the basis of estimates of the yearly disaggregation of energy savings. This approach is also applicable where the indicator of activity is not identical in the indicators used together – an issue of importance in the tertiary sector, whereby different indicators of activity can be used (e.g. beds in hospitals or overnights in hotels).

As an example, let S_t be the sum of the energy savings corresponding to indicators P8 and P9:

$$S_t = \left(\frac{E_{2007}^{CA}}{T_{2007}^{CA}} - \frac{E_t^{CA}}{T_t^{CA}} \right) * T_t^{CA} + \left(\frac{E_{2007}^{TLV}}{T_{2007}^{TLV}} - \frac{E_t^{TLV}}{T_t^{TLV}} \right) * T_t^{TLV}$$

The sum of P8 and P9 can be rewritten as:

$$S_t = \frac{E_{2007}^{CA}}{T_{2007}^{CA}} * T_t^{CA} + \frac{E_{2007}^{TLV}}{T_{2007}^{TLV}} * T_t^{TLV} - E_t^{CA} - E_t^{TLV}$$

or :

$$S_t = \frac{E_{2007}^{CA}}{T_{2007}^{CA}} * T_t^{CA} + \frac{E_{2007}^{TLV}}{T_{2007}^{TLV}} * T_t^{TLV} - E_t^{CA+TLV} \qquad (1)$$

where E_t^{CA+TLV} is the aggregate energy consumption of cars and trucks and light vehicles in year t:

$$E_t^{CA+TLV} = E_t^{CA} + E_t^{TLV}$$

II. Recommended bottom-up calculation model

The recommended bottom-up calculation model set out in this Annex consists of guiding principles, a set of formulas, baselines and default values for measuring final energy savings achieved through the implementation of energy efficiency improvement measures or programmes in residential (households) and tertiary (public and private organisations in the service sector) buildings, including equipment and appliances used in buildings, in compliance with 2006/32/EC Annex IV 1.1.

1 Guiding principles for applying the recommended bottom-up calculation model

It is recommended that Member States apply the following principles:

(a) Member States can calculate final energy savings achieved in residential and tertiary buildings, including equipment and appliances, using the prescribed bottom-up calculation formulas set out this Annex. The savings measurement should reflect the variation in final energy consumption "before" and "after" the implementation of energy efficiency improvement measures or programmes, while ensuring adjustment and normalisation for external conditions commonly affecting energy use.

(b) The recommended bottom-up model applies to early action and new measures.

(c) The recommended bottom-up model does not cover all possible measures in residential and tertiary buildings. When Member States implement measures in residential and tertiary buildings that are not covered by the recommended bottom-up calculation model, Member States can use national bottom-up or top-down methods.

(d) For end-use sectors other than residential and tertiary buildings, including equipment and appliances, Member States can use national bottom-up methods, top-down indicators from the Commission recommendation or national top-down methods.

(e) Energy efficiency improvement measures or programmes implemented in residential and tertiary buildings, including equipment and appliances, fall within one of the following three categories:

- Replacement of existing energy-using equipment and appliances with new, more energy efficient equipment;
- Energy efficient retrofitting of existing equipment or buildings without replacement;
- Acquisition of new energy efficient equipment or appliances, or construction of new energy efficient buildings.

(f) "Before" and "after" refers to measured or estimated data at the level of an individual building, equipment or appliance. When the "before" situation cannot be assessed in terms of final energy consumption for the individual building, equipment or appliance, then for each of the three categories of measures and programmes under point (e), the appropriate baseline prescribed in Table I.1 should be applied as "before" situation in the bottom-up measurement. In the case of new buildings, appliances and equipment, the baseline is always used as "before" situation. The "after" situation is assessed in terms of final energy consumption after the implementation of the measure.

Table I.1 Baselines by category of energy efficiency improvement measures or programmes

Category		**Baseline definition**	**Stock average definition**[24]
1	Replacement of existing equipment with new, more energy efficient one	2-step baseline based on the stock average energy consumption: – Step 1 for measures implemented before 2008: 1995 (1991) stock average energy consumption (early action) – Step 2 for measures implemented between 2008 and 2016: 2007 stock average energy consumption	• In case a measure or program only targets equipment or appliances installed before a certain year (e.g. boilers installed before 1994), the stock average is derived on the basis of the stock of equipment or appliances in that year. • In all other cases the stock average is derived on the basis of the entire stock (population) of appliances or equipment in 1995 (1991) or 2007.
2	Energy efficient retrofitting of existing equipment or buildings without replacing them	3 options based on the stock average energy consumption: – For building never refurbished before 1995 (1991): stock average of the construction period of the building or according to the building code in force at that time[25]; – For building refurbished before 1995 (1991): Stock average of the period when the last refurbishment of the building took place before 1995 (1991); – For equipment: stock average of the year of the original equipment/system to be retrofitted.	• In case a measure or program only targets buildings constructed before a certain year (e.g. building constructed before 1990), the stock average is derived on the basis of the stock of buildings in that year. • In all other cases the stock average is derived on the basis of the entire stock of buildings in 1995 (1991) or 2007.
3	Additional new energy efficient equipment or construction of new energy efficient buildings	• Additional new energy efficient equipment: 2-step baseline based on market average energy consumption (see category 1) • Construction of new buildings: the baseline is the first building code introduced after 1995 (1991) or the building code in force in 1995 (1991).	NA

(i) Member States should ensure that in their reporting of total energy savings based on bottom-up calculation double counting is excluded.

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[24] As alternative to the stock average, Member States may use the *market average* energy consumption in 1995 (1991) or 2008 or in the year when the original equipment was installed.

[25] As it may be difficult to establish the energy consumption of the stock for past periods, a practical way could be to establish classes/types of buildings based on construction periods or construction technologies (e.g. consumption of the stock of panel buildings, consumption of the stock of buildings constructed in the 1950s, 1960s, etc.)

2 Recommended bottom-up calculation formulas

The prescribed bottom-up calculation formulas cover the most common types of refurbishment, replacement or new construction or installation in buildings, energy-using equipment and appliances in buildings and fall within the defined three categories of energy efficiency improvement measure or programmes:

Category 1 Replacement of existing equipment with new, more energy efficient one:

- Replacement of heating supply equipment in residential and tertiary buildings;
- Replacement of water heating equipment in residential and tertiary buildings;
- Replacement of air conditioning split systems (< 12kW) in residential and tertiary buildings;
- Replacement of household appliances (cold appliances, washing machines, dishwashers, televisions, etc.) in residential buildings;
- Replacement of office equipment in tertiary buildings;
- Replacement of lighting in residential buildings (lamp);
- Replacement of lighting in tertiary buildings (system or component);

Category 2 Energy efficient retrofitting of existing equipment or buildings without replacing them:

a) Refurbishment measures in existing residential and tertiary buildings (building envelope and heating system);
b) Insulation refurbishment measures applied to building shell in existing residential and tertiary buildings (walls, roofs, windows);
c) Lighting in tertiary buildings (system or component);

Category 3 Additional new energy efficient equipment or construction of new energy efficient buildings:

a) New building constructed according to or beyond building codes in new residential and tertiary sectors;
b) New household appliances (cold appliances, washing machines, dishwashers, television, etc.) in residential buildings;
c) New office equipment in tertiary buildings;
d) Installation of new air conditioning split systems (< 12kW) in residential and tertiary buildings;
e) New installation of heating supply equipment in residential and tertiary buildings;
f) New installation of water heating equipment in residential and tertiary buildings;
g) Solar water heating in residential and tertiary buildings;
h) New Lighting in residential buildings (lamp);
i) New Lighting in tertiary buildings (system or component);

For categories 1 and 2 in case the "before" and "after" values of final energy consumption (in kWh per year) are available[26] for the individual (single) building, equipment or appliance, then these individual "before" and "after" values can be used instead of the recommended formulas to calculate the unitary savings, provided the normalisation for external conditions commonly affecting energy use are included.

The formulas should enable Member States to calculate the annual unitary final energy savings (UFES) per participant or per unit relevant for each of the energy efficiency improvement measures or programmes listed above[27]. Unless individual "before" and "after" values on final energy consumption

[26] E.g. through an energy audit carried out before and after, or through the EPBD building energy performance certificates (before and after), and by detailed tracking system for equipment replacement.

[27] Accounting for units built, refurbished or sold within the framework of a measure is the most precise way of capturing the energy savings from a program or measure (*additional savings*). Nevertheless, Member States can

are available, the UFES should be calculated in combination with the prescribed baselines and normalisation factors, and national values (individual measure values or programme-specific values or national average values).

National values can be based on Eurostat and national statistic, and/or other nationally approved data based on surveys, samples, stock models, experts calculations or enhanced engineering estimates. Alternatively for equipment the recommended energy savings default values are provided in Table I.2, these can be used to calculate the unitary final energy savings.

The total energy savings achieved are calculated based on the sum of the annual unitary final energy savings and taking into consideration the recommended lifetimes as set in Annex III. In case unitary final energy savings are identical for all units or are averaged among many units, the total energy savings are calculated by multiplying the annual unitary final energy savings either by the number of units built, refurbished or installed under a measure or program (additional savings) or by the total number of units built, refurbished or installed taking into consideration the recommended lifetimes as set in Annex III[28] . This is the case in particular with appliances and lighting, whereby large number of identical units is deployed or average unitary savings are calculated, as is the case with recommended default energy savings values provided in Table I.2.

In case individual "before" and "after" values are used, the total energy savings can only be calculated as the sum of individual annual unitary final energy savings.

2.1 Refurbishment measures in existing residential and tertiary buildings

The formula provides for the evaluation of the annual energy savings due to improvements of the building envelope and the heating system, and other building refurbishment measures. The annual unitary final energy savings are calculated based on the difference in the ratio between specific heating demand (SHD) and the energy efficiency of the heating system before the refurbishment measure and the ratio after the refurbishment measure. The savings are expressed in kWh/m^2 of floor area per year. The before situation should be based on the specific building (individual "before") or should reflect the average energy efficiency in the period of construction of the category of building undergoing refurbishment (relative to building types, installed technologies and/or insulation types) in terms of specific heating demand and energy efficiency of the heating system. The values for the specific heating demand should be corrected with the relevant heating degree days. If the ratio between specific heating demand and energy efficiency of the heating system is available as a single value, this value can be used without having to collect specific heating demand and energy efficiency of heating system values separately.

The annual unitary final energy savings in kWh per building [kWh/building/year] are calculated by multiplying the unitary annual energy savings per m^2 by the total area of the refurbished building's floor area[29]. The total final energy savings achieved by the measure are calculated by summing up the savings of each refurbished buildings.

account for *total savings* by taking into consideration the total number of units built, refurbished or sold, regardless of whether these have been promoted by the program or measure or not.

[28] If a measure with a recommended lifetime of 15 years was introduced in 2005, in order to calculate the total energy savings achieved in 2016 the unitary final energy savings are multiplied by the number of units built, refurbished or installed in the period 2005-2016.

[29] In all formulae where multiplication by the area of the building is done, Member States should specify what floor area they are using (e.g. useful floor area, built area, etc.).

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Cate-gory
$$UFES = \frac{SHD_{init}}{\eta_{init}} - \frac{SHD_{new}}{\eta_{new}}$$ [kWh/m² of floor area /year] Note: UFES is per m² of floor. The savings at the level of a building savings are calculated by multiplying UFES by the floor area.	SHD_{init} =Specific heating demand before the implementation of the refurbishment measure [kWh/m² / year] SHD_{new} = Specific heating demand after the implementation of the refurbishment measure [kWh/m²/year] η_{init} , η_{new} = Energy efficiency of the heating system before (init) and after (new) the refurbishment measure (seasonal)	Heating demand of the stock average in the period of construction of the building type undergoing refurbishment.	2.a)

2.2 *Insulation refurbishment measures applied to building components (walls, roofs, windows) in existing residential and tertiary buildings*

The formula provides for the evaluation of the annual energy savings resulting from building shell insulation measures and from window replacement, without heating equipment replacement.

The annual unitary final energy savings (in kWh/m^2/year) are based on the difference between the specific component U-values before and after the implementation of the refurbishment measure. The before situation should be based on the component U-value of each component refurbished in a specific building (individual "before") or should reflect the U-value of each refurbished component in period of construction of the building undergoing refurbishment or in the year of last refurbishment before 1995 (1991). The U-values should be corrected with the relevant heating degree days and, as far as practicable, with the efficiency and the intermittency of the heating system.

The annual energy savings in kWh per m^2 component [kWh/m^2 component/year] are calculated by multiplying the annual unitary final energy savings per m² of component installed by the total component installed area (m^2) of the refurbished building shell (walls, roofs or windows). This means that the annual unitary final energy savings from window replacements should be multiplied by the total area (m^2) of windows replaced.

Subsequently, the total annual energy savings in kWh per building are calculated by summing the annual energy savings per component. The total final energy savings are calculated by summing up the savings of each building where insulation has been installed or where windows have been replaced.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Cate-gory
$UFES_{wall} = \frac{(Uvalue_{init\_wall} - Uvalue_{new\_wall}) * HDD * 24h * a * \frac{1}{b} * c}{1000}$ [kWh/m^2 of insulated wall area /year] $UFES_{windows} = \frac{(Uvalue_{init\_windows} - Uvalue_{new\_windows}) * HDD * 24h * a * \frac{1}{b} * c}{1000}$ [kWh/m^2 of window replaced/year] $UFES_{roof} = \frac{(Uvalue_{init\_roofl} - Uvalue_{new\_roofl}) * HDD * 24h * a * \frac{1}{b} * c}{1000}$ [kWh/m^2 of insulated roof area /year]	$Uvalue_{init}$, $Uvalue_{new}$ t = the U-values of the building elements (i.e. walls, windows, roofs) before (init) and after (new) the refurbishment W/(m^2*K)], use the values for thermal transmittance of the insulation materials **a** = correction factor depending on the climatic zone of the building, with a=1, if no national correction value is available **b** = Correction factor depending on the heating system efficiency and energy source. This correction factor is the average efficiency of the stock of heating systems. With b= 0,95 for direct electric heating and 0,6 for fossil fuel boilers, if no national correction value is available. **c** = Intermittency coefficient depending on not continuous operation of the heating system. With c= 0,5 if no national correction value is available. **HDD** = Heating degree-days [K*day/year]	U-value of each refurbished component or average U-value of each component in the period of construction of the building undergoing refurbishment or in the year of last refurbishment before 1995 (1991)	2.b)

2.3 Introduction of building codes for new residential and tertiary buildings and promotion of buildings beyond building codes

The formula provides for the evaluation of annual energy savings derived from the introduction of new building codes with stricter requirements in relation to the buildings heating demand and from the implementation of measures that promote buildings that go beyond existing building codes.

The annual unitary final energy savings [kWh/m^2/year] are calculated based on the difference in the ratio between specific heating demand and energy efficiency of the heating system between the initial building code in place in 1995 (1991) or introduced after 1995 (1991) and the new building code to be applied. In case no building code was in force in 1995 (1991), the baseline is the average heating demand of buildings constructed in 1995 (1991).

In case where measures promote buildings that go beyond the building code, the annual unitary final energy savings [kWh/m^2/year] are calculated based on the difference in the ratio between specific heating demand and energy efficiency of the heating system between the initial building code in place or introduced after 1995 (1991) and the ratio in the buildings promoted. If the building code also imposes efficiency requirements for heating systems, these should be included too. The specific heating demand values should be corrected with the relevant heating degree days.

If the ratio between specific heating demand and energy efficiency of the heating system is available as a single value, this value can be used without having to collect specific heating demand and energy efficiency of heating system values separately.

The total annual energy savings in kWh per building are calculated by multiplying the unitary final energy savings per m^2 by the floor area (m^2) of the new building constructed. The total final energy savings achieved are calculated by summing up the savings achieved with each new building.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$$UFES = \frac{SHD_{inicode}}{\eta_{inicode}} - \frac{SHD_{newcode}}{\eta_{new}}$$ [kWh/m²/year]	$SHD_{inicode}$ = Specific heating demand of building according to the initial building code introduced after 1995 (1991) or of the building code in force in 1995 (1991) [kWh/m^2/year] $SHD_{newcode}$ = Specific heating demand of building according to the new building code implemented. [kWh/m^2/year] $\eta_{inicode}$, $\eta_{newcode}$ =Energy efficiency of the heating system in building according to the old (inicode) and the new (newcode) building code. (seasonal)	First building code introduced after 1995 (1991) or the building code in force in 1995 (1991)	3.a)

2.4 *Replacement of heating supply equipment in residential and tertiary buildings*

The formula provides for the evaluation of annual energy savings derived from the replacement or new installation of heating supply equipment in residential and tertiary buildings.

The annual unitary final energy savings are calculated on the basis of the change in efficiency of the heating system after its replacement, multiplied by the specific heating demand and the heated floor area (in kWh/heating system unit/year) heated by the equipment.

The total annual energy savings in kWh per heating equipment unit [kWh/heating equipment unit/year] are calculated by summing up the annual unitary final energy savings achieved by each unit of replaced heating supply equipment.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$UFES = \left(\frac{1}{\eta_{init}} - \frac{1}{\eta_{new}} \right) * SHD \ * A$ [kWh/unit/year]	η_{ini} = Energy efficiency of the old heating supply equipment x before the replacement (seasonal) η_{new} = Energy efficiency of the new heating supply equipment (seasonal) SHD = Specific heating demand [kWh/m^2/yr] A = Average area of the space heated by the heating supply equipments (household, office etc.) [m^2]	Average stock efficiency in 1995 (1991) for early actions and 2007 for new measures For new additional installation: average market efficiency in 1995 (1991) for early action) and 2007 for new measures	1.a) 3.e)

2.5 Replacement or new installation of water heating in residential and tertiary buildings

The formula provides for the evaluation of annual energy savings derived from the replacement or new installation of water heating equipment in existing residential and tertiary buildings.

The annual unitary final energy savings (in kWh/year) are calculated on the basis of the change in efficiency before and after the replacement of the water heater, multiplied by the specific hot water demand.

The total annual energy savings [kWh/year] are calculated by summing up the annual unitary final energy savings achieved by each water heating equipment unit.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$UFES = \left(\frac{1}{\eta_{ini}} - \frac{1}{\eta_{new}} \right) * SWD$ [kWh/unit/year] **With:** $SWD = \frac{C_{hot\_water\_daily} * 365d * n_{persons/building} * (t_{hot\_water} - t_{cold\_water}) * c_{water} * c_f}{1000}$ [kWh/unit/year]	η_{ini}, η_{new} = Energy efficiency of the old and the new water heating equipment SWD =Specific hot water demand [kWh/unit/year]. 365d = 365 days $C_{hot\_water\_daily}$ = Average hot water daily consumption per person in residential or tertiary building supplied by the water heater $n_{persons/hhds}$ = Average number of persons in the building supplied by the water heater t_{hot_water} = Hot water temperature (usually 60^0C) t_{cold_water} = Cold water temperature (usually 15^0C) c_{water}= Specific heat of water =1kcal/kg*^{0}C c_{f} = Conversion factor 0,001163 kWh/kcal with 1 liter of water = 1 kg	Average stock efficiency in 1995 (1991) for early action, 2007 for new measures. For new additional installation: average market efficiency in 1995 (1991) for early actions, 2007 for new measures	1.b) 3.f)

2.6 *Installation or replacement of air conditioning split system (< 12kW) in residential and tertiary buildings*

The formula provides for the evaluation of annual energy savings derived from the installation or the replacement of air conditioning split systems in residential and tertiary buildings.

The annual unitary final energy savings [kWh/unit/year] are calculated on the basis of the improvement of the energy efficiency ratio (EER) of the air conditioning equipment, normalised by nominal cooling power of the equipment and the annual operation hours.

The total annual energy savings achieved [kWh/year] are calculated by summing up the annual unitary final energy savings of all replaced or newly installed air-conditioning units in case of individual "before" and "after".

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$UFES = \left(\frac{1}{EER_{average}} - \frac{1}{EER_{best\_perf\_on\_market}} \right) * P_{fn} * n_h$ [kWh/unit/year] With: $n_h = n_{sh} * f_u$	EER = Energy efficiency ratio of the equipment: (supplied cooling power) / (electric power of the equipment) $EER_{average}$ = Seasonal energy efficiency ratio of the reference equipment; $EER_{best\_perf\_on\_nm}$ = Seasonal energy efficiency ratio of the high-efficiency substituting equipment. P_{fn} = Nominal cooling power of the equipment [kW] n_h = Annual operation hours at full power n_{sh} = Annual switch-on hours f_u = Part-load factor (suggested default value: 58%)	Average stock efficiency in 1995 (1991) for early action, 2007 (for replacement). For new additional installation: average market efficiency in 1995 (1991) for early actions, 2007 for new measures	1.c) 3.d)

2.7 *Solar water heating in residential and tertiary buildings*

The formula provides for the evaluation of annual energy savings derived from the installation of solar panels for water heating in existing or new residential and tertiary buildings.

The annual unitary final energy savings for new solar water heating systems are calculated on the basis of the average annual energy savings per m^2 of solar panel, divided by the average efficiency of the replaced water heating systems stock in the reference year of installation [in $kWh/m^2/year$]. The reference year is the year when the solar water heating unit was installed.

The total annual energy savings achieved [kWh/year] are calculated by multiplying the annual unitary final energy savings by the total installed area in m^2 of solar panels after 1995 (1991).

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$UFES = \dfrac{USAVE}{\eta_{stock\_average\_heating\_system}}$ [kWh/m²/year] Note: USAVE can improve over time. Therefore Member States can update it on annual basis.	USAVE = Average annual savings per m^2 of solar panel, representing the average heat production per m^2 of solar panel [kWh/m^2] $\eta_{stock\_average\_heating\_}$ = Efficiency of the average stock water heaters or heating systems in the year when the solar heater was installed. *Note: This is the efficiency of the existing installed stock and not the efficiency of the solar heaters.*	None	3.g)

2.8 Replacement or new household appliances (cold appliances, washing machines, dishwashers, televisions, etc.) in residential buildings

The formula provides for the evaluation of annual energy savings derived from the replacement of existing household energy-using appliances with new more energy efficient ones.

The annual unitary final energy savings for household appliances [kWh/unit/year] are calculated based on the difference between the annual energy consumption of the reference year stock average (for new appliances the market average) and the annual energy consumption of the efficient appliances sold or installed.

The total annual energy savings per appliance type achieved [kWh/year] are calculated by multiplying the annual unitary final energy savings by the number of energy efficient appliance units sold or installed.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$UFES = AEC_{reference\ year\ stock\ averag} - AEC_{reference\ market\ promoted\ energyclass}$ [kWh/unit/year]	$AEC_{reference\ year\ stock\ average}$ = Annual energy consumption of the stock in the reference year (1995/1991 for early action, 2007 for new action) [kWh/unit/year] $AEC_{reference\ market\ promoted\ energyclass}$ = Annual energy consumption of the efficient appliances on the market [kWh/unit/year] Note: Member States define efficient appliances on the market.	Average energy consumption of stock in 1995 (1991) for early action, 2007 for replacement. For new additional installation: energy consumption of market average in 1995 (1991) for early action, in 2007 for new measures	1.d) 3.b)

2.9 Replacement or new installation of lamps in residential buildings

The formula provides for the evaluation of annual energy savings derived from the replacement of lamps with new more energy efficient ones or installation of new lamps.

The annual unitary final energy savings (in kWh/unit/year) for lamp replacement are calculated by the difference between the lamp stock average power consumption in the reference year ("before" situation) and the power of the efficient lamps sold or installed. In case of additional lamps the market average power consumption in the reference year should be used for the "before" situation.

The total annual energy savings achieved [kWh/year] are calculated by multiplying annual unitary final energy savings by the number of efficient light bulbs sold or installed for residential use.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
$UFES = \frac{(P_{STOCK\_AVERAGE} - P_{BEST\_MARKET\_PROMOTED})*n_h*F_{rep}}{1000}$ [kWh/unit/year]	$P_{STOCK\_AVERAGE}$ = Power average of the existing lighting bulbs in households [W] $P_{BEST\_MARKET\_PROMOTED}$ = Power of the market promoted efficient bulb [W] n_h = Average number of operating hours F_{rep} – Correction factor taking into consideration that a proportion of bulbs sold will not immediately replace existing bulbs; F_{rep}• 1	Average power input of stock in 1995 (1991) for early action, 2007 for replacement. For new additional installation: power input of market average in 1995 (1991) for early action, in 2007 for new measures	1.f) 3.h)

2.10 Replacement or improvement or new lighting systems or components in tertiary buildings

The formulas provide for the evaluation of annual energy savings derived from the replacement of lighting components with new more energy efficient ones or addition of new energy efficient equipment (e.g. occupancy sensors) or from the improvement of existing lighting systems in tertiary buildings.

Formula a provides for the evaluation of energy savings from a wide range of possible improvement measures of the lighting system and take into account the improvement in electrical power input and in electrical power absorbed by the ballast.

The total annual energy savings achieved [kWh/year] are calculated by summing the annual unitary final energy saving expressed per individual building floor or building or group of buildings where the lighting systems have been refurbished.

Formula b provides for the evaluation of energy savings from the improvement in power consumption of lighting components such as lamps [in Watt/unit/year], multiplied by the number of operation hours.

The total annual energy savings achieved [kWh/year] are calculated by multiplying the annual unitary final energy savings by the number of replaced efficient components.

Formula c provides for the evaluation of energy savings per unit of area [kWh/unit/year] defined as the difference between power density (W/m^2) before and after replacement, multiplied by the number of operation hours.

The total annual energy savings achieved [kWh/year] are calculated by multiplying the annual unitary final energy savings by the surface (m^2) of the overall area where the lighting system was improved and then summing up the individual buildings energy savings.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
Formula a: $$\frac{H_{st} \cdot \sum_{i=1}^{Nst} \left(N_{l,st} \cdot P_{l,st} + N_{b,st} \cdot P_{b,st}\right)_i - H_{ef} \cdot \sum_{i=1}^{Nef} \left(N_{l,ef} \cdot P_{l,ef} + N_{b,ef} \cdot P_{b,ef}\right)_i \cdot \left(1 - F_D\right)_i}{1000}$$ [kWh/ unit/year] With: $$H_{ef} = H_{st} * \left(1 - F_c\right)$$	Fc = Control factor, dependent on the efficient control strategy adopted; dimensionless, with Fc between greater or equal 0 and smaller or equal 1. F_D=Dimming factor, introduced to take account of the installation of a dimmable ballast (A1 Class), dimensionless, with F_D between greater or equal 0 and smaller or equal 1 (0 if not dimmable ballast). H_{st}: Number of operating hours with a standard control strategy [hours/year] H_{ef}: Number of operating hours with an efficient control strategy [hours/year] N_{st} =: Number of standard luminaries N_{ef}= Number of efficient luminaries $N_{l,st}$ =Number of standard lamps $N_{l,ef}$ = Number of efficient lamps $N_{b,st}$ = Number of standard ballasts $N_{b,ef}$ = Number of efficient ballasts $\mathbf{P_{l,st}}$ = Electrical power (effective, not nominal) absorbed by the standard lamps [W] $\mathbf{P_{l,ef}}$ = Electrical power (effective, not nominal) absorbed by the efficient lamps [W] $\mathbf{P_{b,st}}$ =Electrical power absorbed by the standard ballasts [W] $\mathbf{P_{b,ef}}$ = Electrical power absorbed by	Average stock efficiency of the lighting systems (lamps, ballasts, no. of luminaries) in 1995 (1991) for early action, 2007 for new measures For new installation: average market efficiency in 1995 (1991) for early action, in 2007 for new measures	1.g), 2.c) 3.i)

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Cate-gory
	the efficient ballasts [W]		
Formula b: $UFES = \frac{P_{ini} * n_{h\_ini} - P_{new} * n_{h\_new}}{1000}$ [kWh/unit/year]	P_{ini} = Existing installed lighting power before replacement [W] P_{new} = New installed lighting power after replacement [W] n_{h_ini} = before situation number of operating hours n_{h_new} = after situation number of operating hours	Average power input of stock in 1995 (1991) for early action, 2007 for new measures. For new installation the baseline is the power input of market average in 1995 (1991) for early action, in 2007 for new measures	1.g) 3.i)
Formula c: $UFES = \frac{p_{ini} * n_{h\_ini} - p_{new} * n_{h\_new}}{1000}$ [kWh/unit/year]	p_{ini} = Existing power density before replacement [W/m^2] p_{new} =New power density after replacement [W/m^2] n_{h_ini} = before situation number of operating hours n_{h_new} = after situation number of operating hours hours	Average power input of stock in 1995 (1991) for early action, 2007 for new measures. For new installation the baseline is the power input of market average in 1995 (1991) for early action, in 2007 for new measures	1.g) 3.i)

2.11 Replacement or new office equipment in existing and new tertiary buildings

The formula provides for the evaluation of annual energy savings from the installation of new office equipment in tertiary buildings or the replacement of existing office equipment with more efficient one.

The annual unitary final energy savings should be calculated by type of office appliance (e.g. PCs, monitors, printers, copiers, faxes, multi-functional devices).

The annual unitary final energy savings for the active mode [kWh/unit/year] are calculated as the difference between electrical power consumption in active mode per appliance of the existing stock in the reference year ("before" situation) and the power consumption in active mode of the efficient office equipment sold on the market ("after" situation) multiplied by the number of hours in active mode.

The annual unitary final energy savings for the standby mode [kWh/unit/year] are calculated as the difference between electrical power consumption in standby mode per equipment of the existing stock in the reference year ("before" situation) and the power consumption in standby mode of the efficient equipment sold on the market ("after" situation) multiplied by the number of hours in standby mode.

The annual unitary final energy savings for usage mode change [kWh/unit/year] refer to improvement of the stand-by/on-mode ratio of the same equipment by programs or measures (without replacement) and are calculated as the difference between the number of hours in on-mode operation per equipment of the existing stock before ("before" situation) and the number of hours in on-mode operation after ("after" situation)

The total annual energy savings achieved [kWh/year] are calculated by multiplying the sum of the unitary annual energy savings in active and standby mode by the number of units of efficient office equipment sold.

Bottom-up formula for calculating the unitary final energy savings (UFES)	Definition	Baseline	Category
For active mode: $UFES = \frac{\left(PA_{referenceyearstockaverage} - PA_{referenceyearbestperfmarket}\right) * h_{active}}{1000}$ [kWh/unit/year] For stand-by: $UFES = \frac{\left(PS_{referenceyearstockaverage} - PS_{referenceyearbestperfmarket}\right) * h_{s\tan dby}}{1000}$ [kWh/unit/year] For improvement of the usage mode (stand-by/on-mode consumption) of equipment by good housekeeping measures (without replacement): $UFES = \frac{\left(PA * h_{active} + PS * hs_{s\tan dby}\right)_{new} - \left(PA * h_{active} + PS * hs_{s\tan dby}\right)_{old}}{1000}$ [kWh/unit/year]	$PA_{referenceyearstockavera}$ = Electrical power input per appliance in active mode: $PA_{referenceyearbestperfma}$ = Electrical power input in active mode per the efficient equipment from the market = $PS_{referenceyearbestperfma}$ = Electrical power input in stand-by mode per the efficient equipment from the market h_{active} = Hours in active mode $h_{s\tan dby}$ = Hours in standby	Average power input of stock in 1995 (1991) for early action, 2007 for new measures For new installation the baseline is the power input of market average in 1995 (1991) for early action, in 2007 for new measures	1.e) 3.c)

3 European recommended energy savings default values for household appliances, lighting and office equipments

Recommended default values have been developed for use where a Member State does not have national data available for use in combination with the recommended bottom-up calculation formulas. In this situation Member States may use the recommended default values as input into the recommended bottom-up calculation formulas. The default values support the calculation of the individual (single or unitary) savings for selected equipment/ appliances common in the buildings sector (e.g. CFL and washing machines). The default values can only be provided for equipment where there is a similar usage pattern across Member States. For heating equipment (e.g. boilers) and buildings recommended default values are not possible due to the diversity in climatic conditions and the buildings' energy performances.

Table I.2: European default values

Equipment type	**European default value**	
1. Household appliances		
1.1. Unitary energy savings for washing machines	13	kWh/year
1.2. Unitary energy savings for dishwashers	44	kWh/year
1.3. Unitary energy savings for refrigerators	67	kWh/year
1.4. Unitary energy savings for freezers	71	kWh/year
1.5. Unitary energy savings for fridge-freezers	69	kWh/year
2. Lighting		
2.1. Residential lighting		
Unitary energy savings GLS[30] to CFL	47	kWh/year
Average operating hours residential	1000	h/year
2.2. Tertiary lighting		
Unitary energy savings GLS to CFL	118	kWh/year
Unitary energy savings T8 to T5 (linear fluorescent lamps)	22,5	kWh/year
Unitary energy savings electronic ballasts	15	kWh/year
Unitary energy savings occupancy sensors	40	kWh/year
Average operating hours office buildings	2500	h/year
Average operating hours commercial buildings	4000	h/year
Average operating hours hospitals	5000	h/year
3. Office equipment		
3.1. Unitary energy savings for desktop computers	39	kWh/year
Desktop PC average annual active mode hours	2279	h/year
Desktop PC average annual standby mode hours	3196	h/year
3.2. Unitary energy savings for LCD monitors	11	kWh/year
Monitor average annual active mode hours	2586	h/year
Monitor average annual standby mode hours	3798	h/year
Laptop PC average annual active mode hours	2613	h/year
Laptop PC average annual standby mode hours	2995	h/year

[30] General Lighting Service or tungsten filament lamps

III. List of recommended average lifetimes of energy efficiency improvement measures and programmes for bottom-up calculations

Energy efficiency improvement measure or programme by sector and type		Recommended lifetime in years	Default lifetime in years
Household sector – technical measures or programmes			
1a	Insulation: building envelope – cavity wall and other insulation (solid, wool, etc.)	30	
1b	Insulation: building envelope – loft/ roof and floor insulation	25	
2	Draught proofing: Material that fills gaps around doors, windows etc. to increase the air-tightness of buildings		5
3	Windows/glazing with low U value	30	
4	New hot water storage tank with foam insulation	15	
5	Insulation of hot water pipes, with material on unexposed hot water pipes	20	
6	Heat reflecting radiator panels: Insulation material installed between radiators and the wall to reflect heat back into the room	18	
7	Small boilers up to 30 kW output	20	
8	Large boilers above 30 kW output		25
9	Heating control: timing devices, thermostats and radiator valve thermostatic controls		10
10	Heat recovery systems for recovering and recirculation of heat	17	
11	Hot water saving faucets with flow restrictors	15	
12a	Heat pumps: air to air	10	
12b	Heat pumps: exhaust air to water	15	
12c	Heat pumps: ground source	25	
13	Energy efficient (class A or above) room air-conditioner	15	
14	New or upgraded district heating	30	
15	Solar thermal collectors for hot water supply	20	
16	Energy efficient (class A or above) cold appliances (e.g. refrigerators, freezers)	15	
17	Energy efficient (class A or above) wet appliances (e.g. dish washers, washing machines and tumble driers)	12	
18a	Consumer electronic goods (e.g. DVD player, set-top box, home computer)		3
18b	Televisions		5
19	Energy efficient compact fluorescent light bulbs for household use		6,000 hours
20	Luminaries with ballast systems (lighting units with dedicated efficient lamp fittings)	15	
21	Energy efficient architecture (e.g. optimisation of the thermal properties of building materials, orientation of building to natural light and heat sources, use of natural ventilation)	25	
22	Micro-CHP		15
23	Photovoltaic solar panels	23	
Household sector – Organisational measures or programmes			

24	Hydraulic balancing of heating adjusting household heating system so that hot water for heat is distributed between rooms in an optimal balance		10
Household sector – Behavioural measures or programmes			
25	Electricity savings (e.g. switching off lights in empty rooms, turning off electronic devices)		2
26	Heat savings (e.g. turning heating off or down in rooms not in use)		2
27	Smart meters providing information on energy consumption		2
Commercial/ Public sector – Technical measures or programmes			
28	Windows/glazing with low U value	30	
29	Insulation: building envelope (cavity wall and solid insulation on wall loft/roof insulation and floor)	25	
30	Heat recovery systems	20	
31	Energy efficient architecture (e.g. optimisation of the thermal properties of building materials, orientation of building to natural light and heat sources, use of natural ventilation)	25	
32a	Heat pumps: air to air	10	
32b	Heat pumps: exhaust air to water	15	
32c	Heat pumps: ground source	25	
33	Energy efficient central air-conditioners and chillers	17	
34	Efficient ventilation systems (mechanically controlled system extracting foul air for ventilation, and supplying new preheated air in the principal parts by means of blowing inlets)	15	
35	Commercial refrigeration		8
36	Energy efficient office appliances (e.g. desktop or laptop computers, printers, photocopiers, fax machines)		3
37a	Combined heat and power below 5 MW		15
37b	Combined heat and power above 5 MW		20
38	Motion detection light controls switching off lights when nobody is present	10	
39	Energy efficient lighting systems in new or renovated offices	12	
40	Energy efficient lighting systems for public spaces (e.g. roads)	15	
41	Boilers with an output larger than 30 kW	25	
Commercial/ Public sector – Organisational measures or programmes			
42	Energy Management System (e.g. monitoring, ISO)		5
Transport sector – Technical measures or programmes			
43	Energy efficient vehicles consuming low amounts of primary energy for distance travelled	10,0000 km	
44	Low rolling resistance tyres for cars	50,000 km	
45	Low rolling resistance tyres for trucks	10,0000 km	
46	Side boards on trucks (aerodynamic additions for heavy goods vehicles)	50,000 km	
47	Automatic tyre pressure monitoring devices for trucks	50,000 km	
Transport sector – Organisational measures or programmes			
48	Modal shift: change of transport mode to a more energy efficient one (e.g. change from car to		5

	bicycle, from trucks to freight trains)		
Transport sector – Behavioural measures or programmes			
49	Econometer: Fuel consumption feedback device for cars and trucks designed to increase fuel efficient driving style		2
50	Optimal tyre pressure		2
51	Eco-driving		2
Industry sector (in scope of ESD) – Technical measures or programmes			
52	Combined heat and power		15
53	Waste heat recovery		15
54	Efficient compressed air systems:		15
55	Efficient electric motors and variable speed drives		12
56	Efficient pumping systems in industrial processes		15
57	Efficient ventilation systems for industrial buildings		15
Industry sector (in scope of ESD) – Organisational measures or programmes			
58	Good energy management & monitoring		5

The default lifetimes should be used in cases where neither a recommended lifetime nor a determined saving lifetime is available. Default values are therefore by definition indicative. Where a Member State can document that it has achieved a lifetime that exceeds the default value, it may use this lifetime provided that the necessary documentation is provided to the Commission.