IEA DSM Task XXI
Standardisation of Energy Savings Calculations

Technology case application Lighting for households; summary on calculations (section 2 in the case applications)

1. Formula used

The formulas for calculating the annual energy savings as used in the countries case applications generally hold 4 elements:

1. the situation before: the old lamp;
2. the situation after: the new lamp;
3. the average burning hours of the lamp;
4. possible normalisations;
5. correction factor(s).

The first three elements are included in formula (1). The latter two are dealt with in respectively paragraph 2.4 and paragraphs 2.5.1 and 2.5.2.

$$\text{Annual energy savings: } ES = 1/1000 \sum^{Units} (P_{old} - P_{new}) \times t \qquad \text{Formula (1)}$$

Where[1]

- *relevant units: installed and operating units*
- *ES: annual energy savings in kWh*
- *1/1000: conversion from W to kW*
- P_{old}*: power old lamp in Watt*
- P_{new}*: power new lamp in Watt*
- *t: time period for the energy consumption in hours per year ("burning hours")*

Formula (1) for calculating the annual energy savings is derived from the relevant formulas as presented in the case applications in the country reports. Table 1 lists these formulas in a summarised fashion. The country reports hold more details.

Table 1. Issued formulas in the case application per country

Country	**Formulas**
France	*ES: (1 - correction factor replacement old cfl units (0,30)) x (number of cfl units promoted/installed x 1/1000 x (capacity old bulbs x burning hours old - capacity in W new bulbs x burning hours new)*
Korea	*ES (Kwh) = Power savings per unit x annual running hours (h) x number of subsidised units*
The Nether-lands	*ES: number of CFL unites sold x 1/1000 x (average capacity in W old bulbs x burning ours old - capacity in W of new CFL x burning ours new)*
Spain	*ES: number households x number of lamps per house substituted x annual number of lighting usage x (sum number lamps specific kind old x installed power W old - sum number lamps specific kind new x installed power new)*
United States: case area California	*ES: installation rate IOU discounted product p x average hours of use iou discounted prod p x 1/1000 (Wp old - Wp new)*

source: the individual case applications as included in the country report

[1] The symbols "P" and "t" in formula (1) follow those as provided by (international) standards such as ISO80000-7, 2008 and NEN-EN 12665. Both use t for time. Like many other norms, NEN-EN 12665 uses P for Power.

2. Parameters

The key parameter Delta Watt *(P_{old} – P_{new})* is derived in two ways:

a. an (average)[2] value of the old as well as the new lamp;
b. an average[3] value for Delta Watt.

The key parameter annual burning hours is also derived in two ways:

a. an average annual value;
b. a average daily value multiplied by 365 (days).

The key parameters can be identified by each country's method of observing and/or measuring energy saving aspects. Table 2 shows the key parameters per country.

The most common parameter is the burning hours being based on all households and on all rooms in a house. They are assumed not to change after replacement.

Table 2. Key parameters in the case application per country

Country	**Key parameters**
France	• *Method is focused on CFL units;* • *Deals with an average 80 W for incandescent bulbs and 18 W for new CFLs. Delta Watt is therefore 62W;* • *Burning hour t is assumed to be 800. This amount is based on the living room and* an assumed utilisation of 2 hours and 10 minutes per day on average*. Burning hours t do not change after the replacement.*
Korea	• *Method is focused on fluorescent lamps;* • *Deals with old fluorescent lamps of 40W and new fluorescent lamps of 32W. Delta is 8W;* • *Burning hour t is assumed to be: 2771. This amount is based on all rooms in a building.*
The Netherlands	• *Method is focused on CLF-units;* • *Average power old lamp is 55,8W and average power new lamp is 12,4W. Delta is 33,4W;* • *Burning hour t is assumed to be 482. This amount is based on all households and on all rooms in a house. Burning hours do not change after the replacement.*
Spain	• *Method is focused on LED-units;* • *Assumed power old lamp is 40W and assumed average power new lamp is 4W. Delta is 36W.* • *Burning hour t is assumed to be around 700. This amount is based on energy auditing experiences. Burning hours do not change after the replacement.*
United States case area California	• *Method is focused on CLF;* • *Overall delta watts 44,5 W. This value depends on CFLs, lamp wattage and the relevant baseline;* • *Burning hours t are approximately 657 hour annually (1,8 daily time 365 and are determined via monitoring e.g. retrieving information on operating hours of installed measures.). This is done as a function of dwelling unit characteristics, room type, fixture type, lamp type, and region.*

source: the individual case applications as included in the country report

3. Baseline issues

For the baseline a reference situation must be determined. The reference for lighting in household is the replacement by the same type of lamp[4].

In all case applications this is the reference situation in which conventional bulbs are being replaced by conventional bulbs, with exception of Korea were the unit of analysis is a fluorescent lamp.

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[2] Depending on CFLs, lamp wattage and the relevant baseline.
[3] Be applied to situations of multiple CFLs having different wattages.
[4] These baselines will in the future no longer be valid for European countries as the European Commission is banning conventional bulbs. On 1 September 2009, the 100W incandescent light bulbs and other energy inefficient lamps, a year later the 75W, two year later the 60W and by 1 September 2012 40W and 25W.

4. Normalisation

Normalisation should be conducted when the estimation of burning hours is based on measurements during a period shorter than a year. Of all case applications only in the case of California normalsiation is applied.

5. Corrections

There are two types of corrections:

- Group 1: gross-net (e.g. couble counting, free riders, technical interactions, spillover effects, rebound effects);
- Group 2: corrections due to data collection problems (imperfect data collections).

Problems concerning data collection problems, e.g. problems concerning observations of underlying values for calculating energy efficiency, can be dealt with by using correction factors. These correction factors can be added to the proposed formula in paragraph 2.1.

The corrections are included in the formula (1) as (1-correction). As follows:

$$\text{Annual energy savings: } ES = (1\text{-correction}) \times 1/1000 \sum^{Units} (P_{old} - P_{new}) \times t \qquad \text{Formula (2)}$$

The corrections are further explained in table 3.

Corrections are only conducted in the case application of California.

5.1. Corrections applied to the situation before (Pold)

A correction could be applied to the situation of a new lamp replacing an existing CFL. In two case applications this is taken into consideration, but not as a correction to the situation before but as a correction of the gross energy savings.

5.2. Corrections applied to the new situation (Pnew)

Concerning the new situation, all case applications deal with data collection methods that are based on sales data and assumptions are made on the amount of the installed lamps. Only in the case application of California corrections are made for not installed lamps and 'gross-to-net'.

Table 3. Corrections applying to the new situation per country

Country	**Corrections**
France	• *It is assumed is that in 30% of the case Pold is already a CFL; for this a correction factor of (1-0,3) is used.*
Korea	• *Assumption units sold = units installed without corrections.*
The Netherlands	• *Assumption units sold = units installed without corrections.*
Spain	• *Assumption units sold = units installed without corrections.*
United States case area California	Several steps in corrections: *1) Not all shipped lamps are sold in the period the program is running;* *2) Overall gross-to-net correction, including CFLs being replaced by CFLs.* *Ad 1)* *An installation rate of 71% (including a leakage factor - for correcting the total sales data covering a larger sales area than those of the distribution company active in the Lighting program- and a factor for shipment versus sales).* *Ad 2) Overall correction of 54%. This means a factor of (1-0,46).*

source: the individual case applications as included in the country report

6. Life time savings applied

All countries have data to calculate savings over lifetime. But the use in practise differs widely over the countries. The used lifetime is often the technical burning hours of the CFL divided by the annual burning hours.

Table 4. Life time savings applied per country

Country	**Corrections**	**explanations**
France	*Life time of CFL Class A is assumed to be 7.5 years.*	• *lifetime is calculated based on 6,000 burning hours during lifetime and annual 800 burning hours: 6,000/800=7.5* • *Energy savings are accounted cumulated over the lifetime of the equipment; in addition these savings are not assumed as constant over this life time but are discounted at 4%, to reflect both a financial discount (economic value of the energy saving certificate) and a technical discount (gradual decrease in savings). This means that the annual savings are multiplied by this discount factor, function of the life time and discount rate.*
Korea	*Economic lifetime of ballast for the 32W fluorescent lamp is 7 years.*	• *lifetime savings is used for evaluating the economic feasibility and is calculated multiplying ESannual energy savings) by lifetime. It is assumed that physical function deterioration would not happen during lifetime period and same ES (annual energy savings) would be created.*
The Netherlands	*The lifetime of a CFL is 12 years*	• *In most cases one calculates with an average of 6,000 burning hours; this value is also indicated in the CEN CWA 27. Based on an average burning hours value of 482 a year, the replacement is accounted as energy saving for 12 years. Following assumptions are made:* ➢ *savings lifetime is equal to the average technical burning hours and that the saving persists over the whole period.* ➢ *Savings start in the year the CFL is bought*
Spain	*The lifetime of the measures would be beyond 70 years.*	• *Useful lifetime of a LED lamp is around 50.000 hours, while the annual burning hours are estimated at 700 hour. Thus, the lifetime of the measures would be beyond 70 years.*
United States case area California	*For the case application only annual demand and energy savings were calculated.*	• *Incremental lifeycle savings are typically calculated by multiplying the number of life time operating hours (e.g., 7,000) by the value of (Pold-Pnew)*

source: the individual case applications as included in the country report