Harmonised domestic energy savings calculation: international experiences and standards

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Overview

- Introduction
- European standards (CEN) & international standards (ISO)
- IEA DSM work: Task 21 Harmonisation of energy savings calculations
- Highlights from case applications
- Global trends

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Introduction (1) Europe

- 2006, the **Energy Service Directive** (ESD) in Europe
  - A regular (every three years) reporting by the Member States
  - Stimulating common efforts to improve energy savings calculations and has initiated
- November 2006 to April 2009, the project "Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services" (*EMEEES*) for a set of calculation methods and case applications, with 21 organisations
- November 2012 a new EU **Energy Efficiency Directive** (EED) came into force
  - Cumulative end-use energy savings target of 1.5% of the annual energy sales to final customers
  - More rules on energy savings calculations
  - A system of energy efficiency obligations
  - Every 4 year a Plan and annual progress reports

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Introduction (2) Standardisation organisations

- 2007 the **European standardisation organisation CEN** started work on standards for
  - Common methods of calculation of energy consumption, energy efficiencies and energy savings
  - A common measurement and verification of protocol and methodology for energy use indicators

- 2011 the **International Organisation for Standardisation (ISO)** started **ISO/TC 257** dealing with "General technical rules for determination of energy savings in renovation projects, industrial enterprises and regions"

Introduction (3) USA

- 2012: US Department of Energy (DOE) starts the Uniform Methods Project (UMP)
  - A framework
  - A set of protocols for determining the energy savings from energy efficiency measures and programmes
  - Publications and updates since 2013

- Northeast Energy Efficiency Partnerships (NEEP)
  - In the Northeast and Mid-Atlantic States of the USA
  - EM&RV Forum, established in 2008 and started publications in 2010

- State and Local Energy Efficiency Action Network (SEE Action)
  - is a state- and local-led effort facilitated by DOE and the U.S. Environmental Protection Agency (EPA)
  - EM&V Working group started publications in 2011

International standards: CEN

- 2007 the European standardisation organisation CEN started two Working Groups
  - one for Top-Down calculations (indicators)
  - one for **Bottom-Up calculations**

- April 2012 the final draft was published for formal voting by the members of CEN

- December 2012: standard EN16212:2012 "Introductory element, Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods Complementary element" became officially available

standard EN16212:2012

- This European standard provides a **general** framework for calculating energy savings
- Organised as follows:
  - the methodology and general rules of calculation;
  - terminology and definitions;
  - the characteristics of the top-down and bottom-up methods;
  - the top-down calculation method;
  - **the bottom-up calculation methods**

Steps and sub-steps in the calculation of bottom-up energy savings as included in EN16212:2012

Step 1: Calculation of unitary gross annual energy savings

Step 1.a:	Definition of elementary unit
Step 1.b:	General formula / calculation model
Step 1.c:	Baselines and specific formulas
Step 1.d:	Normalisation of energy consumption
Step 1.e:	Technical interaction
Step 1.f:	Application of conversion factors (when relevant)

Step 2: Calculation of total gross annual energy savings

Step 2.a:	Calculating the number of elementary units of action
Step 2.b:	Summing up the unitary gross annual energy savings

Step 3: Calculation of total annual energy savings

Step 3.a:	calculation of total annual energy savings
Step 3.b:	correction for double counting
Step 3.c:	correction for multiplier effect
Step 3.d:	correction for free-rider effect
Step 3.e:	correction for rebound effect

Step 4: Calculation of remaining energy savings for target year

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IEA DSM Task 21 Harmonisation of energy savings calculations

- The overall aim of Task 21 was to identify basic concepts, calculation rules and systems for Energy Savings Calculations standards.
- A study on improved comparability and harmonisation of energy saving calculations in a selected group of case applications.
- A template was developed to document the information for the selected case applications.
- Through this template information on the six identified key elements to understand the calculated savings was gathered.
- A report on the key elements and basic concepts for harmonised energy savings calculations

Template to document and report energy savings calculations for case applications

1. Summary of the programme
2. Formula for calculation of Annual Energy Savings
3. Input data and calculations
4. GHG savings

- References
- Annex
- Definitions

1. Summary of the programme

- Short description of the programme
  - Purpose or goal of the programme
  - Type of instrument(s) used; E.g. financial support, subsidize, label and standard, agreements, tax reduction
- General and specific user category
- Technologie(s) involved
- Status of the evaluation and energy savings calculations
  - qualify the status: 1. Legal; 2. Official stamped; 3. Semi official; 4. Use in practice; 5. Under development; 6. Under research
- Relevant as a Demand Response measure

2. Formula for calculation of Annual Energy Savings

- Formula used for the calculation of annual energy savings
- Specification of the parameters in the calculation
- Specification of the unit for the calculation
- Baseline issues
- Normalization
- Energy savings corrections
  - Gross-net corrections
  - Corrections due to data collection problem

3. Input data and energy and 4.GHG savings

3. Input data and calculations

- Parameter operationalization
- Calculation of the annual savings as applied

- Total savings over lifetime
  - Savings lifetime of the measure or technique selected
  - Lifetime savings calculation of the measure or technique

4. Green House Gas (GHG) savings

- Annual GHG-savings
  - Emission factor for energy source
  - Annual GHG-savings calculation as applied
- GHG lifetime savings
  - Emission factor
  - GHG lifetime savings as applied

Highlights from case applications

- Lighting for households
- Residential insulation
- Heat pumps in households

- Heating in commercial buildings programmes
- Air conditioning in commercial building/offices
- Variable Speed Drive and High Efficient motors in industry

- Demand Response programmes

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Case applications on lighting for households

- France Households; Lighting
- Republic of Korea 32W fluorescent lamps
- The Netherlands Lighting in households
- Spain Efficient lighting in the households
- USA Upstream Lighting Programs in California

Issued formulas in the case application per country

- 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 Netherlands

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)

Key parameters in the case application per country

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 hours t are 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 hours t are 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 hours t are 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 hours t are 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 units;*
- *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.*

Corrections applying to the new situation per country

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:
- *Not all shipped lamps are sold in the period the program is running;*
- *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 that of the distribution company active in the Lighting program- and a factor for shipment versus sales).*
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- *Ad 2) Overall correction of 54%. This means a factor of (1-0,46).*

Conclusions on the lighting case applications

- assumptions on the base situation
  - Most cases depart from similar base assumptions as to how to account savings per application
  - Differences in this base situation thus relate mainly to the parameter values used, notably for burning hours and lifetime
    - the assumption for burning hours for use in the living room (with a high) number of burning hours is no longer the most appropriate one
    - An average value for the occupied rooms might also overestimate the burning hours, since replacements more often seem to take place in rooms and spaces with low burning hours (like garages).
- the choice of market and/or baseline situation
  - Some cases take into account that a number of systems ('before' situation) already are CFL units.
  - The assumption that all sold CFLs replace incandescent bulbs is open for discussion, as well as the assumption that sold CFLs are installed immediately.
- whether or not specific corrections are taken into account.
  - clearly distinguishing, the effects of certain corrections is better understood and made more transparent.
  - Corrections due to data problems should get more attention, as these are very rarely well documented

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General formula for lighting

The formulas for calculating the annual energy savings as used in the countries case applications generally contain 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

Annual energy savings: $ES = 1/1000 \ (P_{old} - P_{new}) \times t$

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.

Case applications on residential insulation

- France — Households; Retrofit wall insulation
- The Netherlands — Insulation and glazing
- Norway — Electricity savings from window retrofitting: The "Enova Recommends" Program
- Spain — Retrofit wall insulation
- USA — Residential Insulation Programs in California

Issued formulas in the case application per country

- the French and the Norwegian cases are based on energy savings per m^2 of insulation materials/ windows
- the Dutch case is based on the estimated heat demand, calculated using a model approach for meeting the heat demand
- the Spanish case is based on a model for the building performance
- the USA case is based on billing analysis using two ANCOVA (fixed-effects) models: Conditional Savings (CSA) and Statistically Adjusted Engineering (SAE);

Baseline issues in the case application per country

France

- The baseline insulation coefficient used for external wall is U_0=3.3 W/ m^2K. This corresponds to a non insulated wall.
- For other insulation measures the baseline used for the energy savings calculations is the 'stock average'.

Netherlands

- The baseline situation is the energy usage per year corresponding with the energy label before any energy savings measurements are taken
- The baseline is different for each specific dwelling, depending on the way the dwelling was built and techniques used
- For calculating the baseline the same assumptions apply as for calculating the energy savings

Norway

- It is assumed that the program only triggers an improved retrofit and not a replacement of the windows as such
- For this reason the U value of 1.6 for the old window is used

Spain

- A model is used to calculate the average energy use per type of dwelling en size class. The results of the model are used as a baseline

USA

- the energy use from the billing prior to the installation of insulation was used as the baseline

Conclusions

- The methodologies are quite different.
  - Part of the differences relate to the different aggregation levels in the models or measurements used (a technical system or an entire dwelling)
  - Also the approach is different, varying from model calculations to actual measurements for part of the realisation
- The individual country cases each add other factors and know-how to the situation and methods
- Assessing, discussing and using these experiences may help other countries in their information and avoid the need that each country studies each relevant aspect (again)
- Attention could be given to distinguishing better between the levels in calculations

Case applications on heat pumps in households

- Italy — Use of electric heat pumps to produce hot sanitary water in household plants, in place of conventional electric or gas water heaters
- The Netherlands — Heat pumps in existing buildings
- Norway — Electricity savings from heat pumps: The Norwegian Household Subsidy Programme

Issued formulas in the case application per country

- The formulas for calculating the annual energy savings as used in the three country applications are developed from a different view:
- the Spanish case focuses on replacement of an existing air conditioner (R22 machines) with a water condensed chillier system (electric); the energy savings are based on calculations for that specific system to meet the cooling demand; and
- the Dutch case looks at all types of air conditioners and different energy sources (electricity, gas or heat); the energy savings are based on calculations for the efficiency of several systems that are in use for meeting the cooling demand.
- The USA case application holds HVAC measures, but is not specific for air conditioners

Baseline issues in the case application per country

Spain

- the efficiency of the existing cooling system

The Netherlands

- The reference situation with another air conditioning system or another air conditioner

USA

- the International Energy Conservation Code (IECC) 2006 was applied as baselines.

Conclusions

- The methods are different with regard to level of approach.
- Following issues may be further looked into in the near future to achieve better documentation to make comparisons easier and useful estimates:
  - differences in used assumptions (e.g. life times, deterioration of efficiency over the years)
  - differences in level of aggregation, ranging from a single system replacement to a more integrated assessment. A step by step approach towards level of aggregation may be considered, in which comparability is looked into at these different levels.
  - the need to distinguish between inherent differences in the way savings are calculated and additional programme specific considerations that may determine how to deal with free riders, additionality aspects etc.

- By looking into the first two elements, methodologies may be made more comparable between countries.
- With regard to the latter, these factors may be more country specific. Mutual learning may be possible in the approaches taken.

More detailed Information

- IEA DSM website
  - www.ieadsm.org

- Reports for Task 21 Standardisation of energy savings calculations
  - Country reports (including Demand Response programmes)
  - General report on basic concepts
  - Template to document energy savings calculations

  - Approaches to harmonised energy savings calculations
  - Roadmaps to further developments

Global trends

- Europe
  - Since the end of 2012, after the publication of the CEN standard on energy savings calculations, there is no on going work within the European standardisation body
  - The Energy Efficiency Directive (EED) provides a framework for calculating the impact of energy savings caused by individual actions and puts priority on energy providers' obligations, but assessment of reports and follow up actions are outstanding
- USA
  - Uniform Methods Project: DOE aims to establish easy-to-follow protocols based on commonly accepted engineering and statistical method for savings for energy efficiency measures
  - Continue increasing regional co-operations on MR&V
- Global: ISO
  - Standard is about to be published
  - Work for specific topics continues

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Thank you for your attention

Any Questions?

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