IEA DSM Task XXI
Standardisation of Energy Savings Calculations

Technology case application Residential insulation; Summary on calculations (section 2 in the case applications)

1. Formula used

The formulas for calculating the annual energy savings as used in the four countries case applications are developed from different views:

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

Table 1 lists the formulas in a summarised fashion and for France and Norway harmonised. The country reports hold more details.

Table 1. Issued formulas in the case application per country

Country	Formulas
France	$ES_i = \sum_i A_i \cdot \Delta U_i \cdot HDD_i \cdot CC_i \bullet IC \bullet \frac{1}{\eta_i} \cdot \frac{24}{1.000}$ *i = individual household index, i = 1 …n* *ES_i = energy saving household i, kWh per year* *A_i = area of insulation retrofitted household i, m^2* *ΔU_i = change (abs. value) in U-value of insulation household i, W per m^2 and K* *HDD_i = average (normal) heating degree days per year, household i* *CC_i = Climatic coefficient of climatic zone i* *IC = Intermittency coefficient and incidental gain* *η_i = heat conversion efficiency of heating system, household i*
The Nether-lands	$ES_t = \sum_i E_{tot,ref} - E_{tot,ins}$ *i = houses with improved insulation and/or glazing i= 1.. n* $E_{tot,ref}$ *= Calculated total primary energy use of the building (standard conditions) in MJ/year* $E_{tot,ins}$ *= Calculated total primary energy use of the building (standard conditions) with improved insulation and/or glazing, in MJ/year* ES_t *= annual net savings in the year t in primary energy use (MJ/year)*
Norway	$ES_i = \sum_i A_i \cdot \Delta U_i \cdot HDD_i \cdot \frac{1}{\eta_i} \cdot \frac{24}{1.000}$ *i = individual household index, i = 1 …n* *ES_i = energy saving household i, kWh per year* *A_i = area of windows retrofitted household i, m^2* *ΔU_i = change (abs. value) in U-value of windows household i, W per m^2 and K* *HDD_i = average (normal) heating degree days per year, household i* *η_i = heat conversion efficiency of heating system, household i*
Spain	$ES_t = \sum_i 0.033 * B_i * ES_i$ *i = number of houses with improved insulation per building type i= 1..10* B_i *= building type*

Country	Formulas
	ES_i = average savings per building type in kWh/year
United States: case area California	*CSA Model: $ADC_{it} = i + \beta 1 AVGHDD_{it} + \beta 2\ POST_t + \ _{it}$* *Where, for each customer i and calendar month t,* • *i is a unique intercept for each participant, derived by estimating the relationship using the ANCOVA (fixed-effects) procedure* • *ADC_{it} is the average daily therm consumption during the pre- and post-program periods* • *$AVGHDD_{it}$, is the average daily heating degree days (base 65) based on home location* • *$POST_t$ is a dummy variable that is 1 in the post-period and 0 otherwise.* • *β1 is the average daily therm consumption per heating degree day.* • *β2 is the average daily therm participant savings for the installed measures*
	SAE Model. This model has the following specification: *$ADC_{it} = \ i + \beta 1 AVGHDDit + \beta 2\ EE\ t + \ _{it}$* *Where, for each customer i and calendar month t,* • *i is a unique intercept for each participant, derived by estimating the relationship using the ANCOVA procedure* • *ADCit is the average daily therm or kWh consumption during the pre- and post-program periods* • *AVGHDDit, is the average daily heating degree days (base 65) based on home location* • *EEt is the average daily engineering estimate of savings in the post-period, and 0 otherwise* • *β1 is the average daily therm or kWh consumption per heating degree day* • *β2 is the average daily therm or kWh net participant realization rate. For example, a coefficient of -0.9 indicates a 90% realization rate*

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

2. Parameters

In the France case application additional information is included for estimating the kWh cumac as used in the French White Certificate scheme. Energy savings are calculated in final energy in kWh. They are accounted cumulated over the lifespan of the equipment with the assumption that they are nor constant over this life time and so yearly discounted at 4%, to reflect both a financial discount (economic value of the energy saving certificate) and a technical discount (gradual decrease in savings). The savings are therefore expressed in **kWh cumac** (cumulated and discounted). Only the discounted and cumulated values are officially published; the values for annual energy savings are considered as intermediate parameters.

In the Dutch case application the model calculates the total primary energy use based on the energy use of the components of the building and the energy system:

$$E_{tot} = E_{rv} + E_{tap} + E_{hulp} + E_{verl} - E_{pv} - E_{wkk}$$

where

- E_{tot} = Total primary energy usage of building (standard conditions) [MJ/yr]
- E_{rv} = Energy use for space heating [MJ/yr]
- E_{tap} = Energy use for domestic hot water [MJ/yr]
- E_{hulp}= Energy use for pumps/ventilation [MJ/yr]
- E_{verl} = Energy use for lighting [MJ/yr]
- E_{pv} = Energy supply solar panels [MJ/yr]
- E_{wkk} = Energy supply micro-CHP [MJ/yr]

For the calculation of natural gas to primary energy, the energy content of 35.17 MJ/m^3 and for electricity 3.6 MJ/kWh is used.

In the Norwegian case application for new windows a default U value of 1.0 is used if the manufacturer does not provide evidence for a better value.

In the Spanish case application a penetration factor of 0.033 is used as a correction factor to reflect the penetration of the energy saving measure.

3. Baseline issues

In the France case application the baseline insulation coefficient used for external wall is U_o=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.

In the Dutch case application 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 which techniques where used. For calculating the baseline the same assumptions hold as for calculating the energy savings are used.

In the Norwegian case application 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.

In the Spanish case application a model is used to calculate the average energy use per type of dwelling en size class. The results of the model is used as a baseline.

In the USA case application the energy use from the billing prior to the installation of insulation was used as the baseline.

4. Normalisation

In all case application the energy use is normalised by Heating Degree Days (HDD). In the Dutch case application the model calculations are also normalised for the heating temperature (18 ^oC) and for a specified number of households members (related to the floor area of a dwelling).

5. Corrections

In the Norwegian case application a subsample of households is used to estimate the impact of "other factors changed" and so estimate the gross savings of the households participating in the programme. But this information was not used for a correction in the calculated energy savings.

No corrections are conducted, although in the USA case application information was collected on free ridership using the Joint Simple Self-Report NTG method and a telephone survey for spillovers.

6. Life time savings applied

Only in the France all case application life time savings are calculated following the accounting rules in the White certificate (kWh cumac). This resulted in a discounted lifetime of 19.4 years for insulation material (normal lifetime 35 years).