Harmonised Energy Savings Calculations for selected end-use technologies, key elements and practical formulas

A report produced for the IEA DSM Agreement, Task 21 Harmonisation of Energy Savings Calculations

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In the IEA DSM Agreement, Task 21 Harmonisation of Energy Savings Calculations, the following countries are participating:

France,
Republic of Korea
Netherlands
Norway
Spain
Switzerland
USA

Based on experts meetings, testing, a workshop and discussions with experts during the project, we have developed a template to document energy savings calculations and related GHG emission reduction, as well as the relation with demand response impact. This template was used to collect information in six countries for six technologies. These case applications are presented in the country reports "Energy Savings Calculations for selected end-use technologies and existing evaluation practices in [country]".

This report summarises the experiences we have gained with using the template during the project. For the selected technologies – variable speed drive and high efficient motors, heat pumps, heating systems in commercial buildings, air conditioning , residential insulation and lighting – the key elements are presented for each of the country's case application. These include the formula and its parameters in the baseline issues, application of normalisation and/or corrections and life time savings. The greenhouse gas emission reductions for the case applications and relations with demand response savings are also presented. In addition the report presents the conclusions on harmonised formulas, greenhouse gas reductions and demand response savings, as well as recommendations for further improvements.

The report is available on www.ieadsm.org

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SUMMARY

The overall aim of Task XXI is to identify basic concepts, calculation rules and systems for Energy Savings Calculations standards. This study looks into 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. The experiences with this template showed that it is a good tool to ensure that the most important information to understand energy savings calculations also in future applications may be provided in a comparable way. The study also showed, however that the template needs improvement to better understand the (differences in) level of aggregation that may be chosen in energy saving assessments (system, end-use, integrated energy use in buildings, etc.).

During the project it became obvious that the case applications only for a limited number of technologies directly may result in comparable or *'harmonised' formulas,* e.g. lighting and VSD/high efficient electric motor systems.

For other applications, the 'level of aggregation' proved an important element leading to difficulties in directly comparing calculations. Also during the development of standards on energy savings calculations by CEN and ISO, this level as aggregation showed up as a important topic for selecting the approach for conducting calculations. However, by looking into the various relevant levels comparability may further be improved, also in many of these applications.
This can be done by distinguishing more clearly the various elements in the approaches taken in calculating energy savings. Some elements are, to a large extent, inherent to the type of measure and thus largely country independent. Others are more related to specific situations. By taking a step by step approach in reporting, a clear and more comparable picture may emerge. The report concludes with some practical recommendations to further improve comparability and more cost-efficient evaluation practices.

1. INTRODUCTION

The overall aim of Task XXI is to identify basic concepts, calculation rules and systems for Energy Savings Calculations standards. Both energy savings and emissions avoidance calculation methods and standards will be evaluated for efficiency activities. In addition a methodology should be developed to nominate and describe the several Demand Response products[1].
The Task (or project) also explores how and by what type of organisations these draft standards could be used (and improved) to enhance international comparable evaluation of policies and measures.

The three primary objectives of this Task are to:

1. Summarise and compare the current methods and standards used for determining energy use, energy demand and energy and emissions savings from energy efficiency actions and policies;
2. Identify the organisations that are and could be responsible for use and maintenance of such methods and standards;
3. Recommend how existing methods, standards and resources can be expanded and/ or used for comparing different countries' and international efficiency policies and actions.

This report deals with results for objectives one and three.

During the project the country experts discussed how an overview could be created for the methods that are used for calculating or estimating (ex-post) energy savings. It was decided to use case applications in selected technology areas and energy end-uses. For this project, within the IEA DSM Agreement, the selection of case applications is to illustrate what is or could be used for estimating energy savings from programme or project implementations. The case applications show the practices in a participating country, without suggesting that these are 'best practices'. They should be considered as a snapshot and sometimes also as only one of the applications that are in use in a country. However they clearly illustrate what the key elements are in energy savings calculations, how problems in data collections are handled and how default or standard values are being used.

The case applications are selected for the following technologies and energy end-uses:

a. Industry: Variable Speed Drives and High Efficient motors
b. Commercial Buildings: Heating systems
c. Commercial Buildings: Integrated Air conditioning systems
d. Households: Retrofit wall insulation
e. Households: Lighting

[1] Demand response programs are designed to reduce short-term capacity needs and/or transmission constraints and can include permanent peak reduction efforts. Task XIII, Demand Response Resources, prepared already a range of DR products

These case applications are summarised in chapter 3-8.

Each of the case applications presents the information in a common format, a template. This template, presented in chapter two, holds four groups:

1. Summary of the programme
2. Formula for calculation of annual energy savings
3. Input data and calculations of energy savings
4. Greenhouse gas savings

Additional information is provided in references and annexes, including information on definitions

For the topics on energy savings the template holds six key elements. In chapter 3-8 these key elements are presented for each of the technologies and the participating countries case applications. The six key elements are: the formula as such, the parameters in the formula, the baseline issues, application of normalisation, applied corrections and applied life time savings.

Chapter 9 summarises the harmonised formulas for energy saving calculations and provides recommendations on further improvements, while chapter 10 briefly describes how the countries calculate the resulting green house gas emissions. The information, analyses and conclusions on Demand Response programmes is presented separately in chapter 11.

Annex A contains the final version of the template, while Annex B includes also additional instructions to the topics in this template. Annex C shows the list of case applications for energy savings (as included in the country reports and summarised in this report) and Annex D shows the list of case applications for demand response projects.

2. TEMPLATE TO DOCUMENT AND REPORT ON ENERGY SAVINGS CALCULATION

2.1 Introduction

During the project the country experts discussed how an overview could be created for the methods that are used for calculating or estimating (ex-post) energy savings. It was decided to develop a template to provide the most relevant information on energy savings calculations for case applications in selected technology areas and energy end-users in a transparent and comparable way. Additional information is collected on how related reductions in greenhouse gas emissions were estimated and whether attention was given to demand response elements. Section 2.2 presents the final template. In section 2.3 we present some highlights from the process of testing and improving the templates during the project as well as the experiences in using the template to document the selected case applications. Section 2.4 contains the conclusions regarding the usefulness and future improvements.

2.2 Template with key elements

Each of the case applications presents the information in a common format, a template. The template contains four groups:

1. Summary of the programme (context)
2. Formula for calculation of annual energy savings
3. Input data and calculations of energy savings
4. Greenhouse gas savings

Additional information is provided in one or more Annexes.

The formula for calculation of Annual Energy Savings (group two) consists of six key elements. The information on these six key elements is crucial to understand the calculated savings. This understanding is the first step to harmonise energy savings calculations between countries for a selected technology. In the selection of these key elements the experiences from USA evaluations as well as from the EMEEES project on energy savings for the Energy Service Directive and from the ongoing work on standardisation has been used. More information on these are included in the report "Guidelines for Harmonised Energy Savings Calculations", available at the IEA DSM Website. The six key elements for the calculations in the template are:

1. Formula used for the calculation of annual energy savings
2. Specification of the parameters in the calculation
3. Specification of the unit for the calculation
4. Baseline issues
5. Normalisation
6. Energy savings corrections including gross-net corrections and corrections due to data collection problems

While the key elements present the general elements for a case application, the section "Input data and calculations" provides, in a common structure, the detailed information on how in the specific situation the calculation is conducted. The detailed information is provided for:

- Parameter operationalisation
- Calculation of the annual savings as applied (using the key elements)
- Total savings over the lifetime including
  - Savings lifetime of the measure or technique selected
  - Lifetime savings calculation of the measure or technique

The template is provided in Annex A. To ensure a common understanding, the experts used the template with instructions as presented in Annex B. In these instructions among others options are provided:

- to qualify the status of the evaluation and energy savings calculations, ranging from legal status to a research application;
- for the most commonly used baseline types, such as 'before situation', stock average, market average and common practice;
- to specify corrections such as those for gross-to-net and/or those to handle imperfect data collections.

2.3 Testing and use of template in practice

The template was improved during the project, based on experiences with case applications and discussions during the experts meetings. A workshop was organised in Korea to get feedback on the final draft of the template. During this workshop three different case applications were presented to illustrate the use of the template and to discuss future application. The programme of this workshop is available on the IEA DSM website.

The original idea was to organise the information in 5 groups and additional annexes, as follows:

- General topics:
  - Introduction to the example case/project/programme
  - End user category
  - Technologies
- Key elements for the calculations
  - unit for the savings calculation
  - Key parameters for energy use and measurement type
  - Key element baseline
  - key element gross-to-net
  - key element savings lifetime
- Extended topics
  - GHG emissions
  - Load shape
  - Savings and gains in the Energy system

- The calculation
    - Formula
    - Input data
    - Results
- References and more detailed information
    - Sources, documentation
    - Abbreviations and selected definitions

After testing this first version of the template for one case application in each participating country, the experts concluded that:

- there should be a clear combination of the key elements for the calculation and the formula;
- the input data should be presented as the application of the formula;
- normalisation and corrections of savings should be presented separately;
- information on load shape and energy systems should be collected for the case applications on Demand Response Programmes that are included in this project;
- all additional information should be presented in Annexes;
- often there is a duplication of the information provided under baseline and under normalisation. It was agreed that baseline should describe the situation the energy use is referred to prior to the implication of the programme. If the baseline situation (and the 'after' situation) is/are adjusted to 'standard' conditions this should be presented under normalisation;
- the status of the formulas is often rather different. This is not related to a specific technology or end user but more to the country specific (legal) situation or research. Also rather often an energy saving calculation has not been evaluated. To improve comparability a typology for the status is recommended.

During the Korean workshop it became obvious that the template, even with the instructions is not always easy to understand. But by providing examples, the template showed a good way to organise information on energy savings calculations.

For the same parameters in the draft case applications often different notations are used. By using the same notations, several formulas that looked rather different in their original format, will look more similar and will thus be easier to compare. National and international standards were researched to find such common notations. While this was possible to some extent, often also in such standards different notations were used. Furthermore, the use of notations that would not be in line with national official formulas (e.g. for the French White Certificate Scheme) would result in a situation that those revised formulas would not be recognised as the 'official' national ones. For these reasons the final versions of the formulas hold some kind of harmonisation, though not the maximum possible harmonisation.

2.4 Conclusions

The template for the energy savings calculations proves to be a good tool to ensure that the most important information for understanding the applied energy savings calculation is provided and that it is possible to compare. Although in practice some different interpretations of the instructions will show up – as also in the case applications included in the country reports – the experts hold the opinion that more than 90% of the key information in this way will be transparently and comparably available by using the template.

Future application will further help to fine tune and improve the template. It should be avoided in this, to provide too much detailed information. During the project it became obvious that a lot of details are influencing the calculated energy savings, but to really understand the difference between comparable programmes, these details are not always needed.

As yet, the template does not include a section with 'remarks', dealing e.g. with a warning for users, not to simply copy some formulas or baselines and expert opinions.

The analyses, as presented later on in this report, show the importance of a proper distinction between aspects that are more or less independent from the context or the country. One of these is the 'level of aggregation': e.g. the appliance, the system or the whole building .This may result in future improvements in reporting templates in order to enhance further comparability.

3. VARIABLE SPEED DRIVE AND HIGH EFFICIENT MOTOR PROGRAMMES AND HARMONISED ENERGY SAVINGS CALCULATION

3.1 Introduction

A variable speed drive is a piece of equipment that regulates the speed and rotational force, or torque output, of an electric motor. One of the main reasons why drives save energy is because they can change the speed of an electrical motor by controlling the power that is fed into the machine. High efficient motors have motor's efficiency rates up to 94% and are in efficiency classes IE 2, 3 or 4.

This chapter contains summarised information from case applications in France, Korea, the Netherlands and Spain. For the four case applications, the formulas used to calculate the energy savings are presented. Also the application of the formula in practice in these countries is given, including:

- Parameters in the formula
- Baseline issues
- Normalisation
- Corrections
- Lifetime savings
- Greenhouse gas emissions reductions

The general conclusion is that the basic approach in all case applications is more or less the same and a harmonised formula seems possible.

3.2 Key elements for energy savings

3.2.1 Formula used.

In all four case applications, the formulas for calculating the annual energy savings are in principle based on using (a percentage of) savings per motor, the power of the motor and the number of operating hours. Table 3.1 lists the formulas in a summarised version. The country reports hold more details.

Table 3.1. Reported formulas in the case application per country

Country	Formulas
France	*Annual savings in year t = n_s x PCES*h [in kWh]* n_s = *power in kW of motors in which VSD units are installed in year t* *PCES = % of energy savings from the installation of VSD* *h = operating hours*
Korea	$E_{saved} = P_{saved} \times H_{annual} \times N_s$ *in kWh* E_{saved} = *Energy savings* P_{saved} = *Power savings per unit (kW/unit)* H_{annual} = *operating hours* N_s = *the number of subsidized units*
Netherlands	*No formula is used: for HE motors up to 90 kW and meeting the EFF1 (CEMEP) a tax reduction is granted, without providing an energy savings calculation*[2]
Spain	$(AnnualSavings)_j = k_{Spain} \sum K_{ij} \bullet N_j \bullet \%ES_i \bullet \sum P_{average} \bullet H_{ij}$ *j = Industrial Sector* *i = Type of application* K_{Spain} = *Correction factor* *K = Percentage of motors in which the application of VSDs is cost-effective* *N = Total number of motors* *%ES = percentage of energy saving achieved using VSD for each application* $P_{average}$ = *Average power (kW) of electric motors* *H = Operating hours*

3.2.2 Parameters

Although only in the Spanish case the type of applications (pumps, fans and air compressing), show up in the formula, also in the French one the formula is applied for these three applications.

Parameter for power of the electric motors range from power in kW (for motors in the French case application) to power in classes respectively for 50 and 55 Hz (in the Korean case) and average power (Spanish case).

[2] The Dutch country report holds an Annex presenting potential formulas based on motor categories

In the Korean case application an average of 3,747 of operating hours is used for commercial buildings and 4,189 hours for industry, while in the French one an average per application is used (5,091h for pumping, 6,148h for ventilation and 7,709h for compressed air). In the Spanish case application the number of operating hours is specified for four industrial sectors, three types of applications and six classes of power ranges (operating hours range from 700h to 7,200h).

3.2.3 Baseline issues

A 'market average' is used as baseline in the French case application.
In the Korean case application the 'before' situation is used, related to the power range and to the frequency class. The power savings (kW/unit) of a high efficient inverter are calculated using an instruction.
In the Spanish case application the energy use per type of application prior the implementation is used as the baseline.

3.2.4 Normalisation

Normalisation is not conducted in the case applications.

3.2.5 Corrections

In the French case application, annual savings are corrected in order to account for the average reference market share of variable speed drives (VSD).
In the Spanish case application two different types of corrections are applied. The first is a correction of total energy savings, using the percentage of the existing motors that are susceptible for application of the VSD in the industry sector where such are cost-effective. The second one is related to data collection problems. Energy savings were calculated using data for the European Union as a whole. In order to correct this value and establish the energy savings to the Spanish situation, a correction factor has been used (i.e. $K_{i\ Spain}$ = Final electricity consumption in the Spanish industrial sector/ Final electricity consumption in the EU industrial sector).
In the Korean case no corrections are conducted.

3.2.6 Lifetime savings applied

In the French case application the lifetime savings data are not used for the lifetime of how long savings are accounted for, but for accounting the savings of the investments promoted in year t. The lifetime savings are

discounted (saving in kWh cumac) with a discount rate of 4%. This results in the value of 11.56 years for the discounted lifetime (LTdisc) for variable speed drive (lifetime of 15 years).
In the Korean case application as economic lifetime of a high efficient inverter, 15 years is used.
In the Spanish case application no lifetimes are applied as the remaining lifetime of the motor is not known.

3.2.7 GHG savings

The average emission factor calculated in France, using as a basis the average power mix is quite low because of the high contribution of nuclear energy in France (around 80 g CO_2/kWh [Enerdata data base]) when including also the auto generation in industry. It would be around 50-65 gCO2/kWh is public electricity only is considered).
The GHG emission factor applied in Korea in the performance report in the 2009 electric power demand management program was 445g/kWh (this emission factor related to 2007 [Source KPX Korea Power Exchange).
In Spain, each kWh consumed amounts to 0.360 kg of CO2 (using reference data from REE and being evaluated in accordance to the European Commission Directive 2007/589/CE).
As for the Netherlands case no energy savings were calculated, also no GHG savings were calculated.

3.3 Conclusions and general and practical formulas

Though the cases applications seem very different, further analysis show that these differences may be diminished to a large extent by distinguishing between three elements in the approaches i.e.

a. the basic approach to compose the formula (i.e. the savings per application)
b. the used base line;
c. the context (i.e. the way of aggregation and/or translation to national uses)

Basic approach:
The basic approach for VSD or high efficient motor systems seems very common over all studied cases. They depart from the assumption that per application of VSD and motor systems, the annual savings can be calculated based on using:

- the power of the motor system (KW),
- the annual average operating hours (hrs)
- and the percentage of annual savings (%).

In some formulas (e.g. Korea), two factors are already combined into one combined estimate, but the underlying principle remains similar.

A general formula for annual savings for a particular typical application would then be:

annual savings per unit/system = power (KW) x percentage (%) of savings * average number of annual operating hours for that type of application

The differences in outcomes are then to be found in different values of parameters, notably for:

a) the values used for number of operating hours and
b) % of savings per typical application.

It may be assumed that for many typical applications of VSD/motor systems operating hours and the average % of savings will be in the same range. In case they (occasionally) show large differences, these usually may be well known and explained give specific circumstances. In this respect the basic calculations may be made comparable to a very large extent.

Given its high influence on outcomes, the used values for operating hours, life times and average savings should be made transparent in reports. This will enhance common understanding. Since for many applications values are not likely to differ very much, collecting and comparing these may evolve in towards defaults or good practices for typical applications, that can be used more widely. If these defaults grow into a sufficient reliable set, they may even become standard in ex-ante and ex-durante monitoring and help in avoiding many cost-intensive case specific studies.

<u>Baseline</u>
To a large extent the different use of baselines is interrelated with the purposes of the evaluations. They range from using market averages to 'before-after' comparisons per application.
Future discussions between experts may lead towards better guidance regarding in which situations and which type of base line to use. Not only from a scientific point of view, but also better support policy decisions.
The reports could in future provide more clear arguments for the selection of a baseline. There is currently no attention given to when, where and how baseline estimates should be updated, e.g. to adapt to new market averages or to new actual system efficiencies.

<u>The aggregation to (national) uses</u>
The other differences relate to more country specific assumptions and/or required aggregation levels e.g. over sectors or applications. These are often a matter of choice or priorities in the specific countries. Reporting could be enhanced in comparability of outcomes between countries, if these country or programme specific aspects would be clearly separated from the basic technical formula en parameter choices.

4. HEAT PUMP PROGRAMMES AND HARMONISED ENERGY SAVINGS CALCULATION

4.1 Introduction

Heat pumps are used to provide heating because less high-grade energy is required for their operation, than appears in the released heat. Most of the energy for heating comes from the external environment, and only a fraction comes from electricity. In electrically powered heat pumps, the heat transferred can be three or four times larger than the electrical power consumed, giving the system a Coefficient of Performance (COP) of 3 or 4, as opposed to a COP of 1 of a conventional electrical resistance heater, in which all heat is produced from input electrical energy.

This chapter describes summarised information from case applications in Norway, the Netherlands and Italy. For these three case applications the formula used to calculate the energy savings are presented. Also the way the formula is used in practice in these countries is given, including:

- Parameters in the formula
- Baseline issues
- Normalisation
- Corrections
- Lifetime savings
- Greenhouse gas emissions reductions

The general conclusion is that the calculations depart from different levels of aggregation or angles, ranging from an individual technical installation, to an integrated end-use or even the energy use of an entire building. Though underlying basic elements may be to some extent similar, this cannot easy be deducted from the applications.

4.2 Key elements for energy savings

4.2.1 Formula used.

As mentioned, the formulas for calculating the annual energy savings as used in the three countries case applications are developed from a different view:

- the Norwegian case is based on metered annual electricity use, where the non-heating use is subtracted;
- the Dutch case is based on the estimated heat demand calculated using a model approach for meeting the heat demand;
- the Italian case is based on calculations for replacement of conventional water heaters and for new installations using average Coefficient Of Performance (COPs)[3].

[3] The Italian case application is available at the website www.iea.dsm.org as there is no Italian country report

Table 4.1 lists the formulas in a summarised fashion. The country reports hold more details.

Table 4.1. Issued formulas in the case application per country

Country	Formulas
Norway	$ES_t = \sum_i \left(CT_{-1,i} - CNH_{-1,i}\right)\cdot \frac{DDn_i}{DD_{-1,i}} - \left(CT_{t,i} - CNH_{t,i}\right)\cdot \frac{DDn_i}{DD_{t,i}}$ i = household index, $i = 1 \ldots n$ t = time index, specified as follows: $t = -1$ = The last full year before installation of heat pump (ex-ante year) $t = 0$ = The point in time of installation of the heat pump $t > 0$ =Any full year of operation after installation of the heat pump (ex-post year) ES_t = annual net savings in year t in kWh $CT_{t,i}$ = Observed (metered) annual total consumption of electricity (kWh) in year t for household i $CNH_{t,i}$ =Annual consumption for non-heating purposes of electricity in year t for household i (kWh). DDn_i = Normalised annual degree day sum for household i $DD_{t,i}$ = Observed (metered) degree day sum in year t for household i
The Nether-lands	$ES_t = \sum_i E_{tot,ref} - E_{tot,hp}$ *in GJ (primary energy)* *i = installed heat pumps i= 1.. n* $E_{tot,ref}$ *= Calculated total primary energy use of the building (standard conditions) in MJ/year* $E_{tot,hp}$ *= Calculated total primary energy use of the building (standard conditions) with a heat pump installed, in MJ/year* ES_t *= annual net savings in the year t in primary energy use (MJ/year)*
Italy	$ES_t = \sum_i E_{ref} - E_{pdc}$ *i = installed heat pumps i= 1.. n* E_{ref} *= Energy use in the situation before in the year t in* 10^{-3} *toe/year* E_{pdc} *= Energy use in the situation after, depending on climate zone en COP in the year t in* 10^{-3} *toe/year* ES_t *= annual net savings in the year t in* 10^{-3} *toe/year*

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

4.2.2 Parameters

In the Norwegian case application the annual consumption for non-heating purposes (CNH) is estimated based on a default electricity use of 8,000 kWh and an electricity use of 1,000 kWh per household member.

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 Italian case application a conversion factor of 0.187 toe/MWh from electricity to primary energy is used.

4.2.3 Baseline issues

In the Norwegian case application, electricity use in the 'before' situation is used as the baseline, whatever heating system was in place.
In the Dutch case application, as baseline situation the heating demand of the dwelling is used, based on the same assumptions as for the energy savings calculations, but with another heating system than the heat pump.
In the Italian case application three different baseline situations are used for a single household:

1) a gas water heather (using 163*10^{-3} toe/year);
2) an electric water heater (using 251*10^{-3} toe/year);
3) as reference situation for new installations: a national weighted average of the different type of water heaters in use (using 186*10^{-3} toe/year).

4.2.4 Normalisation

In the Norwegian and Dutch case applications 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 ^{o}C) and for a specified number of households members (related to the floor area of a dwelling). In the Italian case application the COPs are related to four climatic zones.

4.2.5 Corrections

In the Norwegian case application a sample 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.

So in practise no corrections are conducted.

4.2.6 Life time savings applied

No life time savings are calculated.

4.2.7 Greenhouse gas emissions reductions

Norway and Italy did not calculate GHG emission reductions in their case applications.
In the Dutch approach calculations are used from the energy label calculations to calculate annual CO_2 emissions. Since no lifetime is specified, no GHG lifetime savings can be calculated. In this approach the difference per energy carrier between the reference and the actual energy use is calculated. For that the difference in primary energy per energy carrier is calculated and converted into energy use in the dimensions m3, GJ or kWh, dependent on the carrier (gas, heat or electricity, respectively). The used emission factors for energy sources are:

- Natural gas 1,78 kg CO_2/m3
- heat distribution 87,7 kg CO_2/GJ
- electricity 0,566 kg CO_2/kWh (based on an efficiency of Dutch electricity generation of 39%)

4.3 Conclusions and general and practical formulas

The methodologies used seem quite different. The main methodological differences relate to:

- the level of evaluation:
    - the level of a specific technical system (the heat pump)
    - the level of the related specific end-use (electricity for heating)
    - the level of energy use of the entire house or building
- using ex-post calculations or ex-ante modelled estimates

The present case applications thus do not point easily towards one general approach.

To improve comparability and general understanding of saving calculations for heat pumps, it may be considered to:

- distinguish better between the levels of aggregation in calculations. These can thus be made better fit to support decisions on the various levels e.g. ranging from simply replacing a specific system by a better one towards more integrated measures. The latter type of cases not only look at (replacing) a single system, but look into the interaction with other conditions and saving measures on the level of a specific end-use or on the level of an entire house or building.
- use better actual practical data in ex-ante models for decision making. Practical results from ex-post measurements should help in developing defaults that can be used also in ex-ante models, at least for a series of typical applications.

5. HEATING IN COMMERCIAL BUILDINGS PROGRAMMES AND HARMONISED ENERGY SAVINGS CALCULATION

5.1 Introduction

Heating systems in commercial buildings can be improved by installing a more efficient boiler or change to a electric boiler.

This chapter contains summarised information from the case applications in France and Spain. For these two case applications the formulas used to calculate the energy savings are presented. Also the way the formulas are used in practice in these countries is given, paying attention to:

- Parameters in the formula
- Baseline issues
- Normalisation
- Corrections
- Lifetime savings
- Greenhouse gas emissions reductions

As with heat pumps , also in this case the level of aggregation taken is quite different.

5.2 Key elements for energy savings

5.2.1 Formula used.

The formulas for calculating the annual energy savings as used in the two country case applications have a completely different status:

- The French formulas are used by the utilities in the white certificates scheme. One formula applies to the larger buildings, while another, a standardised approach, is applicable to buildings with a total surface area of less than 5,000 m^2;
- the Spanish formulas represent regular methods in use in Spain (due to the non-existence of accepted M&V standards) and are based upon engineering calculations and rooted in simple relationships.

Table 5.1 lists the formulas in a summarised fashion. The country reports contain more details.

Table 5.1. Issued formulas in the case application per country

Country	**Formulas**
France	*Annual savings: ES = $n_s * ES_{m2}$ in kWh* $ES_t = \sum_i n_s \bullet E_{m2}$ *i = individual building, i = 1 …n* *n_s = floor area concerned by energy saving investments (in that year)* *ES_{m2} = unitary energy savings per m^2 of building floor area (in kWh/m^2)* *Fore for a building type j (<5,000 m^2) heated with a fuel type k in climatic zone i, the annual energy savings per m^2 for an individual building are equal to:* $ES_{jk} = ES_{ref} \bullet CC_i \bullet IC_i \bullet EN_k$ *ES_{ref} = reference unitary energy savings per m^2 of building floor area (default value)* *CC_i = coefficient for climatic zone i,* *IC_j = coefficient for building type j* *EN_k = coefficient for heating energy k (electricity versus fuels based systems)*
Spain	$TotalSavings\left(\frac{kWh}{year}\right) = N \bullet F_p \sum_{atoi} [\sum Load \bullet Hours \bullet NominalPower \bullet \left(\frac{1}{\eta_{old}} \bullet \frac{1}{\eta_{new}}\right)]$ *N = the total number of office buildings* *Fp = the capacity factor of yearly heater change* *Load = Power/Nominal Power* *η = Efficiency of the boiler*

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

5.2.2 Parameters

In the French case application a coefficient for the climatic zone (CC) is used, ranging from 0.6 to 1.1, while a coefficient of intermitted and internal gain (IC) is applied ranging (for the five different types of buildings) from 0.6 to 1.1. The coefficient for heating energy (EN) is 95% for electricity and 60% for fuels.

In the Spanish case application the first step is to create a table holding the (estimated) number of working hours per heating load in a year. Per boiler the savings per load fraction are calculated using the formula:

5.2.3 Baseline issues

For the baseline in both the French and Spanish case applications, the initial situation, prior to the energy saving investments is used. However, in the French case application a reference unitary consumption per m^2 is used as the baseline consumption while in the Spanish one an efficiency for each load level of the existing boiler is used.

5.2.4 Normalisation

Normalisation is not conducted in the Spanish case application, while in the France case this is not needed as the calculation is already using a coefficient for climate zones.

5.2.5 Corrections

No corrections are conducted.

5.2.6 Life time savings applied

In the French case application the life time savings are not used for estimating how long savings are accounted for, but for accounting the savings of the investments promoted in year t. The life time savings are discounted (saving in kWh cumac) with a discount rate of 4%.
In the Spanish case application the total electricity savings are calculated using a lifetime of twenty years.

5.2.7 Greenhouse gas emissions reduction

Table 5.2: Lifetime discounted CO_2 savings by climatic area and fuel[4] (estimate)
(t CO_2/m2 insulation material)

Area	Fuel	Electricity (average)	Electricity (heating load)
H1	0,7	0,12	0,35
H2	0,6	0,10	0,29
H3	0,4	0,07	0,20

[4]Case of 2.5 $m^2K/W \leq R < 5$ m^2K/W

X

Activity sector	Building factor
Offices	0.5
Education, commerce, hotels restaurants	0.6
Health	1.1

In the Spanish case application, the emissions factors applied to converting the energy savings, are those of natural gas (0.204 kg of CO_2 per kWh). Using this emission factor would result in annual savings of 116,717 kg CO_2. No lifetime GHG reductions were calculated.

5.3 Conclusions and general and practical formulas

As with heat pumps , also in this case the level of aggregations taken is quite different. The French case takes a higher aggregation level in which savings per area are used, while the Spanish case looks at changes in heaters.

It would need further analyses of the system changes at the lower of the two levels to make the formulas more comparable.

It may be worth considering adapting the reporting practises (and template) to improve reporting more clearly on the appropriate level (or both levels), where such is practical and easily possible, to enhance comparability.

6. AIR CONDITIONING PROGRAMMES AND HARMONISED ENERGY SAVINGS CALCULATION

6.1 Introduction

Central air conditioners circulate cool air through a system of supply and return ducts to regulate the indoor temperature. Today's best air conditioners use 30% to 50% less energy to produce the same amount of cooling as air conditioners made in the mid 1970s. Even compared to a 10-15 years old one, saving in the range of 20% to 40% are achievable.

This chapter provides summarised information from the case applications in The Netherlands and Spain. For these two case applications the formulas used to calculate the energy savings are presented. Also the way the formulas are used in practice in these countries is given, including:

- Parameters in the formula
- Baseline issues
- Normalisation
- Corrections
- Lifetime savings
- Greenhouse gas emissions reductions

The formulas are not easy to compare given their different levels of aggregation level.

6.2 Key elements for energy savings

6.2.1 Formula used

The formulas for calculating the annual energy savings as used in the three country applications[5] 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); so in the Spanish case application 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); so in the Dutch case application the energy savings are based on calculations for the efficiency of several systems that are in use for meeting the cooling demand.

Table 6.1 lists the formulas in a summarised fashion. The country reports hold more details.

[5] The USA case application "2006-2008 comprehensive commercial building Energy Efficiency program in New Mexico" holds HVAC measures, but is not specific for air conditioners

Table 6.1. Issued formulas in the case application per country

Country	Formulas
The Nether-lands	*Annual energy savings:* $ES = \sum^{Units} (\frac{Q_{cool,yr}}{\eta_{gen}})ref - (\frac{Q_{cool,yr}}{\eta_{gen}})sel$ *Unit = number of air conditioning systems installed* *$Q_{cool,yr}$ = yearly cooling demand* *η_{gen} = efficiency of the air conditioner* *ref = reference air conditioner* *se = selected air conditioner*
Spain	*Annual electricity savings:* $ES = \sum^{Units} discount\ factor*load*t*\ P_{nominal} \left(\frac{1}{COPold} - \frac{1}{COPnew}\right)$ Unit = number of (new) air conditioning systems installed Discount factor= annual performance reduction Load = annual cooling load profile t = time of use (in hours) $P_{nominal}$ = Nominal power COP = Coefficient of Performance Old = existing air conditioner New = new installed air conditioner
United States case area New Mexico	Energy savings calculated using simulation models for 29 project applications

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

6.2.2 Parameters

The yearly cooling demand as well as the annual cooling load profile is in all cases a sum of demands or loads in a specific time period: monthly cooling demand or 10% load in combination with hours per year.

In the Spanish case application the annual electricity savings are discounted with 2.5% over the theoretical performance. In the Dutch case application, the parameters on the dimensions of the buildings are in line which those specified in ISSO 75.1.

6.2.3 Baseline issues

For the baseline in the Spanish case application, the efficiency of the existing cooling system is used, while in the Dutch case application the reference situation with another air conditioning system or another air conditioner is used. In the USA case application the International Energy Conservation Code (IECC) 2006 was applied as baselines.

6.2.4 Normalisation

No normalisation is conducted in the Spanish case application, while in the Dutch case the yearly cooling demand is calculated using average monthly values for a standardised year (the so called Test Reference Year in De Bilt). In the US case application, when extrapolating to annual savings, the typical Meteorological Year (TMY) data for the appropriate region were applied.

6.2.5 Corrections

No corrections are conducted, with the exception of the US case application, where corrections for free riders were applied.

6.2.6 Life time savings applied

In the Spanish case application the annual electricity savings are discounted with 2,5% over the theoretical performance. This means e.g. that at the 10^{th} year of the savings (the expected lifetime of a chillier is assumed to be around ten years), the annual savings are discounted with a factor of 0,825. In the US case application the effective useful life (EUL) values from the California DEER 2008 database were used (i.e. 15 years for air conditioners, both split and unitary).

6.2.7 Additional GHG savings

In the Dutch approach, the energy label calculations are applied to calculate annual CO_2 emissions. Since no lifetimes are specified, no GHG lifetime savings can be calculated. In this approach the difference per energy carrier between the reference and the actual energy use is calculated. For that the difference in primary energy per energy carrier is calculated and converted into energy use (in the dimensions m^3, GJ or kWh, dependent on the carrier gas, heat or electricity, respectively).

The emission factors are:

- Natural gas 1,78 kg CO_2/m^3
- heat distribution 87,7 kg CO_2/GJ
- electricity 0,566 kg CO_2/kWh (based on an efficiency of Dutch electricity generation of 39%)

In the Spanish case applications, the GHG savings are determined using the medium emission factor for the national electrical system. For Spain the value is 0.360 kg of CO_2 per kWh of electrical consumption (using as a reference, data from REE; evaluated in accordance to the European Commission Directive 2007/589/CE). This results in annual CO_2 savings of 235.555 kg. There was no calculation of lifetime GHG savings.

In the US case application no GHG emission reductions are calculated.

6.3 Conclusions and general and practical formulas

The methods are different with regard to level of approach. However, 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 (see also under heat pumps), 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. This would enhance also the practical applicability in policy decisions.
- 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.

7. RESIDENTIAL INSULATION PROGRAMMES AND HARMONISED ENERGY SAVINGS CALCULATION

7.1 Introduction

Residential improved insulation is possible by separate improvements as high efficiency glazing, roof, wall and cellar insulation, but also by a combination of such measures or by combining with changes in heating or cooling installations or by a change in the energy source and/or system to provide the energy to the houses.

This chapter contains summarised information from the case applications in France, the Netherlands, Norway, Spain and the USA. For these five case applications the formulas used to calculate energy savings are presented. Also the use of the formulas in practice in these countries is given e.g.:

- Parameters in the formulas
- Baseline issues
- Normalisation
- Corrections
- Lifetime savings
- Greenhouse gas emissions reductions

Although there are rather comparable calculation methods related to the individual technical measures, in the applications there is a wide range in selected approach, varying from model calculations to actual measurements, and the level of aggregation, a technical measure or whole building.

7.2 Key elements for energy savings

7.2.1 Formula used

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

- 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);

Table 7.1 lists the formulas in a summarised fashion[6]. The country reports contain more details.

[6] for France and Norway the formulas are 'harmonised' for the notations compared to those the country reports

Table 7.1. 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_j = 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_j = 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* *ES_i = average savings per building type in kWh/year*

Country	Formulas
United States: case area California	*<u>CSA Model</u>*: $ADC_{it} = \quad i + \beta 1 AVGHDD_{it} + \beta 2\ POST_t + \quad _{it}$ *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*
	<u>SAE Model</u>. 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

7.2.2 <u>Parameters</u>

In the French 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 for cumulative over the lifespan of the equipment with the assumption that they are not constant over this life time and therefore yearly discounted at 4% rate, to reflect both a financial discount (economic value of the energy saving certificate) and a technical discount (gradual decrease in savings). The savings are expressed in **kWh cumac** (cumulated and discounted). Only the discounted and cumulated values are officially published.

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, unless the manufacturer provides 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.

7.2.3 Baseline issues

In the French 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 apply as for calculating the energy savings.

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 are used as a baseline.

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

7.2.4 Normalisation

In all case applications 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 ^{o}C) and for a specified number of households members (related to the floor area of a dwelling).

7.2.5 Corrections

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

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

7.2.6 Life time savings applied

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

7.2.7 Additional GHG savings

There are no calculations of GHG savings in the French white certificate scheme, since the objective of the programme is to generate energy savings. However, evaluations of CO_2 savings linked to electricity savings exist. For emission factors following options are generally used:

- one is the average of the power mix, which is quite low because of the high contribution of nuclear energy in France (50-65 g CO_2/kWh or an average of 60 g CO_2/kWh);

- the second one is a value of 100g CO2/kWh based on the actual power mix estimated as corresponding to the residential lighting load (value was estimated by a working group of experts from ADEME and EDF).
- There is also an option to estimate the CO_2 savings from average emission factors. For fuel we can take a mix between oil and gas, based on the average consumption between these two fuels. For the case project the CO_2 savings were taken from average emission factors. For fuel we can take a mix between oil and gas based on the average consumption between these two fuels. In 2008, gas made up 62% of the consumption of fossil fuels, heating oil 36% and coal 1%. This corresponds to an average emission factor for fossil fuels of 2.6 t CO_2/toe or 224 g CO_2/kWh. Wood is important in France for heating, if the dwelling is heated with wood there are no savings in CO_2 as wood is considered 'neutral' in terms of GHG emissions.

With this last option the lifetime GHG savings would be calculated, taking into account the three climatic areas in France and the fuel mix. This calculation in presented in Table 7.2. The energy savings are calculated including discounting factors; it should be noted that this influences the CO_2 emissions reductions.

Table 7.2: Lifetime discounted CO_2 savings by climatic area and fuel (estimate)

(t CO_2/m2 insulation material)

Area	Fuel	Electricity (average)	Electricity (heating coefficient)
H1	0,7	0,12	0,35
H2	0,6	0,10	0,29
H3	0,4	0,07	0,20

In the Dutch case application, the average GHG emission factor for electricity is taken from the ISSO publication 75.2: 0,566 kg CO_2/kWh. Using this emission factor the annual GHG savings are estimated as (118,776,946 kWh x 0,566 kg CO_2/kWh =) 67,227,751 kg CO_2 (about 67.3 Gg CO_2). For the lifetime savings a lifetime of 12 year is used, and so these are estimated at (118,776,946 kWh x 0,566 kg CO_2/kWh x 12 =) 806,733,017 kg CO_2 (about 806.7 Gg CO_2).

A recent study (Harmelink et all, 2012) holds information on the development of the GHG emission factor since 2000 and on the method used to calculate the efficiency of the electricity production. Using the 'integrated method' the average value for the GHG emission factor for electricity decreased from 0. 54 kg CO_2/kWh in 2000 to 0.46 in 2010. Using the 'marginal central park method' the decrease was from 0. 59 kg CO_2/kWh in 2000 to 0.53 in 2010.

In the Spanish case application, the savings are determined by applying the emission factors to the energy savings; in the case of natural gas, the emission factor is 0.204 kg of CO_2 per kWh. This results in annual savings for a single building of 43.86 kg/year. No lifetime reductions are estimated.

In the Norwegian and the US case applications no GHG emissions reductions were calculated.

7.3 Conclusions and general and practical formulas

As with the cases for heat pumps, 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.

To improve the comparability and use of saving calculations for insulation technologies in the near future attention could be given to distinguishing better between the levels in calculations. These can thus be made better fit to support decisions on the various levels distinguishing better between uses of ex-ante models and ex-post calculations (depending on when what type of approach is needed for in decision making).

A further aspect is that the individual country cases each add other factors and know-how to the situation and methods. France e.g. adds deterioration aspects, while Spain looks into taking into account penetration levels. Further 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)

8. LIGHTING PROGRAMMES AND HARMONISED ENERGY SAVINGS CALCULATION

8.1 Introduction

Compact Fluorescent Lights (CFL) and Light Emitting Diode (LED) bulbs have revolutionised energy-efficient lighting. CFLs are simply miniature versions of full-sized fluorescents. Over time the price of CFL bulbs is going down each year as the manufacturing technology continues to improve.

This chapter contains summarised information from the case applications in France, Korea The Netherlands, Spain and the USA. For these five case applications, the formulas used to calculate the energy savings are presented together with their use in practice, including:

- Parameters in the formula
- Baseline issues
- Normalisation
- Corrections
- Lifetime savings
- Greenhouse gas emissions reductions

From the case applications a series of common practices could be derived. Most cases deviate from similar base assumptions as to how to account savings per application. Differences relate mainly to the parameter values used, notably for burning hours and lifetime

8.2 Key elements for energy savings

8.2.1 Formula used

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 (1). The latter two are dealt with respectively in paragraph 2.4 and paragraphs 2.5.1 and 2.5.2.

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

Where[7]

[7] 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.

- *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 7.1 lists these formulas in a summarised fashion. The country reports hold more details.

Table 7.1. 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

8.2.2 Parameters

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

a. as an (average)[8] value of the old as well as the new lamp;
b. as an average[9] value for Delta Watt.

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

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

[8] Depending on CFLs, lamp wattage and the relevant baseline.
[9] Be applied to situations of multiple CFLs having different wattages.

The key parameters can be identified by each country's method of observing and/or measuring energy saving aspects. Table 7.2 shows the key parameters per country. The most common parameter is the number of burning hours. They are assumed not to change after replacement.

Table 7.2. 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 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.*

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

8.2.3 Baseline issues

For the baseline a reference situation must be determined. The reference situation for lighting in households is the replacement by the same type of lamp[10]. In all case applications this is the reference situation in which conventional bulbs are being replaced by conventional bulbs, with the exception of Korea were the unit of analysis is a fluorescent lamp.

8.2.4 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 normalisation is applied.

8.2.5 Corrections

There are two types of corrections:

- Group 1: gross-net (e.g. double 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 8.2.1.

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

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

The corrections are further explained in table 3.

Corrections are only conducted in the case application of California.

Corrections 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 factor to the situation 'before' but as a correction of the gross energy savings.

[10] 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.

Corrections to the new situation (Pnew)

Concerning the new situation, all case applications deal with data collection methods that are based on sales data. 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 7.3. 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 that 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

8.2.6 Life time savings applied

All countries have data to calculate savings over the lifetime, but the use in practice differs widely. The used lifetime is often taken as the technical burning hours of the CFL divided by the annual burning hours.

Table 7.4. 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; these savings are not assumed constant over this life time but are discounted at 4%, to reflect both a financial discount rate (economic value of the energy saving certificate) and a technical discount rate (gradual decrease in savings). This means that the annual savings are multiplied by this discount factor, being a function of the life time and discount rate.*
Korea	*Economic lifetime of ballast for the 32W fluorescent lamp is 7 years.*	• *lifetime savings are used for evaluating the economic feasibility and are calculated multiplying ES (annual energy savings) by lifetime. It is assumed that physical function deterioration would not happen during this lifetime period and the same ES (annual energy savings) would occur over this period.*
The Netherlands	*The lifetime of a CFL is 12 years*	• *In most cases calculations use 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, replacement would be at 12 years. Following assumptions are made:* ➢ *the savings lifetime is equal to the average technical burning hours and the saving remain constant over the whole period.* ➢ *Savings start in the year the CFL is bought*
Spain	*The lifetime of the measures would be beyond 70*	• *Useful lifetime of a LED lamp is around 50.000 hours, while the annual burning hours are*

Country	Corrections	explanations
	years.	*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.*	• *Life cycle 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

8.2.7 Additional GHG savings

In the French case application there is no calculation of GHG savings in the white certificate scheme. However, evaluations of CO_2 savings linked to electricity savings exist. Two emission factors are generally used:
one is the average of the power mix, which is quite low because of the high contribution of nuclear energy in France (50-65 g CO_2/kWh or an average of 60 g CO_2/kWh) and the second one is a value of 100g CO_2/kWh based on the actual power mix estimated as corresponding to the residential lighting load (value estimated by a working group of experts from ADEME and EDF). With the first value the lifetime GHG savings would be 13.8 kg CO_2 per lamp (230 kWh * 60 g CO_2/kWh), while the second value leads to a lifetime GHG savings of almost twice as high, i.e. 23 kg CO_2 per lamp (230 kWh * 100 g CO_2/kWh).

In Korea the GHG emission factor was taken from the performance report in 2009 on electric power demand management business (445g/kWh for the year 2007). Using this value and the annual energy savings obtained by the subsidy programme of ballasts for 32W fluorescent lamps of 31,614MWh in the year 2009, the corresponding CO_2 reduction would be 14,068 ton annually. The GHG reduction over a lifetime of 7 years is 98,477 ton.

In the Dutch case application, the average value for the GHG emission factor for electricity is taken from the ISSO publication 75.2 (0,566 kg CO_2/kWh). Using this emission factor, the annual GHG savings were estimated at (118,776,946 kWh x 0,566 kg CO2/kWh =) 67,227,751 kg CO_2 (about 67.3 Gg CO_2). For the lifetime savings a lifetime of 12 year is used, leading to reductions of (118,776,946 kWh x 0,566 kg CO2/kWh x 12 =) 806,733,017 kg CO_2 emissions (about 806.7 Gg CO2)

A recent study (Harmelink et al, 2012) shows information on the development of the GHG emission factor since 2000 and on the method used to calculate the efficiency of the electricity production. Using the so called 'integrated method', the average value for the GHG emission factor for electricity decreased from 0.54 kg CO_2/kWh in 2000 to 0.46 in 2010. When using the 'marginal central park method' the decrease would be from 0.59 kg CO_2/kWh in 2000 to 0.53 in 2010.

In the Spanish case application, the GHG savings are determined by using the average emission factor for the national electrical system. For Spain this value is 0,360 kg of CO_2 per kWh of electrical consumption (using as reference data from REE; evaluated in accordance to the European Commission Directive 2007/589/CE). By using this average emission factor, the annual savings of CO_2 for the year 2008 would be approximately 1.140 tons of CO_2. No lifetime emission reductions were calculated.

In the US case application no GHG emission reductions are calculated.

8.3 Conclusions and general and practical formulas

The cases in this field show three types of differences. The first one relates to assumptions on the base situation. The second one concerns the selection of the baseline and the third one relates to corrections conducted on the annual energy savings.

The first difference relates to the base situation: one technical option replacing another. As with VSD and electric motor systems, 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. Since the outcomes on savings depend heavily on these assumptions, this provides an urgent reason to compare these more into detail and discuss and better understand the differences between countries in assumptions used per application. Since there seem to be no inherent technical differences between countries calculations in this respect seem to be susceptible for more comparability. For the assumptions on burning hours the experts already discussed that 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 second type of difference relates to 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.
Since the EU has decided in the Ecodesign Directive to phase out a number of lighting options, also the baseline with regard not using non-CFL as baseline may be discussed. This should be discussed e.g. for future

programmes that might stimulate LED. Will this replace CFLs or incandescent bulbs or a combination of both?

The third difference relates to whether or not specific corrections are taken into account. By clearly distinguishing these from the above aspects in reporting, the effects of certain corrections may be better understood and made more transparent. It seems that corrections due to data problems should get more attention, as these are very rarely well documented.

Improved documentation on (where possible) good practices in calculating energy savings will contribute to better input information for policy making processes. It may also reduce duplication of monitoring and evaluation efforts by improved mutual use of practices and defaults.

9. HARMONISED FORMULAS FOR ENERGY SAVINGS CALCULATIONS

9.1 Introduction

In this chapter we will present conclusions on the usefulness of the template to document energy savings calculations, based on the experiences gained in the case applications, as presented in the previous chapters. We will also present more harmonised formulas for two technologies. In addition we will present the main conclusions regarding possibilities to compare data, as well as the problems and limitations encountered in composing formulas to use in comparisons. Also some recommendations for future improvements are given.

9.2 The template as a tool for harmonised formulas

During the project a template was developed to document the information for the case applications. In the template the formula for calculation of Annual Energy Savings consists of six key elements. The information on these six key elements is crucial to understand the calculated savings. This understanding is the first step in harmonising energy savings calculations between countries for a selected technology. These six key elements for the calculations in the template are:

1. Formula used for the calculation of annual energy savings
2. Specification of the parameters in the calculation
3. Specification of the unit for the calculation
4. Baseline issues
5. Normalization
6. Energy savings corrections
    - Gross-net corrections
    - Corrections due to data collection problem

In addition to annual energy savings attention is also given to energy savings over the lifetime.

Experience shows that this template for energy savings calculations is a good tool for ensuring that the most important information regarding energy savings calculations is provided in such a way that it is easy to make comparisons.

During discussions it became obvious that more detailed information for some elements would improve understanding, but also that one should avoid providing too much detailed information. A lot of details are influencing the energy saved, but to really understand the difference between comparable programmes, these details are generally not really needed.

In the selection of the key elements the experiences from US evaluations, the lessons from the EMEEES project (for the EU Energy Service Directive) and from the ongoing work on standardisation have been used. More information on these experiences is included in the report "Guidelines for Harmonised Energy Savings Calculations". The key elements are in line with steps and sub-steps in the calculation of bottom-up energy savings as included in European CEN standard prEN16212:2012.

During the analysis carried out for this report, in various cases the differences in the level of aggregation taken proved to hamper the comparison of methods and outcomes between similar energy saving applications. To improve comparability in these situations, it is recommended to consider options to more clearly define and distinguish between various levels of aggregation in energy saving applications (system, end-use, integrated energy use in a building, etc.).

9.3 Harmonised formulas

During the project the case applications may directly result in comparable or *'harmonised' formulas* only for a limited number of technologies. These are:

- Lighting
- VSD and high efficient electric motors

The annual savings for lighting can be calculated based on using:

- the situation before: the old lamp (W)
- the situation after: the new lamp (W)
- the average burning hours of the lamp (h)

The annual savings for VSD and high efficient electric motors can be calculated based on using:

- the power of the motor system (KW),
- the annual average operating hours (hrs)
- and the percentage of annual savings (%)

For other applications, the '*level of aggregation'* is an important element to take into consideration for energy savings calculations. Where technologies are related to buildings, such as with air conditioners, insulation and boilers, there proved to be a clear difference in the approaches chosen. In some cases the calculations are conducted for the individual appliance, in others on the level of subsystem (e.g. the heating system) and in others the whole building with the interactions (e.g. the use of building models). Also during the development of standards on energy savings calculations by CEN and ISO, this level as aggregation showed up as a important topic for selecting the approach for conducting calculations. By looking into the various relevant levels comparability may further be improved, also in most of these applications.
With regard to parameters, for the same *parameters* in the draft case applications often different notations are used. During discussions at experts

meetings it became clear that although different notations are used, the content was often easy to compare. National and international standards were researched to find common notations for use in this study. Unfortunately also in such standards different notations were often used, mainly due to differences in the objectives of specific standards. During the discussions, attention was also given to cases where parameters were 'officialised' in some countries. The use of different notations would then not be in line with those national official formulas and might result in confusion. For these reasons the final versions of the formulas hold some kind of harmonisation of notations, although not to the maximum possible extent. We refer further to the formulas presented in the chapters ahead.

9.4 Conclusions

Although the cases for most studied types of measures seem very different, further analysis shows that these differences may be diminished to a large extent. This can be done by distinguishing more clearly the various elements in the approaches taken in the case applications.

Some elements are, to a large extent, inherent to the type of measure and thus largely country independent. Others are more related to specific situations. The elements are:

1. the basic approach (i.e. how to calculate the savings per application) and the used values for basic elements (such as operating hours, life times, etc.) in the calculations. It may be concluded that for technical measures the basic approach will or need not differ much between countries. The influence of the values taken for the parameters in this basic approach, e.g. for lifetimes, operating hours and such is very significant, the differences not always very easy to explain.
2. the level of aggregation or interaction taken in the evaluation. Used levels are:
    a. the level of a specific technical system (one system replacing another)
    b. the level of the related specific end-use (e.g. heating with electricity)
    c. the level of energy use of the entire house or building.

   At present countries differ in the level taken for similar type of case applications, thus making comparisons difficult. This situation may be improved (see recommendations).
3. the status of the evaluation method. This ranges from ex-post assessment of effects to ex-ante model calculations. Both are used for similar types of case applications, making comparison and assessment of 'status' (i.e. reliability) of the outcomes difficult

All three mentioned elements are to a large extent methodological issues. Two other relevant elements for differences between cases are more country or programme specific, i.e.:

- the used base lines, ranging for similar situations, from before-after to market average approaches
- the programme specific and national elements that are taken into account, such corrections for free riders, aggregation over sectors, etc.

To improve comparability and create more useful and cost-effective evaluation practices, the following improvements may be considered.

- Take a step by step approach when reporting on evaluation of energy savings. The above elements, more or less in the order given, can be used as a step by step approach, going from inherent technical country independent aspects, towards more situation or country specific elements. By more clearly distinguishing these elements it will be easier to understand the reasons for different outcomes.

- Comparability may be further enhanced by better assessing the differences in used values for basic parameters, such as typical operating hours, life times (where not yet tackled in agreements such as CEN workshop etc.), etc. with a view of understanding differences and come to a set of reliable and comparable default values for relevant typical applications. The new European Energy Efficiency Directive may result in new research for lifetimes as this Directive is dealing with cumulative, longer lasting energy savings over time.

- Ensure that better documented (ex-post) energy savings data are available as input for ex-ante models. This will improve the possibilities to use such information for better policy decision processes in developing new programmes. With increasing quality of the ex-ante models over time, also the need for actual measurements (ex-post) may be limited to samples and to new types of applications not (yet) measured for longer time before.

- Through discussions between experts, provide better guidance on what type of baseline to use for which type of programmes and/or technologies. Also attention may be given to when and how updates of baseline estimates for longer lasting programmes are needed.

- Additional programme specific factors, such as studies on free riders, may be rather country specific. However, by making these factors more clear in reports and making the experiences and approaches available for exchange between experts, a learning process may be enhanced that may avoid duplication of efforts.

10. ENERGY SAVINGS AND GREENHOUSE GAS EMISSION REDUCTIONS

10.1 Emission factors in case applications

The practices in calculating greenhouse gas (GHG) emission reductions that are a result of the energy savings in the case applications, are described in each of the previous chapters and show a range of approaches and values. (see sections on GHG reductions).

In the French cases two emission factors are generally used: one is the average of the power mix, which is quite low because of the high contribution of nuclear energy in France (average of 60 g CO_2/kWh), or calculated based on the actual power mix excluding nuclear (e.g. 224 g CO_2/kWh in 2008. An alternative value is also used e.g. for lighting; a value of 100g CO_2/kWh based on experts judgement. For insulation also a value t CO_2/m^2 insulation material is used; a value for each of the three climatic zones and for electricity use and for electricity use for heating load.

In the Korean cases a GHG emission factor was taken from the performance report in 2009 on electric power demand management business (445g/kWh for the year 2007).

In the Dutch case application, the average value for the GHG emission factor (0,566 kg CO_2/kWh) for electricity was taken from the ISSO publication 75.2; this is based on an efficiency of Dutch electricity generation of 39%. A recent study shows information on the development of the GHG emission factor since 2000 and on the method used to calculate the efficiency of the electricity production. Using the so called 'integrated method', the average value for the GHG emission factor for electricity decreased from 0.54 kg CO_2/kWh in 2000 to 0.46 in 2010. When using the 'marginal central park method' the decrease would be from 0.59 kg CO_2/kWh in 2000 to 0.53 in 2010.

In the Spanish case application, the GHG savings are determined by using the average emission factor for the national electrical system: 0,360 kg of CO_2 per kWh of electrical consumption (using as reference data from REE; evaluated in accordance to the European Commission Directive 2007/589/CE).

In the Dutch case application, emission factors for energy sources then electricity are:

- Natural gas 1,78 kg CO_2/m^3
- heat distribution 87,7 kg CO_2/GJ

In the French case application a overall fuel factor is used to calculate CO_2/m^2 insulation material, taken into account three climatic areas.

In the Spanish case application, the emissions factors applied for energy savings for natural gas is 0.204 kg of CO2 per kWh.

10.2 Different approaches for estimating GHG emissions

There are a number of approaches that are estimating GHG emissions for electricity:
a) a country specific general value, based on national grid
b) a country specific general value, based on national grid, taken into consideration the impact of combined heat and power
c) a country specific general value, based on national grid (a) and taken into account the import and export of electricity
d) a country value, based on international (regional) grid, e.g. the standard Nordic energy mix
-

For most countries an emissions factor for international comparison is available in the IEA publication: the composite electricity/heat factors in CO_2 Emissions from Fuel Combustion published by the IEA (IEA 2010).

The methodology for electricity-specific emission factors involves calculating the total emissions from the generation of electricity within a country and dividing that figure by the total amount of electricity produced by the country. Data for the quantities of different fossil fuels combusted within dedicated electricity plants, and also within combined heat and power (CHP) plants can be based on national source. For international comparison one also can use an IEA publication (2011a). Total emissions were calculated from these data by applying the appropriate default emission factors from the Guidelines for National Greenhouse Gas Inventories (IPCC 1996, 2006).

For taking into account the impact of combined heat and power, an additional calculation is needed in order to allocate a proportion of the emissions from CHP plants to the electricity and to the heat produced. In order to make this allocation one can use the so-called efficiency method; this method uses the efficiencies of dedicated electricity and dedicated heat plants to derive a ratio for allocating emissions between the two outputs of the CHP. An example of such values is the efficiency of a dedicated electricity plant is 35% and the efficiency of a dedicated heat plant is 80%; these values are used in the figures used in WBCSD/WRI CHP tool (WBCSD/WRI 2006). The efficiency method also requires information on the outputs of electricity and heat from CHP plants. An acceptable assumption is that the electricity output is 0.35 kWh for every kWh input, and the heat output is 0.45 kWh per kWh input (with a total assumed efficiency of 80%). The calculation for the efficiency method is as follows:
Total emissions attributable to heat = (0.45/0.8)/((0.45/0.80) + (0.35/0.35)) = 36%
Total emissions attributable to electricity = 64%

As most European countries have international connected electricity grids, a part of electricity produced is exported to other countries, while a part of the electricity use is produced outside the country. CO_2 emissions for exported and imported electricity can be calculated by the methods presented ahead. These values can then be used to calculate new country specific values. This method is seldom just in practise.

A recent study (Harmelink et al, 2012) shows information on the development of the GHG emission factor since 2000 and on the method used to calculate the efficiency of the electricity production. Using the so-called 'integrated method', the average value for the GHG emission factor for electricity decreased from 0.54 kg CO_2/kWh in 2000 to 0.46 in 2010. When using the 'marginal central park method' the decrease would be from 0.59 kg CO2/kWh in 2000 to 0.53 in 2010.

For the other energy carriers than electricity (gas, coal, and oil) during the project it was concluded to use either IPCC default values or country specific values as reported in National Inventory Reports. This results in clear references and improves comparability. Table 10.1 hold the CO2 emissions for energy industries, as included in the IPCC Guidelines.

Table 10.1 Default CO2 emission factors

	1996	2006
	t CO2/TJ	t CO2/TJ
natural gas	56,1	56,1
coal	94,6	96,1
diesel oil	74,1	74,1
residential fuel oil	77,4	77,4

Source: IPCCC 1996 Table 1.2 Carbon multiplied by 44/12 and IPCC 2006 Table 2.2

11. ENERGY SAVINGS AND DEMAND RESPONSE PROGRAMMES

11.1 Introduction

Demand response (DR) refers to the reduction of customer energy usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. Demand response programmes may include dynamic pricing/tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control/cycling.

During the project the information on DR programmes was collected using a template, related to the template used for the case applications for energy saving. In section 11.2 this template is presented. A summary of the DR programmes in France, Italy, Spain and the USA is given in section 11.3. More detailed information on these programmes is available in the country reports. Section 11.3 holds some conclusions, among others that energy savings were (almost) not available or applicable for the DR programmes.

11.2 Template for Demand Response programmes

The information on Demand Response products is collected in order to relate impacts of DR projects to those for energy savings. For this reason the information is organised as follows.

The template starts off (like that on energy savings) with general information, such as the name and summary on the DR project and relations with other DR initiatives. Subsequent sections are comparable to those in the template for energy savings calculations, dealing with input data, baseline definitions, key parameters considered and savings calculations. This is followed by specific information on Demand Responses e.g. changes in the load shape and benefits. As with the energy savings template, at the end sources and documentation are provided.

In Table 11.1 we present the elements in the template for DR programmes and comparable one in the template for energy savings calculations.

Table 11.1:The elements in the template for DR programmes and comparable one in the template for energy savings calculations.

Template DR programmes	**Template EE programmes**
Summary	Summary of the program
Related DR initiatives	
	Formula for calculation of Annual Energy Savings
Input data	Input data and calculations
Baseline definition and key parameters considered	Baseline issues
Savings calculation	Calculation of the annual savings as applied
Load shape impact	
Benefits to participants	
Other benefits	
Sources and documentation	Sources and documentation & Annex,

11.3 Summary of the DR programmes and their energy impacts

11.3.1 The French DR Programme Tempo Tariff

Summary

This Demand Response programme carried out in France is related to Critical Peak Pricing (CPP) and is known as "Tempo" or "Tempo Tariff". *Tempo* is a product designed for small consumers, every day the utility presents on its website the tariff for energy the next day with a colour: red (high tariff), white (medium high) or blue(cheaper). Figure 1 present an example. The colour is based on the production and demand estimated for the day ahead.

The colour is also sent to each home on a box at 8 pm day ahead and the consumers can be also informed by e-mail or SMS. In addition to a colour, each day also has normal and off-peak periods, which produces six different tariffs. There is a maximum of 22 red days and 43 white days in a year. The red days are kept for between November 1 and March 31 and occur between Monday and Friday, never at a weekend or on public holidays.

There are four different versions of Option Tempo:

1. Standard Tempo - The customer has only an electronic interval meter
2. Dual Energy Tempo - The customer's space-heating boiler can be switched from one energy source to another
3. Thermostat Tempo - The customer has load control equipment which is able to adjust space heating and water heating loads according to the electricity price.
4. Comfort Tempo - The customer has a sophisticated energy controller.

This service was tested during the period 1989-1992 and introduced to more customers until 1995 when this tariff was offered to all customers. In 2003 about 300,000 residential customers and more than 100,000 small business customers had chosen Tempo. In July 2009, EDF discontinued the Tempo tariff for new customers.

Input data

There is no input data used for estimating energy savings.

The only input data is the estimation of energy to be consumed the day ahead that the utility and the grid operator estimate, based on the forecast congestion and demand of electricity. There is no information provided by consumers in this sense.

Baseline definition and key parameters considered

For Tempo, baselines were established adding up different baselines from 800 consumers participating in the experiment in the early 1990s.
Price variation initiatives like Tempo are highly weather-related, so the response is entirely dependent on the weather.

Savings calculation

There is no information available on the electricity savings.
There is only information on changes during the pilot (1989-1992).
Compared with blue days, the Tempo tariff has led to a reduction in electricity consumption of 15% on white days and 45% on red days, on average 1 kW per customer.

Load shape impact

As an example, in 2008, a red day offered about 400 MW of curtailment. EDF estimates that on average, residential consumers decrease their consumptions in peak hours by 50 % and by 25 % in off-peak hours. A part of the consumption is shifted to off-peak hours. The curtailment volume is as high in houses with electrical heating than in houses without electrical heating (In percentage, the consumption decreases by 37% instead of 30% because the house with electrical heating consume more, so the difference in percentage is lower).

Benefits to participants

Tempo customers have saved 10% on average on their electricity bill, was concluded from the introduction in the period 1993-1995. No updated information is available, although also during the roll out after 1995 by early 2000s consumers indicated that they chosen Tempo in order to reduce the electricity bill.
During the introduction about 90% of the customers were satisfied with the tariff while during the roll out customers continued to be rather happy with the tariff.

Less than 20% of electricity customers in France have chosen Tempo. It seems Tempo customers have very particular customer profiles and are interested in managing their energy use. They are prepared to constrain their lifestyles to make comparatively small financial savings relative to their incomes.

11.3.2 The Italian DR Interruptible Programme and the Load Shedding Programme

Summary

In these programmes participants are required to reduce their load to predefined values. Interruptible Programmes are applied to very large industries only. Approximately, the interruptible power represents 6.5% of peak power. Until 2007 their official remuneration was determined by a decision of the energy authority. However, these compensations can be interpreted as forms of state subsidies to sectors facing economic difficulties. For participants who do not respond, they can face penalties.

In the Load Shedding programme, utilities have the possibility to remotely shut down participants' equipment at short notice. There are two types of programmes: real time programmes (without notice) and 15 min notice programmes.
The data for both programmes correspond to the effects of the programs in 2007 and 2008.

Related DR initiatives

There is one initiative related to load shedding recently introduced at policy level by the energy regulator: a new mechanism for calculating the price of energy with the aim of shifting consumption to periods of lower and cheaper loads. The new pricing system will apply to all those end-users in possession of electronic meters. There will be two tariffs: a more expensive one from 08:00 in the morning to 19:00 in the evening Monday to Friday (peak times) and a cheaper one for any other time.

Input data

The available data is the load curves provided by the grid operator, no additional data is collected from customers.

Baseline definition and key parameters considered

The baseline consumption is estimated by the operator taking into account the use of energy from similar periods (day matching, weather conditions, etc.)

Savings calculation

There is no available information on how energy savings are calculated; the only published data is the manageable power under this service (1750 MW in real time plus another 1750 MW for notice programmes), that could be estimated as the maximum energy savings in an event.
A CESI study concludes that the Italian DR technical and economic potential ranges between 1.6 and 4.2% in relation to peak power.
No energy savings are calculated

Load shape impact

Although the impact on load shape of energy savings can be considerable with the Load Shedding Programme, there is no detail about how impact over load shape was provided, neither for the programmes nor for the global load shape.

Benefits to participants

For interruptible programme, the price of remuneration for 2007 consisted of a fixed lump sum of 150,000 €/MW/year for a number of 10 interruptions plus 3000 €/MW for each additional interruption actually incurred throughout the year
For the Load Shedding Programme, participants have to install and maintain Load Shedding Peripheral Units and will be compensated according to a non-market price defined in regulation.

11.3.3 The Norwegian DR Programme Remote Load Control

Summary

This Demand Response programme carried out in Norway in the period 2005-2008 is related to load shifting or peak load reduction The programme took 41 residential households, advised to buy energy with an hourly spot price contract, they got a time-of-day (TOD) network tariff which stimulated to load shifting, and RLC was offered as an "aid" to reduce load and costs in the peak hours.
The key element on this programme is variable price of energy, especially for predetermined peak load hours. The TOD tariff was considered as the best price signal that would give small customers benefit from changes in their consumption pattern for electricity. The tariff is combined with a visual reminder the "El-button", a small watch-like magnetic token that should be placed on the most power-consuming appliances, indicating the peak periods.
This DR programme allows the DSO to switch off/on loads at the customer premises via the AMR system; this pilot RLC is applied to the electric water heaters in the homes. Water heaters have a typical load of 2-3 kW (tap water). Water heaters connected to a hedonically space heating system have

a capacity in the 12-15 kW range. The latter system represents about 10% of all homes in the pilot. The total DR in this pilot is the combined effect of the RLC and voluntary load shifts.

Related DR initiatives

Related to this demand response initiative, there are others conducted within the framework of the market based Demand Response project. These are:
- Fixed price contract with return option; targeted to reduction of energy in shortage periods for a pilot with 2500 households;
- Automatic Demand Response (ADR); testing an automatic scheme disconnecting selected low prioritised appliances;
- Smart house and ToD tariff; advanced load control in 24 flats of a housing cooperative;
- Load shifting for commercial customers.

Input data

The expected peak load for the DSO determines the times for the energy peak payment. The (hourly) peak load periods and levels are predicted based on historical data, and reflects season, weekday, outdoor temperature, and other variables known to affect load level. The expected peak periods are reflected in the hourly prices in the spot market for electricity.
The TOD tariff consisted of traditional components such as fixed and a variable loss payment. Additionally, a new component representing the energy peak payment was included in this pilot programme.

Baseline definition and key parameters considered

The baseline is the load profile that would have been expected in absence of the DR measures, a "typical load profile". Such profiles are calculated on the basis of historical load profiles for similar customers. The baseline can be specified down to hourly periods.

Savings calculation

There is no input data used for estimating energy savings.

The demand response ("savings") is defined as the difference between the projected load (baseline) and the actual metered load during the peak hours. Average response in the pilot is energy savings of 1 kWh/h for customers with standard electrical water heaters, and 2.5 kWh/h for customers with water space heating systems with electrical boilers. The maximum reduction realise is 35% during the morning and 31% during the afternoon.

Load shape impact

RLC clearly shifts the customers' load peak from peak periods to non-peak periods. The effect is most striking for households with a high load demand (electric water based heating systems). This can be measured and documented at the level of the individual customer.

Aggregating the energy savings results for the pilot program to the total Norwegian residential sector, the measured demand response could represent 4,2% of the peak load observed in the Norwegian system (1000 MWh/h).
In this scheme, some electric high demand sources (heating) can be replaced for other non-electric (gas, petrol, etc.).

Benefits to participants

With a standard grid tariff structure, benefits to customers from load shifting are economic savings due to avoidance of peak spot prices. In a normal situation these benefits will be modest. For customers with power contracts with hourly spot price, the benefits from load shifting are dependent on the price difference during the day. The daily price variations during the winter 2003-2004 was only 0,0025-0,00625 €/kWh. A combination of spot price and the intraday ToU tariff as used in the test project gave the most eager customers a cost reduction of ~25 €/month. In a dry and cold winter with high spot price level this amount could rise to ~35 € /month.

Other benefits

The most important benefits from a well-functioning DR scheme are related to grid costs. Transmission losses at high loads and avoided system expansions, thus a more efficient use of the grid, are the most important benefits. These benefits are primarily realized by the DSO.
In this case, GHG are not considered, but could be calculated multiplying the emission factor for Norway with the amount of energy savings achieved.

11.3.4 The Spanish DR Programme Interruptible service

Summary

This Demand Response programme has been available in Spain since 2008 and the key element is the possibility of cut electricity consumption by the grid operator for some big industrial consumers who previously have signed a contract. The service is managed by Red Eléctrica de España (REE), the Electricity transmission operator.
This project seeks to achieve three main objectives: a) Minimising outages ; b) Increasing operating reserve; and c)Reducing peak loads
In 2010, more than 160 clients were subscribed to interruptible service, with a total interruptible power of 2 163 MW, which corresponds to around 10% of total electricity demand in Spain. By 1 June 2012, there were 151 interpretability contracts in force, of which 137 correspond to the mainland system, 13 to the Canary Island system and 1 to the Balearic Island system. The total interruptible power manageable by the system operator in periods

of maximum demand reaches approximately 2 122 MW, of which 2 069 MW correspond to the mainland system, 50 MW to the Canary Island system and 3.3 MW to the Balearic Island system.

Under the Load Interruption Contract, the maximum numbers of interruptions that can be requested by the System Operator are as follows:

- 1 per day (12 hours maximum per day)
- 5 per week (60 hours per week)
- 120 hours per month
- 240 hours per year

Related DR initiatives

In Spain there are at least three other Demand Response programmes:

- Hourly Demand Tariff; is applicable to five different kinds of customers and is mandatory for low voltage customers. The Hourly Demand Tariff has four components: (1) a demand component calculated as the customer's maximum demand in each time of use period multiplied by the rate for that period;(2) an energy component calculated as the energy consumed in a time of use period multiplied by the rate for that period;(3) an interpretability discount; and (4) if applicable, a reactive power discount.
- Load Interruption Contract; an agreement through which large customers receive a discount on their electricity bills in return for being available to reduce their consumption on request from the System Operator.
- Flexible Load Interruption Contract; an extension (Since 2002) of the (basic) Load Interruption Contract and allows customers to reduce their consumption following a specific profile, more appropriate to the real profile of the system load.

Input data

The input data is the schedule of energy demand submitted by clients participating in the Load Interruption Contract:

- At the beginning of the year, participant customers must submit a forecast for estimated energy consumption;
- Bimonthly, customers must submit to REE monthly schedules for hourly energy demand and maintenance planning.

Baseline definition and key parameters considered

Baseline energy is estimated with the schedules submitted by these clients; the key parameters considered for load interruption are the type of interruption depending on the duration (1-12 hours) and the warning time (0-2 hours).
Additional the energy consumption pattern is used based on the evolution from 2 years before and the forecast for the next 2 years

Savings calculation

Energy savings from this initiative are measured as a whole from the energy not consumed by the clients participating in each interruption. Responses from contracted customers are enough accurate as the probability of accepting the load reduction is very high.
Energy savings are highly related with load shape impact.

Load shape impact

The impact on load shape of energy savings can be considerable, as the grid operator decides when to launch the DR event (in periods of peak loads).
As an example, in an event with 164 participants that lasted for 3 hours, the load reduction was around 5%. This load in the system was measured with interval meters each 5 minutes:

- Large Industrial Customers Participating (number): 164
- Peak Load (MW): 45,000 MW
- Peak Load Reduction (MW and % of total demand): 2,300 MW (5,11%)
- Duration of Peak Load Reduction (hours): 3 hours
- Greenhouse Emissions Reduction (tCO_2-eq): Maximum 6.300 tCO_2 per year[11]
- How Load Reduction was Measured: Interval meter with 5 minutes

The load shape impact was measured over the global load curve at country level, since consumers with Load Interruption Contract represent a big share of energy consumed and their impact over the load shape is considerable.

Benefits to participants

In 2011, the budget for payments to costumers joining the interruptible service is 522 Million €.

Other benefits

For TSO, the main benefits are grid stability and the reduction of peak loads in the global system.
Additionally to energy savings and load peak reduction, greenhouse emissions reduction can also be calculated. In this case, GHG savings are considering the current factor for electricity generation.

11.3.5 The California DR State-wide Pricing Pilot Programme (SPP)

Summary

This DR programme was carried out 2003-2004 by The California Public Utilities Commission and the California Energy Commission under about 1,450 customers and a control group of 750. This programme has been

[11] GHG calculated considering the coefficient for the mix generation when this example was measured

implemented by Southern California Edison (SCE), San Diego Gas and Electric (SDG&E) and PacificGas and Electric (PG&E).
This program holds 3 rate forms, additional to the existing rate for residential customers:

1) An experimental rate (Time of USE; TOU), applicable state wide, holding a seasonal, different rate for fixed on-peak and off-peak time periods;
2) An experimental rate (Critical Peak Fixed; CPP-F), applicable state wide, holding a time-of-use rate with an additional ‘critical peak’ price that can be dispatched during the peak-period for up to 15 times each year, with day ahead notice;
3) An experimental rate (Critical Peak Variable; CPP-V), applicable to the target population only, holding a Critical Peak Fixed rate with a critical peak price that can be dispatched during the peak-period for 2-5 hours, with 4 hour advance notice.

Under the pilot the utility could call a critical peak event for up to 15 critical days of the year. A peak-period price was in effect between noon and 6 pm; during the experiment, the critical peak period was either 2 or 5 hours long.

Related DR initiatives

Since this programme, the number of US States and utilities with dynamic pricing programs continue to grow. By the end of 2009 sixteen States and more than twenty utilities offered programmes including critical peak pricing (CPP), real time pricing (RTP), and peak time rebate (PTR)/critical peak rebate (CPR) rate structures.

Input data

In the pricing pilot, the consumption data from customers is gathered through a software solution. With this software, the utility receives real-time energy consumption data.
The impacts of the programmes were analysed using two demand equations in a CES demand system. The models used four types of data: customer-specific load data; hourly temperature; customer characteristics; and electricity prices

Baseline definition and key parameters considered

Based on customer-provided survey information and hourly meter data, customers receive a monthly bill "Scorecard" with a personalized examination of the costs of air conditioning, lighting and other appliances during critical peak periods, and what can be saved by managing how those appliances are used. The current consumption can be considered as the baseline energy use.

Savings calculation

No overall reduction in energy consumption occurred on an annual basis within the CPP-F trial group.

Load shape impact

The average peak load reductions ranged from 12% to 40% of baseline peak usage for different customer types. The degree of reduction depended on the tariff rate, weather, customer appliance holdings, and availability and use of demand response controls:

- Average Residential peak period impacts held constant during multiple day peak pricing events usually associated with heat storms
- Small commercial customers (<20kW) reduced peak period demand on CPP days between 6% to 9%
- Medium commercial customers (>20kW but < 200kW) reduce peak period demand on CPP days between 8% to 10%
- Observed peak load impacts persist across multiple consecutive CPP days and across two years of the experiment.

Benefits to participants

Sending dynamic prices to residential customers led to average peak savings of 14% and bill savings of $60 per year. But about ¼ of the residential and commercial customers had a bill increase .The commercial customers, having a higher energy use than residential customers, on average had higher bill savings, up to over $ 2,000 per year.

Other benefits

The Pricing Impact Simulation Model (PRISM) Suite developed by the Edison Foundation can be used to quantify the benefits of dynamic pricing in the mass market. Its extends models are based on the 2003-2005 California State wide Pricing Pilot to estimate the change in consumption per customer resulting from dynamic pricing programmes. The PRISM Suite allows the user to input a dynamic rate structure, load shapes, weather data, and CAC saturations, then estimates customer bill savings and as well as utility benefits such as capacity cost savings, energy cost savings, and transmission and distribution cost savings.

11.4 Conclusions

No systematic energy savings calculations were applied in these DR programmes and so no methodological 'comparability' could be assessed in this respect. However energy savings were also reported in some of the programmes.

Savings/benefits are primarily related to energy cost savings because of load shifts towards periods with lower tariffs.

In only a very few of the EE programmes the demand response was indicated as a (potential) topic of relevance. So also these did not result in relationships between energy savings calculations and demand response changes and/or DR products.

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ANNEX A: TEMPLATE TO DOCUMENT AND REPORT ENERGY SAVINGS CALCULATION

1. Summary of the programme

1.1 Short description of the programme
1.1.1 Purpose or goal of the programme
1.1.2 Type of instrument(s) used

1.2 General and specific user category

1.3 Technologie(s) involved

1.4 Status of the evaluation and energy savings calculations

1.5 Relevant as a Demand Response measure

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings

2.2 Specification of the parameters in the calculation

2.3 Specification of the unit for the calculation

2.4 Baseline issues

2.5 Normalization

2.6 Energy savings corrections
2.6.1 Gross-net corrections
2.6.2 Corrections due to data collection problem

3 Input data and calculations

3.1 Parameter operationalisation

3.2 Calculation of the annual savings as applied

3.3 Total savings over lifetime
3.3.1 Savings lifetime of the measure or technique selected
3.3.2 Lifetime savings calculation of the measure or technique

4 GHG savings

4.1 Annual GHG-savings
4.1.1 Emission factor for energy source
4.1.2 Annual GHG-savings calculation as applied

4.2 GHG lifetime savings
4.2.1 Emission factor
4.2.2 GHG lifetime savings as applied

References

Annex

Definitions

ANNEX B: TEMPLATE ENERGY SAVINGS CALCULATION, WITH INSTRUCTIONS, FOR CASE EXAMPLES IN IEA-DSM TASK XXI

Front page:
Case application: [Name, including technology and user category]
Country: [Name]
Author(s): [Name]
Date and version: [day month year] [only full numbers of version]

Page 1
1 Summary of the programme

1.1 Short description of the programme
1.1.1 Purpose or goal of the programme
[Also include the period the programme was running or when it started.]

1.1.2 Type of instrument(s) used
[Please indicate the type of instrument used. E.g. financial support, subsidize, label and standard, agreements, tax reduction]

1.2 General and specific user category

[Please by a specific as possible. Make a clear distinction between households, industry, services (commercial and non-commercial. If more users are targeted, please give some specification, especially if formulas would be different for different user categories.]

1.3 Technologie(s) involved

[Present the technology or technologies; please clarify in case a not well-known technology is used]

1.4 Status of the evaluation and energy savings calculations

[Provide information whether the energy savings calculations are used in an evaluation report. Include references and source in the Annex]

[Provide information whether the energy savings calculations itself have been evaluated. Include references and source in the Annex]

[Use one of the following options to qualify the status: 1. Legal; 2. Official stamped; 3. Semi official; 4. Use in practice; 5. Under development; 6. Under research)

1.5 Relevant as a Demand Response measure

[Indicate when the case is relevant for DR; if so refer to the separate DR case application description]

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings
[Short introduction and provide information on the origin of the formula; please use one of the three options:

- an existing formula (give reference; also in reference list in Annex the traceable source), or
- an adapted version of an existing formula; please describe adaptations in short and give reference for the original formula (also in reference list in Annex the traceable source), or
- self developed (short description; present additional documentation in Annex)]

[Present the formula]

2.2 Specification of the parameters in the calculation

[Provide information on the parameters and the reasoning of selecting those parameters]

2.3 Specification of the unit for the calculation

[The most common units are: an object of assessment; an action or an energy end-user]

2.4 Baseline issues

[Brief description which type of baseline is used in the energy savings calculations. The most commonly used types are:

a. before situation; evaluate the measure against the technique used before
b. stock average; evaluate the measure against the average stock technique
c. market average; evaluate the measure against the average technique on the market
d. common practice; evaluate the measure against the most commonly used technique]

[Describe whether a static or a dynamic baseline is used.
The before situation is always a static baseline. The other methods can be either static (using the values of a base-year or base period) or dynamic

(changing over time, for example reflecting the change in most commonly used techniques)]
[Specify if a combination of approaches is used]

[Describe the important assumptions and the reasoning of the choice]

2.5 Normalization

[Normalization is a way to adjust the data in line with a normal situation; most common this is normalization for degree heating or cooling days.]
[Please describe briefly and give sources / references for the normal situation].

2.6 Energy savings corrections

2.6.1 Gross-net corrections

[Specify which (gross to net) corrections have been applied and how these are calculated. Please be clear in the corrections taken into consideration and used to correct.
[The most common categories are: a) double counting; b) free riders; c) technical interactions; d) spill over effects and e) rebound effect]

2.6.2 Corrections due to data collection problem

[Specify which corrections have been applied to handle imperfect data collections e.g. using sales data as a proxy for installation data, using a secondary data source for a bigger region than the region a programme is implemented]

3 Input data and calculations

3.1 Parameter operationalisation

[Describe how the calculation parameters are obtained; both for actual and reference situation.]

[Please also clearly indicate what type of values is used:
a) deemed (rough approximations, expert opinions, etc.)
b) calculated (for example using survey data)
c) measured (for example real measurements taken, billing information, etc.)
d) combination]

3.2 Calculation of the annual savings as applied

[Present the calculation with the values used. Please provide the data is several steps as this improves transparency and understanding]

3.3 Total savings over lifetime

3.3.1 Savings lifetime of the measure or technique selected

[Present information on the lifetime used. Also indicated whether this is an economical lifetime or not.]
[Present the number of years and the source for this value; include the reference in the Annex]

3.3.2 Lifetime savings calculation of the measure or technique

[Present the formula and the conducted calculation. In most cases this will be the outcome of 3.3.1 multiplied with the lifetime years. Please clarify if the energy savings calculated are not the same in all years. Explain if this is the case.]

4 GHG savings

4.1 Annual GHG-savings

4.1.1 Emission factor for energy source

[Present the emission factor used and give reference; included the source in the appendix.]
[Please specify what GHG emissions are included in the calculation: CO2; CH4 or N2O]

4.1.2 Annual GHG-savings calculation as applied

[Present the formula as well as the calculation]

4.2 GHG lifetime savings

4.2.1 Emission factor

[Present the emission factors used when not the same factor is used for the lifetime, and give reference; included the source in the appendix. Otherwise include: The same GHG emission factor(s) are used for the lifetime.]

4.2.2 GHG lifetime savings as applied

[Present the formula as well as the calculation]

[The lifetime should be the same as for the energy savings; if not please clarify]

References

[Please use: Report title, Author, year and if applicable the website]

Annex

[Present in the Annex additional information on methods, data sources etc. to elaborate the data, formulas etc]
[If no or no clear energy savings calculations is used in the case application, but a method could be used, please describe this in an Annex]

Definitions

[Provide definitions used for the target group, unit of saving etc.]

ANNEX C: LIST OF CASE APPLICATIONS PER TECHNOLOGY

Lighting for households

France	Households; Lighting
Republic of Korea	32W fluorescent lamps
The Netherlands	Lighting in households
Norway	No case application
Spain	Efficient lighting in the households
USA	Upstream Lighting Programs in California

Residential insulation

France	Households; Retrofit wall insulation
Republic of Korea	No case application
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

Heat pumps in households

France	No case application
Italy	Use of electric heat pumps to produce hot sanitary water in household plants, in place of conventional electric or gas water heaters
Republic of Korea	No case application
The Netherlands	Heat pumps in existing buildings
Norway	Electricity savings from heat pumps: The Norwegian Household Subsidy Programme
Spain	No case application
USA	No case application

Heating in commercial buildings programmes

France	Commercial buildings; Heating
Spain	Efficient boilers in commercial building

Air conditioning in commercial building/offices

France	No case application
Republic of Korea	No case application
The Netherlands	Air conditioners in commercial buildings
Norway	No case application
Spain	Centralized AC System in offices
USA	Comprehensive Commercial Building Energy Efficiency Program in New Mexico

Variable Speed Drive and High Efficient motors in industry

France	High Efficient electric motors
Republic of Korea	Variable Speed Drive (VSD)
The Netherlands	High Efficient electric motors
Norway	No case application
Spain	Installation of VSDs in electric motors
USA	No case application

ANNEX D: LIST OF DEMAND RESPONSE PROGRAMMES

France **Tempo Tariff**

This Demand Response programme carried out in France is related to Critical Peak Pricing (CPP) and is known as "Tempo" or "Tempo Tariff. This programme is a product designed for small consumers, every day the utility presents on its website the tariff for energy the next day with a colour: red (high tariff), white (medium high) or blue(cheaper).

Italy **Interruptible programmes**

in these programmes participants are required to reduce their load to predefined values. Interruptible Programmes are applied to very large industries only. Approximately, the interruptible power represents 6.5% of peak power. Until 2007 their official remuneration was determined by a decision of the energy authority. However, these compensations can be interpreted as forms of state subsidies to sectors facing economic difficulties. For participants who do not respond, they can face penalties.

Italy **Load shedding programmes**

In this programme, utilities have the possibility to remotely shut down participants' equipment at short notice. There are two types of programmes: real time programmes (without notice) and 15 min notice programmes.
The data for both programs correspond to the effects of the programmes in 2007 and 2008.

Republic of Korea No case application

The Netherlands No case application

Norway **Remote Load Control**

This Demand Response programme is related to load shifting or peak load reduction and was conducted in the period 2005-2008 as part of the Market based Demand Response project. The programme took 41 residential households, advised to buy energy with an hourly spot price contract, they got a time-of-day (TOD) network tariff which stimulated to load shifting, and RLC was offered as an "aid" to reduce load and costs in the peak hours. The key element on this program is variable price of energy, especially for predetermined peak load hours

Spain Interruptible service

This Demand Response programme contains an interruptible service, a Demand Response initiative since 2008 which key element is the possibility of cut electricity consumption by grid operator for some big industrial consumers who previously have sign a contract. The service is managed by Red Eléctrica de España (REE), the Electricity transmission operator. The project target is the whole electricity network, and the market segment addressed is large industrial electricity end users.
This project seeks to achieve three main objectives:

- Minimising outages
- Increasing operating reserve
- Reducing peak loads

USA Pricing Pilot Programme in California

The State-wide Pricing Pilot Programme (SPP) carried out 2003-2004 under about 1,450 customers and a control group of 750. This programme has been implemented by Southern California Edison (SCE), San Diego Gas and Electric (SDG&E) and PacificGas and Electric (PG&E).
This program holds 3 rate forms, additional to the existing rate:

1) Time of USE rate, applicable state wide, holding a seasonal, different rate for fixed on-peak and off-peak time periods;
2) Critical Peak Fixed rate, applicable state wide, holding a time-of-use rate with an additional 'critical peak' price that can be dispatched during the peak-period for up to 15 times each year, with day ahead notice;
3) Critical Peak Variable rate, applicable to the target population only, holding a Critical Peak Fixed rate with a critical peak price that can be dispatched during the peak-period for 2-5 hours, with 4 hour advance notice.

All three rate treatments were examined for residential customers.