Energy Savings Calculations for selected end use technologies and existing evaluation practices in The Netherlands

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

Each country prepared a report on the Energy Savings Calculations for selected end use technologies and existing evaluation practices. These reports are available at www.ieadsm.org

The report holds information on selected case applications. These cases are selected with a view to present information on the energy savings calculations that are or could be done for the selected end use technologies. The case applications are not selected as best practice examples, but are good examples for common practise.

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1. CASE APPLICATION

1.1 Introduction

The country experts discussed during the project 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-users. For this project 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 practise in a participating country, without suggesting that these are 'best practises'. They are a snapshot and sometimes also one of the applications that are in use in a country, but they clearly illustrate what key elements in the energy savings calculations are, how problems in data collections are handled and how default or standard values are used.

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

a. Industry; Variable Speed Drive and High Efficient motor
b. Commercial Buildings; Heating system
c. Commercial Buildings; Integrated Air conditioning system
d. Households; Retrofit wall insulation
e. Households; Lighting

For The Netherlands the following case applications are selected:

- High Efficient electric motors
- Heat pumps in existing buildings
- Air conditioners in commercial buildings
- Insulation and glazing
- Lighting in households

These case applications are presented from section 1.2 onwards with additional information in Annex B.

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

1. Summary of the program
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, one or more annex and on definitions

The template was improved during the project, based on experiences to present the information for case applications and discussions during the experts meetings. A workshop was held in April 2011 in Korea to get feed back on the final draft of the template. During the workshop three different case applications were presented to illustrate the use of the template and to discuss future application.
In Annex A the final version of the template with instructions is enclosed.

1.2 High Efficient electric motors

1 Summary of the program

1.1 Short description of the program.

High efficient electric motors and variable speed drives for motors are included in the annual tax relief programme (Energie Investerings Aftrek; EIA in Dutch). Dutch companies that invest in specific energy-saving equipments may deduct 44% of the investment costs for this equipment from their company's fiscal profit, over the calendar year in which the equipment was purchased.
The Energy List determines which types of equipment qualify for this programme. For the years 2006 – 2010 High Efficient motors (Hoogrendement elektromotoren in Dutch) were applicable.

1.1.1 Purpose or goal of the program
To stimulate (in an easy way) investments in new High Efficient electric motors to improve the energy efficiency.

1.1.2 Type of instrument(s) used

Tax reduction for the company's fiscal profit.

1.2 General and specific user category

All companies that are required to pay income tax or corporate taxes; this includes industrial companies as well as commercial services.

1.3 Technologie(s) involved

For the year 2009 and 2010 only high efficient motors up to 90 kW and meeting the EFF1 (CEMEP) efficiency class were included in the energy list.
For the years 2006, 2007 and 2008, additional to these, also HE motors above 90 kW and with an efficiency of at least 96% (measured following IEC) were included.

1.4 Status of the evaluation and energy savings calculations

The case application holds an approach to calculate savings. At the moment this is not in use. So the status of the calculation is considered as under research.

1.5 Relevant as a Demand Response measure

No

2 Formula for calculation of Annual Net Energy Savings

2.1 Formula used for the calculation of annual net energy savings

A. HE motors up to 90 kW and meeting the EFF1 (CEMEP):
No formula is used. When the motor meets EFF1, a tax reduction is granted.

B. HE motors above 90 kW and with an efficiency of at least 96% (measured following IEC)
With the tax reduction application form an energy savings calculation should be provided; no formula is suggested. In practice no application was done for this type of motors

2.2 Specification of the parameters in the calculation

In the Annex background information relevant for a potential formula with calculation parameters is included.

2.3 Specification of the unit for the calculation

The unit is an electric motor.

2.4 Baseline issues

As no energy savings calculation is conducted, no baselines are set.

2.5 Normalization

No normalization is conducted.

2.6 Energy savings corrections

2.6.1 Gross-net corrections

No gross to net corrections are used.

2.6.2 Corrections due to data collection problem

As the formula is not implemented yet, no corrections due to data collection problems are conducted.

3 Input data and calculations

3.1 Parameter operationalisation

Table 1 holds the information on the subsidised HE motors. As no applications were done for bigger motors, all numbers are for the smaller one.

Table 1: Numbers of high efficient (HE) motors in the EIA 2006-2009

Year	HE electric motors <= 90 kW	HE electric motors > 90 kW	Total
2006	67	0	67
2007	31	0	31
2008	38	0	38
2009	30	Not applicable	30

3.2 Calculation of the annual savings as applied

No calculation conducted.

3.3 Total savings over lifetime

3.3.1 Savings lifetime of the measure or technique selected

Default value of 8 year for electric motors can be taken from CWA 27. The EIA does not count with savings over lifetime.

3.3.2 Lifetime savings calculation of the measure or technique

No calculation conducted.

4 GHG savings

4.1 Annual GHG-savings

4.1.1 Emission factor for energy source

The Dutch ISSO publication 75.2 holds following average value for GHG emission factor for electricity: 0,566 kg CO_2/kWh.

A recent study (Harmelink et all, 2012) holds information on the development of the GHG emission factor since 2000 and the method used to calculate the efficiency of the electricity production. Using the 'integrated method' the average value for 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 is from 0.59 kg CO_2/kWh in 2000 to 0.53 in 2010.

4.1.2 Annual GHG-savings calculation as applied

As no energy savings were calculated, also no GHG savings are calculated.

4.2 GHG lifetime savings

4.2.1 Emission factor

For the lifetime savings the same emission factor as for the annual savings is used

4.2.2 GHG lifetime savings as applied

As no energy savings were calculated, also no GHG savings are calculated.

References

CEMEP website www.cemep.org

Commission Regulation (EC) No 640/2009 of 22 July 2009

Implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors

EIA, Annual reports 2006-2009
EIA, Annual energy lists 2006-2009
EMEEES bottom up case application 12: high efficient motors, April 2009

Harmelink, M., Bosselaar, L., Gerdes, J., Boonekamp, P., Segers, R/. Pouwelse, H., Verdonk, M., Calculating CO_2 emissions, primary fossil energy use and the Dutch efficiency in electricity production (Berekening van de CO_2-emissies, het primair fossiel energiegebruik en het rendement van elektriciteit in Nederland), in Dutch, 2012 forthcoming

ISSO publication 75.2; source for GHG emission factor for electricity

Annexes (in Annex B):

Annex B1: Potential formula for High Efficient electric motors
Annex B2: Future development relevant for standardisation HE motors

1.3 Heat pumps in existing buildings

1 Summary of the program

1.1 Short description of the program

There are two programs in The Netherlands that stimulate the usage of heat pumps in existing buildings:

- More With Less ("Meer Met Minder")
- Annual tax deduction program EIA (Energie InvesteringsAftrek).

More With Less
In The Netherlands the program "Meer Met Minder" (En: "More With Less") has started in 2009. On a national level "More With Less" stimulates energy savings in existing dwellings and other buildings. It is a covenant between the Government, the energy companies, the construction and the installation sector. It aims to achieve its objective by removing impediments in the market, stimulating cooperation between providers, mobilising intermediary organisations and facilitating homeowners. [ref1]
EIA
Dutch companies that invest in specific energy-saving equipments may deduct 41,5% of the investment costs for this equipment from their company's fiscal profit, over the calendar year in which the equipment was purchased.
The Energy List determines which types of equipment qualify for this program. The list contains items for which energy savings need to be proven beforehand, and specific measures for which this is not necessary. There is also a general category called 'Energy performance improvement of existing industrial and commercial buildings'. When applying for tax deduction in this category, amongst other things, it is required to

- have an energy scan made according to a standard that determines the energy label of a building.
- demonstrate a minimum improvement in energy label of two energy classes or arrive at a minimum of label B.

The energy calculation method used to calculate savings in the energy scan (called "EPA-U", Energy Performance advice for commercial buildings and EPA-W Energy Performance advice for dwellings) is also part of the regulations implemented as a consequence of the EPBD. [ref 2]

1.1.1 Purpose or goal of the program

More With Less
The goal of this program is to make existing buildings 20 to 30% more energy efficient compared to building in 1990, on average. [ref3]
EIA
To stimulate investments in improving the energy performance of commercial and non-commercial buildings. The tax deduction program has been in place for more than ten years. The energy list is updated every year as is the deduction percentage.

1.1.2 Type of instrument(s) used

More With Less
Multiple instruments are used:

- Subsidy within Sustainable Heat scheme ("Duurzame Warmte").
  Up to 10 kW_{th} for water/water or brine/water heat pumps: € 500,- / kW_{th}.
  €250,- /kW_{th} for each kW_{th} above 10 kW_{th}.[1]
  For air/water heat pumps: €2.000 per heat pump. [ref 4]
- Scheme Green project ("Regeling Groenprojecten"). Discount on interest rate (~1,5%) for a loan (max 15 years) to be used for heat pumps (and solar panels, solar collectors or increase with 4 energy labels). The discount is possible because people receive a tax advantage when saving or investing in sustainable funds. The tax advantages are going to be reduced to 0 in 2014, therefore the scheme will most probably die a silent death... [ref 5]
- Energy savings Credit (Energiebesparingskrediet): It is possible to borrow money with a 1% lower interest percentage because the Government will guarantee the repayment of the loan. [ref 4]

EIA
The 'EIA' program is a tax deduction program for companies.

1.2 General and specific user category

More With Less
All instruments are applicable for Dutch existing dwellings over 2 years old. For the discount and the energy savings credit it is needed to be both owner and occupier of the dwelling.
EIA
All companies that are required to pay income tax or corporate taxes; this includes industrial companies as well as commercial services and housing associations.

1.3 Technologie(s) involved

More With Less
Depending on the instrument:

- Subsidy within Sustainable Heat scheme
  Water/water or brine/water heat pumps
  Air/water heat pumps
- Scheme Green projects ("Regeling Groenprojecten").
  Water/water with COP $\geq$ 4
  Brine/water heat pumps with COP $\geq$ 3.2
  Heat pumps used for space heating with water as distribution source.
- Energy savings Credit (Energiebesparingskrediet)
  Heat pumps (both electric or gas fired) for space heating and/or domestic hot water with a heat pump certificate ("warmtepompkeurmerk").

[1] For 15 kWth: 10 x € 500 + 5 x 250) = € 6.250 in total.

EIA
Several kinds of heat pumps are represented on the Energy List. They have to be used for heating of commercial buildings or collectively heated dwellings (one heat pump per dwelling is not applicable for the EIA). For each heat pump a minimum efficiency is stated to assure the use of top of the bill technology. Both electrical as gas fired absorption and adsorption heat pumps are listed. Both ground, air and waste heat can be used as a source for the heat pumps. [ref 2]

1.4 Status of the evaluation and energy savings calculations

More With Less
There is no evaluation of the amount of energy saved by the program. There is only an evaluation of certain programs within Meer Met Minder to stimulate home owners to take energy saving measures. This is an evaluation with a psychological perspective trying to find out which sort of programs where able to reach home owners and why/why not.
EIA
Concerning the EIA: an ex-post evaluation has been performed in 2007 for the EIA as whole [ref 11]. An exact quantification of savings was not done due to limited data and because the EIA is part of a mix of instruments.

The calculation for energy use is based on ISSO standards that could be considered as official stamped. But as in practice the baseline is depending on the selection made by the researcher, the. status of the calculation of the energy savings is considered as “use in practice”.

1.5 Relevant as a Demand Response measure

No (for both instruments)

2 Formula for calculation of Annual Energy Savings

2.1 Formula used for the calculation of annual energy savings.

Energy savings for existing buildings are generally calculated based on ISSO 82 - Energy Performance Advise [ref 6] - Dwellings and ISSO 75 - Energy Performance Advice - Commercial buildings [ref 6].

ISSO 82 and 75 are the implementation of the EPBD in The Netherlands. Some measures within More With Less actually ask for the increase of 1 or 2 energy labels, calculated via this method. In the EIA a reference to the energy labels is also made.

The calculations for dwellings and commercial buildings are similar, but not exactly the same. For this reason this chapter will follow ISSO 82. Appendix I will contain the same information based on ISSO 75.

2.1.1 Specification of the formula

Formula for use of heat pump in dwellings
An Energy Index can be calculated for a building with formula 1 [ref6]:

$$EI = \frac{Q_{tot}}{155 A_g + 106 A_{verlies} + 9560} \qquad (1)$$

For the purpose of calculating energy savings only Q_{tot} is needed, which is the total primary energy usage of a building.
Mostly the EI is specified for a certain building, it translates in an energy label (A / G) to be able to compare different types of buildings. With formula 1 Q_{tot} can always be calculated.

Q_{tot} consists of several components (energy usage for space heating, domestic hot water, pumps en ventilation, lighting minus energy supply via solar panels or CHP), as stated below in formula 2.

$$Q_{tot} = Q_{rv} + Q_{tap} + Q_{hulp} + Q_{verl} - Q_{pv} - Q_{wkk} \qquad (2)$$

Heat pumps influence both Q_{rv} and Q_{tap} but not the other energy demands in equation 2. Within ISSO 82 heat pumps are not stated as an option to use as a supply for domestic hot water, therefore the focus here is on space heating.

$$Q_{rv} = \frac{Q_{beh,;verw;bruto} - Q_{ze;vewr}}{\eta_{opw,verw}} + Q_{waakvlam} \qquad (3)$$

This is where the difference in heating system comes in. In table 1 several efficiencies are stated. It is also possible to use another efficiency based on a quality statement for the installation.
When a bivalent system is used an overall efficiency can be calculated depending on the coverage of the individual systems.

Table 1: Efficiencies for a number of space heating installations

Installation	**Efficiency ($\eta_{opw,verw}$)**
Electrical heating	0,39
Efficient gas boiler (HR-107)	0,975 ($T_{supply} \leq 55°C$) 0,95 ($T_{supply} > 55°C$)
District heating	1
Heat pump - ground source	1,72 ($T_{supply} \leq 35°C$) 1,6 ($T_{supply} > 35°C$)
Heat pump - groundwater source	1,95 ($T_{supply} \leq 35°C$) 1,79 ($T_{supply} > 35°C$)
Heat pump - air source	1,48 ($T_{supply} \leq 35°C$) 1,37 ($T_{supply} > 35°C$)

The formulas below are independent of the heating system but show how the heat demand for a dwelling is calculated.

$$Q_{beh;verw;bruto} = \frac{Q_{stook}}{\eta_{sys}} \qquad (4)$$

$Q_{beh,verw,bruto}$ is the heat demand of the dwelling (Q_{stook}), divided by the system efficiency for installations, other then local heating. This system efficiency is dependent on the availability of individual metering and heat loss through pipes depending insulation and supply heat temperature.

$$Q_{stook} = Q_{verlies} - \eta_b Q_{winst} - Q_{serre} \qquad (5)$$

The heat demand for the dwelling is heat losses through ventilation and transmission ($Q_{verlies}$) minus internal heat gains and heat gains from the sun (Q_{winst}) multiplied with a utilization factor minus heat gains from a sun room.

2.2 Specification of the parameters in the calculation

Parameters used in formula 1:

Q_{tot} = Total primary energy usage of building (standard conditions) [MJ/yr]
A_g = Useful surface area (gebruiksoppervlakte) [m^2]
$A_{verlies}$ = Area of heat loss (verliesoppervlakte) [m^2]

Parameters used in formula 2:

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

Q_{wkk} = Energy supply micro-CHP [MJ/yr]

Parameters used in formula 3:
Q_{rv} = Energy use for space heating [MJ/yr]
$Q_{beh;verw;bruto}$ = Gross heat demand for space heating [MJ/yr]
$Q_{ze;verw}$ = yearly contribution of solar-energy system (e.g. solar collector) for space heating [MJ/yr]
$Q_{waarkvlam}$ = Primary energy use for pilot (flame for gas boiler) [MJ/yr]
$\eta_{opw,verw}$ = Efficiency of space heating installation
Parameters used in formula 4:
$Q_{beh;verw;bruto}$ = Gross heat demand for space heating [MJ/yr]
Q_{stook} = Heat demand for dwelling [MJ/yr]
η_{sys} = System efficiency of space heating installation

Parameters used in formula 5:
Q_{stook} = Heat demand for dwelling [MJ/yr]
$Q_{verlies}$ = Total heat losses [MJ/yr]
η_{b} = Utilization factor for heat gains
Q_{winst} = Heat gains [MJ/yr]
Q_{serre} = Heat gains through sun room [MJ/yr]

2.3 Specification of the unit for the calculation

The unit of calculation is one individual dwelling. The energy usage is based on one year (see also paragraph 2.5)

2.4 Baseline issues

The baseline of a separate dwelling is the energy usage per year corresponding with the energy label before any energy savings measurements are taken. The energy label and energy index are calculated as stated above.
This is a "before situation" with a static baseline. The baseline is different for each specific dwelling depending on the way the dwelling was built and which techniques where used. For calculating the baseline the same assumptions hold as for calculating the energy savings (see paragraph 2.5)

2.5 Normalization

Calculations are made based on standard conditions [ref6]:

- Test Reference Year of De Bilt (NL)
  - Average $T_{outside}$ = 5.64°C during heating season (212 days - 1st of October to 30th of April)
- T_{inside} = 18°C
- Specified number of residents (depending on used floor area of dwelling)
  - Range 1,4 - 3,2 residents (see table 2)

- Ventilation based on NEN 5128 (Dutch regulations)
- Internal heat production 6 W/m^2
- Electricity use per year for lighting: 6 kWh/m^2
- Yearly net energy demand for domestic hot water based on number of residents, type of appliance for domestic hot water supply, type of water users (showers, baths etc).

Table 2: Number of residents dependent on floor area

Used floor area [m^2]	**Number of residents**
< 50	1,4
50 tot 75	2,2
75 tot 100	2,8
100 tot 150	3,0
~ 150	3,2

2.6 Energy savings corrections

2.6.1 Gross-net corrections

No gross to net corrections are used.
If gross to net calculations would be done there would be probably be an interaction effect between several technologies since an improvement of an energy label will most often be accomplished through applying several measurements

2.6.2 Corrections due to data collection problem

No corrections due to data collection problems are conducted.

3 Input data and calculations

This chapter will focus on the input data and calculations for dwellings. The same exercise is done for commercial buildings and can be found in appendix I

3.1 Parameter operationalisation

Reference situation
For the reference situation trained Energy Label Advisors will go to the dwelling and gather information of the dwelling. The method is based on ISSO 82.2 Handleiding EPA-W maatwerkadvies [ref9]. Gathered information is input for energy label calculation software based on ISSO 82.3 [ref6].
Information to be gathered is:
General information:

- year of construction
- situation of ownership
- type of dwelling
- orientation

- number of storeys
- type of roof
- floor usage area per storey
- sun room including number of storeys and orientation
- preheating of ventilation air in sun room
- existence of closed balcony or gallery
- preheating of ventilation air in closed balcony/gallery

Architectural information:

- area, construction, orientation of construction-elements
- to which each construction-elements is adjacent
- existence of heated or unheated attic
- placement, area and orientation of glazing
- kind of glazing including solar factor (Dutch: ZTA waarde)

Actual situation

With the information gathered in the reference situation and the used installation for space heating replaced with a heat pump the new energy demand can be calculated with the same software. The difference between the reference and the actual situation is the energy saving.

3.2 Calculation of the annual savings as applied

As stated in paragraph 2.4 the baseline is the calculation as shown in chapter 2. In The Netherlands the majority of dwellings are heated with a central heating boiler (95%) of which 80% has a high efficiency boiler [ref12].
Calculating the energy savings is done by making the same calculation again with efficiency corresponding to a heat pump (actual situation). The difference is the total primary energy saved due to replacement of the high efficiency boiler with a heat pump.

To calculate the energy savings in consumer units both the saving in m^3 gas need to be calculated and the extra energy usage of electricity need to calculated.
From primary energy to m^3 of gas divide by 35,17 MJ/m3.
From primary energy to kWh of electricity divide by 0,39 (efficiency Dutch power plant in these calculations) and 3,6 MJ/kWh [ref6].

Example - Energy savings - Heat pump instead

The most common dwelling in The Netherlands is a town house built between 1975 and 1991. It has a usable area of 106 m^2 and therefore the number of residents is 3. Space heating and domestic hot water is supplied with a condensing boiler. Ventilation is done naturally.
The Rc-values of the facade is 0,36 m^2K/W and both single and double glazing is used with U-values of 5,20 or 2,90 W/m^2K. Rc-values for floor and roof are 0,17 and 1,30 m^2K/W
The temperature of the supply system is on a high temperature

If the condensing boiler is replaced by a heat pump the townhouse will use less primary energy. Both situations (reference and actual) are presented in table 3.
The savings are 23 GJ in primary energy. The consumer will need 1.515 m3 less gas, but 3.260 kWh more electricity.
Since a heat pump would preferably not be used in combination with a high temperature supply system another situation is added where a low temperature supply system is used. This saves 280 kWh of electricity.

Table 3: Energy usage before and after replacement of glazing [ref10]

	Reference situation	**Actual situation Heat pump**	**Actual situation Heat pump + low temperature system**
Energy Index	1,89	1,34	1,28
Energy Label	D	C	B
Total primary energy use	80 GJ	57 GJ	54 GJ
Usage of gas	2030 m^3	515 m^3	515 m^3
Usage of electricity	925 kWh	4185 kWh	3905 kWh

3.3 Total savings over lifetime

No calculations of the savings over a lifetime are done.

3.3.1 Savings lifetime of heat pumps in existing buildings

No calculations are conducted.

3.3.2 Lifetime savings calculation of heat pumps in existing buildings

No calculations are conducted.

4 GHG savings

4.1 Annual GHG-savings

Within the energy label calculations the total CO_2 emission is calculated. No other GHG-emissions are taken into account.

4.1.1 Emission factor for energy source

Emission factor gas	1,78 kg CO_2/m^3
Emission factor heat distribution	87,7 kg CO_2/GJ
Emission factor electricity	0,566 kg CO_2/kWh

[ref6]

4.1.2 Annual GHG-savings calculation as applied

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). [ref6]

Heating value of Dutch Natural Gas 35,17 [MJ/m^3]
Efficiency of Dutch Electricity generation 0,39

4.2 GHG lifetime savings

Since no lifetime is specified, no GHG lifetime savings can be calculated.

References

[1] De markt in beweging - annual report Meer Met Minder 2009, MeerMetMinder, 2009
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[11] www.rekenkamer.nl - Ex-post evaluatie Energie Investeringsaftrek (EIA), SEO, 2007, Tweede Kamer 31492-8,
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Annexes (in Annex B):

Annex B3: Formula for calculation of annual energy savings for heat pumps in non-domestic buildings

1.4 Air conditioners in commercial buildings

1 Summary of the program

1.1 Short description of the program

Air conditioners are included indirectly in the annual tax deduction programme (Energie Investerings Aftrek; EIA in Dutch). Dutch companies that invest in specific energy-saving equipments may deduct 41,5%[2] of the investment costs for this equipment from their company's fiscal profit, over the calendar year in which the equipment was purchased.
The Energy List determines which types of equipment qualify for this programme. The list contains items for which energy savings need to be proven beforehand, and specific measures for which this is not necessary. There is also a general category called 'Energy performance improvement of existing industrial and commercial buildings'. When applying for tax deduction in this category, amongst other things, it is required to

- have an energy scan made according to a standard that determines the energy label of a building[3].
- demonstrate a minimum improvement in energy label of two energy classes or arrive at a minimum of label B.

Reducing cooling demand as well as putting in place more efficient cooling supply is rewarded in the standardized energy calculation method.

The energy calculation method used to calculate savings in the energy scan (called "EPA-U", Energy Performance advice for commercial buildings) is also part of the regulations implemented as a consequence of the EPBD. Whenever a commercial building is sold or rented to a new tenant, it is obligatory to perform an energy scan and to obtain an energy label.

1.1.1 Purpose of goal of the program

To stimulate investments in improving the energy performance of commercial buildings. The tax deduction programme has been in place for more than ten years. The energy list is updated every year as is the deduction percentage.

1.1.2 Type of instrument(s) used

The 'EIA' program is a tax deduction program for companies.

1.2 General and specific user category

All companies that are required to pay income tax or corporate taxes; this includes industrial companies as well as commercial services.

1.3 Technologie(s) involved

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[2] This is the percentage applicable for 2011.

[3] ISSO 75.2 describes the procedure to determine the energy index of the building, and 75.3 contain the formula structure.

Specifically for air conditioning (generation of cold) the following technologies are possible[4]:

1. Compression cooling: a) piston compressors up to 800 kW, b) screw compressors ~ 500 – 2000 kW and c) centrifugal compressors ~ 500 – 2000 kW.
2. Seasonal cold storage: a) the soil is charged with cold in the winter time and released in the summer time through cooling ventilation air or through local cooling systems (fancoils or cooled ceilings) and b) cold storage in combination with heat storage, sometimes including a bidirectional heat pump (= compression cooling)
3. Absorption cooling, preferably using waste heat. The higher the temperature the better the performance.

1.2 Status of the evaluation and energy savings calculations

The energy savings calculations for the whole building are part of an "EPA-U". In 2009 a new version of the standardized calculation method has been published.
These savings estimates the actual energy use and an advice is produced based on general accepted default values for energy saving measures. The status of the calculation method is 'used in practice'.
Concerning the EIA: an ex-post evaluation has been performed in 2007 for the EIA as whole[5]. An exact quantification of savings was not done due to limited data and because the EIA is part of a mix of instruments.

1.4 Relevant as a Demand Response measure

No.

2 Formula for calculation of Annual Net Energy Savings

2.1 Formula used for the calculation of annual energy savings

Below the approach to calculating the cooling consumption according to ISSO 75.3 (Calculation methods 'EPA-U') is given. The method is rather detailed and the parameters used in the main formulas refer to other more detailed formulas. The main formulas are reported here. In addition, a simpler method for calculating savings from more efficient air conditioning is reported in Annex A. This simpler method is used in a European Ecodesign preparatory study on air-conditioners for commercial buildings.

2.1.1 Specification of the formula

The yearly demand for cooling is obtained by summing up the monthly demands:

$$Q_{cool,yr} = \sum_{i=1}^{12} Q_{cool,c,i}$$

The monthly demand is determined through the following formula:

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[4] ISSO 75. 2 p. 95.

[5] Ex-post evaluatie Energie Investeringsaftrek (EIA), SEO, 2007, Tweede Kamer 31492-8, www.rekenkamer.nl

$$Q_{cool,c,i} = f_{latent}(Q_{solar} + Q_{internal}) - \eta_b(Q_{tr} + Q_{vent})$$ MJ[6]

This formula holds for months where the ratio of heat loss (through transmission and ventilation) to heat gain (solar and internal) is less than 2.5. If it is larger, there is no cooling demand.

In the simplest case, the yearly energy consumption due to cooling is

$$Q_{c-consumption,yr} = \frac{Q_{cool,yr}}{\eta_{gen}}$$

Efficiencies to be used for the different types of cooling are listed in the table I below

Table 1: Generation efficiency of various forms of cold supply

Types of cooling	**Generation efficiency η_{gen}**	**Fuel type**
Compression cooling	4 x η_{el}	Electricity
Absorption cooling with 3rd party heat supply	0.7 x η_{heat}	Heat
Absorption cooling on CHP	1.0 x $\eta_{wkk,th}$	Gas
Cold storage	12 x η_{el}	Electricity
Heat pump in cooling mode in summer	5 x η_{el}	Electricity

The generation efficiencies are 'safe' numbers based on experience[7]

It could be that multiple cooling installations are applied simultaneously. In that case, there is always one system used preferentially. In case of absorption cooling with compression cooling, the absorption cooling is used preferentially. In other cases, the cooling supply with the highest efficiency is used preferentially. This then needs to be accounted for in resulting generation efficiency:

$$\eta_{gen,res} = \frac{1}{\frac{\alpha_{cool}}{\eta_{gen,pref}} + \frac{(1-\alpha_{cool})}{\eta_{gen,npref}}}$$

2.2. Specification of the parameters in the calculation

$Q_{cool,yr}$ = yearly cooling demand
$Q_{cool,c,i}$ = monthly cooling demand, corrected for latent cooling demand
f_{latent} = correction factor for latent cooling demand (=1.1)
Q_{solar} = solar heat gain into the building
$Q_{internal}$ = internal heat gain in the building
η_b = a utilization factor for cooling, which is dependent on the ratio heat loss / heat gain per month.
Q_{tr} = heat gain through transmission

[6] ISSO 75.3 §3.8.1

[7] Communication with ISSO

Q_{vent} = heat gain through ventilation
$Q_{c\text{-}consumption}$ = cooling consumption
η_{sys} = system efficiency (efficiency of cold distribution and cold transfer)
η_{gen} = efficiency of the cooling machine
η_{el} = efficiency of electricity generation (0.39)[8]
η_{heat} = efficiency of 3rd party heat generation (1)[9]
$\varepsilon_{wkk,th}$ = thermal efficiency of CHP (0.40 – 0.57, depending on scale and type of CHP)[10]
$\eta_{gen,res}$ = resulting efficiency of the cooling machine when multiple supplies are used
$\eta_{gen,pref}$ = efficiency of the cooling machine that is used preferentially
$\eta_{gen,npref}$ = efficiency of the other cooling machine(s)
α_{cool} = ratio of cold demand met by supply with the highest efficiency and the total cold demand (=0.8)

2.3. Specification of the unit for the calculation

The unit of calculation is one building. All units of heat or cold transfer are in MJ per year, primary energy. The final outcome of an EPA-U calculation is MJ_{prim}/yr of the building, and the energy label of the building (A –G).

2.4. Base line issues

Energy savings as a result of renovation of a building are calculated with respect to the situation before the renovation. The same formulas are used in the before and the after situation. The renovation of the building could change the heat load into and out of the building, which will affect cooling demand and cooling consumption. If the cooling installation itself is improved, this will have an effect on the resulting efficiency of the cooling installation. Thus, the energy savings are only due to the improved efficiency of the cooling system.
For example, when going from compression cooling to cold storage the efficiency changes from $4*\eta_{el}$ to $12*\eta_{el}$.

2.5. Normalization

For calculation of heat loss through transmission and ventilation, an indoor temperature of 24ºC is used. As reference for the outdoor temperature, a Test Reference Year in De Bilt is used.
For ventilation, an average monthly temperature for ventilation is used. The average monthly temperature and average monthly ventilation temperature are reported in the table below.

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[8] ISSO 75.3 table 1

[9] ISSO 75.3 table 2

[10] ISSO 75.3 table 55

Table 2: Average monthly temperature and average monthly outdoor temperature for ventilation, for a Test Reference Year in De Bilt[11].

Month	**T_e (ºC)**	**$T_{e;vent}$ (ºC)**
January	2.5	16.0
February	2.7	16.0
March	5.6	16.0
April	8.0	16.0
May	11.9	16.0
June	15.5	17.0
July	17.0	18.5
August	16.4	17.9
September	13.8	16.0
October	11.2	16.0
November	6.0	16.0
December	3.4	16.0

The cooling season is approximately from May through September. However, whether there is actual cooling need in a given month depends on the ratio of heat loss (through transmission and ventilation) to heat gain (solar and internal) in that particular month for a given building. If it is less than 2.5, there is cooling demand.
The outdoor temperature for ventilation is always 16.0 ºC in winter months.

2.6. Energy saving corrections

2.6.1. Gross-net corrections

No gross-net corrections take place.

2.6.2. Corrections due to data collection problems

No corrections due to data collection problems take place.

3 Input data and calculations

This chapter will focus on the input data and calculations for dwellings. The same exercise is done for commercial buildings and can be found in annex B4.

3.1 Parameter operationalisation

An EPA advisor assesses the situation in the building before renovations as specified in the ISSO 75.1 standard. This entails obtaining the necessary parameters on dimensions of the building, window area, type of insulation, type of cooling installation, in considerable detail.

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[11] ISSO 75.3 §3.2.1

3.2 Calculation of the annual savings as applied

The calculations are done with attested software. Results are reported in terms of overall primary energy consumption and the energy label of the building.
An example calculation is made with an office building of 10.000 m^2 with a D-label. Results are shown in table 3.
The cooling method before is compression cooling. The cooling method upon improvement is cold storage and a cooling tower, the 4th option from table 1.

Table 3: Example calculation improved cooling[12]

	Reference situation	**Actual situation Improved air conditioning**
Energy Label	D	D
Floor space	10.000 m^2	10.000 m^2
Total energy consumption	835 MJ_{prim}/m^2	797 MJ_{prim}/m^2
Energy consumption due to cooling	57 MJ_{prim}/m^2	19 MJ_{prim}/m^2
Savings primary energy m^2		38 MJ_{prim}/m^2

3.3 Total savings over lifetime

3.3.1 Savings lifetime of air conditioners in commercial buildings

The calculations are based on yearly consumption and therefore also yearly savings (under standardized climatological conditions).

3.3.2 Lifetime savings calculation of air conditioners in commercial buildings

No calculations are conducted.

4 GHG savings

4.1 Annual GHG-savings

Within the energy label calculations the total CO_2 emission is calculated. No other GHG-emissions are taken into account.

4.1.1 Emission factor for energy source

Emission factor gas	1,78 kg CO_2/m^3
Emission factor heat distribution	87,7 kg CO_2/GJ
Emission factor electricity	0,566 kg CO_2/kWh

[12] Calculations are carried out with “Energie Prestatie Advies voor Utiliteitsbouw (EPA-U)”. The program reports ‘certificate’ calculations and ‘advice’ calculations. The calculation methods are largely the same, but there are some differences. The calculations used for the ‘advice’ calculations contain more degrees of freedom. Since the formula reported are those used for the certificate calculations, these numbers are used.

4.1.2 Annual GHG-savings calculation as applied

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).

Heating value of Dutch Natural Gas	35,17 [MJ/m3]
Efficiency of Dutch Electricity generation	0,39

As no energy savings were calculated, also no GHG savings are calculated.

4.2 GHG lifetime savings

4.2.1 Emission factor

N/A

4.2.2 GHG lifetime savings as applied

N/A

References

1. ISSO publication 75.2, Maatwerkadvies (tailor made advice)
2. ISSO publication 75.3, Handleiding Energieprestatie advies utiliteitsgebouwen, formulestructuur (manual energy performance advice commercial buildings, formula structure), 2009.
3. Lot 6: Air conditioning and ventilation systems, Draft report of Task 1, June 2010, coordinated by Philippe RIVIERE, ARMINES, France, p. 244 – 247.

Annex (in Annex B):

Annex B4: A simpler energy savings calculations for air conditioners in commercial buildings

1.5 Insulation and glazing

1 Summary of the program

1.1 Short description of the program

In The Netherlands the program "Meer Met Minder" (En: "More With Less") has started in 2009. On a national level "More With Less" stimulates energy savings in existing dwellings and other buildings. It is a covenant between the Government, the energy companies, the construction and the installation sector. It aims to achieve its objective by removing impediments in the market, stimulating cooperation between providers, mobilising intermediary organisations and facilitating homeowners. [ref1]

1.1.1 Purpose or goal of the program

The goal of the program is to make existing buildings 20 to 30% more energy efficient compared to building in 1990, on average. [ref2]

1.1.2 Type of instrument(s) used

Multiple instruments are used.

- VAT decrease: For the promotion of insulation in existing dwellings the VAT on labour is temporarily decreased from 19% to 6%. If the costs for labour are more then 50% then the total costs (labour and materials), the VAT on materials also decreases from 19% to 6%.
- Discount: For the promotion of insulation glass (U < 1,6 W/m2K) a discount of € 35,- per m2 installed glass is given (discontinued).
- Energy savings Credit (Energiebesparingskrediet): It is possible to borrow money with a 1% lower interest percentage because the Government will guarantee the repayment of the loan. The money can be used for insulation and glazing improvement of existing dwellings up to the values of existing building regulations.

1.2 General and specific user category

All instruments are applicable for Dutch existing dwellings over 2 years old. For the discount and the energy savings credit it is needed to be both owner and occupier of the dwelling.

1.3 Technology(s) involved

Insulation and glazing with R and U values of at least the values as stated in Dutch building regulation (Bouwbesluit). R-value > 3,5 m2K/W, U-value < 1,6 W/m2K, respectively.

1.4 Status of the evaluation and energy savings calculations

There is no evaluation of the amount of energy saved by the program. There is only an evaluation of certain programs within Meer Met Minder to stimulate home owners to take energy saving measures. This is an evaluation with a psychological perspective trying to find out which sort of programs where able to reach home owners and why/why not.

1.5 Relevant as a Demand Response measure

No.

2 Formula for calculation of Annual Net Energy Savings

2.1 Formula used for the calculation of annual energy savings

Energy savings for existing buildings are generally calculated based on ISSO 82 - Energy Performance Advise - Dwellings. ISSO 82 is the implementation of the EPBD in The Netherlands. Some measures within Meer Met Minder actually ask for the increase of 1 or 2 energy labels, calculated via this method.

An Energy Index can be calculated for a building with formula 1 [ref3]:

$$EI = \frac{Q_{tot}}{155 A_g + 106 A_{verlies} + 9560} \qquad (1)$$

For the purpose of calculating energy savings only Qtot is needed, which is the total primary energy usage of a building.
Mostly the EI is specified for a certain building, it translates in an energy label (A / G) to be able to compare different types of buildings. With formula 1 Qtot can always be calculated.

Qtot consists of several components (energy usage for space heating, domestic hot water, pumps en ventilation, lighting minus energy supply via solar panels or CHP), as stated below in formula 2.

$$Q_{tot} = Q_{rv} + Q_{tap} + Q_{hulp} + Q_{verl} - Q_{pv} - Q_{wkk} \quad (2)$$

Insulation has an affect on energy demand for space heating (Qrv) only. Qrv is calculated based on the gross space heating demand of the building and the efficiency of the used space heater. The gross space heating demand is the total heat loss minus the heat gains (consisting of solar irradiance and internal heat gains) minus the heat gains from a sun room. The heat losses are due to both transmission and ventilation.
From all this insulation has an affect on heat losses due to transmission which is calculated via formula 3.

$$Q_{transmissie} = H_{transmissie} (T_i - T_e) t_{stook} \qquad (3)$$

Htransmissie is a summation of the heat transfer coefficients multiplied with the corresponding construction areas and a weighting factor, the latter depending on the adjacent area (e.g. outside, sun room, ground) as shown in formulas 4 to 7.

$$H_{transmissie} = H_{tr,constr \neq glas} + H_{tr,constr=glas,verw} + H_{tr,constr=glas,onverw} \quad (4)$$

$$H_{tr,constr\neq glas} = \sum_{k=1}^{K} (a_k A_k U_k) \qquad (5)$$

$$H_{tr,constr=glas,verw} = \sum_{r=1}^{R} (a_r A_r U_r) b_{verwarmd} \qquad (6)$$

$$H_{tr,constr\neq glas,onverw} = \sum_{m=1}^{M} (a_m A_m U_m) b_{onverwarmd} \qquad (7)$$

To summarize:
An increase in insulation leads to a decrease in energy demand due to transmission and therefore a decrease in energy demand for space heating, which in turn leads to a decrease in total energy usage of the building. The total energy usage of a building is stated in primary energy. Depending on the energy source this can be translated in the unit that the consumer is buying its energy in (m^3 gas or kWh electricity of GJ heat).

2.2 Specification of the parameters in the calculation

Parameters used in formula 1:
Q_{tot} = Total primary energy usage of building (standard conditions) [MJ/yr]
A_g = Useful surface area (gebruiksoppervlakte) [m^2]
$A_{verlies}$ = Area of heat loss (verliesoppervlakte) [m^2]

Parameters used in formula 2:
Q_{tot} = Total primary energy usage of building (standard conditions) [MJ/yr]
Q_{rv} = Energy use for space heating [MJ/yr]
Q_{tap} = Energy use for domestic hot water [MJ/yr]
Q_{hulp} = Energy use for pumps/ventilation [MJ/yr]
Q_{verl} = Energy use for lighting [MJ/yr]
Q_{pv} = Energy supply solar panels [MJ/yr]
Q_{wkk} = Energy supply micro-CHP [MJ/yr]

Parameters used in formula 3:
$Q_{transmissie}$ = Heat loss due to transmission [MJ/yr]
$H_{transmissie}$ = Specific heat loss due to transmission [W/K]
T_i = Average indoor temperature (18°C) [°C]
T_e = Average outdoor temperature [°C]
t_{stook} = Duration heating season [s]

Parameters used in formula 4:
$H_{transmissie}$ = Specific heat loss due to transmission [W/K]
$H_{tr,constr\neq glas}$ =Specific heat loss due to transmission through construction other than glass construction
$H_{tr,constr=glas,verw}$ =Specific heat loss due to transmission through glass construction adjacent to heated area
$H_{tr,constr=glas,onvverw}$ =Specific heat loss due to transmission through glass construction adjacent to unheated area

Parameters used in formula 5 to 7:

a	= weighting factor corresponding with construction
A	= area of construction
U	= heat transfer coefficient of construction
k / K	= specific number of construction other then glass / total number of constructions other then glass
r / R	= specific number of glass construction adjacent to heated area / total number of glass constructions adjacent to heated areas
m / M	= specific number of glass construction adjacent to moderately heated area / total number of glass constructions adjacent to moderately heated areas
$b_{verwarmd}$	= correction factor for glass that is on the inside adjacent to heated area.
$b_{onverwarmd}$	= correction factor for glass that is on the inside adjacent to moderately heated area.

2.3 Specification of the units for the calculation

The unit of calculation is one individual dwelling. The energy usage is based on one year (see also paragraph 2.5)

2.4 Baseline issues

The baseline of a separate dwelling is the energy usage per year corresponding with the energy label before any energy savings measurements are taken. The energy label and energy index are calculated as stated above.
This is a "before situation" with a static baseline. The baseline is different for each specific dwelling depending on the way the dwelling was built and which techniques where used. For calculating the baseline the same assumptions hold as for calculating the energy savings (see paragraph 2.5)

2.5 Normalisation

Calculations are made based on standard conditions [ref4]:
- Test Reference Year of De Bilt (NL): Average $T_{outside}$ = 5.64°C during heating season (212 days - 1st of October to 30th of April)
- T_{inside} = 18°C
- Specified number of residents (depending on used floor area of dwelling): Range 1,4 - 3,2 residents (see table 1)
- Ventilation based on NEN 5128 (Dutch regulations)
- Internal heat production 6 W/m^2
- Electricity use per year for lighting: 6 kWh/m^2
- Yearly net energy demand for domestic hot water based on number of residents, type of appliance for domestic hot water supply, type of water users (showers, baths etc).

Table 4: Number of residents dependent on floor area

Used floor area [m^2]	**Number of residents**
< 50	1,4
50 tot 75	2,2
75 tot 100	2,8
100 tot 150	3,0
~ 150	3,2

2.6 Energy savings corrections

No gross to net calculations are done.
If gross to net calculations would be done there would be probably be an interaction effect between several technologies since an improvement of an energy label will most often be accomplished through applying several measurements.

2.6.1 Gross-net corrections

If gross to net calculations would be done there would be probably be an interaction effect between several technologies since an improvement of an energy label will most often be accomplished through applying several measurements

2.6.2 Corrections due to data collection problem

No corrections due to data collection problems are conducted.

3 Input data and calculations

This chapter will focus on the input data and calculations for dwellings. The same exercise is done for commercial buildings and can be found in annex B4.

3.1 Parameter operationalisation

Reference situation
For the reference situation trained Energy Label Advisors will go to the dwelling and gather information of the dwelling. The method is based on ISSO 82.2 Handleiding EPA-W maatwerkadvies [ref5]. Gathered information is input for energy label calculation software based on ISSO 82.3 [ref3].
Information to be gathered is:
1. General information:
- year of construction
- situation of ownership
- type of dwelling
- orientation
- number of storeys
- type of roof
- floor usage area per storey
- sun room including number of storeys and orientation
- preheating of ventilation air in sun room
- existence of closed balcony or gallery

- preheating of ventilation air in closed balcony/gallery

2. Architectural information:

- area, construction, orientation of construction-elements
- to which each construction-elements is adjacent
- existence of heated or unheated attic
- placement, area and orientation of glazing
- kind of glazing including solar factor (Dutch: ZTA waarde)

Actual situation
With the information gathered in the reference situation combined with the new Rc values for insulation and glazing the energy savings can be calculated with the same software.

3.2 Calculation of the annual savings as applied

As stated in paragraph 2.4 the baseline is the calculation as shown in chapter 2 with values for heat transfer coefficients of insulation before any measures are taken (reference situation). Calculating the energy savings is done by making the same calculation again with better value(s) for the heat transfer coefficients for insulation (actual situation). The difference is the total primary energy saved due to improved insulation. This can be calculated in energy savings in a unit understandable by consumers (m^3 gas or kWh electricity of GJ heat).

Example - Energy savings - improving insulation
The most common dwelling in The Netherlands is a town house built between 1975 and 1991. It has a usable area of 106 m^2 and therefore the number of residents is 3. Space heating and domestic hot water is supplied with a condensing boiler. Ventilation is done naturally.
The Rc-values of the facade is 0,36 m^2K/W and both single and double glazing is used with U-values of 5,20 or 2,90 W/ m^2K. Rc-values for floor and roof are 0,17 and 1,30 m^2K/W

If the insulation of the facade is increased to Rc-value of 2,53 m^2K/W the townhouse will use less energy. Both situations (reference and actual) are presented in table 2. Increasing the insulation from 0,36 to 2,53 m^2K/W results in a decrease of usage of gas of 430 m^3 gas.

Example - Energy savings - improving glazing
For the same dwelling instead of increasing the Rc-value of the insulation all glazing is replaced with HR++ glazing (U-value of 1,80). This results in a decrease of energy usage of 260 m^3 gas presented in table 2.

Table 5: Energy usage before and after replacement of glazing [ref6]

	Reference situation	**Actual situation Improved insulation**	**Actual situation Improved glazing**
Energy Index	1,89	1,53	1,67
Energy Label	D	C	D
Total primary energy use	80 GJ	65 GJ	71 GJ
Usage of gas	2030 m^3	1600 m^3	1770 m^3
Savings of gas		430 m^3	260 m^3
Usage of electricity	925 kWh	925 kWh	925 kWh

3.3 Total savings over lifetime

3.3.1 Savings lifetime of insulation and glazing

No calculations of the savings over a lifetime are done.

3.3.2 Lifetime savings calculation of insulation and glazing

No calculations are conducted.

4 GHG savings

4.1 Annual GHG-savings

Within the energy label calculations the total CO_2 emission is calculated. No other GHG-emissions are taken into account.

4.1.1 Emission factor for energy source

Emission factor gas	1,78 kg CO_2/m^3
Emission factor heat distribution	87,7 kg CO_2/GJ
Emission factor electricity	0,566 kg CO_2/kWh

4.1.2 Annual GHG-savings calculation as applied

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).

Heating value of Dutch Natural Gas	35,17 [MJ/m3]
Efficiency of Dutch Electricity generation	0,39

4.2 GHG lifetime savings

4.2.1 Emission factor

N/A

4.2.2 GHG lifetime savings as applied

References

[1] De markt in beweging - annual report Meer Met Minder 2009, MeerMetMinder, 2009
[2] Kansrijke aanpakken in gebouwgebonden energiebesparing - De particuliere eigenaar, MeerMetMinder, 2010
[3] ISSO 82.3 Handleiding Energieprestatie advies Woningen formulestructuur, Stichting ISSO, 2009
[4] ISSO 82.1 Handleiding Energieprestatie advies Woningen energielabel en algemeen deel, Stichting ISSO, 2007
[5] ISSO 82.2 Handleiding Energieprestatie advies Woningen Maatwerkadvies, Stichting ISSO, 2007
[6] Calculations made with Vabi EPA-W attested software

1.6 Lighting in households

1. Summary of the program

1.1. Short description of the program

The government is promoting CFL lighting. In this case application we present the calculation that might be used for calculating savings for all CFLs sold. The same approach can be used for specific programs. One of such programs is Bright Light (Slim Licht) that stimulates municipalities, housing corporations and other organisations to give CFLs away for free to households. The program started in 2008 and is still ongoing in 2011.

1.1.1. Purpose of goal of the program

Bright Light (Slim Licht) stimulates municipalities, housing corporations and other organisations to give CFLs away for free to households. The program started in 2008 and is still ongoing in 2011.

1.1.2. Type of instrument(s) used

Give a way in combination with other actions. Implemented are:

- a free energy box (including among others a CFL) often combined with targeted energy savings advise in the house; financed by municipalities, schools, housing co-operations etc. (about 10.000 CFLs in 2009)
- give away by housing corporations e.g. when signing the contract, information meetings, opening of a new office (ranging from 250 to 4,000 CFLs).

Offer companies to compile their own energy savings (lighting) box for give away to their staff, customers etc.

1.2. General and specific user category

Households

1.3. Technologie(s) involved

Technology involved is CFL units.

1.4. Status of the evaluation and energy savings calculations

This case application holds a way how to calculate the energy savings of lighting in households in an aggregated way.

In the program the savings are not reported in an aggregated way but households get information on estimated savings in Euros over the lifetime of the lamp (8000 hours) and a comparable bulb (W of bulb is on average 5 times the CFL).

The calculation for energy use is based on periodic survey data. The status of the calculation of the energy savings is considered as “use in practice”.

1.5. Relevant as a Demand Response measure

No

2. Formula for calculation of Annual Net Energy Savings

2.1. Formula used for the calculation of annual energy savings

Energy savings realised by installed efficient lighting are calculated based on periodic household surveys.

2.1.2 Specification of the formula

Annual electricity savings in year t = n_s x [1/1000 x (P_{old} x b_o – P_{new} x b_n)] in kWh/yr

According to the choices made as described above, the following applies for the calculation of the amount of energy saved by replacing conventional bulbs by CFL lamps.

P_{old}	= the average capacity in W of bulbs
P_{new}	= the average capacity in W of CFLs sold in year t
bo = bn	= burning hours general average
n_s	= number of CFL units sold in year t
1/1000	= conversion factor from W to kW

Savings are calculated in kWh/yr end use

2.2. Specification of the parameters in the calculation

For the values of important parameters for national savings calculation we use data from annual household inventories HOME and BEK (see appendix).

Annual burning hours are estimated as it is not known how many hours per year a specific bulb is utilised. The BEK research shows that there is much variation in burning hours mainly depending on the type of room.
The energy use is calculated based on the average capacity (Watt) and the average burning hours.
As this is also done for the reference situation, the energy savings are *deemed (average) savings.*

Annual sales data are not available. The number of newly installed CFLs is for this case application estimated based on household surveys in the year 2003 and 2008.

2.3. Specification of the unit for the calculation

The (unitary) object of assessment is a lamp.
In this case no (specific) action is taken into account. All sales of CFLs are included.

The energy savings calculation can also be done for the household (the energy end user) as the number of CFL-units in households is known from household surveys.

2.4. Baseline issues

For the baseline a *reference situation* is used and not the (real) before situation. The reference is a *conventional or incandescent bulb.* The following assumptions are used:

1. an additional unit would otherwise have been installed with a conventional bulb with comparable capacity;
2. replacement of (broken) CFL units is negligible;
3. immediate replacement and use of CFL, so no 'spare units' (that will replace a conventional bulb at some point in the future).

No specific information on the replacement of CFL units is available. But this second assumption will become more and more incorrect over time since earlier installed CFLs will break and there will be less and less conventional bulbs to replace.
The third assumption is open for discussion: a research showed that in 2008 households have in total 65 million CFLs, of which 30% is spare. So of the average number of 9 CFLs in a household, 7 CFLs are in use.

The same reference situation is taken for all years of the replacements, so a static baseline is used.

Reference capacity: We assume that a CFL lamp replaces a conventional bulb that yields a comparable amount of light. For this we use the table that is given below source: Brondocument VERLICHTING), and that is widely used.

Table 1: Comparable lighting bulb and CFL

Yield	Light bulb	CFL
(lumen)	Capacity (Watt)	Capacity (Watt)
200 - 290	25	5 - 7
300 - 500	40	8 - 10
550 - 700	60	11 - 15
700 - 1000	75	14 - 20

In general we assume that a CFL lamp replaces a light bulb of *4.5 times* its wattage[13], reducing the installed capacity therefore with 3.5 times its wattage.

Reference burning hours: Since there is no information available on the actual number of burning hours for the replaced lamp, we decided to use the number of burning hours for an *average lighting unit* in the household for the year 2000 (see annex) as a reference value: 482 hrs.
Uncertainty of the average burning hours.
If we replace a light bulb it may seem attractive to choose the hours of an average light bulb. However this is an average and there are economical arguments that there will be a tendency to replace those bulbs first that burn the most hours. Therefore the number of burning hours for an average conventional bulb (467 hours) can be seen as a lower boundary.
When we think of already installed CFL lamps as already replaced conventional bulbs this seems logical that new replacements will be much like already installed CFLs in terms of burning hours. However, as replacement of bulbs by CFL progresses the number of burning hours of the bulbs replaced by CFLs tends to be less than the burning hours of already

[13] In communication to households often the factor of 5 times is used

installed CFLs. Therefore the number of burning hours of already installed CFLs (519 hours) can be seen as an upper boundary.

2.5. Normalization

No normalisation is conducted.

2.6. Energy saving corrections

2.6.1. Gross-net corrections

In the baseline it is assumed that CFLs are only bought for replacement of existing lamps. Two elements could be taken into consideration for the calculation from gross to net:

- additional lighting (e.g. garden lightning)
- longer burning hours for specific lighting (e.g. whole night burning outdoor lightning)

There is some research indicating these rebound effects, but due to lack of reliable national data this is not taken into account.

As there are no actions included in this case application, other topics as free riders and double counting are not relevant.

2.6.2. Corrections due to data collection problems

No corrections due to data collection problems take place.

3. Input data and calculations

3.1. Parameter operationalisation

Input data for energy savings are follows:

1. For baseline:
   a. Burning hours: 482 hrs (annual)
   b. Average capacity of the replaced lamp
2. For the energy savings calculation
   a. Burning hours: 482 hrs (annual)
   b. Average capacity of CFL: 12.4 W
   c. Life time: 6,000 burning hours or 12 years
   d. CFL lamp replaces a light bulb of 4.5 times its wattage
3. Sales date CFLs:
   a. Annual average of 5.678 million in the years 2004, 2005, 2006 and 2007

Table 2: Lighting zones and average W of CFL in Dutch houses, 2000

Lighting zone	**room / area**	**2000 CFL** (W)
zone 1	kitchen, living room	11
zone 2	main bedroom, bath, toilet, hall	13
zone 3	other bedrooms, garage, loft, cellar, other	12
zone 4	Outdoor	15
Total	all areas	12.4

The capacity of the CFLs in 2000 is different for the lighting zones in a house (see Table 2). We use the average value of 12.4 W.

Between 2003 and 2007 the number of CFLs sold is estimated at annual sales of 5.678 million CFLs (the average number of CFLs increased from 4 to 7 per household).

3.2. Calculation of the annual savings as applied

According to the choices made as described above, the following applies for the calculation of the amount of energy saved by replacing conventional bulbs by CFL lamps.

P_{old} = the average capacity in W of bulbs = 4.5 * P_{new}
P_{new} = the average capacity in W of CFLs sold in year t (12.4 W)
bo = bn = burning hours general average (482 hrs)
n_s = number of CFL units sold in year t (5,678,000 CFL)
1/1000 = conversion factor from W to kW

This reduces the formula to:

Annual electricity savings in year t= (5,678,000 /1000) x (3.5 x 12.4) x 482= 118,776,946 kWh/yr (about 118.8 GWh/yr).

3.3. Total savings over lifetime

3.3.1. Savings lifetime of CFLs

The lifetime of a CFL is between 3,000-15,000 burning hours. In The Netherlands in most cases one calculates with an average of *6,000 burning hours*; the value also indicate in the CEN CWA 27[14].
Based on an average burning hour value of 482 a year, the replacement is accounted as energy saving for *12 years*.
We assume that the savings lifetime is equal to the average technical burning hours and that the saving persists over the whole period.

As we assume that CFL are not used as spare items, the savings start in the year the CFL is bought.

[14] In the Bright Light program the lifetime of 8,000 burning hours is used

3.3.2. Lifetime savings calculation of CFLs

Annual electricity savings (for the period 2004-2007 are 118,776,946 kWh/yr (about 118.8 GWh/yr). So over the whole lifetime of 12 years the national lifetime savings are 12 x 118,776,946 kWh = 1,425,323,352 kWh (about 1.43 TWh)

4. GHG savings

4.1. Annual GHG-savings

4.1.1. Emission factor for energy source

The Dutch ISSO publication 75.2 holds following average value for GHG emission factor for electricity: 0,566 kg CO_2/kWh

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

4.1.2. Annual GHG-savings calculation as applied

Using the GHG 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)

4.2. GHG lifetime savings

4.2.1. Emission factor

For the lifetime savings the same emission factor as for the annual savings is used

4.2.2. GHG lifetime savings as applied

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)

References

BEK 2995-2000

Bright light site (in Dutch) http://www.slimlicht.nl

Brondocument VERLICHTING, Milieu Centraal, August 2009

Harmelink, M., Bosselaar, L., Gerdes, J., Boonekamp, P., Segers, R/. Pouwelse, H., Verdonk, M., Calculating CO_2 emissions, primary fossil energy use and the Dutch efficiency in electricity production (Berekening van de CO_2-emissies, het primair fossiel energiegebruik en het rendement van elektriciteit in Nederland), in Dutch, 2012 forthcoming

Home 2000 onwards

ISSO publication 75.2; source for GHG emission factor for electricity

www.energiecijfers.nl

Annex:

Annex B5: Data for lighting in the Netherlands (households)

2. EVALUATION PRACTISE

2.1 Introduction

2.2 National Evaluation guidelines, guidances and selected reports on evaluations and energy savings calculations

2.2.1 List of guidelines

There is none.

2.2.2 List of guidance

There is a Dutch Protocol monitoring energy savings (PME). This protocol was developed in co-operation of the five main organisations involved in estimating national energy data and energy savings. It is since the early 2000s in use to calculate the annual national energy savings. This protocol uses a top-down approach and holds only minor information for bottom-up energy savings.

Country:	NL
Report number	Evaluation guidance 1
Report title	Protocol monitoring energie besparing Protocol monitoring energy savings
Year	2001
link	http://www.ecn.nl/docs/library/report/2001/c01129.pdf
Highlights/summary	Five institutes (ECN, CPB, CBS, Novem and RIVM), collaborated to create a 'Protocol Monitoring Energy savings', a common method and database to calculate the amount of energy savings realised. This protocol is still in use to calculate the annual national savings.
Sector	households, industry, agriculture, services & government, transportation and the energy sector;
Technologies (max 15)	N/A
Baseline approach	For each segment a reference energy use is calculated according to the trend in a variable which is supposed to be representative for the use without savings. The difference with the actual energy use is taken as the savings realised.
Default energy or savings values	A decomposition method is used to split up the observed change in energy use in a number of effects, on a national and sectoral level. This method includes an analysis of growth effects, effects of structural changes in production and consumption activities and savings on end use or with more efficient conversion processes
GHG emissions	N/A
Comment	This protocol is only available in Dutch and at present under revision.

	The protocol is used to calculated the annual national energy savings.

For the Dutch Long Term Agreement 3 recently (2010) a protocol was published. This protol provides information on the use of data on the implemented energy saving measures for the energy savings on a company level. For most measures default values are used.

Country:	NL
Report number	Evaluation guidance 2
Report title	Protocol Monitoring Meerjarenafspraak Energie Efficiency Industrie 3 Protocol Monitoring Long Term Agreements Industry 3
Year	2010
link	http://www.agentschapnl.nl/sites/default/files/bijlagen/Bijlage_MJA3_Hoofdstuk_3A_Protocol_Monitoring_procedure.pdf and http://www.agentschapnl.nl/sites/default/files/bijlagen/Handreiking%20monitoring%20MJA3%20versie%202.2%20-%204%20januari%202012_0.pdf
Highlights/summary	A new methodology for monitoring the LTA3 results was established in February 2010. The core element of the new methodology is that the result will be solely based on the implementation of measures. This provides greater consistency with national and European guidelines. It includes treatment of the baseline, saving lifetime and instructions for different levels of evaluation.
Sector	Industry
Technologies (max 15)	Various technologies for commercial buildings and industrial processes. **Industrial processes: (among others)** heat exchangers, industrial coolers and freezers, ovens, electro motors, air circulation systems, dryers and moisturizers, etc. **Company buildings:** Insulation building envelope, Ventilation, Hot water, Heating, Cooling (list of techniques numbers 8 thru 12). Furthermore, Lighting, CHP, Fuel Cell
Baseline approach	Before situation
Default energy or savings values	Default values per measure.
GHG emissions	In order to be able to use results in the light of CO2 goals energy efficiency is separated from the generation of clean energy.
Comment	LTA includes the effects of various subsidy schemes and tax incentives for energy efficiency. The effects are evaluated using the company reports. In the company reports often default savings per

	measure are often used. More detailed information can be collected; default savings per appliances at NL Agency, but will be available only in Dutch

2.2.3 Selected reports

Country:	NL
Report number	Evaluation 1
Report title	Long-Term Agreement on energy efficiency in the Netherlands LTA3, Results of 2009
Year	2010
link	http://www.agentschapnl.nl/content/resultaten-meerjarenafspraken-energie-efficiency
Highlights/summary	The LTA3 results can be subdivided into measures in the area of process efficiency (PE), chain efficiency (CE) and the generation and purchase of sustainable energy (SE). The PE is directly related to energy savings. In comparison to the 2005 reference year, the results represent a saving of 12.7 PJ in process efficiency (7.4 percent improvement since 2005)
Sector	Industry
Technologies (max 15)	Various technologies for commercial buildings and industrial processes. **Industrial processes: (among others)** heat exchangers, industrial coolers and freezers, ovens, electro motors, air circulation systems, dryers and moisturizers, etc. **Company buildings:** Insulation building envelope, Ventilation, Hot water, Heating, Cooling). Furthermore, Lighting, CHP, Fuel Cell
Baseline approach	Before situation, based on inspections
Default energy or savings values	Default values per measure.
GHG emissions	No emissions are reported. The primary energy use, the own production of renewable energy and the purchase of renewable energy is presented. Based on this information GHG emissions could be calculated.
Comment	LTA results are reported annually. Additional information e.g. default savings per appliances is available, but only in Dutch

Country:	NL
Report number	Evaluation 2
Report title	Energiebesparing: ambities en resultaten Energy savings: ambitions and results
Year	2011
link	http://www.rekenkamer.nl/Publicaties/Alle_publicaties
Highlights/summary	The overal energy savings and the use of policy instruments for the period 1995-2007 were analysed.
Sector	All, specified in industry, transport, agriculture and buildings
Technologies (max 15)	N/A
Baseline approach	N/A
Default energy or savings values	Both as the study re-used progress reports on national energy savings and evaluation reports
GHG emissions	Only indicative
Comment	Only available in Dutch

Country:	Netherlands
Report number	Evaluation 3
Report title	Ex post evaluation of the Energy Investment deduction (EIA) Ex-post evaluatie Energie Investeringsaftrek (EIA) in Dutch only
Year	2007
link	Ministry of Economic Affairs
	https://zoek.officielebekendmakingen.nl/kst-31492-8-b1.pdf
Highlights/summary	The study includes energy savings for subsidised investments for technologies/appliances in industry and building for the period 2001-2005. It holds no detailed information on the actual energy savings calculation.
Sector	Industry, services and commercial buildings
Technologies (max 15)	Various technologies for commercial buildings and industrial processes. **Buildings:** Insulation building envelope, Ventilation, Hot water, Heating, Cooling (list of techniques numbers 8 thru 12). Furthermore, Lighting, CHP, Fuel Cell, Dryers and Moisturizers **Processes: (among others)** heat exchangers, industrial coolers and freezers, ovens, electro motors, air circulation systems, etc.
Baseline approach	Before situation
Default energy or savings values	Default values per measure.

GHG emissions	Not evaluated
Comment	More detailed information can be collected; default savings per appliances at NL Agency, but will be available only in Dutch

Country:	NL
Report number	Evaluation 4
Report title	Evaluatie EPC-aanscherping woningen; ECN-E--10-043 (Evaluation increased EPC for houses)
Year	2010
link	http://www.ecn.nl/publications/ECN-E--10-043
Highlights/summary	The Dutch building code for new houses was tightened as of January 2006, changing the energy performance coefficient (EPC) from 1.0 to 0.8. This evaluation gives insight in some the experiences. The tightening of the building code has had effect on the energy use. The energy saving ranges from 1 to 15%, which is somewhat lower than anticipated.
Sector	Households
Technologies (max 15)	Heating system; ventilation system, roof insulation, window glazing, wall insulation, floor insulation,
Baseline approach	Houses with an EPC value of 1.0
Default energy or savings values	Real energy (gas) used, normalized for a standard year
GHG emissions	N/A
Comment	The report presents a detailled analysis including behavioral elements and uses real data from a sample of about 2.300 households with energy uses in the period October 2008-October 2009

Country:	NL
Report number	Evaluation 5
Report title	Signed, Sealed, Delivered? Evaluatie van drie convenanten energiebesparing in de gebouwde omgeving Signed, Sealed, Delivered? Evaluating the three agreements energy savings in the building area
Year	2010
link	http://www.lente-akkoord.nl/wp-content/uploads/2010/06/Eindrapport-Evaluatie-3-Convenanten-7-april-2010.pdf
Highlights/summary	For the three agreements More with Less, Spring Agreement and Energy savings by Housing corporations (Meer met Minder, Lente-

	Akkoord, Energiebesparing Corporatiesector) qualitative results are presented. It concentrates on progress in action and impacts in the near future. It does not hold energy savings (calculations)
Sector	New and exisiting residential and non-residential building
Technologies (max 15)	N/A
Baseline approach	N/A; comparison with ex-ante agreed targets
Default energy or savings values	N/A
GHG emissions	N/A
Comment	The report (in Dutch only) provides kwalitative information on the progress in actions and expectations on the impacts for the next years

Country:	NL
Report number	Evaluation 6
Report title	Evaluatie energiebesparingsbeleid in de industrie; Kosten en effecten in de periode 1995-2008 Evaluation Policy on energy saving in industry; costs and impacts in the period 1995-2008
Year	2010
link	http://www.ce.nl/publicatie/evaluatie_energiebesparingsbeleid_in_de_industrie/1186
Highlights/summary	The overall energy savings (based op a top-down approach) are presented in combination with the impacts from programmes as the LTA, the Energy Investment Deduction (EIA) and the European Emission Trading System (ETS) as well as from energy taxation
Sector	Industry
Technologies (max 15)	N/A
Baseline approach	Different approaches as existing monitoring reports are used as input
Default energy or savings values	Energy figures are used from existing monitoring reports and some evaluations. No detailed energy savings data.
GHG emissions	For the European Emission Trading System (ETS) and following their rules
Comment	This report was used for the general evaluation, presented in the report Energy savings: ambitions and results The report is only available in Dutch

2.3 Use of international guidelines and guidance

2.3.1 List of guidelines

There is none.

2.3.2 List of guidance

The EU Directive on energy end-use efficiency and energy services (2006/32/EC), abbreviated to the ESD, and the recast Directive on the energy performance of buildings (2010/31/EU), abbreviated to the EPBD force EU Member States to report on the progress on energy savings.

While both Directives hold guidance for monitoring a calculation of bottom-up energy savings, this did not result in any guidance for national conducted evaluations or monitoring energy savings.

2.3.3 Selected reports

There is none.

3. STANDARDS RELATED TO ENERGY SAVINGS CALCULATIONS

3.1 Introduction

Netherlands standardisation organisation NEN and Dutch experts are involved in preparation of new or revision of existing standards on European (CEN) and global (ISO) level. The more important one are related to the following topics:

- updating standards related to the Energy Performance of Buildings Directive (EPBD)
- development of standards on energy efficiency and energy savings calculations
- development of standards for energy management and for energy audits

It is expected that by December 2012 the standard "Introductory element, Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods Complementary element" will be officially available at CEN as a standard **EN16212:2012**.

3.2 National standards

National standards (abbreviation NEN) are almost always (translations of) European (CEN) or global (ISO) standards.

By July 2012 new national standard is in force for the energy performance of building. The new standard **NEN 7120:2011** replaces the existing standards NEN 5128 (for residential buildings) and NEN 2916 (for non-residential buildings) as well as the methods for energy labels ISSO 75.1 en ISSO 82.1. This standard is applicable to residential and non-residential building as well as for (renovation of) existing and new buildings.

By April 2012 a new national (provisional) standard **NVN 7125** on Energy performance for Measures on a regional level (Energieprestatienorm voor maatregelen op gebiedsniveau (EMG) – Bepalingsmethode) was published. This standard enlarge the energy performance of building with those in its neighbourhood or district (e.g. district heating, district CHP or PV systems). Based on experiences in practise this standard will be upgraded to a national NEN standard.

At the moment there are no national standards on energy efficiency or energy savings calculations. There are standards for electrical appliances and energy conversion installations.

By November 2011 the ISO 50001 standard on energy management systems became available in a Dutch version. This standard **NEN-EN-ISO 50001** specifies requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption. It specifies requirements applicable to energy use and consumption, including measurement, documentation and reporting, design and procurement practices for equipment, systems, processes and personnel that contribute to energy performance.

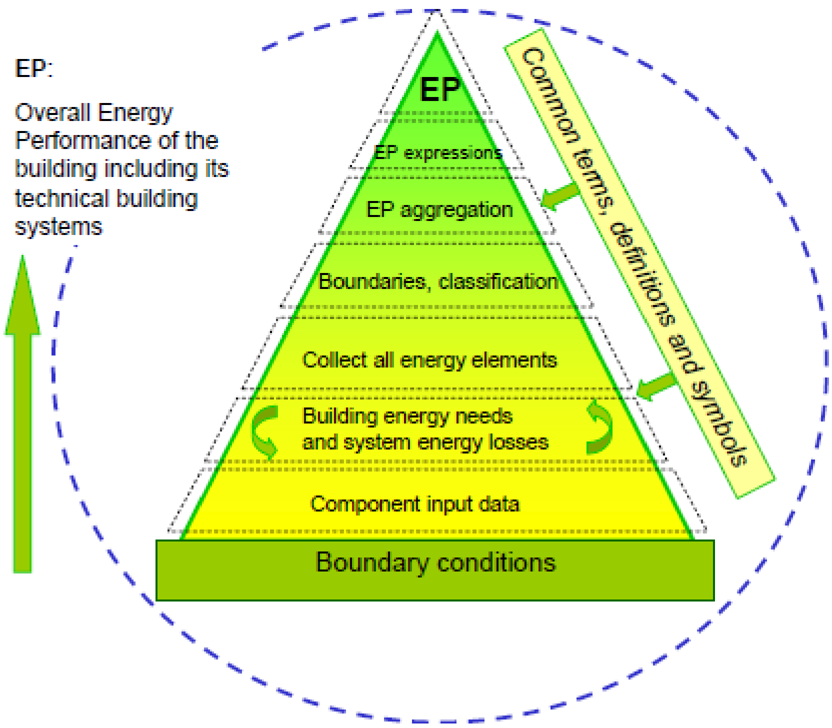
3.3 Developments on standards

The national development is linked into those on European (CEN) and global (ISO) level. New standards are foreseen for all three topics (buildings, savings and energy management). Some standards will become official in 2012.

3.3.1 Ongoing and expected developments

CEN has been conducting the coordination and development of the first set of European standards on the Energy Performance of Buildings and is at present mandated to revisit the system of European Standards relevant to the recast of the Energy Performance of Buildings Directive (EPBD 2010/31/EU). The new second generation set of CEN-EPBD standards should be more usable as direct reference in national legislation, lead to a high transparency in national choices and involve the Member States actively.

Figure 1: Energy Performance and standards



Source CEN/TC 371, request for Tender July 2011

CEN/TC 371 "Project Committee on Energy Performance of Buildings" started in July 2102 the process. In the period 2013-2015 the preparation of new and the revision of the existing individual EPBD standards is foreseen.

Since 2007 CEN[15] is elaborating standards for common methods of calculation of energy consumption, energy efficiencies and energy savings and for a common measurement and verification of protocol and methodology for energy use indicators. Since then experts have participated in two Working Groups – one for Top-Down calculations and one for Bottom-Up calculations. By April 2012 the final draft was published for formal voting by the members of CEN. It is expected that by December 2012 the standard "Introductory element, Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods Complementary element" will be officially available at CEN as a standard **EN16212:2012**.

This European standard provides a general framework for calculating energy savings and is organised as follows:

- the methodology and general rules of calculation;
- terminology and definitions;
- the characteristics of the top-down and bottom-up methods;
- the top-down calculation method;
- the bottom-up calculation methods;
- Annex A example for top-down indicators;
- Annex B the level of detail at which bottom-up methods can be applied;
- Annex C a bottom-up example for the building sector (boiler exchange).

Figure 2: Steps and sub-steps in the calculation of bottom-up energy savings as included in prEN16212:2012

Step 1: Calculation of unitary gross annual energy savings

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

Step 2: Calculation of total gross annual energy savings

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

Step 3: Calculation of total annual energy savings

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

Step 4: Calculation of remaining energy savings for target year

The standard organises elements for calculating unitary gross annual savings in four steps (see figure 2). It starts with the savings per unit (unitary savings), those are summed up to total gross saving and the corrected to get the (net) savings. The savings are annual savings and in step 4 one can count the savings for a period (upto a target year). A working group is dealing with

In 2011 the International Organisation for Standardisation (ISO) started follow-up work on energy savings and installed a Task Committee, **ISO/TC 257** dealing with "General technical rules for determination of energy savings in renovation projects, industrial enterprises and regions". Workgroups are preparing draft documents to be discussed in meetings in the coming years.

In 2010 the ISO and the International Electrotechnical Commission (IEC) decided to install a joint project committee **ISO/IEC JPC 2** dealing with "Energy efficiency and renewable energy sources - Common terminology". By November 2011 a first draft report became available for discussion and commenting. Publication of this ISO standard is planned for January 2014.

In January 2011 **prEN 16231**/ NEN-EN 16231:2011 "Energy Efficiency Benchmarking methodology" was published and formal vote should by finalised by June 2012. This standard specifies the requirements and provides recommendations for energy efficiency benchmarking methodology in all energy consuming sectors. The purpose of energy efficiency benchmarking is to establish the relevant data and indicators on energy consumption, technical and behavioural, qualitative and quantitative in comparing performance between or within entities. Energy efficiency benchmarking can be either internal (within a specific organisation) or external (between organisations including competitors).

3.3.2 Comments on (draft) international standards

The National Standardisation organisation NEN organised the commenting through national mirror groups for an individual standard or a group of standards. In the mirror group the national experts that are participating in CEN and/or ISO work meet regular together with experts from other organisations.

3.4 Relevant organisations

Depending on the topic relevant organisations are involved. For energy savings especially NEN, NL Agency and ECN are involved as experts in CEN and ISO work.

Annexes

Annex A: Template energy savings calculation, with instructions, for case examples in IEA-DSM Task XXI

Annex B1: Potential formula for high efficient electric motors
Annex B2: Future development relevant for standardisation HE motors

Annex B3: Formula for calculation of annual energy savings for heat pumps in non-domestic buildings

Annex B4: A simpler energy savings calculations for air conditioners in commercial buildings

Annex B5: Data for lighting in the Netherlands (households)

Annex A: Template energy savings calculation, with instructions, for case examples in IEA-DSM Task XXI

Frontpage:
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 program

1.1 Short description of the program

1.1.1 Purpose or goal of the program

[Also include the period the program 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

[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]

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 B1: POTENTIAL FORMULA FOR HIGH EFFICIENT ELECTRIC MOTORS

1.1. Formula using EFF motor categories

The energy use of an electric motor can be calculated based on the power and the running hours. The poser information is available at the motor. For running hours a default value could be derived from the EMEEES case application on energy efficient motors, which hold information on:
- 3 motor classes: small (0.75-4) medium (4-10) and large (10-22)
- type of application: pumps, fans, air compressors, conveyers, cooling compressors and others
- sector of application: industry or (tertiary) buildings

Table A1: Running hours of pumps in industry and (tertiary) buildings

Power ranges	Type of Applications	Industry			Tertiary		
		Hours (h)	Load factor	LFH (Load Factor*Hours)	Hours (h)	Load factor	LFH(Load Factor*Hours)
[0,75;4[	Pumps	3.861,03	0,55	2.123,57	3.800,00	0,55	2.090,00
[4;10[		4.501,94	0,58	2.611,13	3.050,00	0,60	1.830,00
[10;22[		5.040,47	0,59	2.973,88	3.000,00	0,60	1.800,00
[0,75;4[	Fans	4.910,47	0,53	2.602,55	2.250,00	0,60	1.350,00
[4;10[		4.137,76	0,56	2.317,15	2.500,00	0,65	1.625,00
[10;22[		5.210,64	0,59	3.074,28	2.500,00	0,65	1.625,00
[0,75;4[	Air Compressor	2.177,99	0,63	1.372,13	1.030,00	0,40	412,00
[4;10[		4.057,72	0,60	2.434,63	1.000,00	0,45	450,00
[10;22[		4.625,99	0,68	3.145,67	980,00	0,45	441,00
[0,75;4[	Conveyors	3.060,75	0,42	1.285,52	621,00	0,61	378,81
[4;10[		2.787,90	0,41	1.143,04	916,00	0,53	485,48
[10;22[		3.908,61	0,51	1.993,39	725,00	0,49	355,25
[0,75;4[	Cooling Compressors	5.051,90	0,60	3.031,14			-
[4;10[		1.890,63	0,65	1.228,91			-
[10;22[		5.066,59	0,70	3.546,61			-
[0,75;4[	Refrigeration				4.200,00	0,70	2.940,00
[4;10[					4.170,00	0,70	2.919,00
[10;22[					4.050,00	0,75	3.037,50
[0,75;4[	Others	3.086,64	0,34	1.049,46	500,00	0,30	150,00
[4;10[		2.859,49	0,39	1.115,20	530,00	0,30	159,00
[10;22[		2.299,44	0,45	1.034,75	570,00	0,30	171,00

Source: EMEEES case application on energy efficient motors

Based on CEMEP EFF motor classes baselines could be developed:
Baseline 1: EEF class 3 is the stock average

Baseline 2: EEF class 2 is the market average

Table A2: Motor efficiencies by EFF classes

Output	EFF3	EFF1, 2 pole	EFF1, 4 pole	Difference EFF1-3, 2pole	Difference EFF1-3, 4 pole	Difference EEF1 2 and 4 pole
KW	Eff (%)	Eff (%)	Eff (%)	Eff (%)	Eff (%)	Eff (%)
1,1	76,2	82,2	83,8	6,0	7,6	1,6
1,5	78,5	84,1	85,0	5,6	6,5	0,9
2,2	81,0	85,6	86,4	4,6	5,4	0,8
3	82,6	86,7	87,4	4,1	4,8	0,7
4	84,2	87,6	88,3	3,4	4,1	0,7
5,5	85,7	88,6	89,3	2,9	3,6	0,7
7,5	87,0	89,5	90,1	2,5	3,1	0,6
11	88,4	90,5	91,0	2,1	2,6	0,5
15	89,4	91,3	91,8	1,9	2,4	0,5
18,5	90,0	91,8	92,2	1,8	2,2	0,4
22	90,5	92,2	92,6	1,7	2,1	0,4
30	91,4	92,9	93,2	1,5	1,8	0,3
37	92,0	93,3	93,6	1,3	1,6	0,3
45	92,5	93,7	93,9	1,2	1,4	0,2
55	93,0	94,0	94,2	1,0	1,2	0,2
75	93,6	94,6	94,7	1,0	1,1	0,1
90	93,9	95,0	95,0	1,1	1,1	0,0

Source CEMEP: table EFF motor classes
Note:
former EFF2 is comparable with IE1 (standard efficiency)
EFF 1 is now split into IE2 and IE3; IE2 is indicated as High Efficiency and IE3 as premium efficiency
EFF was measured using the (previous) standard EN 60034-2:1996
IE is measured using the (new) standard EN 60034-2-1:2007

FORMULA:

EE = motor power class x running hours x delta efficiency (related to number of poles)

While number of poles is 2 or 4 (and more)

1.2. Formula using IE motor categories

These baselines could be followed up be baselines based on the new IE motor classes. The EU uses these new classes in the Commission regulation (EC) 640/2009 (implementing the eco design directive 2005/32/EG with regard to electric motors).

Based on CEMEP new IE motor classes baselines could be developed:
Baseline 1: IE class 3 is the stock average
Baseline 2: IE class 2 is the market average

Table A3: Motor efficiencies by IE classes and average savings

PN(kW)	Efficiency				
	Standard	High Efficiency	Premium Efficiency	$\eta_h = \left(\frac{1}{\eta_{standard}} - \frac{1}{\eta high}\right)$	$\eta_p = \left(\frac{1}{\eta_{standard}} - \frac{1}{\eta_{premium}}\right)$
	(IE1)	(IE2)	(IE3)	standard to high efficiency	standard to premium efficiency
0,75	72,1	81,1	84	15%	20%
1,1	75	82,7	85,3	12%	16%
1,5	77,2	83,9	86,3	10%	14%
2,2	79,7	85,3	87,5	8%	11%
3	81,5	86,3	88,4	7%	10%
4	83,1	87,3	89,2	6%	8%
5,5	84,7	88,2	90	5%	7%
7,5	86	89,1	90,8	4%	6%
11	87,6	90,1	91,7	3%	5%
15	88,7	90,9	92,3	3%	4%
18,5	89,3	91,4	92,7	3%	4%
22	89,9	91,7	93,1	2%	4%
30	90,7	92,4	93,6	2%	3%
37	91,2	92,8	94	2%	3%
45	91,7	93,1	94,3	2%	3%
55	92,1	93,5	94,5	2%	3%
75	92,7	94	95	1%	3%
90	93	94,2	95,2	1%	2%

FORMULA:

EE = motor power class x running hours x delta efficiency (related to number of poles)

While number of poles are 2, 4 or 6

Annex B2: FUTURE DEVELOPMENT RELEVANT FOR STANDARDISATION HE MOTORS

EU 2009: implementing measures for motors

The European Commission adapted on 22 of July 2009 implementing measures for motors under the eco design directive 2005/32/EG: Commission regulation (EC) No. 640.2009 That means that there will be for the first time mandatory regulations for motors. The first measure, mandatory introduction of minimum efficiency class IE2, will start on 16 of June 2011.

Further measures will regulate the use of motors efficiency class IE3:
From 1 January 2015: motors with a rated output of 7,5-375 kW shall not be less efficient than the IE3 efficiency level, or meet the IE2 efficiency level and be equipped with a variable speed drive.
From 1 January 2017: all motors with a rated output of 0,75-375 kW shall not be less efficient than the IE3 efficiency level or meet the IE2 efficiency level and be equipped with a variable speed drive.

Table A2.1.IE2 Efficiency levels for motors

Nominal minimum efficiencies (η) for IE2 efficiency level (50 Hz)

Rated output power (kW)	Number of poles		
	2	4	6
0,75	77,4	79,6	75,9
1,1	79,6	81,4	78,1
1,5	81,3	82,8	79,8
2,2	83,2	84,3	81,8
3	84,6	85,5	83,3
4	85,8	86,6	84,6
5,5	87,0	87,7	86,0
7,5	88,1	88,7	87,2
11	89,4	89,8	88,7
15	90,3	90,6	89,7
18,5	90,9	91,2	90,4
22	91,3	91,6	90,9
30	92,0	92,3	91,7
37	92,5	92,7	92,2
45	92,9	93,1	92,7
55	93,2	93,5	93,1
75	93,8	94,0	93,7
90	94,1	94,2	94,0
110	94,3	94,5	94,3
132	94,6	94,7	94,6
160	94,8	94,9	94,8
200 up to 375	95,0	95,1	95,0

Nominal minimum efficiencies (η) for IE3 efficiency level (50 Hz)

Rated output power (kW)	Number of poles		
	2	4	6
0,75	80,7	82,5	78,9
1,1	82,7	84,1	81,0
1,5	84,2	85,3	82,5
2,2	85,9	86,7	84,3
3	87,1	87,7	85,6
4	88,1	88,6	86,8
5,5	89,2	89,6	88,0
7,5	90,1	90,4	89,1
11	91,2	91,4	90,3
15	91,9	92,1	91,2
18,5	92,4	92,6	91,7
22	92,7	93,0	92,2
30	93,3	93,6	92,9
37	93,7	93,9	93,3
45	94,0	94,2	93,7
55	94,3	94,6	94,1
75	94,7	95,0	94,6
90	95,0	95,2	94,9
110	95,2	95,4	95,1
132	95,4	95,6	95,4
160	95,6	95,8	95,6
200 up to 375	95,8	96,0	95,8

EC regulation 640/2009, *ANNEX II* MEASUREMENTS AND CALCULATIONS

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations shall be made using a reliable, accurate and reproducible method, which takes into account the generally recognised state-of-the-art methods, and whose results are deemed to be of low uncertainty, including methods set out in documents the reference numbers of which have been published for that purpose in the *Official Journal of the European Union*.

They shall fulfil all of the following technical parameters.

- The energy efficiency is the ratio of mechanical output power to the electrical input power.

- The efficiency level of the motor, as specified in Annex I, shall be determined at rated output power (P_N), rated voltage (U_N), and rated frequency (f_N).
- The difference between the output mechanical power and the input electrical power is due to losses occurring in the motor.
- The determination of total losses shall be carried out by one of the following methods:
  1. measurement of total losses, or
  2. determination of separate losses for summation.

Annex B3: FORMULA FOR CALCULATION OF ANNUAL ENERGY SAVINGS FOR HEAT PUMPS IN NON-DOMESTIC BUILDINGS

These formulas are stated in ISSO 75.3 - Energieprestatie advies utiliteitsgebouwen (2009) [ref7].

I.I Formula used for the calculation of annual energy savings.

In ISSO 75.3 there are several functions of commercial dwellings (e.g. office, healthcare, sports etc.). Some functions have other input values for example for the inside temperature. It will be to elaborate to state all different options here (which would more or less mean copying ISSO 75.3). Commercial buildings with an office function will be used as an example.

I.I.I Specification of the formula

The total energy use of a building is the sum of all energy uses per function minus the energy supply by CHP and/or solar panels. The energy use per function is

$$Q_{prim,tot} = Q_{prim,verw} + Q_{prim,vent} + Q_{prim,vl} + Q_{prim,pomp} + Q_{prim,koel} + Q_{prim,bev} + Q_{prim,tap} \quad (1)$$

The heat pump supplies both heat and cooling, therefore those two formula are of interest.

The yearly demand for cooling is obtained by summing up the monthly demands:

$$Q_{cool,yr} = \sum_{i=1}^{12} Q_{cool,c,i} \quad (2)$$

The monthly demand is determined through the following formula:

$$Q_{cool,c,i} = f_{latent}(Q_{solar} + Q_{internal}) - \eta_b(Q_{tr} + Q_{vent}) \quad (3)$$

This formula holds for months where the ratio of heat loss (through transmission and ventilation) to heat gain (solar and internal) is less than 2.5. If it is larger, there is no cooling demand.

In the simplest case, the yearly energy consumption due to cooling is

$$Q_{c-consumption,yr} = \frac{Q_{cool,yr}}{\eta_{gen}} \quad (4)$$

Efficiencies to be used for the different types of cooling are listed in the table I below

Table 1: Generation efficiency of various forms of cold supply

Types of cooling	Generation efficiency η_{gen}	Fuel type
Compression cooling	4 x η_{el}	Electricity

Absorption cooling with 3rd party heat supply	0.7 x η_{heat}	Heat
Absorption cooling on CHP	1.0 x $\varepsilon_{wkk,th}$	Gas
Cold storage	12 x η_{el}	Electricity
Heat pump in cooling mode in summer	5 x η_{el}	Electricity

It could be that multiple cooling installations are applied simultaneously. In that case, there is always one system used preferentially. In case of absorption cooling with compression cooling, the absorption cooling is used preferentially. In other cases, the cooling supply with the highest efficiency is used preferentially. This then needs to be accounted for in resulting generation efficiency:

$$\eta_{gen,res} = \frac{1}{\frac{\alpha_{cool}}{\eta_{gen,pref}} + \frac{(1-\alpha_{cool})}{\eta_{gen,npref}}} \quad (5)$$

The yearly energy use for heating is obtained by summing up the monthly energy usage:

$$Q_{verw} = \sum_{i=1}^{12} Q_{verw,i} \quad (6)$$

The monthly usage is determined through the following formula:

$$Q_{verw,i} = \frac{Q_{verw,beh,i}}{\eta_{opw,ver,i} \cdot \eta_{sys,ver}} \quad (7)$$

Formula 6 stated that the monthly usage is determined by the monthly demand for heating. The demand is comprised of demands due to

- transmission heat losses
- ventilation heat losses
- internal heat gains (minus)
- contribution of the sun (minus)
- contribution of solar space heating system (minus)

As with cooling it is possible to have multiple installations providing the energy for space heating. If this is the case $\eta_{opw,verw,i}$ is as stated in formula 8. Table II shows some efficiencies for space heating as stated in ISSO 75.3 [ref7]

$$\eta_{opw,verw,i} = \frac{1}{\frac{f_{pref,i}}{\eta_{opw,verw,pref}} + \frac{(1-f_{pref,i})}{\eta_{opw,verw,npref}}} \quad (8)$$

Table II ; Efficiencies for a number of space heating installations [ref 7]

Installation	**Efficiency** ($\eta_{opw,verw}$)
Electrical heating	0,39
Efficient gas boiler (HR-107)	0,975 ($T_{supply} \leq 55°C$) 0,95 ($T_{supply} > 55°C$)
District heating	1
Heat pump - ground source	1,3 ($T_{supply} \leq 35°C$) 1,2 ($35°C < T_{supply} \leq 45°C$) 1,1 ($T_{supply} > 45°C$)
Heat pump - groundwater source	1.8 ($T_{supply} \leq 35°C$) 1,6 ($35°C < T_{supply} \leq 45°C$) 1,4 ($T_{supply} > 45°C$)
Heat pump - waste/exhaust air source	2.4 ($T_{supply} \leq 35°C$) 1,6 ($35°C < T_{supply} \leq 45°C$) 1,7 ($T_{supply} > 45°C$)

I.II Specification of the parameters in the calculation

Parameters used in formula 1:

$Q_{prim,tot}$ = Total primary energy usage of building with specific function (standard conditions) [MJ/yr]
$Q_{prim,verw}$ = Energy use for space heating [MJ/yr]
$Q_{prim,vert}$ = Energy use for ventilators/extractors [MJ/yr]
$Q_{prim,vl}$ = Energy use for lighting [MJ/yr]
$Q_{prim,pomp}$ = Energy use for pumps [MJ/yr]
$Q_{prim,koel}$ = Energy use for cooling [MJ/yr]
$Q_{prim,bev}$ = Energy use for humidification
$Q_{prim,tap}$ = Energy use for hot water [MJ/yr]

Parameters used in formula 2:

$Q_{cool,yr}$ = yearly cooling demand
$Q_{cool,c,i}$ = monthly cooling demand, corrected for latent cooling demand

Parameters used in formula 3:

$Q_{cool,c,i}$ = monthly cooling demand, corrected for latent cooling demand
f_{latent} = correction factor for latent cooling demand (=1.1)
Q_{solar} = solar heat gain into the building
$Q_{internal}$ = internal heat gain in the building
η_b = a utilization factor for cooling, which is dependent on the ratio heat loss / heat gain per month.
Q_{tr} = heat gain through transmission
Q_{vent} = heat gain through ventilation

Parameters used in formula 4:

$Q_{c\text{-}consumption}$ = cooling consumption
$Q_{cool,yr}$ = yearly cooling demand
η_{gen} = efficiency of the cooling machine

Parameters used in formula 5:
$\eta_{gen,res}$ = resulting efficiency of the cooling machine when multiple supplies are used
$\eta_{gen,pref}$ = efficiency of the cooling machine that is used preferentially
$\eta_{gen,npref}$ = efficiency of the other cooling machine(s)
α_{cool} = ratio of cold demand met by supply with the highest efficiency and the total cold demand (=0.8)

Parameters used in formula 6:
Q_{verw} = Energy usage for space heating in one year [MJ/yr]
$Q_{verw,i}$ = Energy usage for space heating in one month [MJ]

Parameters used in formula 7:
$Q_{verw,i}$ = Energy usage for space heating in one month [MJ]
$Q_{verw,beh,i}$ = Energy demand for space heating in one month [MJ]
$\eta_{opw,ver,i}$ = Efficiency of heat generation in month i
$\eta_{sys,ver}$ = Yearly average efficiency of system for heating

Parameters used in formula 7:
$\eta_{opw,ver,i}$ = Efficiency of heat generation in month i
$f_{pref,i}$ = Monthly ratio of heat supply with preferentially system.
$\eta_{opw,verw,pref}$ = Efficiency of preferentially system
$\eta_{opw,verw,npref}$ = Efficiency of other then preferentially systems

I.III Specification of the unit for the calculation
The unit of calculation is a building, consisting of several energy sections based on their functions. The calculations result in primary energy use for the building in one year.

I.IV Baseline issues
The baseline of a separate building is the energy usage per year corresponding with the energy label before any energy savings measurements are taken.
This is a "before situation" with a static baseline. The baseline is different for each specific building depending on the way the building was built and which techniques where used. For calculating the baseline the same assumptions hold as for calculating the energy savings.

Energy savings as a result of renovation of a building are calculated with respect to the situation before the renovation. The same formula’s are used in the before and the after situation. The renovation of the building could change the heat load into and out of the building, which will affect heating demand and heating consumption. If the heating installation itself is improved, this will have an effect on the resulting efficiency of the heating installation. Strictly speaking, the energy savings due to switching to heat pumps, are only the energy savings due to improved efficiency of the system.

I.V Normalization

[ref7]

- As reference for the outdoor temperature, a Test Reference Year in De Bilt is used.
  Test Reference Year:
  Average $T_{outside}$ = 5.64°C during heating season (212 days - 1st of October to 30th of April
- Many values are dependent on the function of the (part of) the building. Below stated for offices:
  T_{inside} for heating = 19°C
  T_{inside} for cooling = 24°C
  Minimum ventilation rate = 1,3 $dm^3/s.m^2$
  Internal heat gains persons = 3 W/m^2
  Internal heat gains appliances = 3 W/m^2

I.VI Energy savings corrections

No gross to net calculations are done.

If gross to net calculations would be done there would be probably be an interaction effect between several technologies since an improvement of an energy label will most often be accomplished through applying several measurements

II Input data and calculations

II.I Parameter operationalisation

An EPA advisor assesses the situation in the building before renovations as specified in the ISSO 75.1 standard. This entails obtaining the necessary parameters on dimensions of the building, window area, type of insulation, type of cooling installation, in considerable detail.

II.II Calculation of the annual savings as applied

The calculations are done with attested software. Results are reported in terms of overall primary energy consumption and the energy label of the building. The before situation is calculated and the situation with a heat pump instead of the former installation is also calculated. The difference is the annual savings.

II.III Total savings over lifetime

No calculations of the savings over a lifetime are done. No lifetimes are stated.

II.III.I Savings lifetime of the measure or technique selected

II.III.II Lifetime savings calculation of the measure or technique

Reference

[ref13] ISSO 75.3 Handleiding Energieprestatie advies utiliteitsgebouwen formulestructuur, Stichting ISSO, 2009

Annex B4: A SIMPLER ENERGY SAVINGS CALCULATIONS FOR AIRCONDITIONERS IN COMMERCIAL BUILDINGS

In a preparatory study on air conditioning[16] the calculation is made somewhat simpler than in the ISSO standard. We give it here for comparison. Calculations have been made for the EU, including the Netherlands. Specific parameter values used for the Netherlands are not reported, but an 'average climate' is reported.

The internal and solar gains are not calculated explicitly. Instead, an average temperature increase of 4ºC above the outdoor temperature is used for a temperature climate like the Netherlands.

Formula are as follows:
The cooling demand is

$$Q_{cool} = V * t * \overline{\Delta T}(\overline{U} * \frac{A}{V} + c_{air} * r_{in,vent}) * (1 + h_{latent})$$

The cooling demand is composed of a transmission loss component ($\overline{U} * \frac{A}{V}$) and a ventilation heat loss component ($c_{air} * r_{in,vent}$). The internal gains are incorporated in the average temperature difference between inside and outside.

The cooling consumption is

$$Q_{consumption} = (1 + SL)(1 + AUX)\frac{Q_{cool}}{SEER}$$

Where
Qcool = cooling demand
V = total buildings volume
t = number of full load hours
$\overline{\Delta T}$ = average temperature difference inside – outside over period of 7 – 21 hrs
$\overline{U}$ = average Uvalue of the building (in W/m2 K)
A/V = ratio of surface to volume of the building
C_{air} = specific heat of air, 0,33 Wh/m^3K
$r_{in,vent}$ = a standard infiltration and ventilation air exchange rate (1 m^3/m^3.h)
h_{latent} = latent load

SL = a factor to take into account system efficiency (distribution of cold etc.): 25%
AUX = a factor to take into account auxiliary consumption
SEER = aggregate Seasonal Energy Efficiency Ratio

The SEER rating of a unit is the cooling output during a typical cooling-season divided by the total electrical energy input during the same period.
The SEER can be compared to η_{gen}/η_{el} from table I of the main text.

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[16] Lot 6: Air conditioning and ventilation systems, Draft report of Task 1, June 2010, coordinated by Philippe RIVIERE, ARMINES, France, p. 244 – 247).

The higher the unit's SEER rating the more energy efficient it is. A SEER of 6 is used for an efficient air conditioning in the Ecodesign study. It should be noted though that the SEER's reported there represent an average European climate for cooling, with a dominant contribution from Southern Europe. This will influence the SEER.

Example calculation

V	2.5 m^3 (in order to generate output per m^2)
HRS	1200
$\overline{\Delta T}$	4
$\overline{U}$	1.5
A/V	0.4
C_{air}	0.33
$r_{in,vent}$	1
h_{latent}	20%
T_{amb}	3.9
SL	25%
AUX	25%
SEER	Going from 2,5 to 6 (baseline – new situation)

The cooling load is in this example is 48 MJ/m^2.
With the SEER of 2.5, the cooling consumption is 30 MJ/m^2. With a SEER of 6 the cooling consumption is 13 MJ/m^2, and 17 MJ/m^2 is saved.

Annex B5: DATA FOR LIGHING IN THE NETHERLANDS (HOUSEHOLDS)

Here we present some data on domestic energy consumption for lighting in the Netherlands (the BEK studies for 1995 and 2000). The Dutch energy companies monitored the electricity consumption for lighting and a host of electric appliances in great detail up until the year 2000. Since 2002 a less detailed monitor, the HOME-panel replaced the BEK-studies.

The BEK-data provide a good insight into the role of keys elements and give an order of magnitude of reference values for the key parameters. For the calculations of energy consumption and savings three basic pieces of information are required, volume, capacity and use. In the tables below the BEK-data for these three elements are presented. The studies make a distinction between 14 types of rooms and 4 types of lighting.

Table A1: burning hours

Lighting zone	**room / area**	**1995** (hr/yr)	**2000** (hr/yr)
zone 1	kitchen, living room	886	890
zone 2	main bedroom, bath, toilet, hall	359	361
zone 3	other bedrooms, garage, loft, cellar, other	129	131
zone 4	Outdoor	280	280
Total	all areas	483	482

(For brevity reasons the 14 types of rooms used in the BEK study have been collapsed to four lighting zones)

Table A1 illustrates that the burning hours differ substantially over the zones. Furthermore, the number of burning hours per zone is very stable. Setting the burning hours (b_o and b_n) in the formulas equal will most probably have no or little effect on the outcome of the ESC.

Table A2a: # units 1995

	bulb	halo	cfl	tl	total
zone 1	7.5	1.3	0.9	1.4	11.1
zone 2	6.6	0.4	0.3	0.3	7.6
zone 3	5.6	0.2	0.2	1.6	7.7
zone 4	1.1	0.1	0.5	0.1	1.7
total	20.8	2.0	1.9	3.4	28.1

Table A2b: # units 2000

	Bulb	halo	cfl	tl	total
zone 1	7.1	2.5	1.2	1.4	12.2
zone 2	6.6	1.2	0.5	0.3	8.6
zone 3	5.4	0.7	0.4	1.6	8.1
zone 4	1.2	0.3	0.6	0.1	2.2
total	20.4	4.6	2.7	3.4	31.0

In table A2 it can be seen that the number of lighting units in a household grew with almost 3 units or about 10% between 1995 and the year 2000. Growth occurred in all lighting zones but at different rates. The growth can be attributed mostly to halogen lighting with 2.6 extra units and to a lesser extent to CFL lamps with 0.8 units. The number of conventional bulbs dropped slightly with 0.4 units.

Table A3a: average unit capacity 1995

	bulb	halo	cfl	tl	total
zone 1	39	22	13	37	34.6
zone 2	41	21	16	23	38.2
zone 3	41	21	15	36	38.6
zone 4	55	28	20	40	43.2
total	41.0	22.0	15.4	35.3	37.2

Table A3b: average unit capacity 2000

	Bulb	halo	cfl	tl	Total
zone 1	40	23	11	37	33.3
zone 2	45	25	13	23	39.7
zone 3	42	21	12	37	38.0
zone 4	55	15	15	40	39.3
total	43.0	23.5	12.4	35.8	36.7

Table A3 shows that the average lamp in a household has a somewhat smaller capacity in 2000 as compared to a unit in 1995. But since the number of units increased by 10%, the amount of capacity installed still increased by almost 9%. For the different types of lighting the average capacity resembles the popular types of lamps very closely. The 40w bulb, the 20w halogen lamp, the 11w CFL and the 35w TL-tube can be recognised in the average capacities. The data for average unit capacity are very useful as reference values.