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Energy Efficiency for Buildings — Standard economic evaluation procedure for energy systems in buildings

Energieefficienz von Gebäuden — Wirtschaftlichkeitsberechnungsverfahren für Energiesysteme in Gebäuden

Efficacité Energétique des Bâtiments — Méthode d'évaluation économique des systèmes énergétiques des bâtiments — Présentation en coût global et coût annualisé

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Foreword

This document (TC 228 WI 016) has been prepared by Technical Committee CEN/TC 228 “Heating Systems for Buildings”, the secretariat of which is held by Denmark (DS).

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, B, C or D, which is an integral part of this document.

The subjects covered by CEN/TC 228 are the following:

— Design of heating systems (water based, electrical etc.)

— Installation of heating systems

— Commissioning of heating systems

— Instructions for operation, maintenance and use of heating systems

— Methods for calculation of the design heat loss and heat loads

— Methods for calculation of the energy performance of heating systems

— Method for economic performance of heating systems

Heating systems also include the effect of attached systems such as hot water production systems.

All these standards are systems standards; i.e. they are based on requirements addressed to the system as a whole and not dealing with requirements to the products within the system.

Where possible reference is made to other CEN or ISO standards, however, use of standardised products is no guarantee for complying with the system requirements.

The standard text is composed by requirements accompanied by guidelines.

The requirements are mainly expressed as functional requirements, i.e. requirements dealing with the function of the system and not specifying shape, material, dimensions or the like.

The guidelines are indicating ways to meet the requirements, but other ways to fulfil the functional requirements might be used if the fulfilment can be proved.

Heating Systems differ among the member countries due to climate, traditions and national regulations. In some cases requirements are given as classes so national or individual needs may be accommodated. In cases where the standards contradict with national regulations the latter should be followed.

Introduction

All the standards of CEN TC 228 are system standards. This standard presents a method for the economic calculation of the heating systems, relying on data from other systems that may influence the energy demand or the of the heating system.

This method can be used, fully or partly, for the following applications:

- Consider economic feasibility of energy saving options in buildings

- Compare different economical solutions of energetic options in buildings (plant types, fuels,…);

- Evaluate economic performance of an overall design of the building (for example, trade-off between energy demand and energy efficiency of heating systems);

- Assess the effect of possible energy conservation measures on an existing heating system, by economic calculation of the cost of energy use with and without the energy conservation measure.

The user shall refer to other European Standards or to national documents for input data and detailed calculation procedures not provided by this standard, especially dynamic economical calculation are not detailed in this standard. The methods to calculate the building heating energy demand are provided by TC 89 (EN832, EN 13790, WI related to EPBD standardisation program under convenorship of TC 89WG4).

1 Scope

This standard provides a calculation method for the economical issues of heating systems and other systems that are involved in the energy demand and consumption of the building. It applies to all types of buildings.

The fundamental principles and terminology are explained in the standard.

The main items of the standard will be:

— the definitions and the structure of the types of costs which shall be taken into account for the calculation of the economical efficiency of saving options in buildings,

— data needed for definition of costs related to systems under consideration

— the calculation method(s)

— expression of the result of the economic study

— the informative annexes indicate default values of lifetime, the cost for repair, maintenance, … in order to introduce default values for calculations.

The aim of the standard is to define a common framework. The hypothesis for the calculation could be chosen project by project. But the transparency of the hypothesis taken, is one of the bases of the standard.

This standard is part of the method for calculation of economic performance of energy saving options in buildings (e.g. insulation, better performing generators and distribution systems, efficient lighting, renewable sources, combined heat and power, …).

The scope of this specific part is to standardise

— the required inputs,

— the required outputs,

— the calculation formulas,

of energy systems concerned with the energy performance of the building.

Note : Sensitivity of results increase depending on the number of parameters that are under consideration (lifetime, financial rates, ratio of price rise rates,…) and as numerous are the parameters that changes when comparing different solutions, as difficult will be the conclusions that rise when economic results are compared between solutions.

Economical results are closely related to the project under consideration, and no general conclusion should be drawn from any such results.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies.

EN 12828: *Heating systems in building - Design of water based heating systems .*

EN 14337: *Heating systems in building – Design and installation of direct electrical heating systems.*

prEN 15450 *Heating systems in building – Design of heat pump systems for heat pump*

prEN 15203 *Energy performance of buildings – Assessment of energy and definition of ratings*

3 Terms and definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
Costs
Costs include initial investments costs and annuals costs. Annuals costs includes running costs and periodic costs due to repair or change of components and systems.

3.1.2
Initial investment costs [C_I]
Initial investment costs are to be considered when the building (or the specified equipment) is delivered to the customer, ready to use. This costs include design, purchase of systems and components, connection to suppliers, installation and commissioning process.

The costs are the one that are presented to the customer.

3.1.3
Running costs [C_r]
Running costs includes maintenance cost, operational cost, energy cost and added cost as defined below.

3.1.4
Maintenance cost [C_m]
Costs of measures for preserving and restoring the desired quality of the installation.
This include annual costs for inspection, cleaning, adjustments, repair under preventive maintenance, consumable items.

3.1.5
Operational cost [C_o]
Annual costs for operators.

3.1.6
Energy cost [C_e]
Annual costs for energy and standing charges for energy (and other consumables as well as costs)

NOTE: Contracts for energy delivered are included in energy costs. Use of energy results in external costs, which are not included in the official price. It is considered good practice to include the external costs and metering costs in economic calculations and to specify them.

3.1.7
Added costs [C_d]
Insurance, other standing charges, taxes (including environmental taxes for energy),
Subsidies for renewable energy delivered or local production are consider as benefits or cost reduction.

3.1.8
Periodic costs of year i [$C_{p\,(i)}$]
Substitute investment that is necessary for age reasons; corresponds to cost replacement of components (or system) according to their lifespan.

3.1.9
Replacement costs for component or system [$C_{R\,j,\,Tn}$]
Replacement costs includes the periodic costs of component j at time T_n, $2T_n$, … that corresponds to the lifespan of the component (including disposal of component j).

3.1.10
Annual costs [$C_{a\,(i)}$)]
Annual costs of the year i represent the sum of running costs and periodic costs or replacement costs paid on the year i.

3.1.11
Inflation rate [R_i]
Annual depreciation of the currency
0 < Ri < 100

3.1.12
Discount rate [R_d] - see also definition of present value factor
The discount rate is a definite value to compare the value of money at different period. 3.1.13

3.1.13
Market interest rate [R]
Interest rate agreed by lender (0 < R <100)

3.1.14
Real interest rate [R_R]
Market interest rate adjusted according to inflation rate. Real interest rate may vary during the calculation period for dynamic calculation.

3.1.15
Annuity factor [$a(n)$]
Factor by which any annual costs and yearly incomes are to be divided to be comparable with the initial investment at the time of installation.

Annuity factor a depends on year n.

3.1.16
Cost development for energy and operation
Evolution of prices for energy, products and human operation may be different than the inflation rate. Subsequent rate can be introduced in the calculation process.

Rates are expressed in %

R_m rate of development of the price for maintenance

R_{e_k} rate of development of prices for energy k (rate could be different depending on the energy considered)

R_o rate of development of prices for human operation

R_d rate of development of added costs

3.1.17
Life span [$T_{n(j)}$]
Lifetime expectancy for a component j (or system) normally specified in years.

3.1.18
Present value factor [$f_{pv}(n)$]
Factor by which any annual costs and yearly incomes are to be multiplied to be comparable with the initial investment at the time of installation.

Note: f_{pv} (n) = 1/a(n) ; with a(n) = annuity factor

3.1.20
Design payback period for building ($T_{\_Building}$)
Period decider by owner to complete the payback of the building

3.1.21
Starting year [T_0]
Date on which any calculation is based

3.1.22
Calculation period [T]
Time period considered for the calculation

3.1.23
Final (or residual) value [$V_{f(j)}$]
Final value corresponds to the value of the component j at the end of the calculation period. Final value is compared with the initial investment at the time of installation (example in figure 1)

3.1.24
Present value
Value of all costs and all incomes that will occur during the calculation period at today's time (year 0)

3.1.25
Nominal value
Value of costs (or incomes) considered at year paid

3.1.24
Present value of component [$V_{(j)}$]
Refers to a component j, a system or a charge. The present value refers to the starting year and annual costs are adjusted with the present value factor except for initial investment whom present value factor is 1.

3.1.25
Real value or present value
Corresponds to prices of the starting year

3.1.26
Nominal value
Corresponds to the prices of the year paid

3.1.27
Global cost [$CG(T)$]
Sum of present value of all costs (with reference to starting year) including investment costs. At the end of the calculation the deconstruction cost or the residual value of the components should be taken in account to calculate final costs.

Note1: Global cost is directly linked to the duration of the period T considered for the calculation.

Note2: Taking in account the deconstruction means the calculation period corresponds to the lifetime of the building.

3.1.28
Annuity cost [*CA*]:
Repartition of the costs on an average yearly value. Investment and replacement costs are divided regarding the duration of the calculation and the lifetime of components (see figure 2) . Annuity cost does not depend on the calculation period.

3.2 Symbols and abbreviations

For the purposes of this document, the symbols and units presented in table 1apply.

Table 1 — Symbols and units

Symbol	Name of quantity	Unit
$a(n)$	Annuity factor (for year n)	-
C_I	Initial investment costs	€
$C_{a\ (i)}$	Annual costs of the year I (at nominal value)	€
$C_{R\ j,\ Tn}$	Replacement costs for component or system j at time T_n, $2T_n$, …	€
b_x	Price dynamic present value factor for costs x	-
C_d	Added costs (annual)	€
C_r	Running costs (annual)	€
C_e	Energy costs	€
C_m	Maintenance costs (annual)	€
C_o	Operational costs	€
$C_{p\ (i)}$	Periodic costs of the year I	€
$f_{pv}(n)$	Present value factor (for year n)	-
$n_{(j)}$	Number of replacement of component j within the observation period	- (Integer)
$CG\ (T)$	Global cost (corresponding to period T)	€
R	Market interest rate	%
$R_{R\ (i)}$	Real interest rate (for year i)	%
$R_{d(i)}$	Discount rate (for year i)	%
R_{e_k}	Rate of evolution of prices for energy_k	%
R_o	Rate of evolution of prices for human operation	%
R_d	Rate of evolution of prices for added costs	%
R_m	Rate of evolution of rmaintenance costs	%
$R_{i\ (i)}$	Inflation rate (for year i)	%
T	Calculation period	Year
$T_{\_Building}$	Design payback time for the building	Year

$T_n(j)$	Lifespan or design duration for component j or system j	Year
T_0	Starting year for calculation	Year
$V_{(I,j)}$	Present Value of component j at year i	€
$V_{T\_f(j)}$	Final value of component j (corresponding to period T)	€

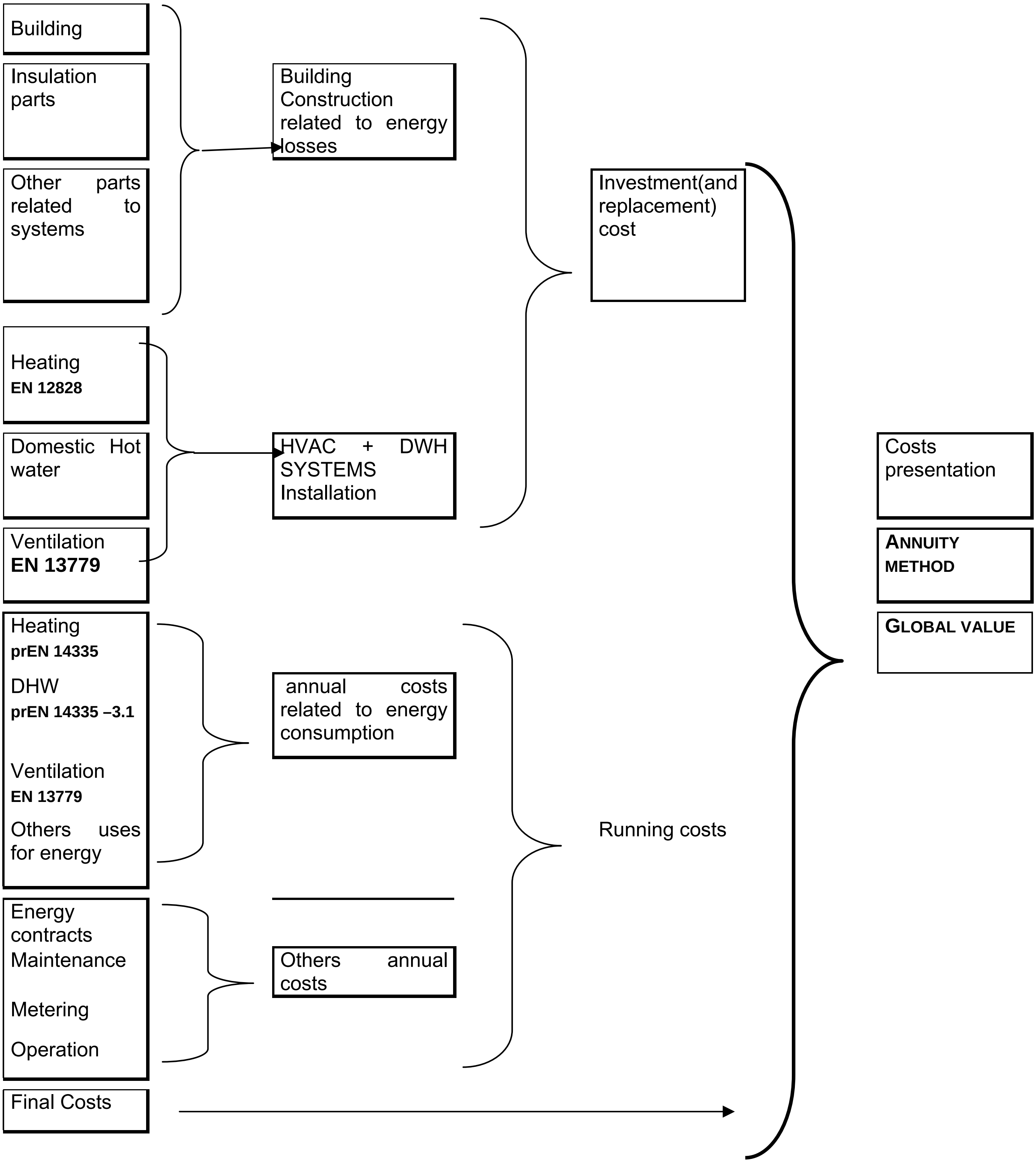
4 Organisation of the method

The method is presented from a global point of view. But regarding the objectives of investor, method could be run only when filling one or two items. For example, calculation about alternative solutions for heating systems can be run considering DWH and heating costs only.

Table 2 presents the global organisation of the data.

Costs are separated within running costs excluding the costs due to initial investments and the periodic replacement of components.

Table 2 — Organisation of data



5 Calculation formulas

5.1 Core calculation formulas

5.1.1 Real interest rate

Real interest rate depends on market rate R and on inflation rate R_i

$$R_R = \frac{R - R_i}{1 + R_i} \qquad (1)$$

5.1.2 Discount rate

The discount rate depends on real interest rate R_R and on year of the considered costs (p)

In the year T_o + p the discount rate will be $\left(\frac{1}{1+R_R}\right)^p$ (2)

5.1.3 Present value factor

Present value factor depends on real interest rate and year (n) considered for the costs

$$f_{pv}(n) = \frac{1-(1+R_R)^{-n}}{R_R} \qquad (3)$$

5.1.4 Annuity factor

Annuity factor in the inverse value of the present value factor. $a(n) = \frac{1}{f_{pv}(n)}$ (4)

5.2 Global cost [C_G (T)]

5.2.1 Principles of the calculation

Calculation are made considering the initial investment $C_{I,}$ the present value of annual costs for any year "i" and final value of any component or system "j". Global cost is directly linked to the duration of the calculation period T

$$C_G(T) = C_I + \sum_{i=1}^{T}\left(C_{a(i)} \times f_{pv}(i)\right) - \sum_{j=1} V_{T\_f}(j) \qquad (5)$$

Calculation may be driven either when taking in account costs calculation year after year, either when taking in account the economic calculation for any component and any subjects.

Dynamic calculation introduces yearly variations of the inflation rate and the evolution of energy prices, operation and servicing related costs.

5.2.2 Calculation of the final value

The final value $V_{T\_f}(j)$ of a component is determined by straight-line depreciation of the investment premium until the end of the duration of calculation and discounted at the beginning of the calculation period.

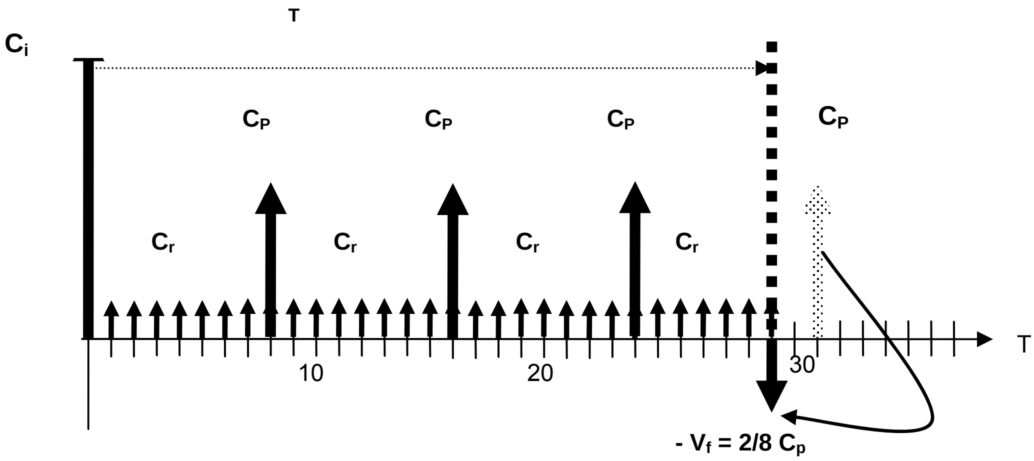


Figure 1 – Illustration of final value concept

If the calculation period T exceeds lifespan $T_n(j)$ of the component (j) under observation, the last replacement investment is considered for the straight-line depreciation.

$$V_{T\_f}(j) = V(0,j) * (1+R_P)^{n*Tn(j)} * \left[\frac{(n+1)*T_n(j)-T}{T_n(j)}\right] * \frac{1}{(1+R_i)^T} \quad (6)$$

$V(0,j)*(1+R_p)^{n*Tn(j)}$ represents the price at point of purchase when taking in account the evolution of costs for products

$\left[\frac{(n+1)*T_n(j)-T}{T_n(j)}\right]$ represents the straight-line depreciation

$\frac{1}{(1+R_i)^T}$ represents the discount value factor when using annuity method.

Figure 2 illustrates such a principle

With T: calculation period (30 years for example)

Tn : lifetime for component (8 years for the example)

Total cost for the calculation period considered is the sum of:

— initial investment A0 (value of initial investment rises due to inflation rate)

— any time lifespan of the component is achieved, component must be replaced when taking in account present value factor (as a function of inflation rate and market interest rate)

Final value is calculated with linear interpolation of the replacement cost, In the case of the figure 2 V_f(component) = V0 + V1 + V2 – Vf_{Ao}

A'_0 and A''_0 represent the nominal of the component at T_n and 2^*T_n

With $V_1 = V'\frac{V'_0}{(1+R_D)^{Tn}}$ and $V'_0 = V_0(1+R_i)^{Tn}$

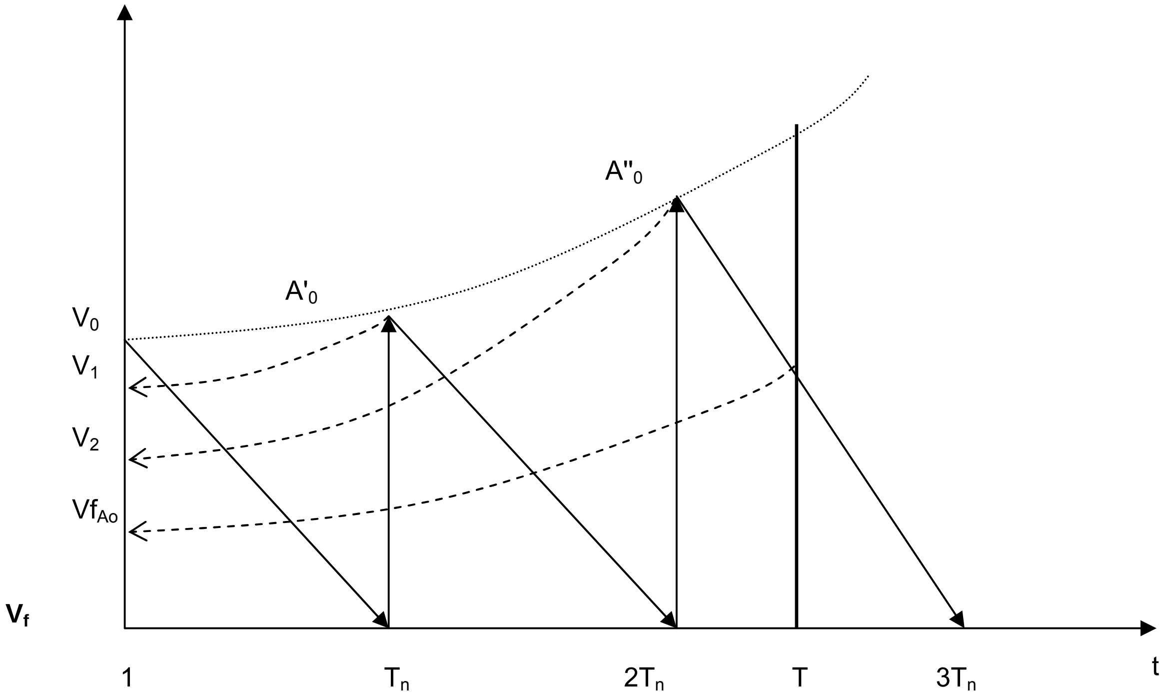


Figure 2 — Evolution of value during calculation period T

5.3 Annuity calculation

An alternative approach is to present annuity costs of the building. Annuity calculation method transforms any costs as an average actualized value.
Where as the global cost methods gives a total value on the defined calculation period T, for annuity calculation, any costs are transformed with the annuity factor a(n) and annuity costs represents the annual cost effort.

Calculations are separated in 3 categories:

- investment part considers the designed payback time of the building for unchanged components (and part of the building structure to be taken in account).
- replacement costs consider lifetime of components
- investment costs related to the unchanged part of the building are divided with the design lifetime of the buildings
- running costs. if evolution rates of the different categories of running costs are different dynamic annuity factor shall be used (chapter 5.2.4).

Table 3 illustrates flows of information and calculation process.

	Initial value		2	3		n		T_building (components unchanged)	Σ
Component 1	V(1,0)		0	1	0	0	0	0	Σ (line) = 1
			0	0	1	0	0	0	1
Component j	V(j,0)		0	0	0	1	0	0	1
Component k	V(k,0)		0	0	0	1	0	0	1
Component l	V(l,0)		0	0	0	0	1	0	1
			0	0	0	0	1	0	1
Component y	V(y,0)		0	0	0	0	0	1	1
			a^2 Σ	a^3 Σ		a^n Σ	0	$a^{T\_building}$ Σ	

Table 3 – Organisation of calculation for annuity calculation

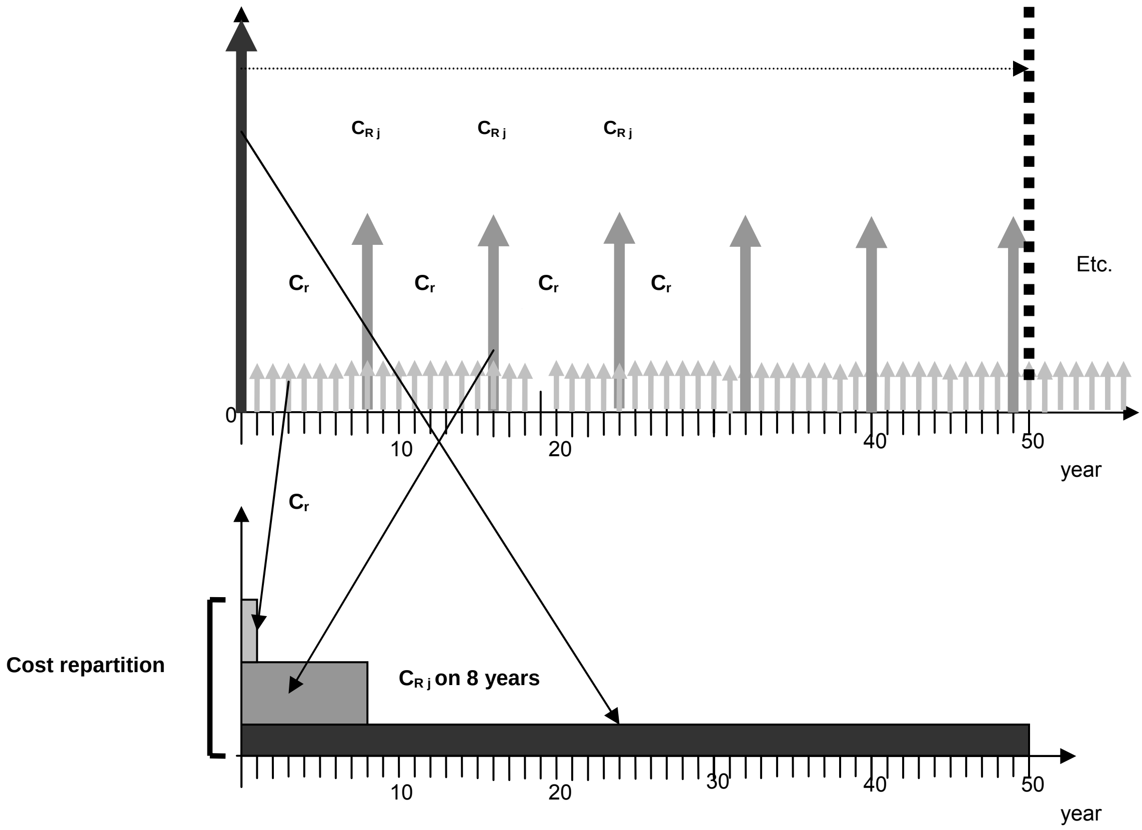


Figure 3 — Annuity cost presentation

5.3.1 Annuity calculation for unchanged component during the design payback period of the building

All initial costs of the unchanged components or part of the systems that remain unchanged during the design payback period of the building are multiplied by the corresponding annuity factor a($T_{\_Building}$)

For $T_{\_Building}$ = 50 years, R_i=2% and R=4,5% a'T_Building) = 0,0395 (see Annex E Step 6)

5.3.2 Annuity calculation for replaced components

The initial replacement costs shall be multiplied by the corresponding annuity factor depending on R_m (rate of development of the price for maintenance) and of the lifespan of the considered component (See Annex A).

For Rm = 2% and Tn(Boiler) = 15years the corresponding annuity factor is 0,0805 (see annex E step6)

5.3.3 Annuity calculation for annual costs

Annual costs covers energy but also insurance and usual operation and maintenance on installation and building.

For example $C_r = (C_e + C_o + C_m)$

If differential evolution rates are to be taken in account, coefficient b_x shall be introduced to moderate any annual cost to the different evolution of rates. Formulas becomes*:*

$$C_r = (C_e \times b_{en\_x} + C_o \times b_{OP} + C_m \times b_P)$$

5.3.4 Influence of prices evolution for dynamic calculation

If prices of the regular payments are considered to change during the calculation period, these payments must be multiplied by the price dynamic present value factor b_x as function of the present value factor and the rate of evolution of the nature of the prices considered.

Example of dynamic calculation are detailed in national methods or standards

$$b_x = \frac{1 - \left(\frac{1 + R_x}{1 + R_i}\right)^{T\_building}}{(R_x - R_i)}$$

$R_x = R_i$ implies $b_x = 1$

6 Principles of the method

Figure 4 illustrates the different stages necessary to fulfill the method.

The different stages of the method are presented within chapter 6.1 to 6.6.

The process is linear an

Some of the information are given for information (environment of the project), but shall be documented in order to give the possibility for comparison between buildings or for use of conventional costs ratio in the buiding construction (Cost par Surface unit).

Choice of these parameters shall be in accordance with those considered for the energy certification of the building

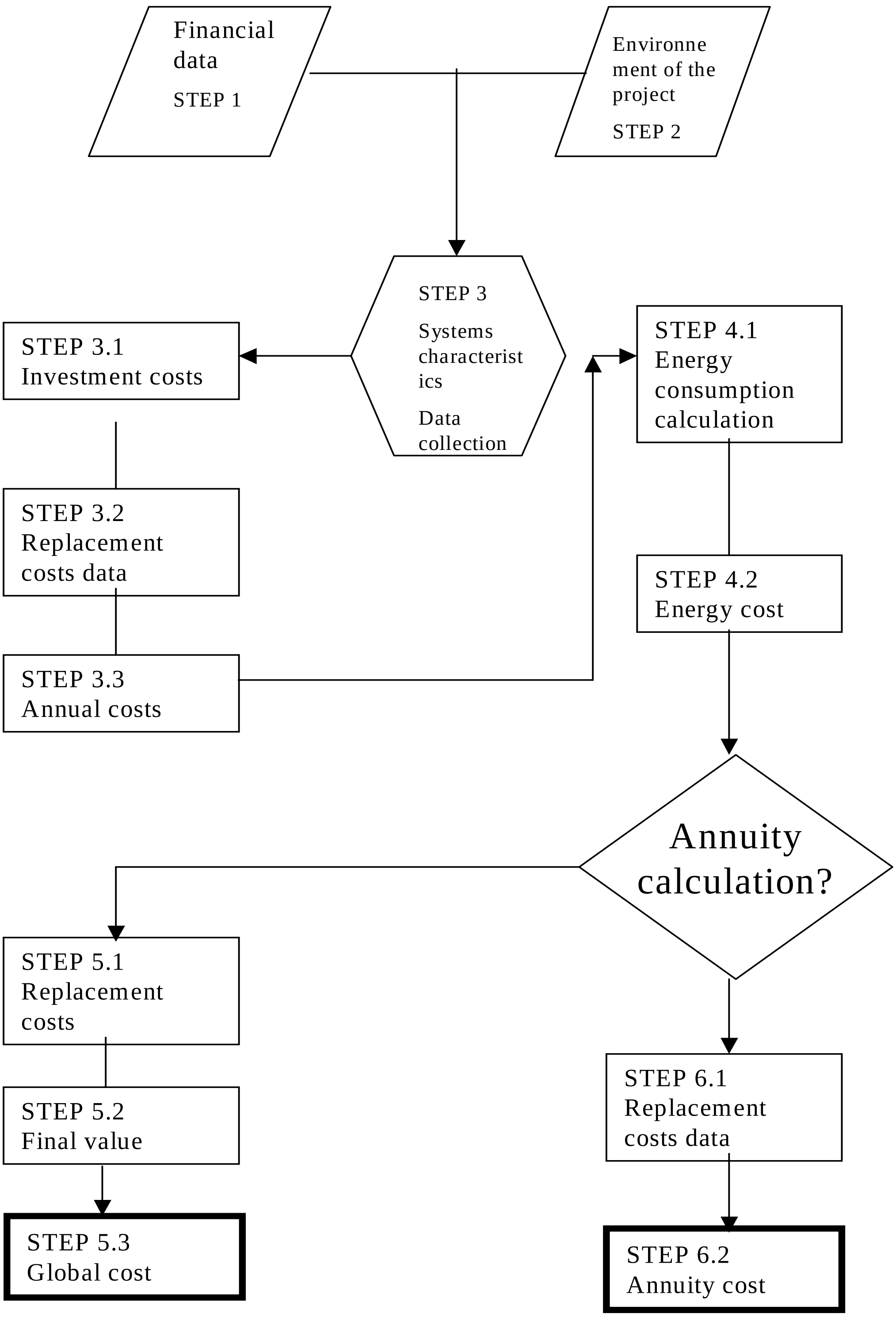


Figure 4 — Flowchart – Organization of the different STAGES

6.1 STEP 1 - Financial data

Data needed are expressed in clause 6.1.1 to 6.1.4

6.1.1 Duration of the calculation

Duration of the calculation is fixed according with the objectives (or given by the building owner). Default value could be the expected lifetime of the building. But it is also interesting to run the calculation on a shorter value to evaluation the costs during the duration or the mortgage subscribed for example.

Duration of the calculation is taken in account for the number of years to be considered for the global cost. For annuity calculation, only the design life time of the building is necessary.

6.1.2 Evolution of financial rate

Inflation rate is obtained or estimated from available economical institute data as an average value over the calculation period.

Market interest rate is the average expected value of the interest rate over the calculation period

6.1.3 Evolution of human operation costs

Evolution of human operation costs depends of the cost due to staff in operation (usually maintenance rise costs is higher than inflation rate). This is the average expected value of the interest rate over the calculation period.

6.1.4 Evolution of energy prices

As a basis, evolution of energy prices as considered to inflation rate. Available information can be obtained from energy utilities or form economical analysis regularly provided by European Commission or national energy forecasting organizations.

NOTE : added information about costs of supplied water to the building can be added for annual costs.

6.2 STEP 2 - Project data

This STEP identifies the systems that will be considered for economic calculation and provides data necessary to run the process. Information are obtained from the design project and from the contractors.

6.2.1 Environment of the project

These data are given for information as they are necessary to identify the constraints and that could define or influence the energy consumption and the choice between alternative solutions the contractors would like to be analyzed.

- Country or region
- Location of the building : city center, urban zone, …
- Construction constraints on the external aspect of the building (roof, envelope)
- Type of buildings (row house, detached house, co-housing, multistorey…)
- Noise

6.2.2 Meteorological data (not mandatory)

These data are given for information.

6.2.3 Constraints/oppportunity related to energy

Official energy requirements on building fabric and systems

- forbidden fuel
- orientation of the building
- flue (possible- impossible)
- district heating existing
- difficulties for energy access for fuel distribution
- fuel gas network proximity
- renewable energy possibilities (for solar collectors, fuel cells, natural ventilation, heat pump,…)

identify customers approach on comfort and occupancy

6.3 STEP 3 - Costs regarding components and systems (investment, replacement)

6.3.1 Data collection

Data concerning component and system are collected and information about lifespan, maintenance, operation,… are gathered.

Annex A gives some default value for main components.

6.3.2 STEP 3.1 - Investment costs for systems related to energy

This step is applied to the systems identified in step2, which are related to energy and energy conservation. Table 4 provides examples for different applications of the calculation method.

Example of costs calculation	**Heating**	**Domestic Hot Water**	**Ventilation**	**Cooling**	**Lighting**	**Building fabrics and insulation**
Existing building Comparison between 2 heating systems	X	X				
New building Estimation of the annualized cost	X	X	X	X	X	X
Existing building Comparison between 2 heating systems with reduction of heat demand (insulation of	X		X	X		X

the building)						
Existing building Balancing between better performing heating system and insulation of the envelope	X					X

Table 4 — Example of systems under consideration for costs calculation

Description of systems are given as examples in annex B.

Lists given in clause 6.3.2.1. to 6.3.2.7 are given as illustration lists and shall be completed according to the objectives of the calculation.

6.3.2.1 Investment cost for building construction

Indicates part of the structure that is related to energy efficiency or energy consumption.(building fabrics, insulation, openings, glazing, doors, solar protection…).

Calculation may be run with all the building structure but the influence of the energy system will be reduced.

6.3.2.2 Space Heating

6.3.2.2.1 Generation and storage

- Includes boiler or heat pump or substation with control and heat exchanger
- Solar collectors
- Others (district heating, Combined Heat Production, Fuel cells,…)
- Includes storage tank and control system (valve, sensor, heat exchanger, pump)

6.3.2.2.2 Distribution

- Main piping, pump(s) and equilibrium valves
- Wiring for control
- Wiring for electrical emitters

6.3.2.2.3 Emission

- Radiators,
- Embedded systems (surfacic emission) should be considered as heating emission and not part of the building construction
- Electric emitters (includes radiators, convectors and storage emitters with their control system)

6.3.2.2.4 Control

- Consider functions and products functions that are necessary to control heating in an efficient way (cf. EN 12098 series)

6.3.2.3 Domestic hot water

DWH systems includes

- Generation (boiler, heat pump, heat exchanger, electric storage water heater,…)
- Storage (intermediary storage heater
- Distribution (piping, mixing valve, thermostatic valve,…)
- Emission (thermostatic valve, mixing valve)
- Control (temperature, charge control for storage, …)

6.3.2.4 Ventilation

- Air supply
- Distribution (ducts, fans,…)
- Emission
- Control (includes filters, room control ,…)

NOTE: Natural ventilation is directly linked to the conception of the building, but specific items needed for air inlet and air outlet should appear in this part

6.3.2.5 Cooling

- Generation (related to heating or specific chiller)
- Storage (if necessary)
- Distribution (piping, equilibrium valves)
- Emission
- Control

6.3.2.6 Lighting

- Type of lighting and associated control system
- Solar protection and closing may be concerned if natural lighting is enhanced

6.3.2.7 Connection to energy supplies

- Consider the specific cost to be connected to energy network and the specific protection in the electric board.
- Storage tank for fuel oil, gas or biomass

6.3.2.8 Others systems

Process with energy that could be recoverable for the building

Building Management System that introduces supervising function that authorizes coupling between systems or reduction of the costs of energy contracts should be introduced as a specific costs.

If not, control function (and associated costs) are introduced in the specific domains.

6.3.3 STEP 3.2 - Periodic costs (replacement, …)

At this stage just indicate the cost of replacement for systems or components.

Some data about lifetime of components are presented in Annex A.

Depending of the year of replacement, present value factor shall be used to obtain the present value of the replaced component (or system)

6.3.4 STEP 3.3 – Running costs

6.3.4.1 Operational costs (excluding energy)

Operational costs represents the cost for energy operators of the building.

6.3.4.2 Maintenance and repairs

Consider staff and inspection and consumable items or annual contracts for cleaning, maintenance of components or systems.

As periodic inspection of energy systems for heating and air conditioned systems are mandatory, periodicity of thses verifications shall be include all periodic maintenance operations.(boilers, chillers,…)

6.3.4.3 Added costs Insurance, taxes

Are included insurance or taxes that are related to energy systems.

For example special taxes related to pollutants or energy use are to considered at this step.

6.4 STEP 4 - Energy costs

Energy costs are mainly separated in two parts:

— First part is directly related to energy consumption according with meters or fuel-oil consumption of the building. Method for calculation of the energy consumption shall be coupled to energy value according with data cost from the provider.

— Second part is fixed according to the quantity of energy subscribed with energy utilities or rental for energy systems (gas tank, electricity transformation,…).

For district heating may have special subscription.

Environmental (or social) costs could also be introduced as a cost related to energy.

Energy sales (if exists) are counted separately. They are counted as negative costs.

6.4.1 STEP 4.1 - Calculation for energy consumption

Calculation should be run according to standardized methods. EN 15203 allows calculation of the energy consumption for the whole buildings. If the economical analysis refers only to some of the energy systems, then energy consumption methods refers only to the standard or calculation method related to these systems (i.e. 15316 series for space and domestic hot water heating systems)

Reference to the standards (or specific methods if needed) should be referenced in the results report.

6.4.2 STEP 4.2 - Energy cost

Energy consumption is coupled with tariff for the energy considered.

In some case the energy consumption could be calculated according to the flexibility or the tariff of the utility.

These tariffs (mainly for electricity) may vary during the day and during specific period of the year.

Renewable energies or energy sales (electricity or hot water) shall be consider either as an financial income (as electricity from Photovoltaic cells can be sold directly on the electric grid) or as way to reduce energy cost of the building (example of solar collectors). Design of the system shall be consider in accordance with these two possibilities.

6.5 STEP 5 - GLOBAL COST CALCULATION

6.5.1 Step 5.1 Calculation of the replacement costs

Replacement costs throughout the calculation period are calculated based on timing of and costs for replacement of systems and components, as gathered in step2.

Present value factor is used to consider cost at year 0

6.5.2 Step 5.2 Calculation of final value (for global costing calculation only)

Final value by the end of the calculation period is determined by summing the final value of all systems or components.

Figure 3 illustrated the calculation process for one unit (component or system).

6.5.3 Step 5.3 Calculation of the global cost

The different types of costs (initial investment costs, periodic costs, annual costs) as well as the final value are converted to global cost (i.e. referred to year 0) by applying the appropriate present value factor (see annex E)

The present value factor may be different for the different categories of costs, due to different rates of prices development for energy, human operation, components, etc.

The global cost (depending on the period T) is determined by summing up the global costs of initial investment costs, replacement costs and energy costs and the final value of systems.

Annex C illustrates organization of the result data sheet.

6.6 STEP 6 - ANNUITY COST CALCULATION

Annuity calculation is run for any component of part of the system according formula given in § 5.2

For the annuity cost calculation, the calculation period is fixed and corresponds to the design pay back time of the building.

The annuity cost is determined by summing up the annualised costs of systems and components (investment and replacements), the annual costs (operation, maintenance, insurance, taxes, etc.) and the energy costs. (see annex D).

The different types of costs are converted to annualized costs by applying the appropriate annuity factor (see example in annex E)

For systems and components with a lifespan greater than or equal to the payback time, the annualized cost is determined from the initial investment cost and the annuity factor corresponding to the payback time.

For systems and components with a lifespan less than the calculation period, the annualized cost is determined from the replacement cost and the annuity factor corresponding to the lifespan.

Annual costs and energy costs are by definition annualized costs.

Annuity cost corresponds to the total value; the annuity cost corresponds to the average cost at year 0.

Annex A
(informative)
Economical data for energy systems

Table A1 presents some data about life span, annual maintenance costs and disposal cost for components and products. Column 3 displays a global value. National annex can provide more detailed values of the costs displayed for maintenance, repair and service costings. Terms and definitions in accordance with existing standards

Table A.1 - Data for lifetime and maintenance costs

Component	Life span Min – Max (years)	Annual preventive maintenance including operation, repair and servicing costs in % of the initial investment	Disposal cost in % of the initial investment
Air conditioning units	15	4	
Air coolers	15 - 20	2	
Air heaters, electric	15 – 20	2	
Air heaters, steam	15 – 20	2	
Air heaters, water	15 – 20	2 - 4	
Boiler - condensing	20	1 - 2	
Boiler – direct evacuation	20	1 - 2	
Boiler – Flue evacuation	20	1 - 2	
Burners, oil and gas	10	4 – 6	
Chimney	15 – 20		
Condensers	20	2	
Control equipment	15 –20	2 - 4	
Control system - Central	15-25	4	
Control system – room control	15 -25	4	
Control valves, automatic	15	6	
Control valves, manual	30	4	
Convectors	20	1	
Cooling compressors	15	4	

Cooling panels and ceilings	30	2	
Dampers	20	1	
Dampers with control motors	15	4	
Diffusers	20	4	
Dual duct boxes	15	4	
Duct system for filtered air	30	2	
Duct system for non filtered air	30	6	
Electric board	30	0,5 - 1	
Electric heater – thermal storage heater	20 – 25	1	1
Electric heating – convector	20 – 25	1	
Electric floor heating	25 –50* (*) if lifespan agreed according with tests results	2	20
Electric wiring	25 - 50	0,5 - 1	
Water floor heating	50	2	20
Evaporators	15 - 20	2	
Expansion vessels – membrane	15	0,5	
Expansion vessels with pad	15 - 25	2	
Expansion vessels, stainless	30	1	
Expansion vessels, steel	15	2	
Extract air grills	20	10	
Fan coil units	15	4	
Fans	15 - 20	4	
Fans with variable flow	15	6	
Filter frames	15	2	
Filter material to be exchanged	1	0	

Filter material, to be cleaned	10	10	
Fire dampers, easy accessible	15	8	
Fire dampers, hidden	15	15	
Fuel tank	30	0,5	5 – 10
Gas tank	30	0,5	5
Grills in general	30	4	
Heat pumps	15 - 20	2 - 4	
Heat recovery units, cyclic	15	4	
Heat recovery units, static	20	4	
Humidifiers, steam	4 - 10	4	
Humidifiers, water	10	6	
Meters	10	1	
Valve	10	1	
Motors, diesel	10	4	
Motors, electric	20	1	
Pipes, Cu	30	1	
Pipes, composite or (look at Water floor heating)	50	1	
Pipes, stainless	30	1	
Pipes, steel in closed system	30	1	
Pipes, steel in open system	15	1	
Piping systems	30	0,5	
Pumps – circulation	10 -20	2	
Pumps - reglauted	10 - 15	1,(5 - 2	
Radiators paint	20 - 30	0	
Radiators, water	30 -40	1- 2	
Shut off valves, automatic	15	4	
Shut off valves, manual	30	2	

Solar collector (Vacuum collector or plate collector	15 - 25	0,5	
Sound traps	30	1	
Tank storage for domestic hot water	20	1	
Tank storage with internal heat exchanger for domestic hot water	20	1	
Thermostats for radiators	15	4	
Valve with auxiliary power	10	1	5
Valve - Thermostatic	20	1,5	5
Variable flow units	15	6	
V-belt drive	10	6	
Wiring	30	1	

Annex B
(informative)

Systems description

Table B.1 - Description of space heating system with heat pump as hot water generator

Heating system: **Electrical heat pump for space heating**	**Component**	**Investment costs**	**Running costs** **Maintenance (as percentage of investment)**
Conception of the system			Information from WI 228 015
Emission	Embedded heat emission	X	Water treatment against corrosion and moisture
	Room control	X	Check set up
	Radiators	X	Cleaning and evacuate waste
	Fan coil units	X	Clean filters
Distribution	Pump	X	Check speed (or noise)
	Piping	X	Corrosion Deposit from the pipe (from cleaning operation)
	Mixing valve (including control)	X	Flow equilibrium
	Collectors	X	
	Expansion vessel	X	Pressure
Storage	Tank	X	Corrosion protection Prevent tartar deposit
	Seasonal storage	X	
Generation	Heat pump	X	Check pressure
	Control	X	Check set point
	Source collector	X	Corrosion Cleaning
	Electric board	X	Specific rate for electric charge Check connection and wire

Table B.2 - Description of heating system with combined gas boiler as hot water generator for DHW and space heating

Heating and DWH system **Combi Boiler for heating and DHW**	Component	Investment costs	Specific running costs Maintenance
Conception of the system			EN 12828
Emission	Embedded heat emission	X	Water treatment against corrosion and moisture
	Room control	X	Check set up
	Radiators	X	
Distribution	Pump	X	
	Piping	X	
	Mixing valve (including control)	X	Flow equilibrium
	Collectors	X	
	Expansion vessel	X	
Storage	Vessel if combined DHW	Optional	
	Pump and valve	Optional	
Generation	Energy supply -fuel or gas tank or gas connection - electric connection	X	
	Specific room for boiler	Optional	Depends on regulation and power of the boiler
	Boiler	X	Annual Inspection for combustion and safety
	Control system	X	
	Condensing discharge	X	
	Flue system or chimney	X	
Other cost	Metering (cost attribution)	X	In case of individual repartition from centralized boiler

Table B.3 - Description of heating system for DHW with solar collectors

System **Solar system for domestiC hot water**	Component	Initial costs	Running costs Maintenance (as percentage of investment)
Performance of the system			EN 12975
Emission	Valve	X	
Distribution	Piping	X	
	Heat exchanger	X	
Storage	Tank	X	
	Thermal charge control	X	
Solar Generation	Solar collector	X	Cleaning
	Piping and insulation	X	
	Pump and regulation		
	Frost protection	X	Check the composition of the fluid
	Energy supply for pump and regulation	X	
Secondary generation	Boiler or electrical resistance in the tank	X	

Table B.4 - Description of direct electrical heating system

Heating - System **Direct electrical heating system**	Component	Initial cost	Running cost Maintenance (as percentage of investment)
Conception of the system Pr EN 14437			
Emission	Direct heating including temperature control	X	
Distribution			
Storage			
Generation			
Energy supply	Electric board	X	

Table B.5 - Description of DHW systems with storage electrical water heater

System **Electrical storage water heater for domestic hot water production**	Component	Initial costs	Running costs Maintenance (as percentage of investment)
Conception of the system			
Emission	Valve Thermostatic valve Low flow valve	X	
Distribution	Piping	X	
Storage			
Generation	Hot water storage tank including temperature control	X	
Energy supply	Electric board	X	

Table B.6 - Description of electrical heat pump for space heating and DHW

Heating system **Electrical heat pump for space heating and domestic hot water**	Component	Initial costs	Running costs Maintenance (as percentage of investment)
Conception of the system			See EN 15450
Emission	Radiators Heating floor VAV Louvres (air)	X X X	
Distribution	Piping (water) Ducts (air)	X X	
	Pump Heat exchanger	X X	
Storage	Tank	X	
Generation	Heat pump	X	
Energy supply	Electric board	X	

Table B.7 - Description of ventilation system with VMC

VENTILATION SYSTEM VMC	Component	Investment costs	Specific running costs Maintenance
Conception of the system			
Emission	Terminal	X	Water treatment against corrosion and moisture
Distribution	Flexible ducts	X	
Storage			
Generation	Fan		
Connection to energy source	Electric board		

Table B.8 - Description of ventilation system with heat recovery unit(s)

Ventilation system **VMC with heat recovery units**	Component	Investment costs	Specific running costs Maintenance
Conception of the system			
Emission	Extract air grills	X	Water treatment against corrosion and moisture
Distribution	Flexible ducts	X	
Storage			
Generation	Fan and heat recovery units	X	
Connection to energy source	Electric board	X	

Table B.9 - Description of natural ventilation system

Ventilation system **Natural ventilation**	Component	Investment costs	Specific running costs Maintenance
Conception of the system			
Emission	Air grills	X	
Distribution	Conducts	X	
Storage			
Generation	Static extractors on the roof	X	
Connection to energy source			

Table B.10 - Description of ventilation system with humidity control

Mecanical ventilation VMC with humidity control	Component	Investment costs	Specific running costs Maintenance
Conception of the system			
Emission	Extract air grills	X	
Distribution	Flexible ducts	X	Cleaning
Storage			
Generation	Fan and heat exchanger or exhaust air (static or dynamic)	X	Cleaning filters
Connection to energy source	Electric board	X	

Table B-11 - Description of building envelope system

BUILDING CONSTRUCTION	Component	In any case	Running costs Maintenance (as percentage of investment)
Wall	Structure External cover Internal Insulation External insulation Internal cover (finish) …	X X x x X	
Facade – glazing	Doors Windows Solar protection	X X	
Roof	Structure Cover Insulation Finish	X X X X	
Floor	Structure Insulation	X X	
Thermal bridges	Industrial product Customised realisation		
Boiler adaptation	Chimney Room Flue systems		Depends on power of boiler
Others features	Technical galleries Access Building adaptation for fuel storage Building adaptation for electric transformer, gas valve, counting units		

Annex C
(informative)
Global cost – Presentation of results

Table C.1 – Presentation of results for global cost calculation

Duration of calculation (T)		Year	Operating cost factor				%	
Inflation rate		%	Energy cost evolution 1				%	
Market interest rate		%	Energy cost evolution 2				%	
Product cost factor		%	Electricity cost evolution				%	(for auxiliary components)
		Total TTC year 0	Inflation rate	Present value factor		Cost due to owner		Costs due to occupancy
1 – INITIAL COSTS								
Investment costs for HVAC and DWH systems				1,0000				
Investment costs for part of building construction related to energy savings and losses				1,0000				
2 – PERIODIC COSTS				Calculated for any year				
Costs for year 2								
Costs for year i								
Final value reduction					-			
3 – Running costs (operation, insurance,…) except energy				T years				
Annual costs								
4 – ANNUAL COSTS FOR ENERGY				Consider T years				
Annual costs energy 1	(to be multiply by T)							
Annual costs energy 2	(to be multiply by T)							
Annual costs for auxiliary (electricity)	(to be multiply by T)							
		GLOBAL COST						
		TOTAL GLOBAL COST						

Annex D
(informative)
Global cost calculation - Organisation of data and results

Table D.1 - Organisation of data for global cost calculation

Systems		Annuity cost	Initial Investment	Year 1						Year i						Year k						Year T_building			
		any Item to be considered		Operation	Maintenance	Repair				Operation	Maintenance	Repair				Operation	Maintenance	Repair				Operation	Maintenance	Repair	Final Value
System	Component1			X	X					X	X					X	X	X				X	X		Vf(1)
HVAC				X	X					X	X	X				X	X				X	X	X		
DWH				X	X					X	X					X	X					X	X		
Building	Component j		$A_0(j)$	X	X					X	X					X	X					X	X		Vf(j)
				X	X					X	X					X	X					X	X		
Operation cost				Σ						Σ						Σ									
Maintenance cost					Σ						Σ						Σ								
Repair cost						Σ						Σ						Σ							
Energy	Energy 1 Energy 2 …/…																								
Taxes, Insurance																									
Annuity factor																									
		RESULT	A_0	AC(1)						AC(i)						AC(k)						AC(T)			

Annex E
(informative)

Example 1 – Dwelling 100 m² with gas heating system

E.1 STEP 1 - Financial Data

- duration of the calculation : 30 years
- inflation rate : 2%
- market interest rate : 4%
- evolution of human operation costs : 2%
- evolution of energy prices :2% (gas and electricity)

E.2 STEP 2 - General information about project

E.2.1 Operated by owner

E.2.2 Environment of the project

Low rise building (ground floor)
Surface : 100 m² located in a residential area
Heated volume : 250 m^3
3 rooms – 1 Bathroom
Design room temperature : 18°C

E.2.3 Environment data (for information)

Heat demand: 2583 degree/day
Summer season E3 (french rating)
Noise area : BR3 (french rating)
Heating period : from October the 1st to May the 20th (232 Days)

Energy chosen for heating and domestic water: natural gas (network close to the construction)

E.3 STEP 3 - Investment costs

E.3.1 STEP 3.1 - Building Equipment costs

Table E.1 – description of the components used to defined the energy systems

Building construction		Identification	Number of units	Total cost including VAT	Lifespan
	Walls	Concrete Bricks	89	3083	Building
		External cover	89	1558	Building
		Insulation TH 38 8+1	89	1720	Building
	Glazing and doors	Insulating windows 4/12/4	12,8	2451	30
		External door	1	229	25
		Service door (to garage)	1	152	25
		Shutters	12.8	2100	25
	Cover	Roof cover (wooden structure+ terracosta cover)	140	8278	30
		Rockwool thickness : 200 mm	100	1021	40
		Plaster coating	100	1860	Building
	Floor	Floor structure concrete : thickness : 18 cm	100	6564	Building
		Floor insulation	100	820	Building
Heating system	Emission	Steel Radiators including hydraulic valve control, thermostatic valve and room control system	8	3792	20
	Distribution	Steel pipe		474	30
	Generation	Gas Combi boiler with flue Power :23 kW		1494	15
	Connection to energy	Gas Electricity		457 762	25

Building construction		Identification	Number of units	Total cost including VAT	Lifespan
Domestic Hot Water	Emission	Thermostatic valve	3 (kitchen and bathroom	153	20
	Distribution	Copper Piping	20 m	237	30
	Generation	See heating system			
Ventilation	Emission	Air input VMC in kitchen and bathroom	48 255	303	25
	Generation	Fan + flexible ducts	273	273	25
	Connection to electric board		69	69	25

E.3.2 STEP 3.2 - Replacement costs

Note 1: costs indicated here at different time are not actualised or calculated with real interest rate. As evolution rate for equipment, human costs and repairs are the same, costs are not displayed in the different categories.

Note 2 : Replacement will be ordered in the future. Hopefully better quality of replaced component is expected, and therefore lower energy consumption after this first lifespan can be foreseen. AT least the energy consumption shall not be higher than the original one.

Table E.2 – Costs for components of the energy systems

Heating			lifespan	lifespan	lifespan	lifespan	lifespan	lifespan
	Constituents	Investment cost	5 years	10 years	15 years	20 years	25 years	30 years
Emission	8 steel radiators (including fixing and connection)	3792				3792		
	thermostatic valve							
	+ Equilibruum valve + room thermostat							
Distribution	Steel piping	474						474
Generation	Combi boiler with flue	1494			1494			
	23 kW							
Connection to energy source	Gas connection	457					457	
	Electricity connection	762					762	

DHW			lifespan	lifespan	lifespan	lifespan	lifespan	lifespan
	Constituents	Investment cost	5 years	10 years	15 years	20 years	25 years	30 years
Émission	Mixing valve : 3	153				153		
	42,68 Euro HT / unit							
	2 in bathroom - 1 in kitchen							
Distribution	Copper piping	237						237
	9,91 Euro HT / m							

3 – Ventilation	Constituants	Investment costs TTC	lifespan 5 years	lifespan 10 years	lifespan 15 years	lifespan 20 years	lifespan 25 years	lifespan 30 years
Émission	Inlet air	46					46	
	Mecanical extraction (2 rooms)	255					255	
Generation	Fan unit + gains	273				273		
connection to energy suplly / and network	see heating							
TOTAL		**7944**	0	0	1494	4219	1520	711

E.3.3 Step 3.3 - Annual costs

Maintenance costs : 2,75% of the investment costs related to emission and generation for heating and distribution : 150 €

E.4 STEP 4 – Energy costs

E.4.1 STEP 4.1 - Energy consumption

Table E.3 – energy costs for the different energy systems

1 – Heating

Method of software used	Main assumption	Degree-day	2583	Dj 18 °C	Rating vs standard requirements or regulation	5	%
Méthod AC V6 (French)		Heating season		dayss	From		to
		Room temperature	18	°C	Night temperature		°C
					Exhaust air recuperation (Y/N	N	

Main energy used	Type	Unit for energy	Power	Unit	Storage	Unit
	Gaz	**9446 kWh**		kW		

2 - Domestic Hot Water

Main assumption	Average daily consumption		m³ / j
	Inlet temperature for water		°C

Main energy used	Typee	Unit	Power	Unit	Storage	Unit
	Gas	**2787 kWh**				

3 – Ventilation

minimum flow rate		m³/h	maximal flow rate		m³/h

Electricity	Power	Unit
	680	kWh

E.4.2 Step 4.2 - Energy costs

Table E.4 – Energy costs for the different systems

1 - Heating

				Reference	Price per unit	%	Consumption	Total HT	VAT and Taxes	Total TTC
Main energy	Energy	Gas	annual access		98			98	5,5	104
	Annual consumption	9446	Consumption		0,023	100	9446	216	19,6	259
	Power		Période 2							
	Tariff	B1	Période 3							
Auxiliary	Energy	Electricity	annual access		49			49	16,98	58
	Annual consumption		Consumption							
	Power		Période 2							
	Tariff (utility description)	6 kVA HP	Période 3							
			TOTAL HEATING					364		**420**

2 - Domestic hot water

				Reference	Price per unit	%	Consumption	Total HT	VAT and Taxes	Total TTC
Main energy used	Type	Gas	annual access							
	Annual consumption	2787	Consumption		0,023	100	2787	64	19,6	77
	Power or price per delivery		Période 2							
	Tariff	with heating	Période 3							
			TOTAL DHW					64		77

3 - Ventilation

				Reference	Price per unit	%	Consumption	Total HT	VAT	Total TTC
Electricity	Energy	**electricity**	annual access							
	Annual consumption	680	Consumption		0,078	100	680	53	31,08	70
Ad auxiliary at total	Power		Période 2							
	Tariff (utility description)	with heating	Période 3							

		Total HT	Total TTC
TOTAL VENTILATION		53	70
TOTAL Energy 1	Gas	379	439
TOTAL Electricity (auxiliary)		102	127
TOTAL ENERGY		**481**	**567**

E.5 STEP 5 - Global costs

E.5.1 Step 5.1 - Calculation of replacement costs and final value

Table E.5 - final value of the component

Calculation period Tn	30	years	Paybacktime for building	50	years

		lifespan 5 years	lifespan 10 years	lifespan 15 years	lifespan 20 years	lifespan 25 years	lifespan 30 years	lifespan 35 years	lifespan 40 years	lifespan 45 years	lifespan 50 years	lifespan Building
Replacement costs(building part)				1 494 1494	4 219	1 520	711					
Replacement costs(energy systems)						4 056	2 451		1 021			22 325
TOTAL				2888	4 219	5 576	4 656		1 021			22 325
At the end of period Tn	30years											
Final value		100,00%	100,00%	100,00%	50,00%	80,00%	100,00%	14,29%	25,00%	33,33%	40,00%	40,00%
Final value at Tn	20411	0	0	1494	2109	4461	3162	0	255	0	0	8930

NOTE : Part of the table dealing with replacment costs present only the value of replacement at the first replacement. In a second time calculation shall proceeds to the number of replacements due to combined lifespan of component and duration time choose for of the calculation.

E.5.2 Step 5.2 - Global cost report

Table E.6 – data sheet report for global cost calculation

General data for calculation						
Calculation period	30	Years	Operation cost rise rate	2	%	
Inflation rate	2	%	Gas price evolution	2	%	
Real interest rate	4,5	%			%	
Payback period for building	50	Years	Electricity price evolution	2	%	

	Total VAT incl. year 0	Inflation rate	Present value factor		Total due for owner	Total duefor occupant
1 - Investment (Steps 2.1 / 2.2)						
Investment cost for energy system	8 013		1,0000		8 013	
Investment cost for building	29 853		1,0000		29 853	
2 - Replacement costs (Step 3.)			Discount rate coefficient			
Replacement program for lifespan 15 years		2,0%	0,6954			
Replacement program for lifespan 20 years		2,0%	0,6161			
Replacement program for lifespan 25 years		2,0%	0,5459			
Replacement program for lifespan 30 years		2,0%	0,4836			
Final value at the end of the period of calculation	20 411	2,0%	0,4836	-	9 871 *	

3 - Annual cost (operation, maintenance, insurance,…) (step 3.3)				Present value factor	
		150	2,0%	21,0678	3 169

4 - Energy cost (module 3.4)				Present value factor	
Energy cost 1 – Gas		439	2,0%	21,0678	9 253
Energy cost for auxiliary (electricity)		127	2,0%	21,0678	2 682

Total global per actor	27 995	15 104
TOTAL GLOBAL COST	43 099	

E.6 STEP 6 – annuity calculation costs

Table E.7 - Data sheet report for annuity calculation

General data for calculation (from STEP 1)

Design payback period for building	50	Years	Operation cost rise rate	2	%
Inflation rate	2	%			
Real interest rate	4,5	%			

	Value TTC year 0	Inflation rate	Annuity factor	**Annualized cost for owner**	**Annualized cost for occupant**
1 - Investment					
2 - Replacement costs			For each period		
Lifespan 5 years		2,0%			
Lifespan 10 years		2,0%			
Lifespan 15 years	1 494	2,0%	0,0805	120	
Lifespan 20 years	4 219	2,0%	0,0639	270	
Lifespan 25 years	5 576	2,0%	0,0540	301	
Lifespan 30 years	3 162	2,0%	0,0475	150	
Lifespan 35 years		2,0%			
Lifespan 40 years	1 021	2,0%	0,0395	40	
Lifespan 45 years		2,0%			
Lifespan 50 years		2,0%			
Components unchanged during design calculation period of building	22 325	2,0%	0,0349	779	
3 - Running costs (except energy consumption - see STEP 4)					
Annual cost for operation, insurance, maintenance	150		1,0000		150
4 - Energy costs (module 3.4)					
Annual cost for all energies delivered	567		1,0000		567
Annualized costs depending on actors				1 661	717
Total annualised cost results				**2 378**	

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EN 13465 *Energy calculation for ventilation in residential systems*

EN 13779 *Energy calculation for ventilation in non-residential buildings*

EN 12170 *Heating systems in buildings – Procedure for the preparation of document for operation, maintenance and use – Heating systems requiring a trained operating*

EN 12171 *Heating systems in buildings – Procedure for the preparation of document for operation, maintenance and use – Heating systems not requiring a trained operating*

ISO/DIS 15686-5 *Buildings and constructed assets – Service life planning- Part 5 Life cycle*