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Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-6 Space heating generation systems, the performance of other renewables heat and electricity

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Foreword

This document (prEN 15316-4-6:2006) has been prepared by Technical Committee CEN/TC 228 “Heating systems in buildings”, the secretariat of which is held by DS (Danemark).

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.

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 European or International Standards, a.o. product standards. However, use of products complying with relevant product standards is no guarantee of compliance with the system requirements.

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 describe ways to meet the requirements, but other ways to fulfil the functional requirements might be used if 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

This standard presents a method for calculation of the electricity production of building integrated photovoltaic systems.

The calculation is based on the performance characteristics of the products given in product standards and on other characteristics required to evaluate the performance of the products as included in the system.

The user shall refer to other European Standards or to national documents for input data and detailed calculation procedures not provided by this standard.

Only the calculation method and the accompanying input parameters are normative. All values required to parameter the calculation method should be given in a national annex, containing appropriate national values corresponding to the tables given in annex B.

1 Scope

This standard is part of a set of standards on the method for calculation of system energy requirements and system efficiencies.

The scope of this specific part is to standardise for photovoltaic systems:

— required inputs;

— calculation method;

— resulting outputs.

The calculation method applies only to building integrated photovoltaic systems.

The calculation method does not take into account:

— electrical storage;

— PV/thermal photovoltaic systems.

The calculation method describes how to calculate the electricity production of photovoltaic systems.

Primary energy savings and CO_2 savings, which can be achieved by photovoltaic systems compared to other systems, are calculated according to prEN 15315.

Standards linked to photovoltaic systems are listed in annex A.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN 15315, *Energy performance of buildings - Overall energy use, primary energy and CO_2 emissions*

EN ISO 7345, *Thermal insulation - Physical quantities and definitions (ISO 7345:1987)*

EN ISO 15927 – 4, *Hygrothermal performance of buildings - Calculation and presentation of climatic data - Part 4: Hourly data for assessing the annual energy use for heating and cooling (ISO 15927-4:2005)*

3 Definitions and symbols

3.1 Definitions

To be updated according to the results of the joint working group

For the purposes of this standard, the definitions given in EN ISO 7345 and the following terms and definitions apply.

3.1.1
building system
technical equipment for heating, ventilation, cooling, lighting, domestic hot water and electricity production

3.1.2
recoverable losses
part of the losses from the heating, cooling, ventilation, domestic hot water and lighting systems, which may be recovered to lower the energy requirements

3.1.3
recovered loss
part of the recoverable losses which are recovered to lower the energy requirements

3.1.4
renewable energy
energy taken from a source which is not depleted by extraction (e.g. solar, wind)

3.1.5
resource energy
energy taken from a source which is depleted by extraction (e.g. fossil fuels)

3.2 Symbols and units

To be updated according to the results of the joint working group

For the purposes of this document, the following symbols and units (Table 1) and indices (Table 2) apply:

Table 1 — Symbols and units

Symbol	**Name of quantity**	**Unit**
E	emissions	Kg CO_2
f	primary energy conversion factor	-
FT	tilt and orientation conversion factor	-
G	solar irradiance	kW/m^2
H	annual solar irradiation	kWh/m^2 /a
P	peak power	kW
Q	quantity of heat, energy	kWh
R	system performance factor	-
RS	peak power factor	kW/m^2
S	surface	m^2

Table 2 — Indices

hor	horizontal	o	nominal conditions	p	performance
pv	photovoltaic	ref	reference	i	irradiation

4 Calculation method

4.1 Electricity delivered by the photovoltaic system

The electricity delivered by the photovoltaic system Q_{pv} is calculated by:

$$Q_{pv} = H_i \times P_0 \times R_p / G_{ref} \quad (1)$$

where:

H_i annual solar irradiation on the photovoltaic system

P_0 peak power
represents the electrical power of a photovoltaic system with a given surface and for a solar irradiance of 1 kW/m^2 on this surface (at 25 °C)

R_p system performance factor (see Table B.4)

G_{ref} reference solar irradiance equal to 1 kW/m^2

Calculation examples are given in annex C. Take in account also the influence of shadowing effects on the yearly produced electricity of parts of the building (like chimneys, ventilation units etc.).

4.2 Solar irradiation on the photovoltaic modules H_i

The solar irradiation on the photovoltaic modules is calculated by:

$$H_i = H_{hor} \times FT \quad (2)$$

where:

H_{hor} annual solar irradiation
on a horizontal surface in a geographic region.

Values shall be given in a national annex. For information, see Table B.1

FT tilt and orientation conversion factor
for calculation of the solar irradiation on the photovoltaic module surface.

Values shall be given in a national annex. For information, see Table B.2

4.3 Peak Power P_0

The peak power P_0 is obtained under standard test conditions (T = 25°C ±2°C, G_{ref} = 1 kW/m²).

If P_0 is not available, it can be calculated by:

$$P_0 = RS \times S \quad (3)$$

where:

RS peak power factor
depending on the type of building integration of the photovoltaic module.

Values shall be given in a national annex. For information, see Table B.3

S total surface of all photovoltaic modules (without frame)

4.4 System performance factor R_p

The system performance factor R_p takes into account the system performance of the building integrated photovoltaic installation depending on:

— conversion system from direct current to alternating current;

— actual operation temperature of the photovoltaic modules

— building integration of the photovoltaic modules.

Distinction between different building integration could be according to the type of ventilation of the photovoltaic modules.

Values for the system performance factor R_p shall be given in a national annex. For information, see Table B.4.

4.5 Auxiliary energy consumption

Auxiliary energy consumption is taken into account by applying only the net power production i.e. the total power production minus all auxiliary energy consumption inside the system boundaries.

4.6 Recoverable heat losses

No losses are recoverable for the diminution of the space heating needs.

Annex A
(informative)

Standards linked to photovoltaic systems

Table A.1 — Standards linked to photovoltaic systems

Standard	Note	Title
IEC 61173	system standard	Overvoltage protection for photovoltaic (PV) power generating systems - Guide
IEC 61194	system standard	Characteristic parameters of stand-alone photovoltaic (PV) systems
IEC 61277	system standard	Terrestrial photovoltaic (PV) power generating systems - General and guide
IEC 61683	system standard	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 61702	system standard	Rating of direct coupled photovoltaic (PV) pumping systems
IEC 61724	system standard	Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
IEC 61725	system standard	Analytical expression for daily solar profiles
IEC 61727	system standard	Photovoltaic (PV) systems - Characteristics of the utility interface
IEC 61829	system standard	Crystalline silicon photovoltaic (PV) array - On-site measurement of I-V characteristics
IEC 61836 TR2	system standard	Solar photovoltaic energy systems - Terms and symbols
IEC 61427	system standard	Secondary cells and batteries for solar photovoltaic energy systems (PVES) - General requirements and methods of test
IEC 61721	component standard	Susceptibility of a photovoltaic (PV) module to accidental impact damage (resistance to impact test)
IEC 61701	component standard	Salt mist corrosion testing of photovoltaic (PV) modules
IEC 61646	component standard	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
IEC 61345	component standard	UV test for photovoltaic (PV) modules
IEC 61215	component standard	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval
IEC 60904-10	component standard	Photovoltaic devices - Part 10: Methods of linearity measurement
IEC 60904-9	component standard	Photovoltaic devices - Part 9: Solar simulator performance requirements
IEC 60904-8	component standard	Photovoltaic devices - Part 8: Measurement of spectral response of a photovoltaic (PV) device
IEC 60904-7	component standard	Photovoltaic devices - Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device
IEC 60904-6 AMD1	component standard	Photovoltaic devices - Part 6: Requirements for reference solar modules, Amendment 1
IEC 60904-5	component standard	Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method
IEC 60904-3	component standard	Photovoltaic devices. Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data

IEC 60904-2 AMD1	component standard	Photovoltaic devices. Part 2: Requirements for reference solar cells, Amendment 1
IEC 60904-1	component standard	Photovoltaic devices. Part 1: Measurement of photovoltaic current-voltage characteristics
IEC 60891 AMD 1	component standard	Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices, Amendment No. 1

Annex B
(informative)

Informative values

B.1 Solar irradiation on the photovoltaic modules

Table B.1 — Annual solar irradiation on a horizontal surface (see also EN ISO 15927 – 4)

Zone	Regions	H_{hor} (kWh/m²)/a
PV1	PACA, Languedoc Roussillon	**1500**
PV2	Rhône Alpes, Midi Pyrénées	**1350**
PV3	Pays de la Loire, Poitou Charente, Aquitaine, Limousin, Auvergne	**1250**
PV4	Bretagne, Basse Normandie, Centre, Bourgogne, Franche Comté	**1150**
PV5	Nord Pas de Calais, Haute Normandie, Picardie, Ile de France, Champagne Ardenne, Loraine, Alsace	**1050**

Table B.2a — Zone PV1-Tilt and orientation conversion factor for calculation of the energy radiation on the photovoltaic module surface (see also EN ISO 15927 – 4)

Zone PV1		Orientation				
		West	South-West	South	South-East	East
		Conversion factor FT -				
Angle	0°	1.00	1.00	1.00	1.00	1.00
	30°	0.93	1.09	1.15	1.09	0.93
	45°	0.87	1.06	1.13	1.06	0.87
	60°	0.79	0.99	1.06	0.99	0.79
	90°	0.59	0.74	0.77	0.74	0.59

Table B.2b — Zone PV2-Tilt and orientation conversion factor for calculation of the energy radiation on the photovoltaic module surface (see also EN ISO 15927 – 4)

Zone PV2		Orientation				
		West	South-West	South	South-East	East
		Conversion factor FT -				
Angle	0°	1.00	1.00	1.00	1.00	1.00
	30°	0.93	1.06	1.10	1.06	0.93
	45°	0.87	1.02	1.08	1.02	0.87
	60°	0.79	0.95	1.00	0.95	0.79
	90°	0.60	0.70	0.71	0.70	0.60

Table B.2c — Zone PV3-Tilt and orientation conversion factor for calculation of the energy radiation on the photovoltaic module surface (see also EN ISO 15927 – 4)

Zone PV3		Orientation				
		West	South-West	South	South-East	East
		Conversion factor FT -				
Angle	0°	1.00	1.00	1.00	1.00	1.00
	30°	0.93	1.07	1.13	1.07	0.93
	45°	0.87	1.05	1.11	1.05	0.87
	60°	0.79	0.98	1.04	0.98	0.79
	90°	0.60	0.73	0.76	0.73	0.60

Table B.2d — Zone PV4-Tilt and orientation conversion factor for calculation of the energy radiation on the photovoltaic module surface (see also EN ISO 15927 – 4)

Zone PV4		Orientation				
		West	South-West	South	South-East	East
		Conversion factor FT -				
Angle	0°	1.00	1.00	1.00	1.00	1.00
	30°	0.93	1.06	1.11	1.06	0.93
	45°	0.87	1.03	1.09	1.03	0.87
	60°	0.79	0.96	1.02	0.96	0.79
	90°	0.60	0.72	0.74	0.72	0.60

B.2 Peak power

Table B.3 — Informative values of peak power factor

Type of photovoltaic module	**RS** kW/m²
Mono crystalline silicon [1)]	0.12-0.18
Multi crystalline silicon [1)]	0.10-0.16
Thin film amorphous silicon	0.04-0.08
Other thin film layers	0.035
Thin film Copper-Indium-Galium-diselenide	0.105
Thin film Cadmium-Telloride	0.095

[1)] with a minimum package density of 80 %

B.3 System performance factor

Table B.4 — Informative values of system performance factor

Type of building integration of the photovoltaic modules	**R_p** -
unventilated modules	0,70
moderately ventilated modules	0,75
strongly ventilated or forced ventilated modules	0,80

Annex C
(informative)

Calculation examples

Table C.1 — Calculation examples

Project data	**Example 1**	**Example 2**	**Example 3**
Geographic region	Rhône Alpes PV2	Languedoc Roussillon PV1	Ile de France PV5
Orientation	South	South	South
Angle	30°	90°	60°
Technology	Mono-crystalline	Multi-crystalline	Amorphous
Peak power P_0 [kW]	1.1	10	22
Module ventilation	unventilated	forced ventilation	poorly ventilated
Calculations			
H_{hor} (kWh/m²)/a (Table B.1)	1350.0	1500.0	1050.0
FT [-] (Table B.2)	1.10	0.77	1.01
H_i (kWh/m²)/a (chapter 4.2 equation (2))	1485.0	1155.0	1060.5
R_p [-] (Table B.4)	0.70	0.80	0.75
Results			
Q_{pv} [kWh/a] (chapter 4.1 equation (1))	1143.5	9240.0	17498.3