

# Altener program: SOLAR COMBISYSTEMS

## DOCUMENTATION OF PLANTS CALCULATION OF MAIN ENERGY DATA OF SOLAR COMBISYSTEMS

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## Symbol list

<b>Symbol</b>	<b>Definition</b>	<b>Unit</b>
A	area	m <sup>2</sup>
C	consumption	kWh
I	solar irradiation	kWh/m <sup>2</sup> .j
N <sub>im</sub>	number of days in a month	-
Q	energy quantity, load, loss	kWh
Q <sub>H</sub>	space heating load	kWh
Q <sub>DHW</sub>	domestic Hot Water load	kWh
η	efficiency	%
<b>Suffixes</b>		
aux	auxiliary	
bur	boiler	
c	solar collector	
conv	conventional	
e	outdoor	
H	space heating	
i	internal	
ref	reference	
sav	saved	
solar	solar	
st	stored	
DHW	Domestic Hot Water	

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## Introduction

This guidelines are elaborated in order to be in coherence with the monitoring procedure already documented.

For calculation of indicators of the box "MAIN ENERGY DATA OF SOLAR COMBISYSTEMS", comparison between actual energy consumptions of the solar combisystem and a single **reference** system will be made to calculate FSC (Fractional Solar Consumption), and comparison between actual energy consumptions of the solar combisystem and a single **conventional** system (without solar part) will be made to calculate Fsav (Fractional Energy Savings). FSC is calculated according what has been elaborated within framework of task 26. Fsav calculation is adapted from what has been elaborated within framework of task 26 in order to take better into account the variety of systems and auxiliary energy used.

### 1. Reference system (FSC calculation)

**Reference system is a system without solar collectors, identical for all studied combisystems, used to calculate the Fractional Solar Consumption. It is defined hereunder :**

Reference monthly DHW tank losses are given by :

$$Q_{st,ref} = (UA)_{S,DHW,conv} \cdot (\theta_{st,DHW} - 15) \cdot N_{jm} \cdot 24 / 1000 \quad (\text{kWh}) \quad (1)$$

with  $V_{S,DHW,ref} : 150 \text{ l}$

$(UA)_{S,DHW,conv} = 0.16 \sqrt{V_{S,DHW,ref}}$  : heat loss rate (W/K) (prENV 12977-1:2000).

$\theta_{st,DHW}$  : storage temperature, fixed at 52.5 °C

$N_{jm}$  : number of days in a month

Monthly reference energy consumption is given by :

$$C_{ref} = (Q_h + Q_w + Q_{st,ref}) / 0.85 \quad (2)$$

FSC is then calculated from available irradiation on collector area  $A_c \cdot I_c$  :

$$FSC = \frac{\sum_1^{12} \min(C_{ref}, A_c \cdot I_c)}{\sum_1^{12} C_{ref}} \quad (3)$$

## 2. Conventional systems (Fsav calculation)

Conventional systems are systems without solar collectors, using only auxiliary energy, to which solar combisystems are compared, in order to calculate savings. Several conventional systems are defined, according to the studied SCS.

### 2.1. SCS with separated auxiliary for space heating, based on Joule effect

Very few systems belong to this category : for example system #1 of the coloured booklet [1].

Space heating is provided by electric convectors with an efficiency of 1 :  $h_{bur,conv} = 1$   
DHW is provided by an electric Domestic Hot Water tank, with a **300 l** volume

### 2.2. SCS with integrated auxiliary for space heating

Most systems belong to this category.

Space heating of the conventional system is the same as the one of the SCS  
DHW is provided by a **150 l** Domestic Hot Water tank, heated by the auxiliary boiler  
The boiler uses the same energy as the auxiliary boiler of the SCS, with following efficiencies:

Electricity :  $h_{bur,conv} = 0.9$

Oil, gas :  $h_{bur,conv} = 0.85$

Wood :  $h_{bur,conv} = 0.75$

A space heating is considered only for SCS using wood logs as auxiliary energy. In That case, the volume of the SH tank of the conventiuonal system is supposed to be the same as the one of the combisystems

### 2.3. Conventional DHW tank losses

$$Q_{st,DHW} = (UA)_{S,DHW,conv} \cdot (\theta_{st,DHW} - \theta_{loc}) \cdot 24 \cdot N_{jm} \quad (\text{kWh}) \quad (4)$$

with  $V_{S,DHW,conv}$  : conventional DHW storage volume : 150 or 300 l

$(UA)_{S,DHW,conv} = 0.16 \sqrt{V_{S,DHW,conv}}$  : heat loss rate (W/K) (prENV 12977-1:2000).

$\theta_{st,DHW}$  : storage temperature, fixed at **52.5 °C**

$\theta_{loc}$  : room temperature where the tank is located

$N_{jm}$  : number of days in a month

## 2.4. Conventional SH tank losses (for SCS using wood boiler with long running time)

$$Q_{st,SH} = (UA)_{S,SH,conv} \cdot (\theta_{st,DHW} - \theta_{loc}) \cdot 24 \cdot N_{jm} \quad (\text{kWh}) \quad (5)$$

with  $V_{S,SH,conv}$  : conventional SH storage volume (l)

$(UA)_{S,SH,conv} = 0.16 \sqrt{V_{S,SH,conv}}$  : heat loss rate (W/K) (prENV 12977-1:2000).

$\theta_{st,SH}$  : storage temperature, fixed at **70** °C

$\theta_{loc}$  : room temperature where the tank is located

$N_{jm}$  : number of days in a month

## 2.5. Room temperature where the tank is located

$\theta_{loc}$  is related to the tank location. It is calculated on a monthly basis with following equation :

$$\theta_{loc} = \theta_i - b \cdot (\theta_i - \theta_e) \quad (^\circ\text{C}) \quad (6)$$

with  $\theta_i$  : set point inside temperature (°C)

$\theta_e$  : outdoor temperature (°C)

b : location factor, given in the following table :

Tank location	Location factor b
In the heated volume	0
In a non heated volume (garage, basement)	0,5
Outside	1

*Table 1 : Location factor*

## 2.6. Conventional consumptions calculation (space heating and Domestic Hot Water)

In order to estimate the consumption of the conventional system without solar, the losses of the Domestic Hot Water tank, the space heating tank and of the boiler must be added. This calculation is made on a monthly basis.

$$C_{conv} = (Q_h^* + Q_w^* + Q_{st}) / \eta_{bur} \quad (7)$$

with  $Q_{st}$  : storage losses =  $Q_{st,DHW} + Q_{st,SH}$  (kWh)

$Q_{st,DHW}$  : DHW storage tank losses (kWh)

$Q_{st,SH}$  : space heating storage tank losses (kWh)

$\eta_{bur}$  : boiler efficiency of the conventional system, depending on the auxiliary energy used (%)

### 3. Indicators calculation

In this chapter,  $C_{aux}$  is the monthly auxiliary energy needed by the solar combisystems, evaluated at the boiler inlet, obtained either from a simulation, either from measurements. Hereunder are given the equations to be used for the box "MAIN ENERGY DATA OF SOLAR COMBISYSTEMS"

#### 3.1. Energy savings

$$\sum_1^{12} C_{conv} - \sum_1^{12} C_{aux} \quad (\text{kWh/a}) \quad (8)$$

#### 3.2. Energy savings per $m^2$

$$\left( \sum_1^{12} C_{conv} - \sum_1^{12} C_{aux} \right) / A_c \quad (\text{kWh/m}^2.\text{a}) \quad (9)$$

#### 3.3. Fractional energy savings

$$\left( \sum_1^{12} C_{conv} - \sum_1^{12} C_{aux} \right) / \sum_1^{12} C_{conv} \quad (\%) \quad (10)$$

#### 3.4. FSC

Calculated with equations 1, 2 and 3

#### 3.5. Specific space heating load per $m^2$

$$\left( \sum_1^{12} Q_H \right) / A_c \quad (\text{kWh/m}^2.\text{a}) \quad (11)$$

#### 3.6. Specific DHW load per $m^2$

$$\left( \sum_1^{12} Q_{DHW} \right) / A_c \quad (\text{kWh/m}^2.\text{a}) \quad (12)$$

### 3.7. *Specific total load per m<sup>2</sup>*

$$\left( \sum_1^{12} Q_H + \sum_1^{12} Q_{DHW} \right) / A_c \quad (\text{kWh/m}^2 \cdot \text{a}) \quad (13)$$

### 3.8. *Solar conversion factor*

$$\left( \sum_1^{12} C_{\text{conv}} - \sum_1^{12} C_{\text{aux}} \right) / A_c \cdot I_c \quad (\%) \quad (14)$$

### 3.9. *System efficiency (incl. Boiler eff.)*

$$\left( \sum_1^{12} Q_H + \sum_1^{12} Q_{DHW} + \text{circulation losses} \right) / \left( \text{solar gain} + \sum_1^{12} C_{\text{aux}} \right) \quad (\%) \quad (15)$$

### 3.10. *System efficiency (excl. Boiler eff.)*

$$\left( \sum_1^{12} Q_H + \sum_1^{12} Q_{DHW} + \text{circulation losses} \right) / \left( \text{solar gain} + \sum_1^{12} (C_{\text{aux}} \times \eta_{\text{bur}}) \right) \quad (\%) \quad (16)$$

## 4. Bibliography

[1] : SUTER J.-M., LETZ T., WEISS W., INÄBNIT J., SOLAR COMBISYSTEMS in Austria, Denmark, Finland, France, Germany, Sweden, Switzerland, the Netherlands and the USA; overview 2000 ; IEA SHC – TASK 26, Bern, 2000, 42 p.