Altener program: SOLAR COMBISYSTEMS

WORKPACKAGE 6
MONITORING PROCEDURE

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Symbol list

Symbol	Definition	Unit
A	area	m²
C	consumption	kWh
H	mean heat loss coefficient	W/K
I	solar irradiation	kWh/m².j
N_{jm}	number of days in a month	-
Q	energy quantity, load, loss	kWh
Q_c	energy delivered by the solar collector	kWh
Q_h	space heating load	kWh
Q_i	internal gains	kWh
$Q_{inj,h}$	energy injected in the space heating loop	kWh
Q_w	domestic Hot Water load	kWh
θ	temperature	°C
θ_w	cold water temperature	°C
θ_e	outdoor temperature	°C
θ_i	inside temperature	°C
η	efficiency	%
X	Ration irradiation/reference consumption	-
W	electric consumption	kWh
Δt	running time	H
Suffixes		
aux	auxiliary	
bur	boiler	
c	solar collector	
conv	conventional	
e	outdoor	
el	electrical	
ext	extended (thermal and electrical)	
h	space heating	
i	internal	
loss	losses	
m	monthly	
ref	reference	
sav	saved	
solar	solar	
st	stored	
therm	thermal	
w	Domestic Hot Water	
*	used when a definition is slightly modified	
Fonts		
normal	calculated values	
bold	identified or estimated values	
italic	measured values	

<u>Annual and monthly values</u> :

In general, energy balances can be calculated on a yearly or monthly period, with same formula. If the annual formula are ambiguous, the symbol S is placed before the concerned figure.

Introduction

In order to be in coherence with the ranking and comparison criteria proposed in Task 26, a method for monitoring solar combisystems has been elaborated, that gives as an output a value for the Fractional energy savings F_{sav} according to the Fractional Solar Consumption FSC [1]. Hereunder, a method based on monthly energy balances is described. F_{sav} is evaluated by comparison between the auxiliary energy used by the SCS and the one used by a conventional system without solar collector, using the same energy.

FSC doesn't not depend on the SCS and the auxiliary energy used. It only characterises the solar potential compared to a reference consumption necessary for space heating and DHW production. It is for this reason that it doesn't take into account the real auxiliary energy usd by the SCS.

First, the list of data required, and the place where measurements have to be done, are given. Then a diagram is presented, that gives an overview of the way the measured data are used. Then the estimation of the conventional load is presented. Next the reference systems are described in details. Then, the estimation of the conventional consumption is presented (the word "conventional" means that a conventional space heating and DHW system is considered, but installed in the "same" house as the monitored one). At last, the indicators are calculated.

The method can be used when no solar heat is stored in the building itself (heating floors or walls). In that case, the real space heating load can be assessed with the energy injected in the space heating loop. At the opposite, if the building is used as space heating storage for solar heat, the real space load must be assessed by using an identification process, that allows to evaluate the real heat loss coefficient if the building.

SCS sold in european countries differ in their hydraulic diagram, the boundaries of the system (is the auxilary boiler sold or not with the SCS ?), the auxilary energy used. Moreover, the national Thermal Regulations are not the same in all countries. So it is impossible to define a single way to monitor SCS. But it is important to try to define the most common method, in order to make comparisons possible, between results for different SCS in different countries.

1. Classification of SCS with respect to monitoring

1.1. SCS with separated auxiliary for space heating

This category contains SCS with an auxiliary space heating delivered by electrical heaters or a wood stove (or equivalent). It is almost impossible to measure correctly the used or delivered energy by a wood stove. So monitoring can only be made with an electrical auxiliary space heating. But of course, these SCS will also be able to be sold with wood as auxiliary energy for space heating.

1.2. SCS with integrated auxiliary for space heating

In this category, two variations can be found :

- SCS with an auxiliary boiler integrated in the storage tank, where it is impossible to measure energy at the boiler outlet
- SCS with a remote auxiliary boiler, that can be :
  - A wood boiler. In this case, it is almost impossible to measure energy at the boiler inlet : it is difficult to assess the exact amount of energy of the wood put in the boiler, because of the variation of its humidity.
  - An electric, oil or gas boiler. In this case, energy can measured either at the inlet or at the outlet of the boiler.

The following table and diagram give a list of required heat-meters and their location, according to the type of studied SCS, using the classification of task 26 [2].

Type	Auxiliary boiler input (1)	Auxiliary boiler output (1')	DHW (2)	Space heating loop (3)	Solar collector loop (4)	Generic system n°
SCS with separated auxiliary for space heating	**Electricity meters for the heaters and for the auxiliary DHW tank**		**yes**	**yes**	yes	1
SCS with integrated auxiliary burner	**Oil-meter or gas-meter**		**yes**	**yes**	yes	5; 6; 7; 8; 15
SCS with wood auxiliary boiler		**yes**	**yes**	**yes**	yes	11; 12; 13; 14
SCS with coupled auxiliary oil- or gas-boiler	Oil-meter or gas -meter or electric-meter **or**	yes	**yes**	**yes**	yes	2; 3; 4; 9; 10; 11; 12; 14; 16; 17; 18

+ indoor temperature, outside temperature, irradiation in the collector plane

*Legend : **mandatory**, optional. ("yes" means "a heat meter is required")*

Table 1 : Required meters

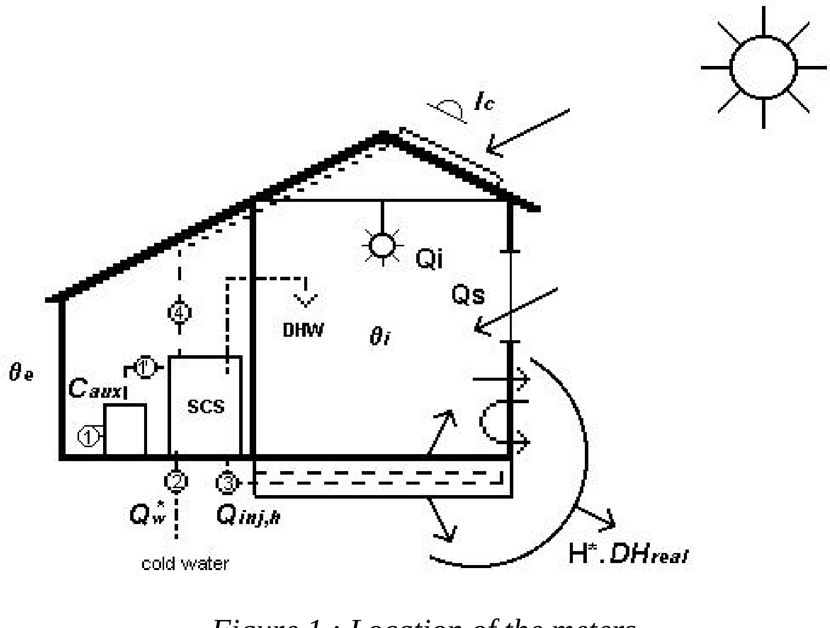

Figure 1 : Location of the meters

The choice between the two possibilities 1 and 1' will be made according to the boundaries of the system sold by the manufacturer. If a special auxiliary boiler is sold or recommended by the manufacturer, auxiliary energy should be measured at the boiler inlet. At the opposite, if an existing boiler is used, or if an auxiliary wood boiler is used, or if the boiler can not be considered as a part of the system, auxiliary energy should be measured at the boiler outlet.

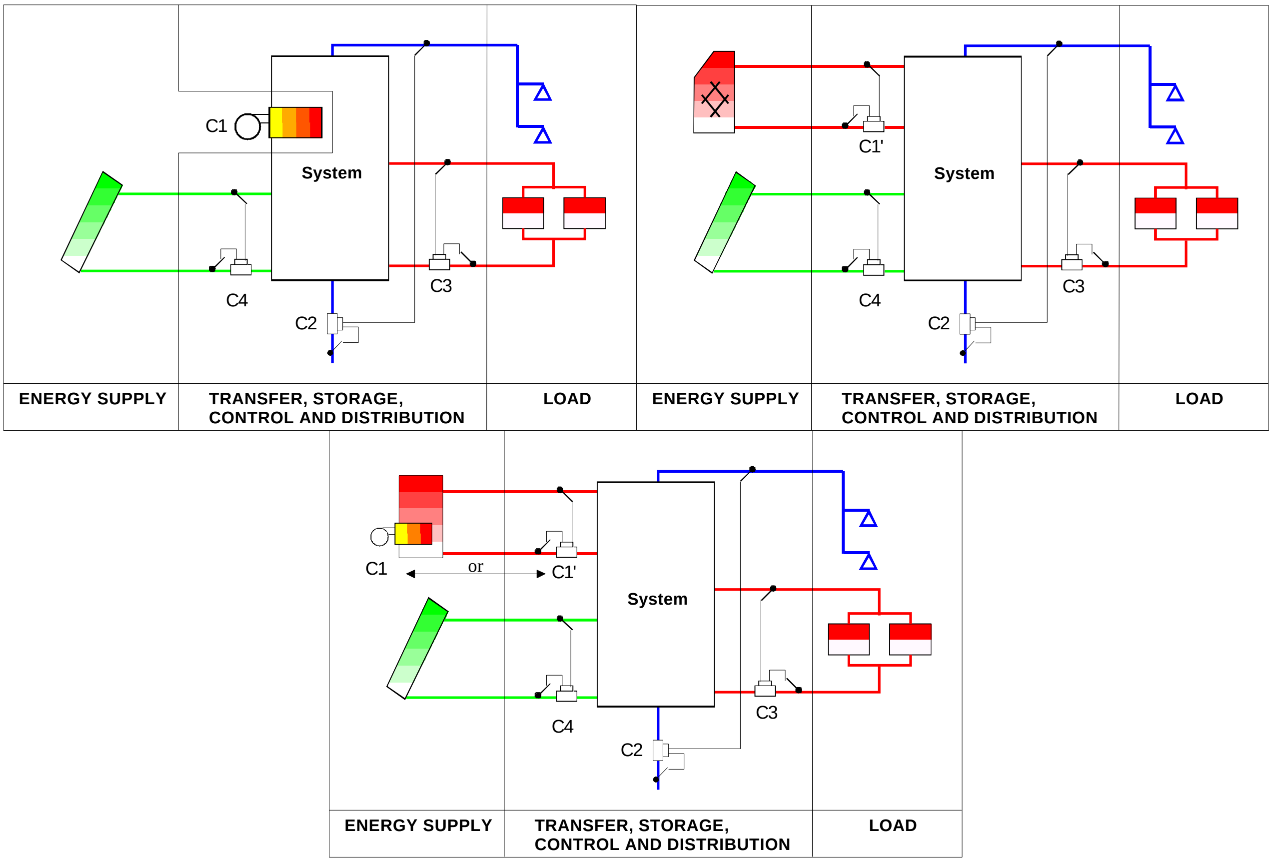

Figure 2 : Location of the meters

2. Monitoring equipment

The following tables gives the list of measured data :

Symbol	Meaning	Unit	Location
C_{aux}	**auxiliary consumption**	**kWh**	**1 or 1'**
I_c	**solar irradiation on the solar collector**	**kWh/m²**	**in the collector plane**
Q_w^*	**DHW load**	**kWh**	**2**
$Q_{inj,h}$	**energy injected in the space heating loop**	**kWh**	**3**
W_{el}	**parasitic electricity consumption**	**kWh**	
Q_c	energy delivered by the solar collector	kWh	4
q_i	**inside temperature**	**°C**	
q_e	**outdoor temperature**	**°C**	
Δt	running time of pumps	h	
$Q_{s,inj,h}$	solar energy injected in the space heating loop	kWh	
$Q_{aux,inj,h}$	auxiliary energy injected in the space heating loop	kWh	

Legend : **mandatory**, optional.

Table 2 : measured data

The upper calorific value of oil or gas consumed must be used for C_{aux} assessment.

3. Monitoring diagram

Following diagrams present the methodology proposed for measurements analysis, in order to determine the parameters FSC and F_{sav}.

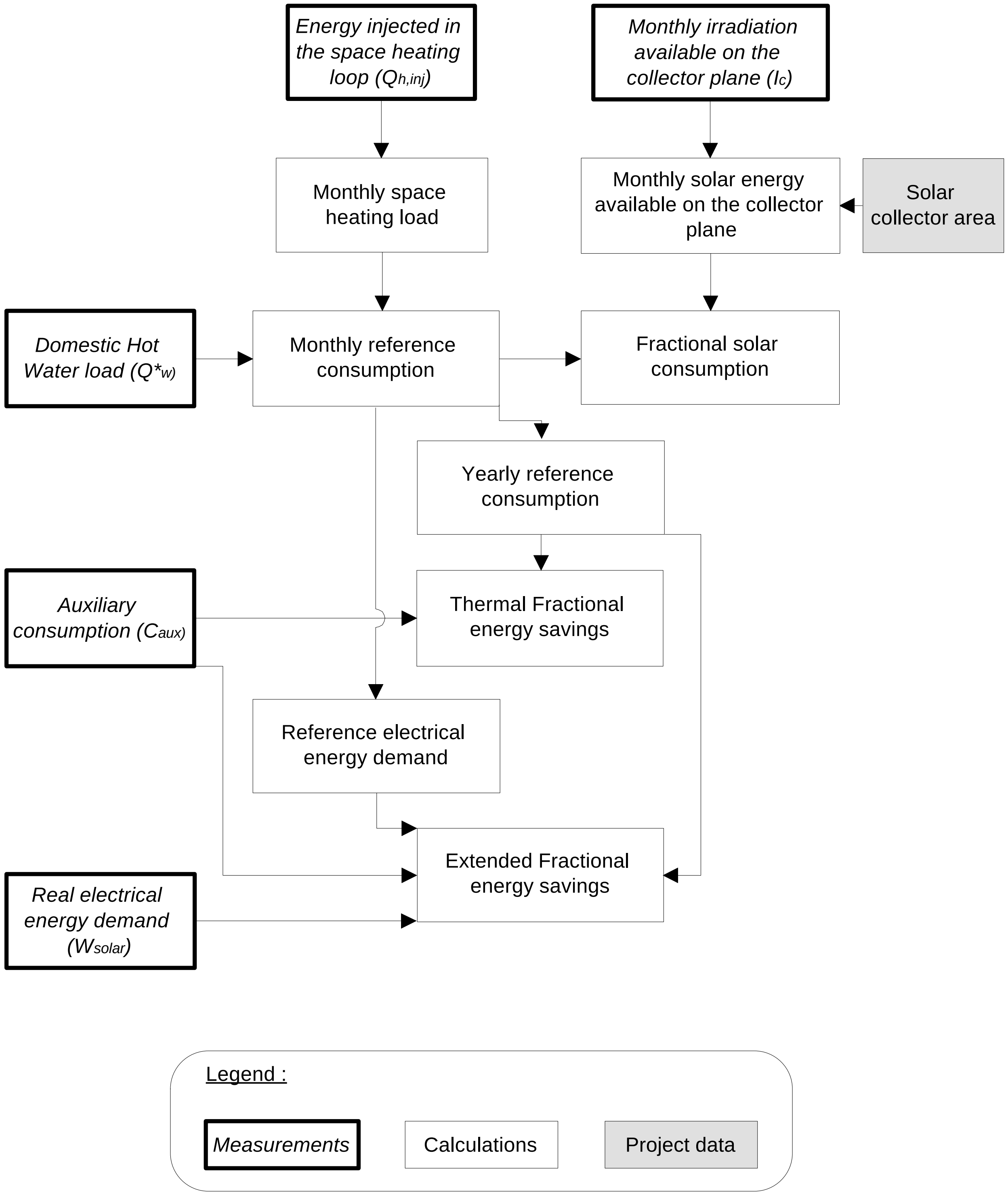

Figure 3 : how to use monitored data

- The first step consists in calculating the monthly values for the solar irradiation available on the collector area.

The best method is to use a pyranometer located in the collector plane. A calibrated PV cell can also be used, but provides usually a worse accuracy.

If no irradiation measurements are done on site, the meteorological data from the nearby station will be used : monthly sun duration or monthly irradiation available on the horizontal plane. Shadows created by masks should be taken into account when calculating corresponding irradiations in the collector plane.

- The <u>second step</u> consists in calculating reference monthly consumptions.
- The <u>third step</u> consists in calculating the Fractional Solar Consumption ratio.
- The <u>fourth step</u> consists in calculating thermal and extended Fractional Energy Savings

4. Conventional load calculation (space heating and Domestic Hot Water)

4.1. Conventional space heating load

For SCS not using the building itself as storage, the energy injected in the space heating loop, and measured directly by the heatmeter n°3, can be considered as space heating load $Q^*_{h.}$. This quantity is not strictly the space heating load, because it takes into account the distribution and emission losses.

For SCS using the building itself as storage for space heating, or a part of it like the heating floor, the inside air temperature is sometimes higher than the set point air temperature. The conventional load must be then calculated with a three steps procedure :

- Identification of the real thermal coefficients of the house (heat loss coefficient, internal gains, passive solar gains)
- Determination of the lenth of the heating season
- Calculation of the space heating load

This special method should be used for example with SCS #1 abd #3, so-called Direct Solar Floors, where solar energy is stored directly in the heating floor.

4.2. Domestic Hot Water load

The Domestic Hot Water Load Q^*_w is measured directly by the heatmeter n°2. This quantity is not strictly the DHW load, because it takes into account the distribution losses.

5. Definition of conventional systems (without solar equipment)

Proposed indicators $F_{sav,th}$, $F_{sav,ext}$ are calculated with regard to a conventional system, that must be exactly defined. The controllers of some combisystems not only manage the solar contribution, but also the operation of the auxiliary boiler. The question is then : which system without solar part should the combisystem be compared with ? And how are the savings defined ?

In order to be able to compare two different combisystems, it is necessary for the conventional systems to be independent of the studied combisystems. The conventional system will just be chosen to deliver the same comfort as the studied combisystem : same space heating emitter, Domestic Hot Water produced in a storage tank.

At a national level, one can use a national reference system, defined for example according the national thermal regulation. For international comparison, the definition of one common reference system is mandatory. It is based on definitions agreed on in the framework of task 26, with additional proposals to take into account a greater variety of systems.

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

The conventional system includes electric convectors, and a electric Domestic Hot Water tank.

5.2. SCS with integrated auxiliary for space heating

The conventional system includes a boiler burning the same energy as the auxiliary boiler of the SCS, and a Domestic Hot Water tank, heated up by the boiler.

Space heating emitters are the same as for the monitored SCS.

For SCS using biomass as auxiliary energy, a storage tank has to be included in the conventional system if it is necessary for a good working of the boiler (for example buffer storage tank for wood boiler using wood logs)

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.

$$C_{conv} = (Q^*_h + Q^*_w + Q_{st}) / \eta_{bur} \qquad (1)$$

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

6.1. DHW Tank losses

Conventional DHW tank losses are given by :

$$Q_{st,DHW} = (UA)_{S,DHW,conv} \cdot (\theta_{st,DHW} - \theta_{loc}) \cdot N_{jm} \cdot 24/1000 \quad \text{(kWh)} \qquad (2)$$

with $V_{S,DHW,ref}$: storage volume (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

θ_{loc} : room temperature where the tank is located

N_{jm} : number of days in a month

The size of the reference DHW tank $V_{st,DHW}$ is a function of the category of auxiliary heating system :

SCS with an separated auxiliary space heating, based on Joule effect : $V_{st,DHW}$ = 300 l

SCS with an integrated auxiliary space heating : $V_{st,DHW}$ = 150 l

θ_{loc} is related to the tank location. It is given by :

$$\theta_{loc} = \theta_i - b \cdot (\theta_i - \theta_e) \quad \text{(°C)} \qquad (3)$$

with θ_i : set point inside temperature (°C)

θ_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 3 : Location factor

6.2. Space heating tank losses (for SCS using wood boiler with long runnig time)

Conventional tank losses are given by :

$$Q_{st,SH} = (UA)_{S,SH,conv} \cdot (\theta_{st,SH} - \theta_{loc}) \cdot N_{jm} \cdot 24/1000 \quad \text{(kWh)} \qquad (4)$$

with $V_{S,SH,ref}$: storage volume, identical to the SCS storage volume (l)

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

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

θ_{loc} : room temperature where the tank is located

N_{jm} : number of days in a month

6.3. Heat generation efficiency

6.3.1. Remote Joule effect generators

For these devices, the generation efficiency is 100 %.

6.3.2. Electric boiler

For these devices, the generation efficiency is 90 %.

6.3.3. Combustion generators

For these devices, the generation efficiency is fixed at 85 % for gas or oil boiler, and 75 % for biomass boiler.

The reference nominal boiler power is chosen with table 5, according to the maximum heat losses of the house P_n given by :

$$P_n = 1{,}2 \,.\, H \,.\, (19 - T_{base}) \qquad (5)$$

Where T_{base} : ambient design temperature (°C)
H : heat loss coefficient of the house (W/K)

	Nominal boiler power P_n
$P_n < 14$	14
$14 < P_n < 18$	18
$18 < P_n < 23$	23
$23 < P_n < 27$	27
$27 < P_n < 36$	36
$36 < P_n < 45$	45

Table 4 : Reference nominal boiler power

6.4. *Parasitic electric consumptions*

The approach presented here is based on the propositions made by Task 26 of the IEA [4].

6.4.1. Boiler

The monthly running time of the boiler is given by :

$$\Delta t_{bur,on,ref} = \frac{Q^*_h + Q^*_w + Q_{st}}{P_n} \qquad (6)$$

with P_n : reference nominal boiler power (kW)
Q^*_h : space heating load (kWh)

Q^{*}_{w} : Domestic Hot Water load (kWh)
Q_{st} : storage losses = $Q_{st,DHW} + Q_{st,SH}$ (kWh)

The electrical energy demand of the reference boiler is given by :

$$W_{bur,ref} = P_{el,bur,on} \,.\, \Delta t_{bur,on,ref} + P_{el,bur,stby} \,.\, (24 * N_{jm} - \Delta t_{bur-on,ref}) \quad \text{(kWh/month)} \qquad (7)$$

with $P_{el,bur,on}$: electrical power of the reference boiler when working (kW)
$P_{el,bur,stby}$: electrical power of the reference boiler when standby (kW)

Combining both equations 5 and 6, $W_{bur,ref}$ is given by :

$$W_{bur,ref} = \frac{Q^{*}_{h} + Q^{*}_{w} + Q_{st}}{P_{n}} \cdot (P_{el,on} - P_{el,stby}) + 24 * N_{jm} \cdot P_{el,stby} \quad \text{(kWh/month)} \qquad (8)$$

The electrical power of the conventional boiler are given by :

$$P_{el,bur,stby} = 9\ \text{W}$$
$$P_{el,bur,on} = 0{,}8349 \times P_{n} + 22{,}257 \qquad (9)$$

Reference nominal boiler power	Electrical power of the boiler
14 kW	34 W
18 kW	37 W
23 kW	41 W
27 kW	45 W
36 kW	52 W
45 kW	60 W

Table 5 : Electric power of the boiler

The electric power of the conventional pump of the DHW tank loop is given by :

$$P_{el,w} = 60\ \text{W}$$

The electric power of the pump of the space heating loop is given by :

$$P_{el,sh} = 95\ \text{W}$$

6.4.2. DHW load pump

The yearly running time of the pump for DHW preparation is given by :

$$\Delta t_{W} = \frac{Q^{*}_{w} + Q_{st}}{P_{n}} \qquad (10)$$

The electrical energy demand of the reference pump for DHW preparation is given by :

$$W_{el,w,ref} = \Delta t_w \cdot P_{el,w} \quad (11)$$

with $P_{el,w}$: electrical power of the reference pump for DHW (kW)

6.4.3. Space heating loop

The electrical energy demand of the reference pump of the space heating loop is given by :

$$W_{el,h,ref} = \Delta t_h \cdot P_{el,h} \quad (12)$$

with $P_{el,h}$: electrical power of the reference pump of the space heating loop (kW)
Δt_h : length of the time heating season (h), considered to be the same as the real one

6.4.4. Controller

The electrical energy demand of the controller is neglected.

6.4.5. Global electricity consumption

The global electrical energy demand $W_{el,ref}$ is calculated with :

$$W_{el,ref} = W_{bur,ref} + W_{el,s,ref} + W_{el,w,ref} \quad (13)$$

7. Indicators calculation

In order to be able to compare performances of different plants, the FSC method developed in the framework of task 26 is used, with some adaptations. Indicators are calculated in two different ways, according to the location of the meter for auxiliary energy. If auxiliary energy is measured at the boiler inlet, boiler efficiency is taken into account.

7.1. Fractional solar consumpion

FSC is calculated according to task 26 definitions, i.e. with a 0.85 efficiency for the reference boiler.

$$FSC = \frac{\sum_{1}^{12} \min((Q^*_h + Q^*_w + Q_{st,DHW}) / 0.85, A_c . I_c)}{\sum_{1}^{12} (Q^*_h + Q^*_w + Q_{st,DHW}) / 0.85} \quad (14)$$

7.2. Fractional thermal energy savings

This indicator only takes into account the thermal behaviour of the SCS.

7.2.1. With boiler efficiency

$$f_{sav,th} = 1 - \frac{C_{aux,(1)}}{(Q^*_h + Q^*_w + Q_{st}) / \eta_{bur}}$$ *C_{aux} is measured with the meter n°1* (15)

η_{bur} is the conventional efficiency defined in chapter 6.2.

7.2.2. Without boiler efficiency

$$f^*_{sav,th} = 1 - \frac{C_{aux,(1')}}{(Q^*_h + Q^*_w + Q_{st})}$$ *C_{aux} is measured with the meter n°1'* (16)

7.3. Extended fractional solar savings

This indicator also takes into account the parasitic electricity used by the SCS for pumps, valves, controller, and the boiler. Electricity is calculated at the primary energy level, considering an efficiency η_{el} of 40 % for generation and distribution.

7.3.1. With boiler efficiency

$$f_{sav,ext} = 1 - \frac{C_{aux,(1)} + W_{solar} / \eta_{el}}{(Q^*_h + Q^*_w + Q_{st}) / \eta_{bur} + W_{el,ref} / \eta_{el}}$$ *C_{aux} is measured with the meter n°1* (17)

7.3.2. Without boiler efficiency

$$f^*_{sav,ext} = 1 - \frac{C_{aux,(1')} + W_{solar} / \eta_{el}}{(Q^*_h + Q^*_w + Q_{st}) + W_{el,ref} / \eta_{el}}$$ *C_{aux} is measured with the meter n°1'* (18)

8. Practical recommandations for monitoring

8.1. Location of heat-meters

Flow-meters should be located on pipes where the flow is as constant as possible. So, when monitoring a loop with a three-way valve, the flow-meter should be located in the same section as the pump.

8.2. Choice of temperature sensors

Temperature sensors should be chosen so as to have the smallest response time. This is very important for the Domestic Hot Water loop, where there is no continuous flow, and where the water temperature falls down when there is no draw-off. So in order to minimize the measurement error made when a water draw-off begins, the temperature sensor should be able to give very quickly an accurate measure. Temperature sensors placed in "doigt de gant" should be preferred to contact sensors;

9. Extrapolations to get yearly energy balances from the real monitoring period

9.1. Monthly results diagram

When plotting the monthly fractional energy savings $f_{sav,th}$ according to the ratio X defined by the total monthly irradiation on the collector area divided by the monthly conventional consumption for a chosen plant, a characteristic curve can be observed (figure 4). X is calculated according equation 19.

$$X = \frac{A_c . I_c}{(Q^*_h + Q^*_w + Q_{st}) \ / \ \eta_{bur}} \qquad (19)$$

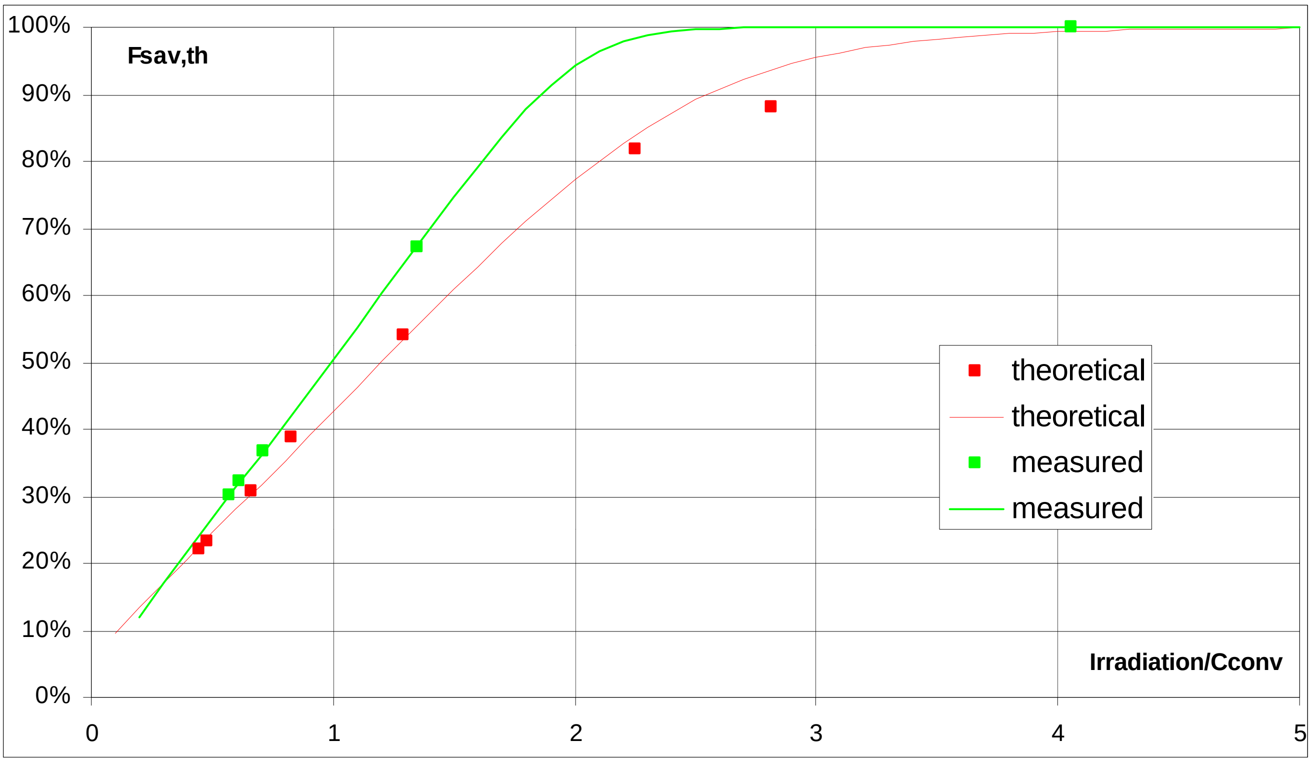

Figure 4 : example of characteristic curves of a plant

An analytic expression of the curve which interpolates best the monthly points is given by equation 20.

$$f_{sav,th,m} = \frac{A\,(X - B) - [A\,(X - B)]^C}{1 - [A\,(X - B)]^C} \qquad (20)$$

The coefficients of the curve A, B and C are adjusted to get the best fitting of the interpolating curve with real points.

This method can be used as well for the theoretical values resulting from the dimensionning study as for monitoring results. The curves can differ more or less, because of differences between the real space heating loads created by different inside set-point temperatures, and also differences in the DHW loads. In the example shown in figure 4, the extrapolated curve is slightly above the theoretical one, which shows that the system works quite well. However, the curve interpolated from measured values can be considered as more significant and representative of the real behaviour of the system. It will therefore be used for further extrapolations.

9.2. Yearly extrapolation from monthly results

To obtain yearly extrapolation from monthly monitoring results, the following method is used :

1. At the very least, 3 monthly data sets are necessary. But obviously more data stes will improve the accuracy of the extrapolation method. For each month, following measurements are needed :
   - Irradiation
   - "Real" degree-days, evaluated with measured inside air temperature and outdoor temperature
   - Space heating load
   - DHW load
   - Auxiliary energy consumption

   From these data, the space heating "signature" of the house is calculated, by plotting the measured space heating load according to the degree-days DD. Monthly space heating load can be represented as a linear function of degree-days :

   $Q_h = a \cdot DD + b$ (kWh) (21)

   In the given example (figure 5), the signature is characterized by the values a = 9.36 and b = -575.

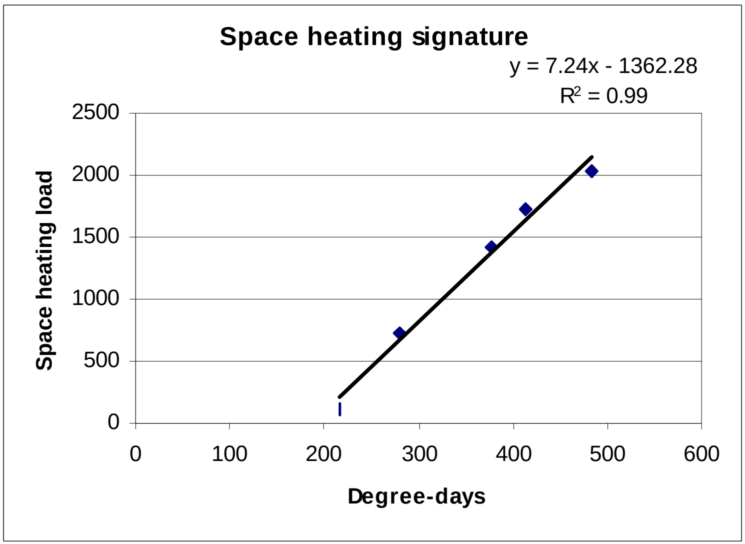

Figure 5 : space heating "signature" of a house

2. From the monitored DHW loads (or from the DHW draw-off and the cold and hot water temperatures), a mean value can be calculated for the DHW daily load.
3. From the monitored space heating and DHW loads, and using the conventional DHW tank losses, the conventional energy consumption C_{conv} is calculated using equation 1
4. The ratio total irradiation on the collector area divided by the conventional energy consumption C_{conv} can then be calculated, using equation 21. The coefficients of the curve A, B and C can be determined as explained in chapter 9.1 (equation 20)
5. Extrapolation is made for missing monitoring months with following method, using theoretical degree-days and irradiations :

   - From the theoretical monthly degree-days, the conventional space heating load is calculated with equation 21 and parameters a and b calculated in step 1.
   - The conventional DHW load is calculated using the mean monthly value determined with first measurements.
   - The conventional energy consumption C_{conv} is calculated using equation 1
   - The X ratio is calculated with equation 19
   - The monthly fractional energy savings $f_{sav,th,m}$ are obtained from equation 20 and parameters A, B and C calculated in step 4.
   - The monthly energy savings come from equation 22 :

$$Q_{sav,th} = f_{sav,th,m} \cdot C_{conv} \quad (22)$$

It now possible to calculate yearly extrapolations for FSC and $f_{sav,th}$, using monthly monitored data when there are available and monthly extrapolated data for other months in equation 13 and 15. Table 6 gives an example.

		J	F	M	A	M	J	J	A	S	O	N	D	Total
Number of days		31	28	31	30	31	30	31	31	30	31	30	31	
Degree-days		484	414	281	188	0	0	0	0	0	216	280	377	2241
Irradiation	kWh	1721	1714	2343	2556	2652	2592	2866	2871	2507	2280	1690	1188	26980
Reference DHW tank losses	kWh	68	61	64	60	59	54	53	54	55	55	63	68	712
Space heating load	kWh	2032	1719	673	2	0	0	0	0	0	112	728	1414	6680
DHW load	kWh	277	257	287	278	287	278	287	287	278	311	277	276	3378
Qaux	kWh	1894	1518	87	0	0	0	0	0	0	0	411	1444	5354
Cref	kWh	2797	2396	1205	399	407	390	400	401	391	562	1257	2067	12671
Usable irradiation	kWh	1721	1714	1205	399	407	390	400	401	391	562	1257	1188	10034
FSC														0.79
Cconv	kWh	2797	2396	1205	399	407	390	400	401	391	562	1257	2067	12671
Irradiation/Cconv		0.615	0.715	1.944	6.406	6.523	6.649	7.161	7.163	6.415	4.057	1.345	0.575	
Fsav,th (points)		32.3%	36.7%	92.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	67.3%	30.1%	57.7%

legend

monitoring data
theoretical values
calculations

Table 6 : Example of extrapolation

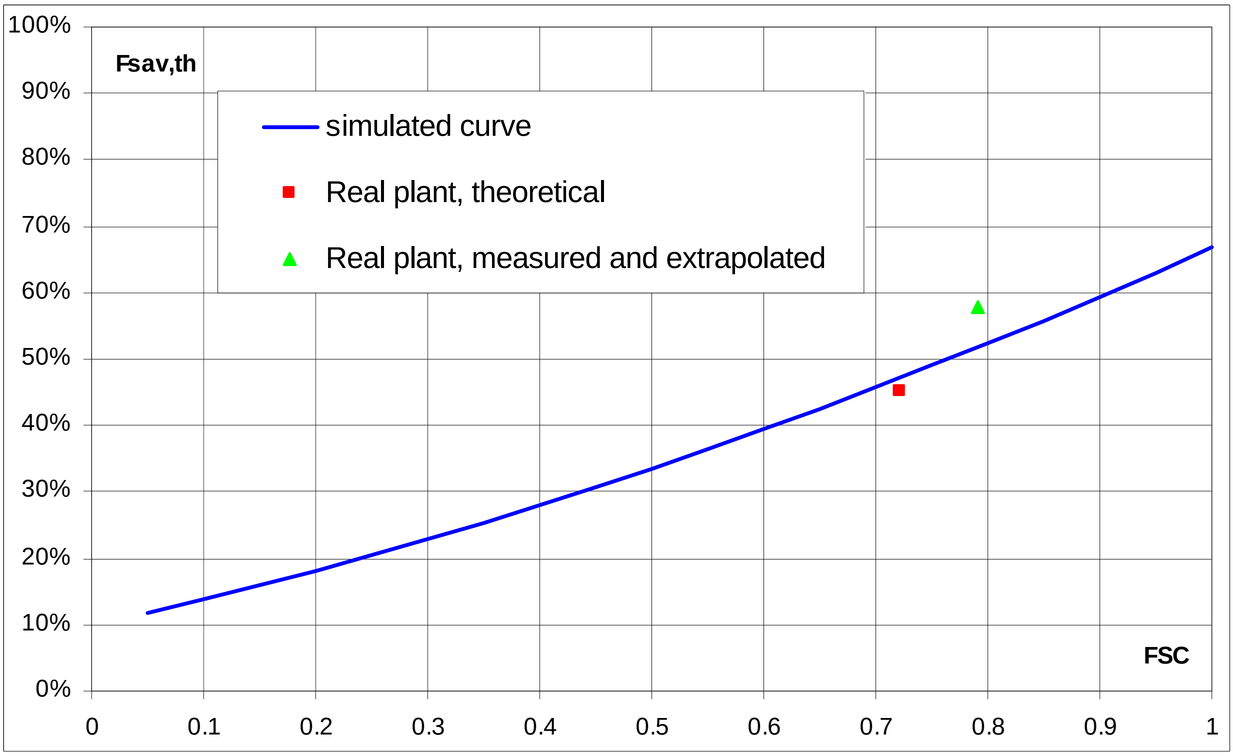

Figure 6 : Example of extrapolated yearly results

10. Bibliography

[1] : **LETZ T.**, Combisystems characterisation, IEA SHC – TASK 26, 6th Experts Meeting, Delft, Finland, April 2 - 4, 2001

[2] : **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.

[3] : **CSTB** : Méthode de calcul Th-C : Annexe n°1 à l'arrêté portant approbation des méthodes de calcul Th-C et Th-E, 2001

[4] **: IEA SHC – TASK 26 : SOLAR COMBISYSTEMS** ; subtask C milestone report C 0.2 ; Reference conditions ; october, 2001. Rapperswil, Switzerland, October 7 - 10, 2001